MECHANIC DIESEL

TRADE THEORY

NSQF LEVEL - 4

HANDBOOK FOR CRAFTS INSTRUCTOR TRAINING SCHEME

कौशलं बलम्
Directorate General of Training

DIRECTORATE GENERAL OF TRAINING
MINISTRY OF SKILL DEVELOPMENT & ENTREPRENEURSHIP
GOVERNMENT OF INDIA

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE, CHENNAI

Post Box No. 3142, CTI Campus, Guindy, Chennai - 600 032

Published by

National Instructional Media Institute
Post.Box.No. 3142,
Guindy, Chennai - 600032
Email : chennai-nimi@nic.in
Website: www.nimi.gov.in

First Edition, 2024

Rs. 435/-

Printed in India at
National Instructional Media Institute
Post. Box. No. 3142,
Guindy,
Chennai - 600032

Disclaimer

The information contained herein has been obtained from sources reliable to Directorate General of Training, New Delhi. NIMI disclaims all warranties to the accuracy, completeness or adequacy of such information. NIMI shall have no liability for errors, omissions, or inadequacies in the information contained herein, or for interpretations thereof. Every effort has been made to trace the owners of the copyright material included in the book. The publishers would be greatfull for any omissions brought to their notice for acknowledgements in future editions of the book. No entity in NIMI shall be responsible for any loss whatsoever, sustained by any person who relies on this material. The material in this publication is copyrighted. No parts of this publication may be reproduced, stored or distributed in any form or by any means either on paper or electronic media, unless authorized by NIMI.

A Comprehensive Training Program
under Crafts Instructor Training Scheme (CITS)
for Instructors

HANDBOOK ON TECHNICAL INSTRUCTOR TRAINING MODULES

अतुल कुमार तिवारी, I.A.S.
सचिव
ATUL KUMAR TIWARI, I.A.S.
Secretary

भारत सरकार
कौशल विकास एवं उद्यमिता मंत्रालय
GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT
AND ENTREPRENEURSHIP

सत्यमेव जयते

Foreword

In today's rapidly evolving world, the role of skilled craftsmen and women is more crucial than ever. The Craft Instructor Training Scheme (CITS) stands at the forefront of this transformation, shaping the educators who will train the next generation of artisans and technicians. This book aims to provide an in-depth understanding of the subject, exploring its significance, methodologies, and impact on vocational training.

The Craft Instructor Training Scheme was established with the objective of enhancing the quality of instruction in industrial training institutes and other vocational training institutions. By equipping instructors with advanced skills and knowledge, the scheme ensures that they are well-prepared to impart high-quality training to their students. This, in turn, contributes to the creation of a highly skilled workforce capable of meeting the demands of modern industry.

The initial chapters provide the importance of specialized instructor training. Following this, detailed chapters delve into the curriculum covering advanced techniques, safety protocols, and instructional strategies. Each section is designed to offer both theoretical insights and practical applications, ensuring a well-rounded understanding of the subject.

The book offers recommendations for overcoming obstacles and enhancing the effectiveness of the program, with the ultimate goal of producing highly skilled instructors capable of shaping the future workforce.

This book is intended for a diverse audience, including current and aspiring instructors, vocational training administrators, policymakers, and industry stakeholders. It serves as a valuable resource for understanding the intricacies of the subject and its pivotal role in vocational education.

I extend my heartfelt gratitude to all contributors who have shared their experiences and expertise, enriching this book with their valuable insights. Special thanks to the contribution of the development team, reviewers and NIMI that have supported this endeavor, providing essential data and resources.

It is my sincere hope that this book will inspire and guide readers in their efforts to enhance vocational training, ultimately contributing to the development of a skilled and competent workforce.

ATUL KUMAR TIWARI, I.A.S.
Secretary, MSDE

त्रिशलजीत सेठी
महानिदेशक
Trishaljit Sethi, IPoS
Director General

सत्यमेव जयते

भारत सरकार
कौशल विकास एवं उद्यमशीलता मंत्रालय
प्रशिक्षण महानिदेशालय
GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT & ENTREPRENEURSHIP
DIRECTORATE GENERAL OF TRAINING

FOREWORD

The Craftsmen Training Scheme (CTS) implemented by the Directorate General of Training (DGT) provides skill training to the youth and ensures a steady flow of skilled manpower for the industry. It aims to raise quantitatively and qualitatively the industrial production by systematic training, and to reduce unemployment among the youth by providing them with employable skills.

The Craft Instructor Training Scheme (CITS) is an indispensable part of the Craftsmen Training Scheme (CTS). It offers comprehensive training both in 'skills' and in 'training methodology' to the instructor trainees to make them conversant with techniques of transferring hands-on skills.

I congratulate NIMI for taking the initiative of preparation of the course content for CITS. This will help institutionalize the mechanism for imparting training to the trainers all across the ecosystem. I also extend my gratitude to the Instructors and Officials of National Skill Training Institutes (NSTIs) and the DGT for their invaluable contribution in preparation of the CITS course content.

As we navigate the complexities of a rapidly changing world and the technological disruptions, the significance of CTS and CITS has increased manifold. It not only empowers individuals with practical skills but also lays the foundation for a prosperous future. I am confident that this book will serve as a guiding light to all instructor trainees for skill development and nation-building.

Trishaljit

(Trishaljit Sethi)

PREFACE

The Craft Instructor Training Scheme is an indispensable module of the Craftsmen Training Scheme, which has been an integral part of the Indian skill development industry since its inception. This program aims to equip instructors with the necessary skills and teaching methodology to effectively transfer hands-on skills to trainees and promote a holistic learning experience. The first Craft Instructor Training Institute was established in 1948, followed by six more institutes across India in 1960. Today, these institutes, including the National Skill Training Institute (formerly Central Training Institute for Instructors), offer the CITS course, which is mandated by the Directorate General of Training (DGT).

The Craft Instructor training program is designed to develop skilled manpower for industries. The course aims to offer instructors an opportunity to improve their instructional skills, engage learners effectively, offer impactful mentoring, and make efficient use of resources, leading to a more skilled workforce in various industries. The program emphasizes collaborative and innovative approaches to teaching, resulting in high-quality course delivery. Overall, the Craft Instructor Training Scheme is a pivotal program that helps instructors grow in their careers and make a significant contribution to society. This program is essential for developing skilled manpower and promoting a robust learning environment that benefits both trainees and instructors alike.

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following experts to bring out this Instructional material **(Trade Theory)** for **CITS Mechanic Diesel (NSQF Level - 4)** under the **Automotive** Sector for **Instructors**.

MEDIA DEVELOPMENT COMMITTEE MEMBERS

Shri. Nitin Jaising Mane	-	Training Officer, NSTI, Mumbai.

COORDINATORS

Shri. G.C. Ramamurthy	-	Joint Director, CD - Section, DGT.
Shri. T.V. Rajasekar	-	Joint Director, NIMI, Chennai.
Shri. Shiv Kumar	-	Training Officer, CD - Section, DGT.

NIMI records its appreciation of the Data Entry, CAD, DTP Operators for their excellent and devoted services in the process of development of this Instructional Material.

NIMI also acknowledges with thanks, the invaluable efforts rendered by all other staff who have contributed for the development of this Instructional Material.

NIMI is grateful to all others who have directly or indirectly helped in developing this IMP.

ABOUT THE TEXT BOOK

The Vocational Instructor Training Program is a comprehensive initiative designed to equip aspiring students with the necessary skills and knowledge to effectively teach in vocational education settings. This program encompasses a range of pedagogical strategies, instructional techniques, and subject-specific content tailored to the diverse vocational fields. Participants engage in coursework that covers curriculum development, assessment methods, classroom management, and the integration of industry-relevant technologies. Practical experience and hands-on training are emphasized, allowing participants to apply theoretical concepts in real-world teaching environments. Through collaborative learning experiences and mentorship opportunities, aspiring vocational instructors develop the confidence and competence to facilitate engaging and impactful learning experiences for their students. This training program aims to cultivate a new generation of educators who are not only proficient in their respective vocational fields but also adept at fostering the success and employability of their students in today's competitive workforce.

This text book covers communication, self-management, information and communication technology, entrepreneurial and green skills. It has been developed as per the learning outcome-based curriculum.

G C Rama Murthy,
Joint Director,
Curriculum Development, DGT,
MSDE, New Delhi.

CONTENT

CONTENT

CONTENT

Lesson No.	Table of Contents	Page No.
	Module 18: Stationary Engine and Sub System	
121 - 125	Study about PT fuel system, definition, function, components, function and working of each component and advantages and disadvantages of PT system	347
126 - 128	Read and interpret the name plate details-selecting ohmmeter for proper range-advantages of using meggerresidual magnetism-residual voltage and current	351
129 - 131	Importance of pumps in agricultural & industrial applications. Classification of pumps, parts, constructional details and its working	354
132 - 135	Classification of rotary Pumps - Construction and operation repairing procedure. Brief description of turbine & stage pumps, positive displacements and their advantages	368

MODULE 1 : Work Shop Maintenance

LESSON 01 - 04: Importance of Safety, Safety Precautions& First Aid

Objectives

At the end of this lesson you shall be able to

- explain importance of safety
- demonstrate use of first aid kit

Importance of safety in a diesel machanic workshop

Safety in workshops is of paramount importance for several reasons

1 Protection of Human Lives: The primary importance of safety in workshops is to protect the lives and well-being of workers Workshops can be hazardous environments with various tools, machinery, and materials that, if not handled safely, can cause accidents and injuries.

2 Prevention of Injuries and Fatalities: Workshop safety measures are crucial for preventing accidents, injuries, and fatalities These incidents can have long-lasting physical, emotional, and financial consequences for workers and their families.

3 Compliance with Regulations Many countries have regulations and standards in place to ensure workplace safety Compliance with these regulations is not only a legal requirement but also a moral responsibility.

4 Productivity and Efficiency: Safe working environments lead to increased productivity Workers can focus on their tasks without worrying about potential hazards, which can result in more efficient and effective work.

5 Cost Savings Accidents and injuries can be costly for both employees and employer's Medical expenses, worker's compensation, and lost productivity due to absences can result in financial burdens for businesses.

6 Reputation and Employee Morale A commitment to safety in the workshop enhances a company's reputation as a responsible and caring employer. It also boosts employee morale, leading to a more satisfied and engaged workforce.

7 Reduced Downtime: Accidents and injuries can lead to work stoppages and downtime Safety measures help minimize disruptions and keep production processes running smoothly.

8 Risk Management: Workshop safety is a key component of risk management. Identifying and mitigating risks proactively can prevent accidents and their associated costs.

9 Legal Liability Failure to maintain a safe workshop can result in legal liability for businesses in the event of accidents, companies may be held responsible for negligence if safety measures are not in place.

10 Environmental Considerations Safety in workshops also extends to environmental safety Proper handling and disposal of hazardous materials and waste are essential for reducing environmental impact.

11 Skill Development: Promoting safety in workshops involves training employees to operate machinery and handle materials safely. This skill development can lead to a more shilled and competent workforce.

12 Sustainability: A safe workshop is often more sustainable in the long term by preventing accidents and injuries, businesses can reduce waste, energy consumption, and other resources that would otherwise be needed to address workplace incidents.

In summary, the importance of safety in workshops cannot be overstated. It protects human lives, prevents injuries, ensures legal compliance, and contributes to the overall well-being of employees Moreover, it has tangible benefits for businesses, including increased productivity, cost savings, and a positive reputation Prioritizing safety is a fundamental aspect of responsible and ethical business practices.

First Aid in Diesel Mechanic Section

First aid in the diesel mechanic section is essential for addressing injuries or medical emergencies that may occur in the course of work. Here are some key details:

First Aid Kit: A well-equipped first aid kit should be easily accessible in the diesel mechanic section. It should contain items such as bandages, antiseptic wipes, adhesive tape, scissors, gloves, and pain relievers.

Training: All employees working in the diesel mechanic section should receive basic first aid training.

This training should cover common injuries and how to respond in emergency situations.

Emergency Response Plan: There should be an emergency response plan in place specific to the diesel mechanic section. This plan should include procedures for contacting emergency services and evacuating the area if necessary.

Safety Equipment: Employees should have access to safety equipment, such as goggles, gloves, and protective clothing, to prevent injuries while working.

Reporting and Record-Keeping: Any injuries or medical emergencies that occur in the diesel mechanic section should be promptly reported and recorded. This information can help identify areas for improvement in safety practices.

Regular Inspections: Regular inspections of the diesel mechanic section should be conducted to identify and address potential safety hazards.

Communication: Clear communication is essential in the event of an emergency. Employees should know how to communicate their location and the nature of the emergency when contacting emergency services.

Follow-Up Care: Employees who are injured or experience a medical emergency should receive follow-up care as needed. This may include seeking medical attention from a healthcare professional.

By implementing these measures, diesel mechanic sections can create a safer work environment and be better prepared to respond to medical emergencies.

Concept about house keeping and 5s method, 7qs tools

Contact of housekeeping: Housekeeping is the systematic process of making home/work place neat and clean. House keeper is responsible for systematic administration of activities that provide segregation, storage, transfer, processing treatment and disposal of solid waste (which is collected during cleaning)

Scope of house keeping maintenance: The scope of work highly depends on where the house keeping activity is performed in general, maintains cleanliness and orderliness, Furnishes the room, office, workplace, housekeeping supervisor assisted by an assistant house keeper.

- Eye appeal
- Safety
- Maintenance

Importance of good house keeping: people can live in any kind of environment but for a decent environment it is important to follow a habit of "good housekeeping.' In the same way training can be imparted under any conditions. But when the training is imparted in an environment, which creates better students, then teaching will be effective. Hence it is the responsibility of an instructor imparting training to create a positive atmosphere for learning. This is possible only when the trainer adopts the principle of good housekeeping. Good housekeeping is creating a favorite environment and providing sufficient facilities for positive and active learning. Someone in a house arranges the furniture and other items of a house properly and are assessed easily when they are required, then we can say the person has very good knowledge of housekeeping. So good housekeeping means proper placement of everything in proper way.

Elements of good house keeping

Cleanliness: The first and foremost thing of housekeeping, which has to be taken care is cleanliness. If the place of work or the place where the training is imported is untidy trainees will not have interest to undergo training in such environment.

Maintenance of floor: Floor must be maintained properly. It must be free from oil, grease, water and other slippery things. Floor level must be uniform so that it will not be difficult for fixing machines and also for the movement of men and material.

Placing of machines: Machinery items must be placed properly. In running condition, the machines should not cause any sort of damage to the person moving around the machine. Care should be taken to see that heavy equipment has proper foundation. Overcrowding in one place to be avoided.

Gangways: For the movement of men and material proper gangways and storage space should be provided. It should have minimum width as required and should be marked with suitable color (ex. Yellow or white printed lines for walking).

Storage of materials: After obtaining the training materials from the stores the instructor has to store in a proper peace. Explosives and Inflammable items should be kept at a distance in order to avoid accidents. Storage must be in such a manner that the material should be available for use at a right time.

Scrap and waste materials: It must be collected before disposing it. For metal scraps, enquires must be made to find out if they can be purchased by some agents, which may be useful for them. Waste items must be disposed-off in a proper manner.

Lighting and ventilation: Without proper ventilation and lighting it will not be possible for doing any kind of work at the workshop. Lighting can be made available by using tube lights but care should be taken to see that brightness is not too much and it should not be too dull. Natural lighting is always preferred. Proper lighting avoids accidents and enhances the speed of work. Ventilation must be provided by the use of fans and natural ventilators.

Colour dynamics: Colour plays important role in workshops. Proper use of colours in work place, equipment's are important. Light colours give or create pleasant atmosphere. Ceiling must be in white, walls must be with light colours, machinery equipment's normally in olive green. By looking at the colours we can make out what it exactly means. For example: When the red bulb glows it means 'stop' and when the yellow bulb glows it means 'be ready or alert' and when the green bulb glows it means 'proceed or go'.

Fire extinguishers and first aid: As per the Factory's act every institution is required to have fire extinguishers. Students must be trained to use them if fire breaks out. Carbon dioxide is normally used as a fire extinguisher agent. Some other agents used are Carbon tetra chloride, soda acid foam and sand. Even after taking all kinds of preventive measures there is a possibility of an accident in case of which all the sections must be able to help themselves without waiting for a doctor. There must be a first aid box, which M contains all essential materials by which an injured person can be treated immediately. Teacher must also train the students how to use it when it is needed. It is absolutely necessary to locate the box in a place where pupil can have easy access. Finally, it can be said that a training workshop should be designed keeping in view of all the above aspects which will be an ideal place for imparting training.

Concept of 5S & 7QC tools, time management as employed for quality circle. importance of healthy environment

Objectives: At the end of this lesson you shall be able to

- understand, explain and apply 5s in workshop
- demonstrate 7QC in workshop
- explain time management in workshop.

5S Concept: 5s is a people-oriented and practice-oriented approach. 5S expects every one to participate in it. It becomes a basic for continuous improvement in the organization. The terms (5s) 5 steps are

Step 1: SEIRI (Sorting out)

Step 2: SEITON (Systematic arrangement)

Step 3: SEISO (Shine cleanliness)

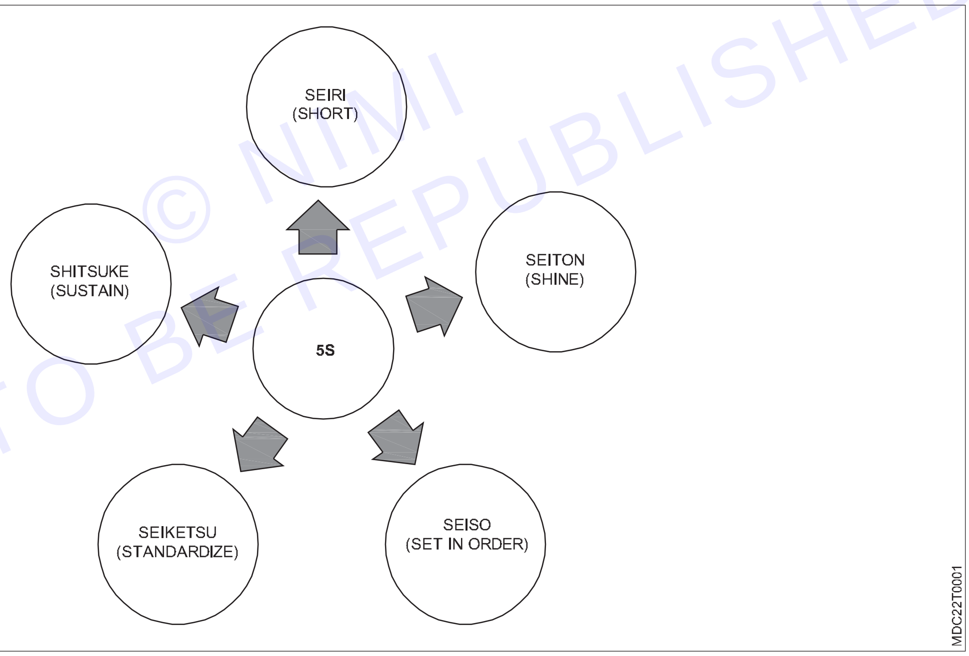
Step 4: SEIKTSU (Standardization)

Step 5: SHITSURE (Self-discipline)

shows the 5s concept wheel.

The list describes how to organize a work space for efficiency and effectiveness by identifying and storing the items used, maintaining the area and teams and sustaining the new order.

Fig 1



Benefits of 5S

- Work place becomes clear and better organized.
- Working in working place becomes easier.
- Reduction in cost.
- People tend to be more disciplined.
- Delay is avoided.
- Less absenteeism.
- Better use of floor space.
- Less accidents.
- High productivity with quality etc.

Safety slogans

Whether you are at work, or at home or at play, safety should always be in the front of our minds. Following are few safety slogans which you can remember:

1 ”A casual attitude towards safety = CASUALTY”

2 “Accidents hurt - safety doesn’t “.

3 “A wound neglected is a wound infected”.

4 “ Do your work with pride, put safety in every stride”.

5 “Don’t be a fool, use the proper tool”.

6 “Safety starts with ‘S’ but begin with ‘U’!

Seven Basic Tools of Quality Control: The Appropriate Techniques for Solving Quality Problems in the Organization.

Abstract

Dr. Kaoru Ishikawa was first total quality management guru, who has been associated with the development and advocacy of using the seven quality control (QC) tools in the organizations for problem solving and process improvements. Seven old quality control tools are a setoff the QC tools that can be used for improving the performance of the production processes, from the first step of producing a product or service to the last stage of production. So, the general purpose of thispaperwastointroducethese7QCtools.This study found that the set tools have the significant roles to monitor, obtain, analyze data for detecting and solving the problems of production processes, in order to facilitate the achievement of performance excellence in the organizations.

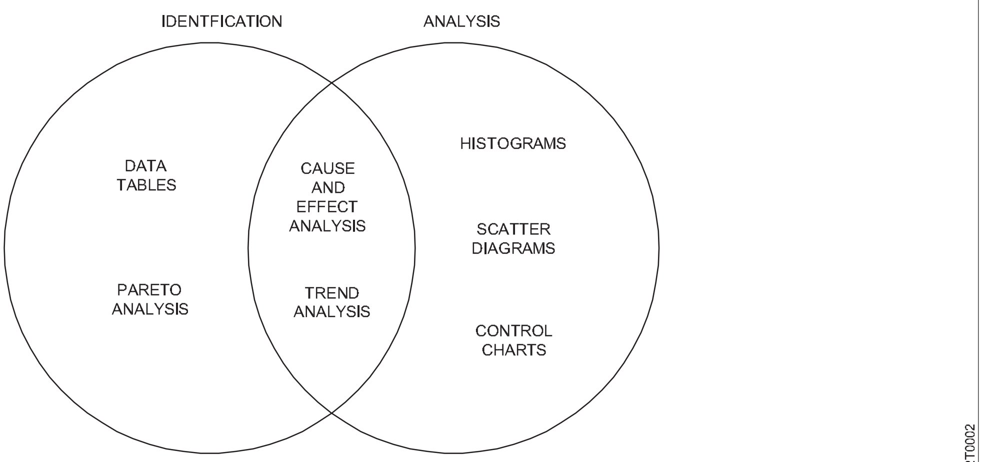
Keywords: Seven QC Tools; Check Sheet; Histogram; Pareto Analysis; Fishbone Diagram; Scatter Diagram; Flowcharts, and Control Charts.

Introduction

There are seven basic quality tools, which can assist an organization for problem solving and process improvements. The first guru who proposed seven basic tools was Dr. Kaoru

Ishikawa in 1968, by publishing a book entitled “Gemba no QC Shuho” that was concerned managing quality through techniques and practices for Japanese firms. It was intended to be applied for “self-study, training of employees by foremen or in QC reading groups in Japan. It is in this book that the seven basic quality control tools were first proposed. valuable resource when applying the seven basic tools (Omachonu and Ross, 2004). These seven basic quality control tools, which introduced by Dr. Ishikawa, are: 1) Check sheets; 2) Graphs (Trend Analysis); 3) Histograms; 4) Pareto charts; 5) Cause-and-effect diagrams; 6) Scatter diagrams; 7) Control charts. Figure 1 indicates the relationships among these seven tools and their utilizations for the identification and analysis of improvement of quality (Kerzner, 2009).

Fig 2



THE SEVAN QUALITY CONTROL TOOLS

Checksheet

Check sheets are simple forms with certain formats that can aid the user to record data in a firm systematically. Data are “collected and tabulated” on the check sheet to record the frequency of specific events during data collection period. They prepare a “consistent, effective, and economical approach” that can be applied in the auditing of quality assurance for reviewing and to follow the steps in a particular process. Also, they help the user to arrange the data for the utilization later (Montgomery, 2009; Omachonu and Ross, 2004). The main advantages of check sheets are to be very easily to apply and understand, and it can make a clear picture of the situation and condition of the organization. They are efficient and powerful tools to identify frequently problems, but they don’t have effective ability to analyze the quality problem into the workplace. The check sheets are in several, three major types are such as Defect-location check sheets; tally check sheets, and; defect-cause check sheets (Kerzner, 2009). Fig 2 is depicted a tally check sheet that can be used for collecting data during production process.

Telephone Interruptions

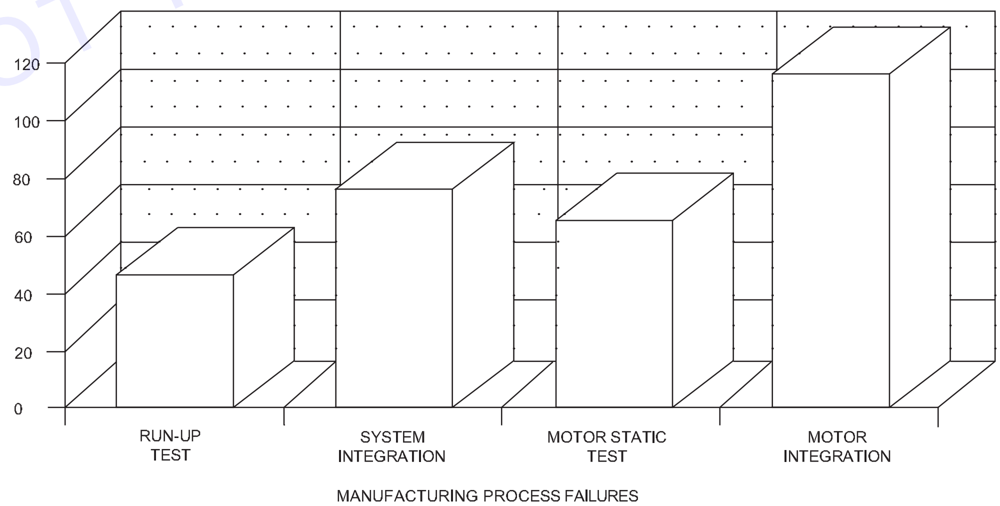
Reason	Day					
	Mon	Tues	Wed	Thurs	Fri	Total
Wrong number	卌	II	I	卌	卌 II	20
Info request	II	II	II	II	II	10
Boss	卌	II	卌 II	I	IIII	19
Total	12	6	10	8	13	49

Check sheet (Tally) for telephone interruptions

Histogram

Histogram is very useful tool to describe a sense of the frequency distribution of observed values of a variable. It is a type of bar chart that visualizes both attribute and variable data of a product or process, also assists users to show the distribution of data and the amount of variation with in a process. It displays the different measures of central tendency (mean, mode, and average). It should be designed properly for those working into the operation process can easily utilize and understand them. Also, a histogram can be applied to investigate and identify the under lying distribution of the variable being explored (Omachonu and Ross, 2004; Forbes and Ahmed, 2011). Fig 3 illustrates a histogram of the frequency of defects in a manufacturing process.

Fig 3



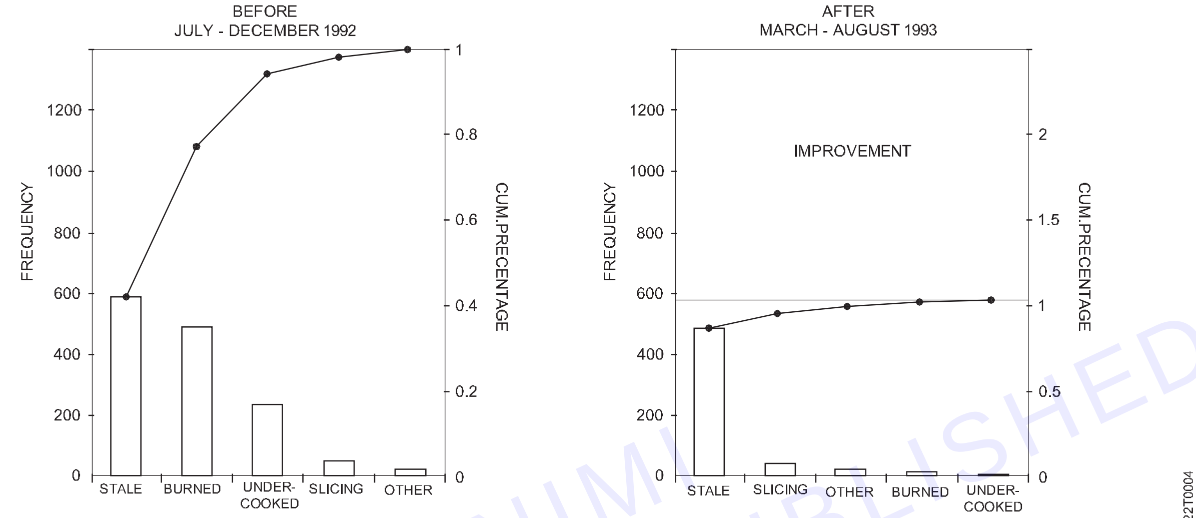
HISTOGRAM FOR VARIABLES

MDC22T0003

Pareto analysis

It introduced by an Italian economist, named Vilfredo Pareto, who worked with in come and other unequal distribution since 19thcentury, he noticed that 80% of the wealth was owned by only 20% of the population. later, Pareto principle was developed by Juran in 1950. A Pareto chart is a special type of histogram that can easily be apply to find and prioritize quality problems, conditions, or their causes of in the organization (Juran and Godfrey, 1998). On the other hand, it is a type of bar chart that shows the relative importance of variables, prioritized in descending order from left to right side of the chart. The aim of Pareto chart is to figure out the different kind of “nonconformity” from data figures, maintenance data, repair data, parts scrap rates, or other sources. Also, Pareto chart can generate a mean for investigating concerning quality improvement, and improving efficiency, “material waste, energy conservation, safety issues, cost reductions”, etc., as Fig 4 demonstrated concerning Pareto chart, it can able to improve the production before and after changes (Montgomery, 2009; Kerzner, 2009; Omachonu and Ross, 2004).

Fig 4



PARETO CHARTS

Fish bone diagram

Kaoru Ishikawa is considered by many researchers to be the founder and first promoter of the ‘Fishbone’ diagram (or Cause and Effect Diagram) for root cause analysis and the concept of Quality Control (QC) circles. Cause and effect diagram was developed by Dr. Kaoru Ishikawa in 1943. It has also two other names that are Ishikawa diagram and fishbone because the shape of the diagram looks like the skeleton of a fish to identify quality problems based on their degree of importance (Neyestani, 2017). The cause and effect diagram is a problem solving tool that investigates and analyzes systematically all the potential or real causes that result in a single effect. On the other hand, it is an efficient tool that equips the organization’s management to explore for the possible causes of a problem (Juran and Godfrey, 1998). This diagram can provide the problem-solving efforts by “gathering and organizing the possible causes, reaching a common understanding of the problem, exposing gaps in existing knowledge, ranking the most probable causes, and studying each cause” (Omachonu and Ross,2004). The generic categories of the cause and effect diagram are usually six elements (causes) such as environment, materials, machine, measurement, man, and method, as indicated in Fig 5. Furthermore, “potential causes” can be indicated by arrows entering the main cause arrow (Neyestani,2017).

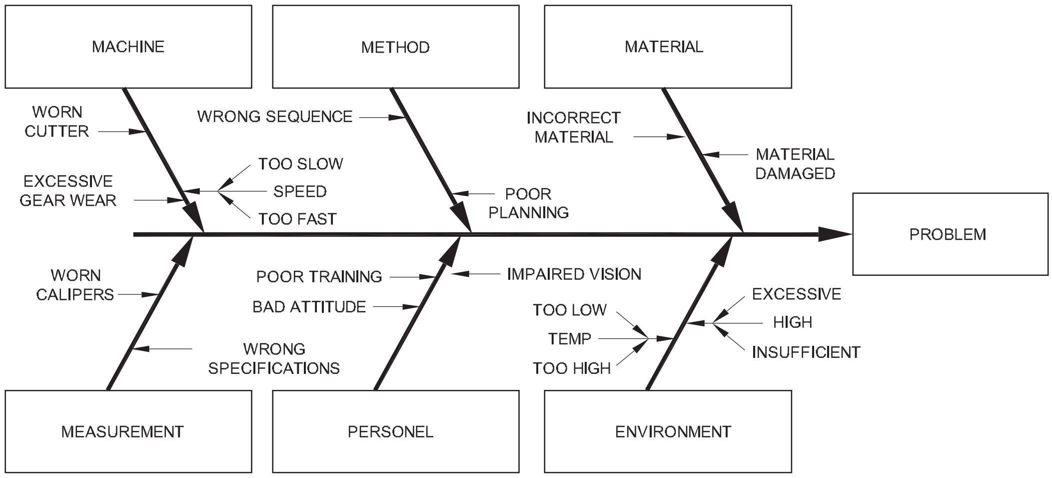
Scatter diagram

Scatterdiagramisapowerfultooltodrawthedistributionofinformationin two dimensions, which helps to detect and analyze a pattern relationship between two quality and compliance variables (as an independent variable and a dependent variable), and understanding if there is a relationship between them, so what kind of the relationship is (Weak or strong and positive or negative). The shape of the scatter diagram often shows the degree and direction of relationship between two variables, and the correlation may have revealed the causes of a problem. Scatter diagrams are very useful in regression modeling (Montgomery,2009; Oakland,2003). The scatter diagram can indicate that there is which one of these following correlation between two variables: a) Positive correlation, b) Negative correlation, and c) No correlation, as demonstrated in Fig 6.

Flowchart

Flowchart presents a diagrammatic picture that indicates a series of symbols to describe the sequence of steps existing an operation or process. On the other hand, a flow chart visualizes a picture including the inputs, activities, decision points, and outputs for using and understanding easily concerning the overall objective through process. This chart as a problem solving tool can apply methodically to detect and analyze the areas or points of process may have had potential problems by "documenting" and explaining an operation, so it is very useful to find and improve quality into process (Forbes and Ahmed,2011), as shown in Fig 7.

Fig 5

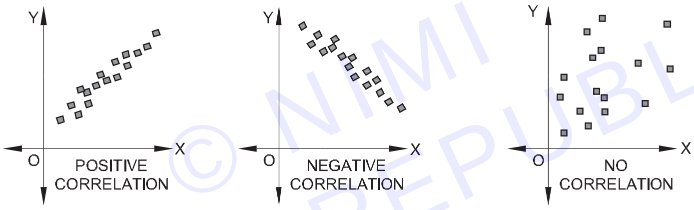


THE CAUSE AND EFFECT DIAGRAM (FISHBONE DIAGRAM)

MDC22T0005

Fig 6

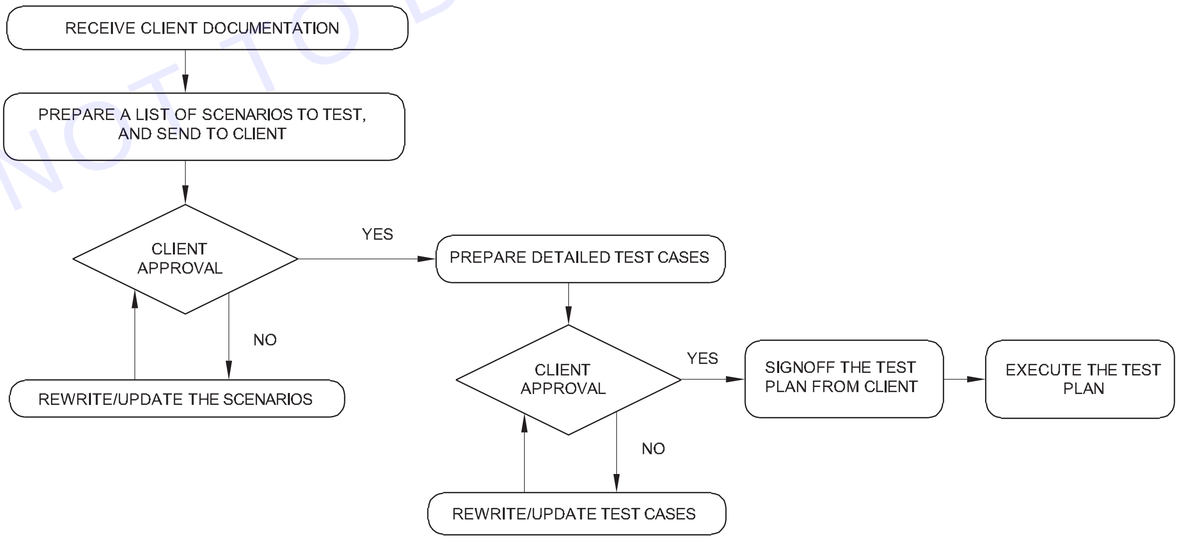
SCATTER PLOT EXAMPLES



SCATTER DIAGRAMS

MDC22T0006

Fig 7



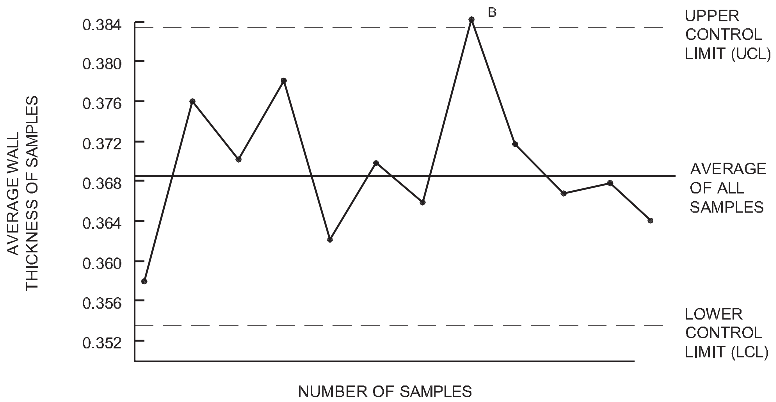
FLOW CHART OF REVIEW PROCESS

MDC22T0007

Control chart

Control chart or Stewart control chart was introduced and developed by Walter A. Stewart in the 1920s at the Bell Telephone Laboratories, and is likely the most "technically sophisticated" for quality management (Montgomery, 2009). Control charts is a special form of "run chart that it illustrates the amount and nature of variation in the process over time". Also, it can draw and describe what has been happening in the process. Therefore, itis very important to apply control chart, because it can observe and monitor process to study process that is in "statistical control" (No problem with quality) accordant to the samplings or samplings are between UCL and LCL (upper control limit (UCL) and the lower control limit (LCL)). "statistical control" is not between UCL and LCL, so it means the process is out of control, then control can be applied to find causes of quality problem, as shown in Fig 8 that A point is in control and B point is out of control. In addition, this chart can be utilized for estimating "the parameters" and "reducing the variability" in a process (Omachonu and Ross, 2004). The main aim of control chart is to prevent the defects in process. It is very essentially for different businesses and industries, there a sonic that unsatisfactory products or services are more costed than spending expenses of prevention by some tools like control charts (Juran and Godfrey, 1998). A Control Chart is presented in the following Figure.

Fig 8



THE SHEWHART CONTROL CHART

MDC22T0008

Conclusion

This study identified that is very essential to apply all seven QC tools for troubleshooting issues with in production processes in the organizations. Doubtlessly, all of the aforementioned quality tools should be considered and used by management for identifying and solving quality problems during producing the products and services. Thus, the production processes can be affected and improved by multiple factors of these statistical QC tools. Also, Marko teal (2009) designed and developed an effective layout for using these QC in the organizations based on the performance of them, in order to apply appropriately these quality tools for solving quality problems and quality improvement, as demonstrated in Fig 9. Accordingly, the following Figure interpret show the 7QC should be employed from first step to end of production processes for identifying the problems of quality performance and controlling them.

Time management as employed for quality circle

Time management within a quality circle involves efficiently allocating resources and scheduling tasks to ensure maximum productivity in problem-solving and decision-making processes. This includes setting clear objectives, prioritizing tasks, delegating responsibilities, and regularly reviewing progress to stay on track and meet deadlines. Effective time management helps quality circles focus on continuous improvement initiatives and achieve their goals efficiently.

Time management within a quality circle is crucial for ensuring that the team effectively addresses issues and implements improvements.

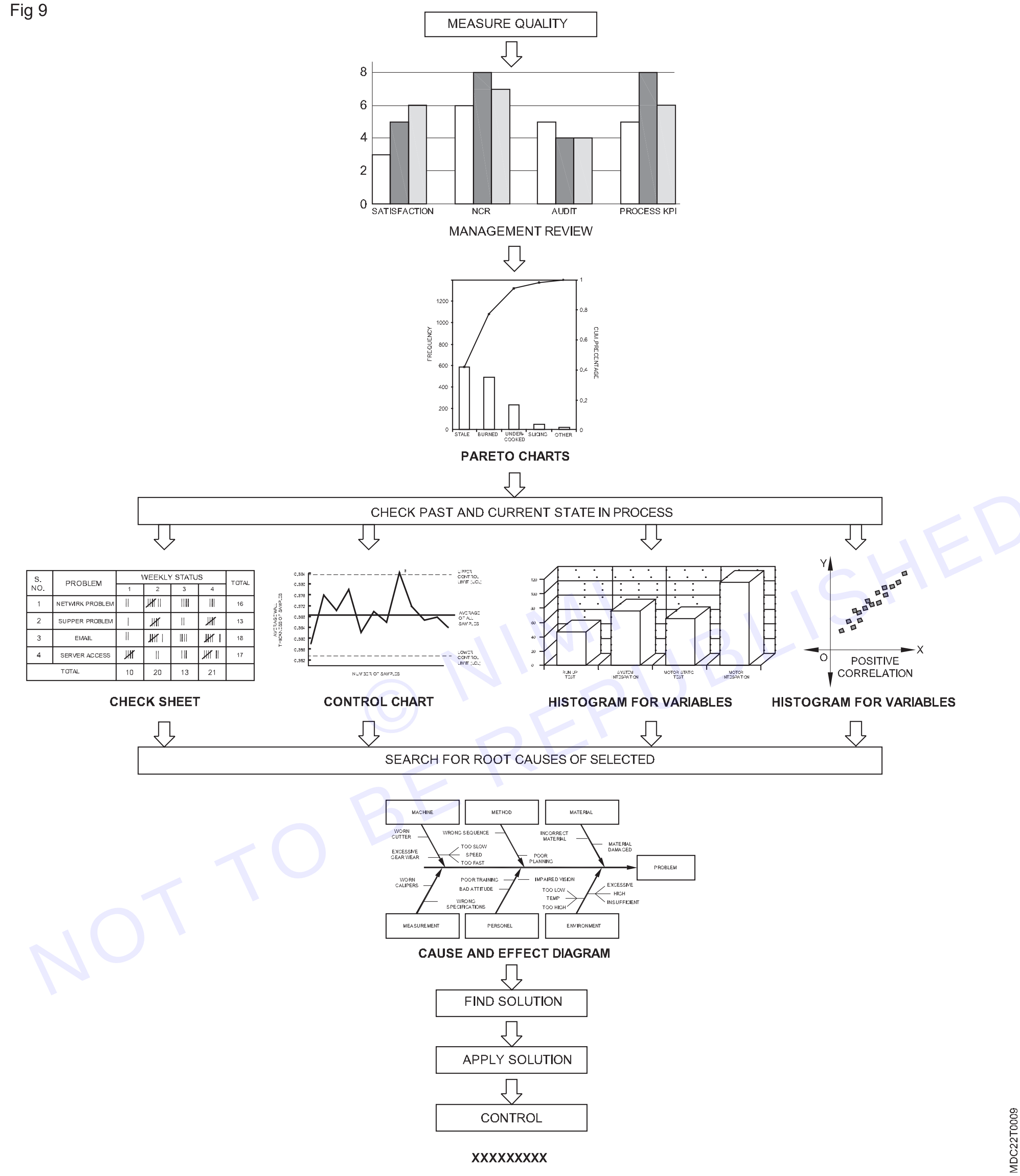
Here's a detailed breakdown of how time management is employed within a quality circle:

1 **Setting objectives:** Before starting any project or problem-solving initiative, the quality circle defines clear objectives and goals. These objectives should be specific, measurable, achievable, relevant, and time-bound (SMART). Clear objectives help the team stay focused and guide their efforts throughout the process.

2 **Prioritizing tasks:** Once the objectives are established, the team prioritizes tasks based on their importance and urgency. They identify key activities that need to be completed to achieve the objectives and determine their order of execution. Prioritization ensures that the team focuses on the most critical tasks first, maximizing efficiency and effectiveness.

3 **Creating timelines:** Timelines or schedules are developed to outline when each task or activity will be completed. The team considers factors such as deadlines, resource availability, and dependencies between tasks when creating timelines. By establishing realistic timelines, the team ensures that they can complete the project on time without compromising quality.

Fig 9



4 **Allocating resources:** Time management also involves allocating resources effectively, including human resources, budget, and equipment. The team identifies the skills and expertise required for each task and assigns responsibilities accordingly. Proper resource allocation ensures that the team has the necessary support to complete tasks efficiently.

5 **Delegating responsibilities:** Delegation is an essential aspect of time management within a quality circle. Team members are assigned specific responsibilities based on their skills, experience, and availability. Delegating tasks allows the team to distribute workload evenly and ensure that each member contributes to the project's success.

6 **Monitoring progress:** Throughout the project, the team monitors progress to ensure that tasks are being completed according to the established timelines. Regular progress updates allow the team to identify any delays or issues early on and take corrective action as needed. Monitoring progress also helps the team stay accountable and motivated to achieve their goals.

7 **Adjusting plans:** Despite careful planning, unexpected challenges may arise during the project. Time management involves being flexible and adaptable to changes in circumstances. If tasks take longer than expected or priorities shift, the team adjusts their plans accordingly to stay on track and minimize delays.

8 **Reviewing and reflecting:** After completing the project, the quality circle conducts a review to evaluate their performance and identify areas for improvement. They reflect on their time management practices, identifying what worked well and what could be improved in future projects. By learning from their experiences, the team continuously improves their time management skills and enhances their effectiveness in quality improvement initiatives.

Fig 10

Importance of healthy environment

Environment management and social welfare

1 **Greenhouse gases -** An overview: Gases that trap heat in the atmosphere are called greenhouse gases. This section provides information on emissions and removals of the main greenhouse gases to and from the atmosphere. For more information on the other climate forcers, such as black carbon, please visit the Climate Change Indicators: Climate Forcing page.

- **Carbon dioxide (CO_2):** Carbon dioxide enters the atmosphere through burning fossil fuels (coal, natural gas, and oil), solid waste, trees and other biological materials, and also as a result of certain chemical reactions (e.g., manufacture of cement). Carbon dioxide is removed from the atmosphere (or "sequestered") when it is absorbed by plants as part of the biological carbon cycle.

- **Methane (CH_4):** Methane is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices, land use and by the decay of organic waste in municipal solid waste landfills.

- **Nitrous oxide (N_2O):** Nitrous oxide is emitted during agricultural, land use, industrial activities, combustion of fossil fuels and solid waste, as well as during treatment of wastewater.

- **Fluorinated gases:** Hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and nitrogen difluoride are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes.

2 **Global warming**

- 2011-2020 was the warmest decade recorded, with global average temperature reaching 1.1°C above pre-industrial levels in 2019. Human-induced global warming is presently increasing at a rate of 0.2°C per decade. In increase of 2°C compared to the temperature in pre-industrial times is associated with serious negative impacts on to the natural environment and human health and wellbeing, including a much higher risk that dangerous and possibly catastrophic changes in the global environment will occur. For this reason, the international community has recognized the need to keep warming well below 2°C and pursue efforts to limit it to 1.5°C

3 Causes for rising emissions

- Burning coal, oil and gas produces carbon dioxide and nitrous oxide.
- Cutting down forests (deforestation). Trees help to regulate the climate by absorbing CO2 from the atmosphere. When they are cut down, that beneficial effect is lost and the carbon stored in the trees is released into the atmosphere, adding to the greenhouse effect
- Increasing livestock farming. Cows and sheep produce large amounts of methane when they digest their food.
- Fertilizers containing nitrogen produce nitrous oxide emissions.
- Fluorinated gases are emitted from equipment and products that use these gases. Such emissions have a very strong warming effect, up to 23000 times greater than CO2.

Components of climate change: Climate change has already begun to impact our planet in more ways than we can think. Temperatures continue to rise throughout the planet and we are experiencing changes in precipitation patterns as we have never seen before. The main cause of these catastrophic effects on our planet is pollution.

Harmful effect of climate change: The layer of Greenhouse Gases (GHG), including carbon dioxide (CO2), methane, nitrous oxide and others, in their optimum concentration in Earth's atmosphere, acts like a protective blanket which maintains its temperature and the natural ecosystem. Lately, anthropogenic (human induced) activities, mainly burning of fossil fuels, have resulted in increasing the concentration of these gases which in turn trap extra heat and increase Earth's average temperature leading to climate change. This in turn leads to a wide ranging impact including sea level rise, melting of snow and glaciers, changes in weather patterns, increased frequency and intensity of extreme events and natural disasters etc.

Factors affecting climate change: Fortunately, there are always things that we can do to fight against climate change. Saving the environment starts with us and it is our responsibility to act against these terrible changes to preserve the planet for future generations.

Prevention of climate change and best ways to help environment

1 Make your commute green

Millions of people drive to work every day. It is simply unavoidable in our modern-day society. However, the downside to this is that millions of cars emit greenhouse gases that destroy our atmosphere. Vehicle emissions are a close second when it comes to the top causes of climate change.

There are always other options that you can utilize to make your commute to work eco-friendly. For starters, taking public transportation to work is a great way to cut out emissions. Riding your bike to work is also incredibly helpful to the environment and is a great method to get exercise.

2 Be more conservative with energy usage

Becoming more energy efficient is a great way to prevent pollution. It causes the power plants to expend less energy that can lead to the production of greenhouse gasses. This means that you should do what you can to cut down on energy usage in your household.

Make sure to turn off lights and unplug devices that you are not using anymore when you are done with them. Replace your light bulbs with energy-efficient light bulbs to help you save electricity too.

3 Get active and vote

One of the best ways to improve climate change is to help those who will fight against it get into office. This means voting for legislation and politicians that aid against the detrimental effects of climate change. Many corporations have politicians on their payroll and use them to lobby against legislation that would require more regulations against them. Voting the right people into office will help pass legislation that allows us to fight against these corporations that are mainly to blame for climate change.

4 Recycle

Manufacturing plants emit a large number of greenhouse gasses per year. It is unavoidable in the production of goods that we use on a regular basis. However, a cleaner alternative would be to invest in recycling. Recycling is a cost-effective and eco-friendly process that eliminates waste and doesn't emit greenhouse gasses into the environment. Be sure to collect your discarded paper, glass, plastic, and electronics to your local recycling center. The professionals will take these items to a processing plant where they will be remade into other recyclable materials again.

5 Educate yourself and others

The importance of educating others about climate change cannot be overstated in our modern society. There are many platforms for us to utilize that can allow us to spread our message easily. Whether you use word of mouth or social media, there are always ways to educate others on what climate change is doing to our planet. You can help protect the planet by educating others about the dangers of climate change and how to act against it.

6 Encourage the use of renewable energies

Focusing your efforts to spread awareness about renewable energy is the best way to create a positive impact in your community. By informing others about how renewable energy is better than utilizing fossil fuels, you will sway others into investing in the idea.

Standards, target and performance measures to ensure health and safety of the workers in the industry

1 **Pollution prevention in industrial processes:** The possibilities of P2 strategies are still being implemented at the corporate level, but benefits are already being realized by many companies. If companies invest in P2 methods early in their development, they realize greater gains not too far down the road. Additionally, if companies do not produce waste, they do not have to worry about properly disposing of it. Thus, P2 is a proactive measure taken to reduce costs in the long run that would have been dedicated to disposal and elimination of waste.

There are two main ways to reduce waste through P2: Increased efficiency and technology improvements. Waste reduction at the source implies the same amount of input raw materials with less waste and more output of the product. Technology improvements imply changes to the production process that reduce the amount of output waste, such as an improved recycling process.

One strategy is "in-process recycling. "Though it is not the most efficient form of "reduction at the source," recycling is very profitable due to its ease of process. By engaging in recycling practices, industries not only cut down on the amount of material discarded as environmentally-hazardous waste, but they also increase profitability by reducing the amount of raw material purchased.

The most widespread strategy is "reduction at the source," which is the idea that byproducts of production can be reduced through efficient and careful use of natural resources. This method reduces the amount of dangerous pollutants present in waste before the waste is released. In turn, this creates a safer environment free of hazardous waste. This idea ties strongly into the benefits to corporations of investing in newer, more efficient technology. (Fig 11)

Fig 11

The P2 program task force has 5 main goals

1 create feasible P2 objectives and corresponding time frames

2 provide training to the individuals involved in the effort

3 oversee the program's main tasks and measure progress

4 evaluate the progress of the effort

5 maintain the program's goals long term

A Voluntary approach: Voluntary approaches to P2 are on the rise. Governmental organization often collaborates with businesses and regulatory agencies to create a structure of guidelines. There are four types of voluntary approach programs:

1 Public voluntary programs,

2 Negotiated agreements,

3 Unilateral commitments, and

4 Private agreements.

Environmental authorities collaborate and create specific guidelines. Companies are then invited to follow these procedures on a strictly voluntary basis.

Negotiated agreements are created through collaboration between public authorities and industry authorities. The agreement establishes bargains that are beneficial to the industry.

Unilateral commitments are established by industry authorities alone, and the guidelines they set are self-regulated.

Private agreements are established between "polluters" and other affected parties. The regulations set forth create a compromise regarding a variety of pollution regulation strategies. (Fig 12)

Fig 12

There are a few keys to a successful voluntary approach. First, the program needs a dependable source of funding (from the government, usually). The program also needs a dynamic relationship with the targeted industries. This creates a base of trust between all involved in the agreement. In terms of regulation, the program should be monitored by a reliable source. In order to assure that the program will establish itself long term, there should be visible benefits to the participants and obvious results to the greater community. The long-term establishment of the program also comes from setting attainable goals to measure progress.

2 Governmental approach: EPA has published waste minimization guidelines that comprise 5 major steps:

1 Organizing the primary task force

2 Assessing the current pollution situation

3 Evaluating the feasibility of different program options

4 Reporting and planning the preparations based upon the analysis

5 Implementing the program.

A Waste Reduction algorithms: The EPA makes available software that employs the Waste Reduction Algorithm. They use the acronym WAR for this method and state "the goal of WAR is to reduce environmental and related human health impacts at the design stage. The WAR tracks pollutants through the entire production process in order to obtain accurate measurements.

B Industrial efforts: By maximizing P2 opportunities, some companies choose to redesign their entire industrial process. Managers focus more on what enters and moves through the entire process, instead of only focusing on the output. Overall, the P2 strategies that financially benefit companies are the most likely to be implemented. However, since P2 has only recently been realized as a cost benefit, many corporations have not adopted significant measures to realize the potential gain.

C Potential benefits: Pollution prevention can also be viewed as a form of environmental entrepreneurship, as companies see opportunities to reduce costs of waste treatment, storage, and disposal. For example, 3M has accrued a savings of over $750 million since 1973 due to their implementation of P2 incentives. If implemented correctly; P2 strategies can result in an increase in process yield. By reducing the amount of pollution released, companies can avoid some of the liability costs accrued when large amounts of pollution are released and contaminate the land on which the facility is located.

According to EPA, there are some everyday steps that can be taken to prevent pollution

- Use paper in limited quantities, and print double-sided. Also, look for paper that has been made with recycled materials.
- Look for products made with recycled materials. Bring reusable bags in which to carry purchased goods in order to reduce the number of disposed paper/plastic bags.
- Use water sparingly by installing water-efficient shower heads and faucets, and install energy-efficient appliances. Make sure that sinks and hoses are not dripping. Do not excessively water plants.
- Use transportation efficiently, and utilize mass transportation when possible. Recycling used motor oil is also a way to eliminate the disposal of a hazardous material.
- Eating locally produced foods reduces the amount of fuel required for the food's transportation. (Fig 13)

Fig 13

Additional examples of P2 include using energy efficient machinery, developing clean-burning

fuel, reducing the amount of chemicals released into water sources, creating a production process that results in a reduced amount of waste, and utilizing water conservation techniques.

Water pollution: Water pollution is the contamination of water bodies, usually as a result of human activities. Water bodies include for example lakes, rivers, oceans, aquifers and groundwater. Water pollution results when contaminants are introduced into the natural environment. For example, releasing inadequately treated wastewater into natural water bodies can lead to degradation of aquatic ecosystems. In turn, this can lead to public problems for people living downstream. Water pollution is the leading worldwide cause of death and disease, e.g. due to water-borne diseases.

Sources of water pollution are either point sources or nonpoint sources.

1 Point sources have one identifiable cause of the pollution, such as a storm drain or a wastewater treatment plant

2 Non-point sources are more diffuse, such as agricultural runoff.

The effects can damage individual species and impact the natural biological communities they are part of. Water pollution is measured by analyzing water samples. Physical, chemical and biological tests can be conducted. Control of water pollution requires appropriate infrastructure and management plans. The infrastructure may include wastewater treatment plants. Sewage treatment plants and industrial wastewater treatment plants are usually required to protect water bodies from untreated wastewater. Agricultural wastewater treatment for farms and erosion control at construction sites can also help prevent water pollution. Nature-based solutions are another approach to prevent water pollution. Effective control of urban runoff includes reducing speed and quantity of flow. In the United States, best management practices for water pollution include approaches to reduce the quantity of water and improve water quality. (Fig 14)

Fig 14

A Control of water pollution in industry: Some industrial facilities generate wastewater that is similar to domestic sewage and can be treated by sewage treatment plants. Industries that generate wastewater with high concentrations of organic matter (e.g. oil and grease), toxic pollutants (e.g. heavy metals, volatile organic compounds) or nutrients such as ammonia, need specialized treatment systems.

Some industries install a pre-treatment system to remove some pollutants (e.g., toxic compounds), and then discharge the partially treated wastewater to the municipal sewer system. Industries generating large volumes of wastewater typically operate their own treatment systems. Some industries have been successful at redesigning their manufacturing processes to reduce or eliminate pollutants, through a process called pollution prevention.

To remove heat from wastewater generated by power plants or manufacturing plants the following technologies are used:

- Cooling ponds, man-made bodies of water designed for cooling by evaporation, convection, and radiation
- Cooling towers, which transfer waste heat to the atmosphere through evaporation or heat transfer
- Cogeneration, a process where waste heat is recycled for domestic or industrial heating purposes.

4 Hazardous waste management: Hazardous-waste management, the collection, treatment, and disposal of waste material that, when improperly handled, can cause substantial harm to human health and safety or to the environment. Hazardous wastes can take the form of solids, liquids, sludge or contained gases, and they are generated primarily by chemical production, manufacturing, and other industrial activities.

They may cause damage during inadequate storage, transportation, treatment, or disposal operations. Improper hazardous-waste storage or disposal frequently contaminates surface and groundwater supplies. In an effort to remedy existing problems and to prevent future harm from hazardous wastes, governments closely regulate the practice of hazardous waste management.

Hazardous - waste characteristics: Hazardous wastes are classified on the basis of their biological, chemical, and physical properties. These properties generate materials that are toxic, reactive, ignitable, corrosive, infectious, or radioactive. Toxic wastes are poisons, even in very small or trace amounts. They may have acute effects, causing death or violent illness, or they may have chronic effects, slowly causing irreparable harm. Some are carcinogenic, causing cancer after many years of exposure. Others are mutagenic, causing major biological changes in the offspring of exposed humans and wildlife. Reactive wastes are chemically unstable and react violently with air or water. They cause explosions or form toxic vapors. Ignitable wastes burn at relatively low temperatures and may cause an immediate fire hazard. Corrosive wastes include strong acidic or alkaline substances. They destroy solid material and living tissue upon contact, by chemical reaction. (Fig 15)

Fig 15

Importance of healthy Environment

Welfare facilities are an essential part of good working conditions. Good welfare facilities contribute not only to the welfare of workers, but also to production and better relations. If workers are denied facilities to meet their needs, problems will eventually result. The cost of welfare facilities is usually lower if the enterprise provides them than if workers' pay for them individually.

A Sanitary facilities

B Repair of sanitary facilities

The workplace should have good sanitary facilities. Clean toilets, washing facilities and shower rooms are important. It is necessary to provide a sufficient number of such facilities and to keep them clean.

These sanitary facilities are necessary for workers' wellbeing and to prevent disease. Well-maintained sanitary facilities help to improve productivity because healthy workers are more efficient and there will also be less absenteeism.

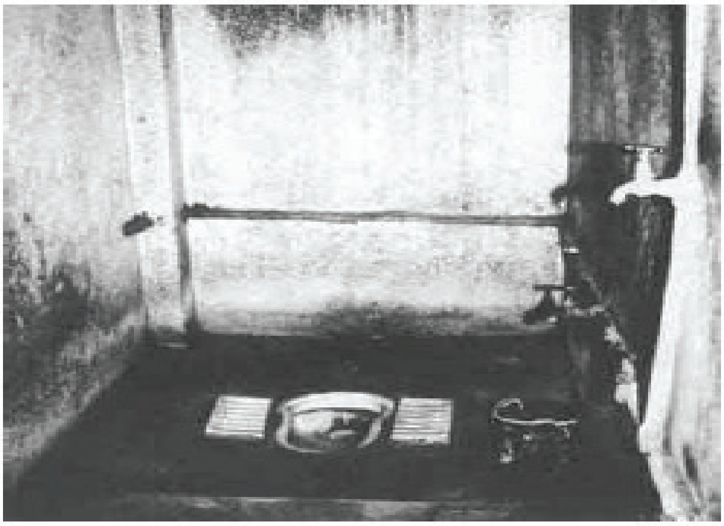
Fig 16

Fig 17

A Cleaning toilets

The cost incurred was practically nil. Tools and other equipment for cleaning were already available. The bins were manufactured using scrap material. The manager proposed giving a monthly award to the group which could best keep the lavatory in good condition. This also helped change the attitude of the workers in maintaining clean toilets.

Fig 18



Waste bins in toilets

Fig 19

Fig 20

Fig 21

Facilities for beverages and meals: Facilities for beverages and meals are basic necessities. Drinking water is essential for all types of work. Especially when working in a hot environment, much water is lost in the form of sweat or evaporation from the skin. Water loss in a hot climate can easily amount to several liters per shift. Workers, if not provided with drinking facilities, will have to make arrangements themselves or leave the workplace quite often looking for water. When only unhygienic water is available, this can lead to frequent disease. If workers become dehydrated, they rapidly tire and become less productive. Therefore, clean water should be provided in sufficient quantities near the worksite.

Maintaining clean environment at work

- Designate storage space for everything.
- Provide sufficient housekeeping tools, including brooms, clean rags, and spill absorbers.
- Define areas for scrap storage and schedule regular collection, removal, and disposal.
- Assign clean-up responsibilities and make sure work sites are cleaned and cleared before quitting time.

Hygiene - It is a set of practices performed for preservation of health. It is maintained in personal, home, food and workplace.

Personal Hygiene - The cornerstone of hygiene. The body is the source and entry point of many illnesses. Appropriate personal hygiene can prevent all sorts of diseases Hygiene at home - When you spend your time at home you may as well maintain hygiene as the air you breathe can affect your breath.

Food - Whether in the home, in industry or in catering, food hygiene should be second nature at this time when new food risks are sharply on the increase

Instilling hygiene rules and basics - These should rapidly become second nature and act as a safeguard for the health of the population at large. Setting an example, repetition and education are most important in successfully applying personal, domestic, food or pet hygiene. Hygiene is essentially a healthy attitude towards life in general, including a balanced diet, a well ordered lifestyle, balanced sleeping patterns and avoiding smoking, alcohol and drugs. Living hygienically is the first step towards a healthier society.

To be followed in industry as per factories act Cleanliness: (Fig 22)

- Every factory shall be kept clean and free from effluvial arising from any drain, privy or other nuisance, and in particular
  - a accumulation of dirt and refuse shall be removed daily by sweeping or by any other effective method from the floors and benches of workrooms and from staircases and passages and disposed of in a suitable manner;
  - b the floor of every workroom shall be cleaned at least once in every week by washing, using disinfectant where necessary, or by some other effective method;

c where a floor is liable to become wet in the course of any manufacturing process to such effective means of drainage shall be provided as maintained; -

Fig 22

All inside walls and partitions, all ceilings or tops of rooms and all walls, sides and tops of passages and staircases shall be repainted or re-varnished at least once in every period of five years;

1 where they are painted with washable water paint, be repainted with at least one coat of such paint at least once in every period of three years and washed at least once in every period of six months;

2 where they are painted varnished or where they have smooth impervious surfaces, be cleaned at least one in every period of fourteen months by such methods as may be prescribed

3 in any other case, be kept whitewashed, or Colour washed, and the whitewashing or colour washing shall be carried out at least once in every period of fourteen months;

4 all doors and window-frames and other wooden or metallic framework and shutters shall be kept painted or varnished and the painting or varnishing shall be carried out at least once in every period of five years;

5 the dates on which the processes required by clause 'd' are carried out shall be entered in the prescribed register.

6 If, in view of the nature of the operations carried on in a factory or class or description of factories or any part of a factory or class or description of factories, it is not possible for the occupier to comply with all or any of the provisions of sub-section (1), the State Government may by order exempt such factory or class or description of factories or part from any of the provisions of that sub-section and specify alternative methods for keeping the factory in a clean state

Disposal of wastes and effluents (Fig 23)

- Effective arrangements shall be made in every factory for the treatment of wastes and effluents due to the manufacturing process carried on therein, so as to render them innocuous, and for their disposal.
- The State Government may make rules prescribing the arrangements to be made under sub-section (1) or requiring that the arrangements made in accordance with sub-section (1) shall be approved by such authority as may be prescribed.

Control measures for vapor clouds formation and combating & Workplace Exposure Limit

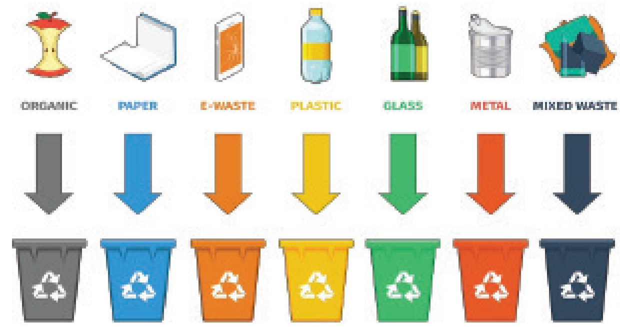
The following control measures focus on actions and tactics that can be considered once a flammable material is in the vapor phase. Control measures for preventing vaporization from an uncontained liquid will be considered under

1 Where flammable vapors are released under pressure, such as when escaping from a ruptured pressurized container, their temperature will drop rapidly. Because of this, even vapors that are lighter than air will sink to low-lying areas initially and therefore the highest concentrations of vapor will be found low to the ground and

close to the release. As the temperature falls, the rate of release will reduce and in the case of some flammable vapors, ice will form at the point of release.

2 Liquefied pressurized releases from pipelines may take considerable time to depressurize following an emergency shutdown. When a vapor cloud is formed, particularly where the release is indoors, one option would be to prevent ventilation. This is not generally recommended as it will increase the concentration of flammable vapors and therefore increase likelihood of ignition. However, if the flammable vapors pose additional health effects such as being toxic (such as ammonia and hydrogen sulphade), ventilation may reduce the flammable hazard only to produce a much wider toxic hazard. In such instances, factors such as the total quantities of vapors, location of the incident, wind speed and direction will all contribute to determine the tactic that will take precedence.

Fig 23



Flammable vapours will only ignite when they encounter a source of ignition at concentrations within their flammable range. The precise range is specific to each substance; consequently, flammable vapours with a wide flammable range are more likely to create large ignitable vapour clouds than those with a narrow flammable range. At operational incidents, a vapour cloud at concentrations above its upper explosive limit (UEL) should still be regarded as a dangerous environment. A key control measure for flammable vapours is to reduce the concentration in air below the lower explosive limit (LEL) and prevent ignition. Vapours in an uncontrolled state will naturally spread and in doing so, dilute.

Ventilation: Good ventilation can assist in dispersing flammable vapours to minimize the size of any ignitable plumes. This approach will need to be weighed against the generation of a larger plume and the potential to find ignition sources. This depends on the LEL of the vapour.

Water sprays: Adding water in the form of fine spray or mist will create convection currents that will assist in dispersing flammable vapours. Water mist will also act as a good absorber of heat if ignition occurs. Most hydrocarbon fuel vapours have little or no solubility in water. Where vapours are water soluble, such as ammonia and hydrogen sulphide, water sprays may be used to dissolve the vapour cloud out of the air.

Weather: Strong winds can disperse flammable vapours and gases, rain can dissolve soluble gases (atmospheric scrubbing) and promote the mixing/dilution of any vapour plume.

Inerting gas: By replacing the air with a gas that does not support combustion, the risk of fire can be greatly reduced or eliminated. This will not only reduce the concentration of flammable vapours but also reduce the concentration of oxygen present. Portable monitoring equipment known as LEL meters or combustible gas detectors can be used to detect the presence of flammable vapours.

Once a flammable vapour cloud has formed, the options available to reduce this hazard are limited, until vapours have dissipated to a safe concentration.

Chemical protective clothing (CPC) is generally not suitable where heat, fire or flammable risks are present. Personal protective equipment (PPE) for emergency teams may need to be sufficient to protect wearers in the event of ignition of a vapour cloud that leads to a flash fire or uncontrolled vapour cloud explosion.

Occupational Hazards & Dangerous Chemicals

1 Classification of Air borne Contaminants

When chemicals are disseminated in air and contaminate it, they are called air-borne contaminants. They are classified according to their physical state as under:

A Gases and Vapors

Gases: Normally formless fluid which occupy the space of enclosure and which can be changed to the liquid or solid state only by the combined effect of increased pressure and temperature gases diffuse. The particle size varies from 0.0005 to 0.01 micron.

Example are chlorine, ammonia, sulfur dioxide, Hydrogen sulfide (H2s), Hydrogen cyanide, carbon monoxide, etc. Main pollution are oxides of carbon, sulfur and nitrogen.

Vapors: The gaseous form of substance which are normally in the solid or liquid state and which can be changed to these states by either increasing the pressure or decreasing the temperature alone. Vapors diffuse. The particle size varies from 0.005 to 0.01 micron.

Examples are vapours of lead oxide, benzene, xylene, trichloroethylene, and other solvents.

Gases and vapors are also classified as under

- Organic solvent vapors e.g. alcohol acetone, CS2, CCI4, benzene, xylene.
- Pulmonary irritant gases e.g. CL2, NO2 and phosgene.
- Upper respiratory irritant gases NH3, SO2, formaldehyde, acetic acid.
- Chemical asphyxiant gases CO, CHN.
- Simple asphyxiant gases H2. CO2, methane, its homologues and acetylene.
- Other inorganic and organic gases H2S, arsine and pesticides vapors.

B Particulate Matters:

These are solid tiny particles produced by blasting, crushing, drilling, grinding, mixing etc. and suspended in air. Examples are as under:

a **Dust:** Solid particles generated by handling, crushing, grinding, rapid impact, detonation and decrepitating of organic or inorganic materials such as rocks, metal, coal, wood, grain etc. Dusts do not tend to flocculate except under electrostatic forces. They do not diffuse in air but settle under the influence of gravity. The particle size varies from 0.1 to 1000 microns. Fly ash from chimneys varies from 3 to 80 microns.

b **Fumes:** Solid particles generated by condensation from the gaseous state, generally after volatilization from molten metals etc. and often accompanied by a chemical reaction such as oxidation. Fumes flocculate and sometimes coalesce. The particle size varies from 0.001 to 100 microns. Examples: lead, zinc. or nitrous fumes.

c **Mists:** Suspended liquid droplets generated by condensation from the gaseous to the liquid state, such as by splashing, foaming and atomizing. The particle size varies from 50 to 100 microns. Example: sulphuric acid mist.

d **Smokes:** Small gas-borne particles resulting from incomplete combustion and consisting predominantly of carbon gaseous material are grouped in this category. The particle size varies from 0.1 to 1 micron.

e **Smog and Fog:** The air contaminants may be present in the forms of smog and fog which are not usually encountered in an industrial environment. The particle size varies from 1 to 50 micron.

f **Aerosols:** It is a colloidal system in which the dispersion medium is a gas and the dispersed phase is solid or liquid. The term aerosol is applicable till the solids or liquids remain suspended in the gaseous media. The particle size varies from 0.01 to 100 micron. Dust, smoke or mist are examples. Aerosols affect weather, damage materials and impair health. Atmospheric aerosol like hydrocarbons, lead, arsenic, sulfuric acid etc. may injury human health because of their toxic nature.

- **Permissible exposure Limit:**
  - Set by OSHA, 29 CFR, 1910.1000, and 1910.1001 through 1910.1450.
  - Specify the maximum amount of concentration of a chemical to which a worker may lie exposed.
  - Generally, define in three different ways (Salary limit, Short term expose limit & time weighted average).
- **Concepts of Threshold Limit Values (TLVs):**
  - Prepared by ACGIH volunteer scientists.

- Denotes the level of expositive that nearly all workers can experience with out and unreasonable risk of disease or injury.
- An advisor limit not enforceable by law.
- Generally, can be define as selling limit, short term exposure limit and time weighted averages.
- Usually equivalent to PELs

- **Excursion Limit (ACGIH)**
  - Excursion in worker exposure levels exceed 3 times the TLV-TWA for no more than a total thirty minutes during a work day.
- **Recommended Exposure Limits (RELs)**
  - Recommended by NIOSH
  - Indicates the concentration of substances to which a worker can be exposure up to a 10 hours work day during a 40-hour work week without adverse effect.
  - Based on the animal and human studies.
  - Generally expressed as a selling limit, short term exposure limit, or a time weighted average often more conservative then PELs and TLVs.
- **Workplace Environmental Exposure Limits (WEELs)**
  - Developed by AIHA volunteers
  - Advisor limit not enforceable by law
- **Company Developed Limits**
  - Developed by company scientists
  - Advisor limit not enforceable by law
  - Usually based on only short-term studies of animals.
- Immediately dangerous to Life & Health (IDLH) Concentration immediately dangerous to life or health from which a worker could escape without any escape impairing symptom or any irreversible health effect (NIOSH/ OSHA)
- Tentative Biological Expose Limits & Health weights Limits: In fact, the human organism itself may be regarded as a kind of sampling service. A worker's body represent his own individual collector, resistor and monitor of his personal exposure. To arrive at an accurate evaluation of toxic exposure effect limit. The biological exposure (biological monitoring) has been gaining increasing attention recently. The tentative biological exposure limits for the most important toxic substances present in industry have been developed.

The most modern approach is to consider the integral exposure resulting from all modes of entry. (Inhalation, Ingestion, Skin absorption) Including exposure in the living environment. Adopting this approach WHO (World Health Organization) study group recently published 'health based limits' for occupational exposure to some common heavy metals.

10 Classification of hazards: Hazards can be classified as different types in several ways. One of these ways is by specifying the origin of the hazard. One key concept in identifying a hazard is the presence of stored energy that, when released, can cause damage. Stored energy can occur in many forms: chemical, mechanical, thermal, radioactive, electrical, etc.

Another class of hazard does not involve release of stored energy, rather it involves the presence of hazardous situations. Examples include confined or limited egress spaces, oxygen-depleted atmospheres, awkward positions, repetitive motions, low-hanging or protruding objects, etc.

Hazards may also be classified as natural, anthropogenic, or technological. They may also be classified as health or safety hazards and by the populations that may be affected, and the severity of the associated risk. In most cases a hazard may affect a range of targets, and have little or no effect on others. Identification of hazards assumes that the potential targets are defined.

a **Biological hazard:** Biological hazards, also known as biohazards, originate in biological processes of living organisms, and refer to agents that pose a threat to the health of living organisms, the security of property, or the health of the environment.

b **Chemical hazard:** A chemical can be considered a hazard if by virtue of its intrinsic properties it can cause harm or danger to humans, property, or the environment. Health hazards associated with chemicals are dependent on the dose or amount of the chemical. Some chemicals have a cumulative biological effect, while others are metabolically eliminated over time. Other chemical hazards may depend on concentration or total quantity for their effects.

The potential hazards of these chemicals can be identified by performing a variety of tests prior to the authorization of usage. The number of tests required and the extent to which the chemicals are tested varies, depending on the desired usage of the chemical. Chemicals designed as new drugs must undergo more rigorous tests that those used as pesticides.

Some harmful chemicals occur naturally in certain geological formations, such as radon gas or arsenic. Other chemicals include products with commercial uses, such as agricultural and industrial chemicals, as well as products developed for home use. Pesticides, which are normally used to control unwanted insects and plants, may cause a variety of negative effects on non-target organisms. DDT can build up, or bio accumulate, in birds, resulting in thinner-than-normal egg shells which can break in the nest.

c **Ergonomic Hazard:** Ergonomic hazards are physical conditions that may pose risk of injury to the musculoskeletal system, such as the muscles or ligaments of the lower back, tendons or nerves of the hands/ wrists, or bones surrounding the knees. Ergonomic hazards include things such as awkward or extreme postures, whole-body or hand/arm vibration, poorly designed tools, equipment, or workstations, repetitive motion, and poor lighting. Ergonomic hazards occur in both occupational and non-occupational settings such as in workshops, building sites, offices, home, school, or public spaces and facilities.

d **Mechanical Hazard:** A mechanical hazard is any hazard involving a machine or industrial process. Motor vehicles, aircraft, and air bags pose mechanical hazards. Compressed gases or liquids can also be considered a mechanical hazard. Hazard identification of new machines and/or industrial processes occurs at various stages in the design of the new machine or process.

e **Physical Hazard:** A physical hazard is a naturally occurring process that has the potential to create loss or damage. Physical hazards include earthquakes, floods, fires, and tornadoes. Physical hazards often have both human and natural elements. Flood problems can be affected by the natural elements of climate fluctuations and storm frequency, and by land drainage and building in a flood plain, human elements. Another physical hazard, X-rays, naturally occur from solar radiation, but have also been utilized by humans for medical purposes; however, overexposure can lead to cancer, skin burns, and tissue damage.

f **Psychosocial hazard:** Psychological or psychosocial hazards are hazards that affect the psychological well-being of people, including their ability to participate in a work environment among other people. Psychosocial hazards are related to the way work is designed, organized and managed, as well as the economic and social contexts of work and are associated with psychiatric, psychological and/or physical injury or illness. Linked to psychosocial risks are issues such as occupational stress and workplace violence which are recognized internationally as major challenges to occupational health and safety.

Bio-medical waste and management

a **Introduction to Biomedical-waste:** Biomedical waste or hospital waste is any kind of waste containing infectious (or potentially infectious) materials. It may also include waste associated with the generation of biomedical waste that visually appears to be of medical or laboratory origin (e.g. packaging, unused bandages, infusion kits etc.), as well research laboratory waste containing biomolecules or organisms that are mainly restricted from environmental release. As detailed below, discarded sharps are considered biomedical waste whether they are contaminated or not, due to the possibility of being contaminated with blood and their propensity to cause injury when not properly contained and disposed.

b **Sources, composition and characteristic of hazardous waste:** Biomedical waste may be solid or liquid. Examples of infectious waste include discarded blood, sharps, unwanted microbiological cultures and stocks, identifiable body parts (including those as a result of amputation), other human or animal tissue, used bandages and dressings, discarded gloves, other medical supplies and laboratory waste that exhibits the characteristics described above. Waste sharps include potentially contaminated used (and unused discarded) needles, scalpels, lancets and other devices capable of penetrating skin.

Biomedical waste is generated from biological and medical sources and activities, such as the diagnosis, prevention, or treatment of diseases. Common generators (or producers) of biomedical waste include hospitals, health clinics, nursing homes, emergency medical services, medical research laboratories, offices of physicians, dentists, veterinarians, home health care and morgues or funeral homes. Medical facilities generate waste hazardous chemicals and radioactive materials. While such wastes are normally not infectious, they require proper disposal. Some wastes are considered multi hazardous, such as tissue samples preserved in formalin.

Characteristics of Bio-medical waste: Disposal of this waste is an environmental concern, as many medical wastes are classified as infectious or biohazardous and could potentially lead to the spread of infectious disease. The most common danger for humans is the infection which also affects other living organisms in the region. Daily exposure to the wastes (landfills) leads to accumulation of harmful substances or microbes in the person's body.

Biomedical waste those settings may pose an injury and exposure risks via occupational contact with medical waste for doctors, nurses, and janitorial, laundry and refuse workers. Further, there are opportunities for the general public to come into contact medical waste, such as needles used illicitly outside healthcare settings, or biomedical waste generated via home health care.

Techniques of bio-medical waste management: Biomedical waste must be properly managed and disposed of to protect the environment, general public and workers, especially healthcare and sanitation workers who are at risk of exposure to biomedical waste as an occupational hazard. Steps in the management of biomedical waste include generation, accumulation, handling, storage, treatment, transport and disposal. The development and implementation of a national waste management policy can improve biomedical waste management in health facilities in a country.

Generation, accumulation and collection of biomedical waste: Biomedical waste should be collected in containers that are leak-proof and sufficiently strong to prevent breakage during handling. Containers of biomedical waste are marked with a biohazard symbol. The container, marking, and labels are often red. Discarded sharps are usually collected in specialized boxes, often called needle boxes.

Storage & Handling of biomedical waste: Storage refers to keeping the waste until it is treated on-site or transported off-site for treatment or disposal. There are many options and containers for storage. Regulatory agencies may limit the time for which waste can remain in storage. Handling is the act of moving biomedical waste between the point of generation, accumulation areas, storage locations and on-site treatment facilities. Workers who handle biomedical waste must observe standard precautions.

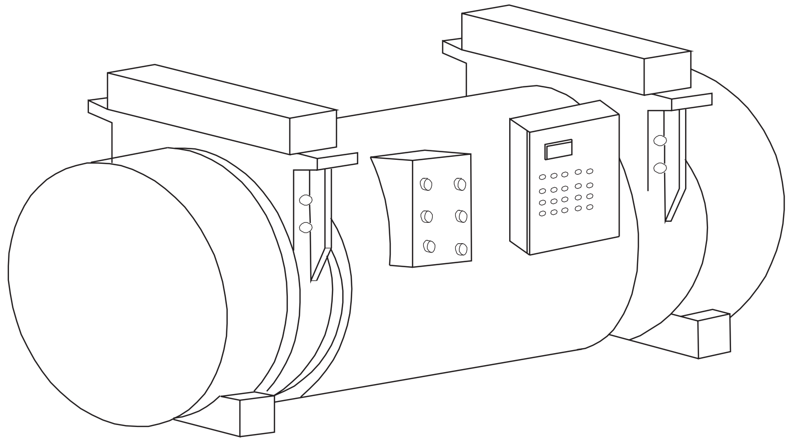
Treatment of bio-medical waste: The goals of biomedical waste treatment are to reduce or eliminate the waste's hazards, and usually to make the waste unrecognizable. Treatment should render the waste safe for subsequent handling and disposal. There are several treatment methods that can accomplish these goals. It includes segregating the bio waste.

Biomedical waste is often incinerated. An efficient incinerator will destroy pathogens and sharps. Source materials are not recognizable in the resulting ash. Alternative thermal treatment can also include technologies such as gasification and pyrolysis including energy recovery with similar waste volume reductions and pathogen destruction. An autoclave may also be used to treat biomedical waste. An autoclave uses steam and pressure to sterilize the waste or reduce its microbiological load to a level at which it may be safely disposed of. Many healthcare facilities routinely use an autoclave to sterilize medical supplies. If the same autoclave is used to sterilize supplies and treat biomedical waste, administrative controls must be used to prevent the waste operations from contaminating the supplies. Effective administrative controls include operator training, strict procedures, and separate times and space for processing biomedical waste.

Autoclave (Fig 24)

Microwave disinfection can also be employed for treatment of biomedical wastes. Microwave irradiation is a type of non-contact heating technologies for disinfection. Microwave chemistry is based on efficient heating of materials by microwave dielectric heating effects. When exposed to microwave frequencies, the dipoles of the water molecules present in cells re-align with the applied electric field. As the field oscillates, the dipoles attempts to realign itself with the alternating electric field and in this process, energy is lost in the form of heat through molecular friction and dielectric loss. Microwave disinfection is a recently developed technology which provides advantage over old existing technologies of autoclaves as microwave based disinfection has less cycle time, power consumption and it requires minimal usage of water and consumables as compared to autoclaves.

Fig 24



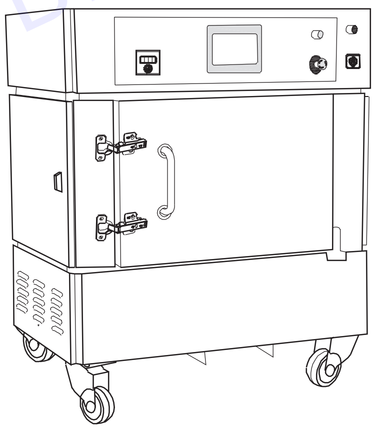
AUTOCLAVE

Microwave (Fig 25) For liquids and small quantities, a 1-10% solution of bleach can be used to disinfect biomedical waste. Solutions of sodium hydroxide and other chemical disinfectants may also be used, depending on the waste's characteristics.

Microwave disinfection can also be employed for treatment of biomedical wastes. Microwave irradiation is a type of non-contact heating technologies for disinfection. Microwave chemistry is based on efficient heating of materials by microwave dielectric heating effects. When exposed to microwave frequencies, the dipoles of the water molecules present in cells re-align with the applied electric field. As the field oscillates, the dipoles attempts to realign itself with the alternating electric field and in this process, energy is lost in the form of heat through molecular friction and dielectric loss. Microwave disinfection is a recently developed technology which provides advantage over old existing technologies of autoclaves as microwave based disinfection has less cycle time, power consumption and it requires minimal usage of water and consumables as compared to autoclaves.

Microwave (Fig 25) For liquids and small quantities, a 1-10% solution of bleach can be used to disinfect biomedical waste. Solutions of sodium hydroxide and other chemical disinfectants may also be used, depending on the waste's characteristics.

Fig 25



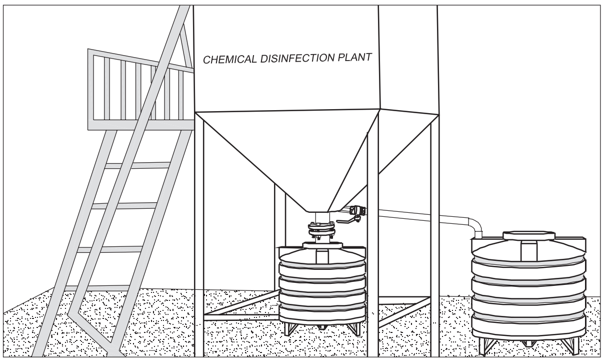
Chemical disinfection plant (Fig 26)

Other treatment methods include heat, alkaline digesters and the use of microwaves. For autoclaves and microwave systems, a shredder may be used as a final treatment step to render the waste unrecognizable. Some autoclaves have built in shredders.

Bio-medical Waste (Management and Handling) Rules & Amendments

The Bio-medical Waste (Management and Handling) Rules, 1998 and further amendments were passed for the regulation of bio-medical waste management. On 28th Mar 2016 Biomedical Waste Management Rules 2016 were also notified by Central Govt. Each state's Pollution Control Board or Pollution Control Committee will be responsible for implementing the new legislation. New regulations affect the distribution of medical waste by medical professionals into their proper receptacles.

Fig 26



CHEMICAL DISINFECTION PLANT

Fig 27

Hydro clave

In India, though there are a number of different disposal methods, the situation is desultory and most are harmful rather than helpful. If body fluids are present, the material needs to be incinerated or put into an autoclave. Although this is the proper method, most medical facilities fail to follow the regulations. It is often found that biomedical waste is dumped into the ocean, where it eventually washes up on shore, or in landfills due to improper sorting or negligence when in the medical facility. Improper disposal can lead to many diseases in animals as well as humans. For example, animals, such as cows in Pondicherry, India, are consuming the infected waste and eventually, these infections can be transported to humans who consume their meat or milk. Large number of unregistered clinics and institutions also generate bio-medical waste which is not controlled.

Due to the competition to improve quality and so as to get accreditation from agencies like ISO, NABH, JCI, many private organizations have initiated proper bio-medical waste disposal but still the gap is huge.

Many studies took place in Gujarat, India regarding the knowledge of workers in facilities such as hospitals, nursing homes, or home health. It was found that 26% of doctors and 43% of paramedical staff were unaware of the risks related to biomedical wastes. After extensively looking at the different facilities, many were undeveloped in the area regarding biomedical waste. The rules and regulations in India work with The Bio-medical Waste (Management and Handling) Rules from 1998, yet a large number of health care facilities were found to be sorting the waste incorrectly.

The latest guidelines for segregation of bio-medical waste recommend the following color coding:

- Red Bag - Syringes (without needles), soiled gloves, catheters, IV tubes etc. should be all disposed of in a red colored bag, which will later be incinerated.

- Yellow Bag - All dressings, bandages and cotton swabs with body fluids, blood bags, human anatomical waste, body parts are to be discarded in yellow bags.
- Cardboard box with blue marking - Glass vials, ampules, other glass ware is to be discarded in a cardboard box with a blue marking/sticker.
- White Puncture Proof Container (PPC) - Needles, sharps, blades are disposed of in a white translucent puncture proof container.
- Black Bags - These are to be used for non-bio-medical waste. In a hospital setup, this includes stationary, vegetable and fruit peels, leftovers, packaging including that from medicines, disposable caps, disposable masks, disposable shoe-covers, disposable tea cups, cartons, sweeping dust, kitchen waste etc.

The syringe tide environmental disaster

The syringe tide environmental disaster of 1987-1988 raised awareness about medical waste as medical syringes washed ashore in Connecticut, New Jersey, and New York. A similar situation occurred in 2013 at Island Beach State Park in New Jersey, and brought about the Floatables Action Plan. The syringes endangered marine species and posed a threat to humans who visited the beach. The crises spurred scientists and lawmakers to create mechanisms, policies, and laws so that health care providers would process their bio-waste in an environmentally friendly way. Improper management of health care waste can have both direct and indirect health consequences for health personnel, community members and on the environment. Indirect consequences in the form of toxic emissions from inadequate burning of medical waste, or the production of millions of used syringes in a period of three to four weeks from an insufficiently well planned mass immunization campaign. Biomedical waste is not limited to medical instruments; it includes medicine, waste stored in red biohazard bags, and materials used for patient care, such as cotton and band aids. The high volume of plastic use in the medical field also poses a dangerous threat to the environment. According to North and Hilden, 85% of disposable plastic materials make up all medical equipment. Our current reliance on plastic materials is rooted in their unique capabilities to be lightweight, cost-effective, and durable while preserving the sterility of medical equipment. In addition to the serious health implications of releasing harmful toxins in the environment from medical waste deposits, introducing this volume of single-use plastics can catalyze the compounding health detriments caused by macro and micro plastics.

Methods of biomedical waste incineration: The three type of medical waste incinerators are controlled air, excess air, and rotary kiln. Controlled air is also known as starved-air incineration, two-stage incineration, or modular combustion. This is the process of which waste is fed to a combustion chamber and combustion air begins to dry and facilitates volatilization of the waste. As a result, carbon dioxide and other excess gases are released into the atmosphere. The second type of incineration is the excess air process. This is similar to the controlled air process, such as the waste being dried, ignited, and combusted by heat provided by the primary chamber burner. However, the main difference is that moisture and volatile components in the waste are vaporized. In a rotary kiln, the process is similar to the two mention above, however, it is more versatile in terms of being able to mix wet and dry waste components and viewed by many waste engineers as being the most environmentally friendly.

Impact on the environment: Post incineration process, toxic ash residue is produced and is often disposed at landfills. These landfills are not protected by any barrier and the residue has the potential of reaching underground water that is often exposed to human use. The combustion of plastic material releases toxic gases that escapes and joins breathable air. Human and animal exposure to such gases can cause long term breathing and health issues. Air pollution caused by the incinerators depletes the ozone layer, causes crop and forest damage, and increases climate change. Constant exposure to such toxins and chemicals in the air could be deemed detrimental to trees and plants and could eventually lead to extinction of certain plants in specific areas. Pollution and chemical leaks also affect the fruits of trees and would cause them to be poisonous and therefore, inedible.

Environmentally friendly alternatives: Reusable RMW or sharps containers reduce the amount of plastic sent to landfills and CO 2 emissions. Non-incineration treatment includes four basic processes: thermal, chemical, irradiative, and biological. The main purpose of the treatment technology is to decontaminate waste by destroying pathogens. Modern technology invented mechanics that would allow medical professionals and hospitals to dispose medical waste in an environmentally friendly way; such as: autoclaving, plasma pyrolysis, gasification, chemical methods, and microwave irradiation. These alternatives are also highly versatile and can be used for all different types of waste.

Other possible solutions: Initiative from corporations and hospitals is essential to creating a healthier environment, Consequences could be implemented where individuals would be required to pay a fine, or face unpaid suspension from work. Companies and governmental organization should also initiate non-routine check-ups and searches; this would place pressure on hospitals to ensure that waste is properly disposed all year round. Voluntary clean-ups would involve hospital staff in assuring that medical waste is not littered around the hospital or thrown into regular garbage bins.

E-waste

Electronic waste or e-waste: describes discarded electrical or electronic devices. Used electronics which are destined for refurbishment, reuse, resale, salvage recycling through material recovery, or disposal are also considered e-waste. Informal processing of e-waste in developing countries can lead to adverse human health effects and environmental pollution. Electronic scrap components, such as CPUs, contain potentially harmful materials such as lead, cadmium, beryllium, or brominated flame retardants. Recycling and disposal of e-waste may involve significant risk to health of workers and their communities.

Significance of e-waste: E-waste or electronic waste is created when an electronic product is discarded after the end of its useful life. The rapid expansion of technology and the consumption driven society results in the creation of a very large amount of e-waste. The term “waste” is reserved for residue or material which is dumped by the buyer rather than recycled, including residue from reuse and recycling operations, because loads of surplus electronics are frequently commingled (good, recyclable, and non-recyclable). Several public policy advocates apply the term “e-waste” and “e-scrap” broadly to all surplus electronics. Cathode ray tubes (CRTs) are considered one of the hardest types to recycle.

On the other hand, the Partnership on Measuring ICT for Development defines e-waste into six categories, namely: (1) Temperature exchange equipment (e.g., air conditioners, freezers), (2) Screens, monitors (e.g., TV, laptop), (3) Lamps (e.g., LED lamps), (4) Large equipment (e.g., washing machines, electric stoves), (5) Small equipment (e.g., microwave, electric shaver), and (6) Small IT and telecommunication equipment (e.g., mobile phones, printers). Products in each category vary in longevity profile, impact, and collection methods, among other differences.

CRTs have a relatively high concentration of lead and phosphors (not to be confused with phosphorus), both of which are necessary for the display. These CRT devices are often confused between the DLP Rear Projection TV, both of which have a different recycling process due to the materials of which they are composed.

The high value of the computer recycling subset of electronic waste (working and reusable laptops, desktops, and components like RAM) can help pay the cost of transportation for a larger number of worthless pieces than what can be achieved with display devices, which have less (or negative) scrap value. In A 2011 report, “Ghana E-waste Country Assessment found that of 215,000 tons of electronics imported to Ghana, 30% were brand new and 70% were used. Of the used product, the study concluded that 15% was not reused and was scrapped or discarded. This contrasts with published but uncredited claims that 80% of the imports into Ghana were being burned in primitive conditions.

E-waste is considered the “fastest-growing waste stream in the world with 44.7 million tons generated in 2016equivalent to 4500 Eiffel towers. In 2018, an estimated 50 million tons of e-waste was reported, thus the name ‘tsunami of e-waste’ given by the UN. Its value is at least $62.5 billion annually. Rapid changes in technology, changes in media (tapes, software, MP3), falling prices, and planned obsolescence have resulted in a fast-growing surplus of electronic waste around the globe. Technical solutions are available, but in most cases, a legal framework, a collection, logistics, and other services need to be implemented before a technical solution can be applied.

Display units (CRT, LCD, LED monitors), processors (CPU, GPU, or APU chips), memory (DRAM or SRAM), and audio components have different useful lives. Processors are most frequently outdated (by software no longer being optimized) and are more likely to become “e-waste” while display units are most often replaced while working without repair attempts, due to changes in wealthy nation appetites for new display technology. This problem could potentially be solved with modular smartphones (such as the Phonebooks concept). These types of phones are more durable and have the technology to change certain parts of the phone making them more environmentally friendly. Being able to simply replace the part of the phone that is broken will reduce e-waste.

In 2006, the United Nations estimated the amount of worldwide electronic waste discarded each year to be 50 million metric tons. According to a report by UNEP titled, "Recycling - from E-Waste to Resources," the amount of e-waste being produced - including mobile phones and computers - could rise by as much as 500 percent over the next decade in some countries, such as India. The United States is the world leader in producing electronic waste, tossing away about 3 million tons each year. China already produces about 2.3 million tons (2010 estimate) domestically, second only to the United States. And, despite having banned e-waste imports. China remains a major e-waste dumping ground for developed countries.

Since the invention of the iPhone, cell phones have become the top source of e-waste products because they are not made to last more than two years. Electrical waste contains hazardous but also valuable and scarce materials. Up to 60 elements can be found in complex electronics.

While there is agreement that the number of discarded electronic devices is increasing, there is considerable disagreement about the relative risk (compared to automobile scrap, for example), and strong disagreement whether curtailing trade in used electronics will improve conditions, or make them worse.

Benefits of recycling: Recycling raw materials from end of-life electronics is the most effective solution to the growing e-waste problem. Most electronic devices contain a variety of materials, including metals that can be recovered for future uses. By dismantling and providing reuse possibilities, intact natural resources are conserved and air and water pollution caused by hazardous disposal is avoided. Additionally, recycling reduces the amount of greenhouse gas emissions caused by the manufacturing of new products. Another benefit of recycling e-waste is that many of the materials can be recycled and re-used again. Materials that can be recycled include "ferrous (iron-based) and non-ferrous metals, glass, and various types of plastic." "Non-ferrous metals, mainly aluminum and copper can all be re-smelted and re-manufactured. Ferrous metals such as steel and iron also can be re-used. Due to the recent surge in popularity in 3D printing, certain 3D printers have been designed (FDM variety) to produce waste that can be easily recycled which decreases the amount of harmful pollutants in the atmosphere. The excess plastic from these printers that comes out as a by-product can also be reused to create new 3D printed creations.

Health hazards of e-waste: Children are especially sensitive to e-waste exposure because of several reasons, such as their smaller size, higher metabolism rate, larger surface area in relation to their weight, and multiple exposure pathways (for example, dermal, hand-to-mouth, and take-home exposure). Studies have found significant higher blood lead levels (BLL) and blood cadmium levels (BCL) of children living in e-waste recycling area compared to those living in control area. For example, one study found that the average BLL in Guiyu was nearly 1.5 times compared to that in the control site (15.3 ug/dL compared to 9.9 ug/dL), while the CDC of the United States has set a reference level for blood lead at 5 ug/dL. The highest concentrations of lead were found in the children of parents whose workshop dealt with circuit boards and the lowest was among those who recycled plastics. Exposure to e-waste can cause serious health problems to children. Children's exposure to developmental neurotoxins containing in e-waste such as lead, mercury, cadmium, chromium and PBDEs can lead to a higher risk of lower IQ, impaired cognitive function, and other adverse effects. In certain age groups, a decreased lung function of children in e-waste recycling sites has been found. Some studies also found associations between children's e-waste exposure and impaired coagulation, hearing loss, and decreased vaccine antibody tilters in e-waste recycling area.

E-waste recycling workers

The complex composition and improper handling of e-waste adversely affect human health. A growing body of epidemiological and clinical evidence has led to increased concern about the potential threat of e-waste to human health, especially in developing countries such as India and China. For instance, in terms of health hazards, open burning of printed wiring boards increases the concentration of dioxins in the surrounding areas. These toxins cause an increased risk of cancer if inhaled by workers and local residents. Toxic metals and poison can also enter the bloodstream during the manual extraction and collection of tiny quantities of precious metals, and workers are continuously exposed to poisonous chemicals and fumes of highly concentrated acids. Recovering resalable copper by burning insulated wires causes neurological disorders, and acute exposure to cadmium, found in semiconductors and chip resistors, can damage the kidneys and liver and cause bone loss. Long-term exposure to lead on printed circuit boards and computer and television screens can damage the central and peripheral nervous system and kidneys, and children are more susceptible to these harmful effects.

Storage and occupational hazards

Noise Pollution

The word noise is derived from a Latin word 'Nausea' which means sickness in which one feels the need to vomit. Noise is the unpleasant and undesirable sound which leads to discomfort in human beings. The intensity of sound is measured in decibels (dB). The faintest sound which can be heard by the Human ear is 1 Db. Due to increasing noise around the civilizations, noise pollution has become a matter of concern. Some of its major causes are vehicles, aircraft, industrial machines, loudspeakers, crackers, etc.

a Transport Noise It mainly consists of traffic noise which has increased in recent years with the increase in the number of vehicles. The increase in noise pollution leads to deafening of older people, headache, hypertension, etc.

b Neighborhood Noise The noise from gadgets, household utensils etc. Some of the main sources are musical instruments, transistors, loudspeakers, etc.

c Industrial Noise It is the high-intensity sound which is caused by heavy industrial machines. According to many researches, industrial noise pollution damages the hearing ability to around 20%.

Some other appliances also contribute to noise pollution like television, transistor, radio, etc. when used at high volume.

Types of Noise Pollution (Fig 1)

Following are the three types of pollution:

- Transport Noise
- Neighborhood Noise
- Industrial Noise

Fig 28

Types of Noise pollution

Causes and Sources of Noise Pollution

Following are the causes and sources of noise pollution: b Neighborhood Noise The noise from gadgets, household utensils etc. Some of the main sources are musical instruments, transistors, loudspeakers, etc. c Industrial Noise It is the high-intensity sound which is caused by heavy industrial machines. According to many researches, industrial noise pollution damages the hearing ability to around 20%. •

Industrialization: Industrialization has led to an increase in noise pollution as the use of heavy machinery such as generators, mills, huge exhaust fans are used, resulting in the production of unwanted noise.

- **Vehicles:** Increased number of vehicles on the roads are the second reason for noise pollution.
- **Events:** Weddings, public gatherings involve loudspeakers to play music resulting in the production of unwanted noise in the neighborhood.
- **Construction sites:** Mining, construction of buildings, etc. add to the noise pollution.

Noise Pollution Examples

Following are the examples of noise pollution:

- Unnecessary usage of horns
- Using loudspeakers either for religious functions or for political purposes
- Unnecessary usage of fireworks
- Industrial noise
- Construction noise
- Noise from transportation such as railway and aircraft

Effects of Noise Pollution on Human Health Noise pollution can be hazardous to human health in the following ways

- **Hypertension:** It is a direct result of noise pollution which is caused due to elevated blood levels for a longer duration.
- **Hearing loss:** Constant exposure of human ears to loud noise that are beyond the range of sound that human ears can withstand damages the eardrums, resulting in loss of hearing.
- **Sleeping disorders:** Lack of sleep might result in fatigue and low energy level throughout the day affecting everyday activities. Noise pollution hampers the sleep cycles leading to irritation and an uncomfortable state of mind.
- **Cardiovascular issues:** Heart-related problems such as blood pressure level, stress and cardiovascular diseases might come up in a normal person and a person suffering from any of these diseases might feel a sudden shoot up in the level.

Prevention of Noise Pollution

Some noise pollution preventive measures are provided in the points below.

- Honking in public places like teaching institutes, hospital, etc. should be banned.
- In commercial, hospital, and industrial buildings, adequate soundproof systems should be installed.
- Musical instruments sound should be controlled to desirable limits.
- Dense tree cover is useful in noise pollution prevention.
- Explosives should be not used in forest, mountainous and mining areas

Also other natural and manmade ingredients are important for destroy and secure necessary care clean atmosphere provided for healthy &environment.

Application of computers & its Features

Objectives: At the end of this lesson you shall be able to

- explain about the application of computers & its features

Application of computer & features

- **Computer applications**

In the modern era, there is hardly any field where computers are not used.

Following are the applications of computer in some main areas:

1 **Education:** Through internet we can get information about any subject in a few moments. The development of multimedia and availability of Internet has made computers extremely useful for students.

2 **Bank:** The application of computers has brought a revolution in the banking sector. Most of the time-consuming tasks of banks today are; Such as online banking, withdrawing money through ATM, paying cheque, counting rupees etc. are possible only through computers.

3 **Communication:** The use of computers has made the use of Internet possible in the field of communication. Modern communication system cannot even be imagined in the absence of computers. Telephone and Internet have given birth to a communication revolution. Computers are also used in fiber optics communication.

4 **Health:** In the field of medicine, computers are used to detect various physical diseases. Analysis and diagnosis of diseases is also possible through computers. In the modern era, computers are being used extensively in various tests like X-ray, CT scan, ultrasound etc.

5 **Air-lines and Railway Reservation:** Reservations for going from one place to another by air and rail are made through computers and through computers we can also get information about the scheduled time sitting at home.

6 **Entertainment:** In the field of entertainment, computers are often used in the form of movies, television programs, video games etc. The use of multimedia has made the computer multidimensional.

7 **Administration:** Every institute has its own internal administration and administrative work is done through computers only.

8 **Security:** Without computers, our security system will become completely weak. Computers are used in tracking aircraft, air strikes etc.

9 Computers are used maximum in commerce shops, banks, insurance and credit companies etc. It has become impossible for the financial world to work without computers.

10 **Science and Engineering:** Computers are used to perform difficult mathematical and scientific calculations. Apart from this, computers also help in storing various types of records, accounts, books or magazines in the library.

11 **Industry:** Many industrial institutions like steel chemical and oil companies etc. are dependent on computers. Computers have also been used for actual control of plant processes.

- **Computer features**

The main features of computer are as follows

1 **Speed:** Computer performs millions of calculations in one second. At present, computers can do calculations even in Nano seconds or Pico seconds.

2 **Error-free work (Accuracy):** Computer displays the results of even the most difficult questions without any error.

Even if any error is found during calculations, it is due to human errors in the program or data.

3 **Storage Capacity:** Computer can store a huge amount of information in its memory. In this, the capacity of storing data and programs depends on the capacity of the hard disk.

4 **Various:** Types of work can be accomplished with the help of versatile computers. Modern computers have the ability to perform different types of tasks simultaneously.

5 **Secrecy:** The working of computer can be made confidential by using password.

6 **Diligence:** Being a machine, the computer is not affected by the external environment. It can do any work millions and millions of times without stopping.

7 **Automatic:** Computer is an automatic machine, in which the possibility of human intervention during calculation is negligible. Instructions for the computer to work are given by humans only.

8 **Reliability:** The memory power and accuracy of the computer is of very high order, hence all the activities in it or related to it are reliable.

LESSON 05 - 07: Application and safety to be observed while handling hand tools, special tools, equipment & machineries Importance and types of maintenance of vehicles/ engines

Objectives

At the end of this lesson you shall be able to

- explain application and safety while handling hand tools
- explain application and safety while handling special tools, equipments and machineries
- demonstrate inmortance and types of maintenance of vehicle/engines.

Application and safety to be observed while handling Hand tools, special tools, equipment & machineries

Hand tools: Hand tools are instruments that operates manually. Hand tools used for preform specific task. when there is no external power source, small space for operating machine work or short time work which can easily perform by workers at this time instruments which is used called Hand tools.

Application of Hand tools: Hand tools have wide range of applications nearly all industries and workshops used hand tools for construction, woodworking, automotive repair, metal working, electric working and emergency working when no power tools available etc.

Safety observed while handling hand tools

1 Edges of a square are grounded perfectly.

2 Do not drop down the square.

3 Do not knock the edges of a square against any metal parts.

4 Edges of the blade of try square must be parallel to the stock.

5 For adjusting the caliper, never strike the measuring tip.

6 After use, calipers should be cleaned and kept in separate box.

7 Divider should be handled carefully.

8 Do not sharpen the divider points on grinding wheels.

9 Scriber points are very sharp, so it should be handled very carefully.

10 Do not put the scriber in your pocket.

11 Damaged hammer handles are very dangerous, so beware of them.

12 Mushroom head hammer should not be used.

13 Beware the oil and grease to the face and peen of hammer.

14 Do not strike a hardened surface with hammer.

15 Do not use the screw drivers with defective handles.

16 Hands of work and handle of screwdriver should be dry, while using for electric work.

17 Always use screwdrivers with tips correctly fitted into the screwdriver.

18 Mushroom head chisels must never be used.

19 When using a chisel, goggles and a chip guard must be used.

20 Do not use files as hammer.

21 Do not use file without the correct size handle fitted.

22 Do not strike file with a hammer.

23 Keep files away from oil and grease.

24 Always clean pinned file with file card or brush.

25 Keep guard from handles on all scrapers.

26 Reamers should not be dropped on the floors.

Special tools: Special Tools are made for perform the special task. For example, for set specific torque we used torque wrench, measuring tools etc.

- Use the special Tools carefully for safety purpose of your safety and tools safety.
- Place special Tools at specific place.
- Don't use Special Tools when you don't have knowledge of how to use it.

Equipment's and machineries safety

Machine Safety: Machine and equipment's are not a personal property of a worker. But he should take care of it. Following are main points of consideration for safety of machine and equipment's.

1 One should have proper knowledge and training of machine on which one have to work.

2 Before operating a machine cleaning of machine, greasing and checking of Nut Bolt and Guard should be done.

3 Never change the gear of a running machine.

4 Never go anywhere while machine is in running condition.

5 During failure of electricity, the switches should be switched off.

6 According to time table the greasing and oiling of machine should be done.

7 Never take measurement of job on a running machine.

8 Before making cut by cutting tool on lathe, it should be moved by hands.

9 Never place any tool on the table of shaper, slater and planner machine.

10 Never stop the machine with hands after switching off.

11 Never give your machine in running condition to other worker.

12 Before doing a work the tool should be checked. It should be tied firmly.

13 The work should be done with concentration. Never talk during work.

Importance of regular maintenance of vehicle/engine

- Increased safety
- Improved fuel efficiency
- Extended vehicle lifespan
- Enhance resale value
- Save your money
- Maintenance of cars value
- Longevity
- Improved performance
- Promote overall Reliability
- Avoid expensive repair
- Keeps car running longer

- Prevent from breakdown
- Reduces emission
- Saving time or money in the long run.
- Reduce harmful emission

Vehicle/engine maintenance divided into several types

- Preventive maintenance
- Corrective maintenance
- Predictive maintenance
- Condition-based maintenance
- Scheduled maintenance
- Emergency maintenance

1 **Preventive maintenance:** it is regular scheduled maintenance it prevents breakdown and keep vehicle in optimal condition. It has oil changes, tire rotation, and fluids checks.

2 **Corrective maintenance:** To fix specific issues or malfunction after failure or breakdown.

3 **Predictive maintenance:** this type of maintenance depends on data and analytics (vehicles condition, sensor data) to predict when maintenance needed.

4 **Condition-based maintenance:** maintenance done by seeing current condition of vehicle components, as shown by diagnostic system physical inspection.

5 **Scheduled maintenance:** this type of maintenance done by the manufacturers recommended schedule at specific tasks and intervals.

6 **Emergency maintenance:** immediate repair done in unexpected breakdown or emergencies to carry a vehicle in working order.

LESSON 08 - 10: Explanation of Principle of All types of SI and CI Engines with respect to pressure, volume and temperature

Objectives

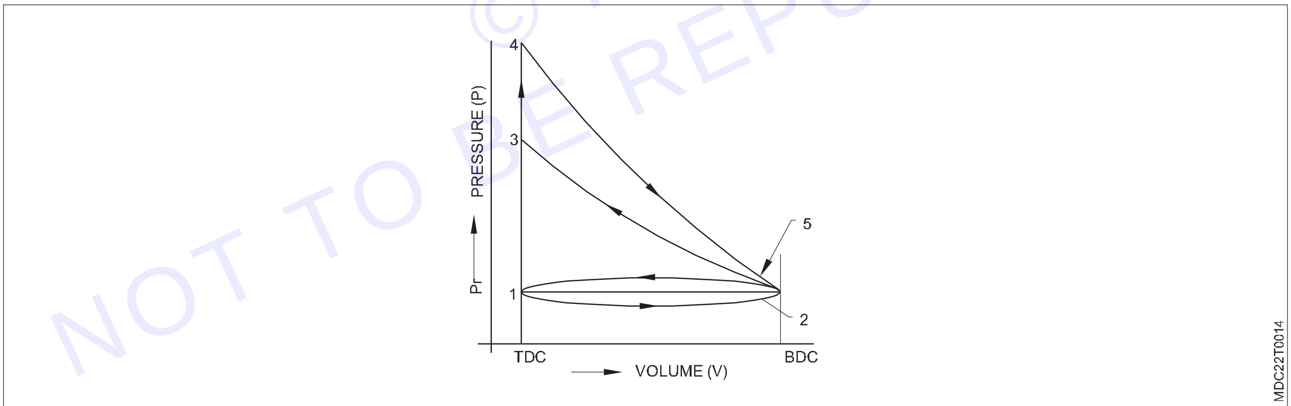
At the end of this lesson you shall be able to

- explain principles of SI & CI engines
- understand and explain PV diagram.

Petrol Engine - Petrol fuel based engine is a type of internal combustion engine which is made up of gasoline and Also known as spark ignition engine. These engines generally occupy less space and due to low torque, there is no need to strengthen the parts used in it. These engines are mostly used in cars, scooters, motorcycles etc.

Principle of petrol Engine -The petrol engine was invented by Nikolaos Otto; hence it is also called Otto cycle engine. Its design is like a large stationary single cylinder internal combustion engine. Often these engines are also known as low revolutions per minute (RPM) machines. These engines produce combustion in every second stroke due to the Otto cycle; Like car etc. Otto cycle is also called constant volume cycle, because the exchange of heat in it depends on constant volume.

Working method of petrol Engine -In the mechanics of petrol engines, when the mixture of petrol and air enters the cylinder, power is generated as a result of combustion.



In the suction stroke (1-2) of a petrol engine, the piston is at T.D.C. (TDC) to B.D. C. (BDC) and the suction process starts at a pressure lower than atmospheric pressure. After this, during the compression stroke (2-3) when the piston B. When the cylinder goes from D.C. to T.D.C., the mixture of petrol and air present in the cylinder is compressed.

In the heat addition stroke (3-4), the fuel mixture is ignited by sparking at a constant volume by the spark plug, then during the power expansion stroke (4-5), the temperature and pressure are Increased due to the expansion of the gas generated in the cylinder. Both are reduced

Types of petrol engine

1 Two stroke engine

2 Four stroke engine

Two stroke engine - Petrol is used as fuel in these types of engines and they are used in applications where a simple and low cost prime mover is required; Like scooter, motorcycle etc. In two stroke petrol engines, usually all four strokes of the engine operating cycle (suction, compression, power and exhaust) are completed in just two strokes of the piston.

In these types of engines, the fuel combustion time is short while the fuel consumption per horse power is high.

Principle - In two stroke petrol engines, a working cycle is completed in just two strokes of the piston, that is, the engine gets power in every revolution of the crank shaft. This power is obtained as a result of combustion of the mixture of air and petrol in the engine's crank case. These engines are based on Otto cycle.

Four stroke engine - Spark ignition engine is also called petrol engine. In these engines petrol and air mixture is compressed in the combustion chamber through the spark plug. Power is generated by igniting. For this reason, this type of engine is called spark ignition engine. This type of engines is mostly used in the automobile sector. In this, to burn fuel (petrol), it is necessary to make arrangements like carburetor, ignition coil, spark plug, distributor and battery etc.

The torque of this engine is low. Therefore, there is no need to make its parts very strong. Generally, all four strokes of the engine operating cycle (suction, compression, power and exhaust) are completed in just four strokes of the piston.

In this type of engines, there is only one action in one stroke and one spark is available per cylinder for every two revolutions and their fuel consumption per horse power is also less. The most important thing is that in these engines valves are used instead of ports

Principle - In four stroke petrol engine one cycle completed when the piston completes its four strokes.

Therefore, one working cycle is achieved only when the suction, compression, power and exhaust strokes of the engine are completed, that is, in one working cycle of the engine, the crankshaft completes two cycles. Four stroke petrol engines are also based on Otto cycle.

Diesel engine - Compression ignition engine is also a type of internal combustion engine. In these, diesel is used as fuel and it is used as fuel in airless form. In these, fuel ignition occurs due to temperature increase in the cylinder as a result of combustion of the engine.

Principle - Compression ignition engine is also called diesel engine. In these engines, only air is compressed in the combustion chamber, due to which the pressure and temperature of the air increases. In this compressed air, a fine spray of diesel is sprayed through the injector, due to which combustion starts in the combustion chamber and the engine starts getting power. This engine (compression ignition engine) works on the principle of diesel cycle.

Two stroke diesel engine - Diesel is used as fuel in this type of engines and these engines are generally used in ship propulsion. These engines are not very flexible due to their lower governed (ii) speed; Like- ship engine.

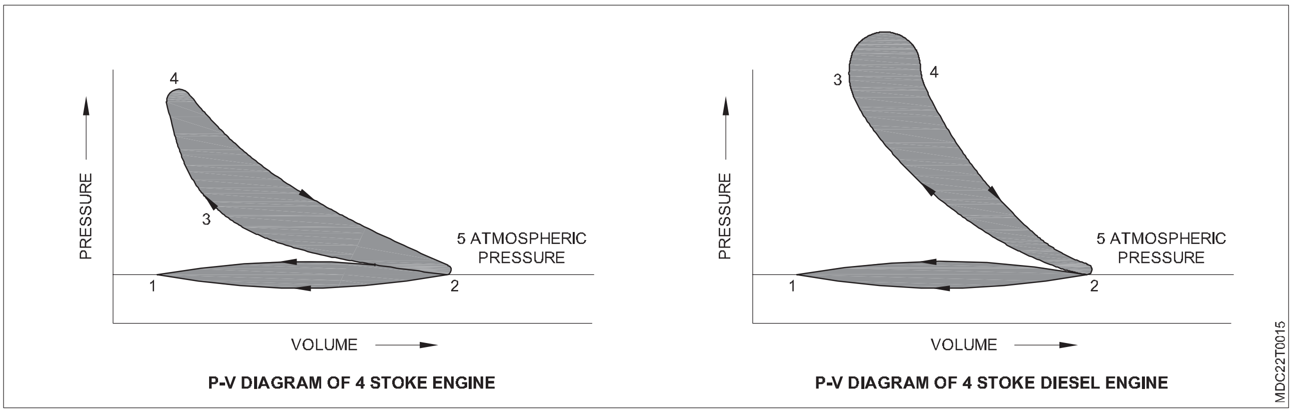
Principle - Two stroke based diesel engines are based on diesel cycle. In these, power is obtained as a result of combustion of diesel vapor and compressed air. In this type of engine, one working cycle is completed in two strokes of the piston, that is, all four strokes of the engine (suction, compression, ignition and exhaust) are completed in only two strokes of the piston.

Like a two-stroke petrol engine, in a two-stroke diesel engine, power is obtained in each cycle of the crankshaft.

Four stroke engine - Generally, in these engines, all four strokes of the engine operating cycle (suction, compression, power and exhaust) are completed in four strokes of the piston. In this type of engines, there is only one action in one stroke and one spark is available per cylinder for every two revolutions and the fuel consumption per horse power is less in these engines. The most important thing is that in these engines valves are used instead of ports. Such engines are often used in petrol and diesel engines like two-stroke engine.

Principle - In a four stroke petrol engine one working cycle is completed in four strokes of the piston. Therefore, one working cycle is achieved only after the suction, compression, ignition and exhaust strokes of the engine are completed, that is, in one working cycle of the engine, the crankshaft completes two cycles. Four stroke petrol engines are based on Otto cycle.

P - V Diagram of 4 stroke engine **P-V Diagram of 4 stroke diesel engine**



Thermodynamic cycles with respect to PV & TS diagrams

Objectives: At the end of this lesson you shall be able to

- explain thermodynamic cycles with respect to PV & TS diagrams

Compression ignition engine: Compression ignition engines include diesel engines. Diesel engines are used in goods transport vehicles, agricultural implements, railways, boats and ships. Diesel engines are also used for generator sets used to generate electricity for stationary plants in factories or hydro projects. A diesel engine is less expensive than a steam engine, petrol engine or electric motor, as more power can be obtained from the engine while minimizing fuel consumption. A diesel engine is different from the group of other engines. Now let's see how this engine works.

Function of four stroke diesel engine

Suction stroke: Piston T. D. C. From B. D. C. At this time, the inlet valve opens and due to the vacuum created in the cylinder, air is drawn through the inlet valve and the cylinder is filled with clean air.

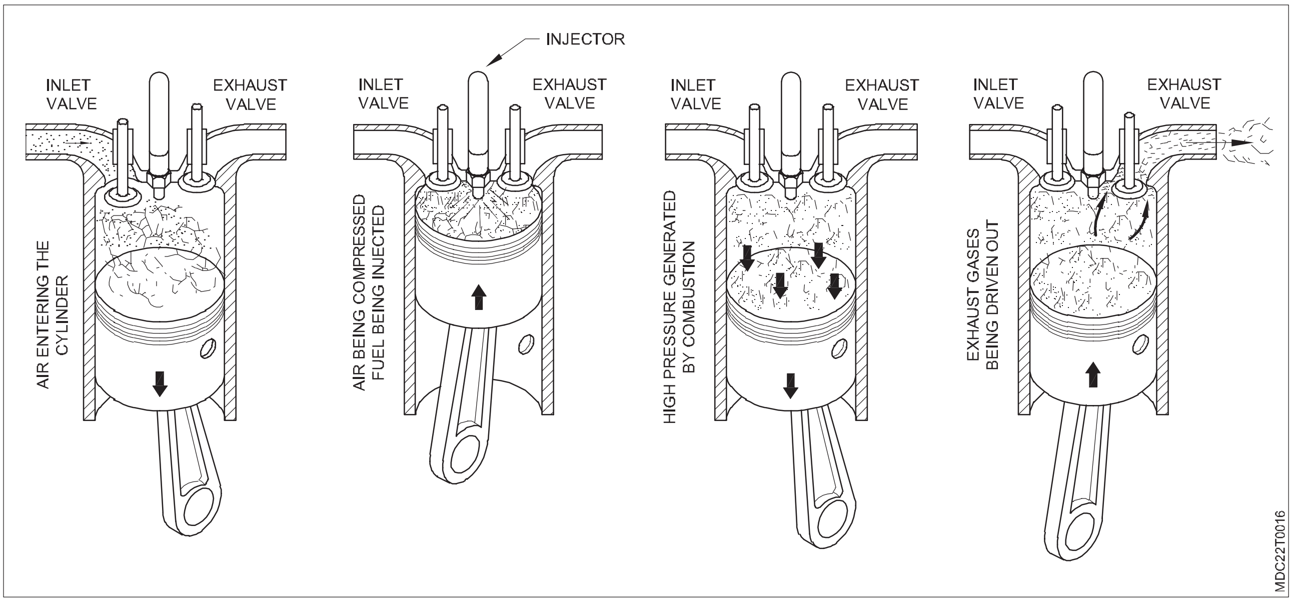
Compression stroke: Piston B. D. C. From T. D. C. At that time, the inlet valve closes and the air in the cylinder is compressed by the piston. Piston T. D. C. At that time, the compression ratio (compression ratio) between the piston head and the entire cylinder ranges from 12.5.1 to 24.1 depending on the engine design. The resulting compressed air pressure is 450 to 600 psi. inches and a maximum temperature of 425°C. It goes from 800°C to gray.

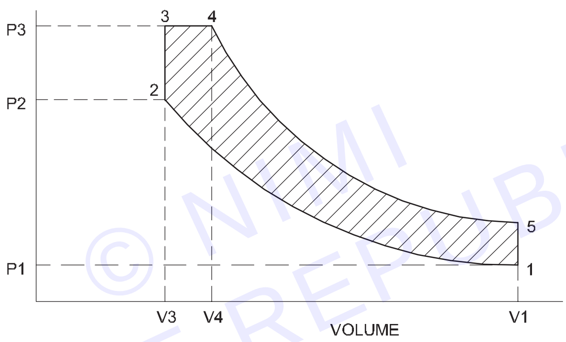
Power stroke: Piston T to compression stroke. D. C. A few degrees before reaching TDC, fine particulate (mist) form of diesel fuel is sprayed into the cylinder from the injector and the sprayed diesel is compressed until the piston reaches TDC. Mixing well with air, it self-ignites at high temperature of pressurized air. At that time the temperature in the cylinder was for a moment 20000 centigrade. It is 25000 cm gray. is increased up to Also, the gas pressure in the cylinder is 700 to 1000 bara/sq. Increases to inch and piston T. D. C. From B. D. C. is pressed to

Exhaust stroke: A piston compressed by the power stroke b. D. C. A few degrees before reaching A, the exhaust valve is opened and piston B. D. C. From T. D. C. On approach, the burnt gases in the cylinder are compressed by the piston and exit through the exhaust valve. Thus completing four strokes in sequence completes a four stroke cycle.

From the above discussion you must have understood how a compression ignition engine normally works. Now let's explain how the diesel engine four stroke actually works with the help of the pressure volume diagram in the figure.

Diesel engine four stroke cycle is also known as "constant pressure cycle" Figure no. The suction air is compressed during the compression stroke as shown in the diagram. At that time the air pressure increases slowly. (1 to2).

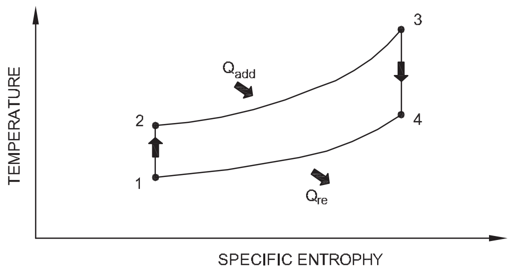




DIESEL ENGINE PRESSURE VOLUME DIAGRAM

Piston T. D. C. By injecting the fuel prior to arrival, the fuel mixes well with the air in the combustion chamber and increases the pressure. (2 to 3). At the same time uniform combustion of the entire injected fuel begins with the temperature exceeding the constant volume. The combustion process is completed in 3 to 4 hours and the heat is increased under constant pressure. That is, a power stroke occurs. At this point (3-4) the T of the piston. D. C. From B. D. C. Movement has started. So the volume is increasing. But the pressure is constant. Thus, under constant pressure, combustion of fuel stops at point 4 and expansion of gas begins. (4 to 5) and 5 to 1 constant volume heat is released. Or the burnt gases are released directly from the cylinder. In a diesel engine, the expansion stroke pressure is never less than atmospheric pressure.

Temperature – entropy: The temperature-entropy diagram (TS diagram) in which the thermodynamic state is specified by a point on a graph with specific entropy (s) as the horizontal axis and absolute temperature (T) as the vertical axis. TS diagrams are a useful and common tool, particularly because it helps to visualize the heat transfer during a process. For reversible (ideal) processes, the area under the T-s curve of a process is the heat transferred to the system during that process.



Valve timing diagram of all types of Engine

Objectives: At the end of this lesson you shall be able to

- explain valve timing diagram

The time taken for the opening and closing of the valve in the eternal combustion engine related to the movement of the piston and the flywheel is called valve timing.

Functions of Valve Timing

Theoretically at the time of suction the inlet valve is at TDC of the piston. But Should open and similarly at the time of exhaust stroke the exhaust valve B.D.C. But should open. In the same sequence, the inlet valve should close at BDC after the end of the suction stroke and the exhaust valve should close at TDC after the end of the exhaust stroke. But it should stop.

Thus, the inlet valve T.D.C. (TDC) to B.D.C. (BDC) opens 180° and similarly the exhaust valve opens up to B.D.C. From T.D.C. Opens up to 180°. This diagram is only theoretical.

In reality this does not happen in the practical aspect of the engine. In fact, the inlet valve opens a few degrees before the start of the suction stroke and remains open for a few degrees during the compression stroke also.

In this, the inlet valve opens 25° before the suction stroke and B.D.C. Remains open till after 30°C.

Similarly, the exhaust valve opens a few degrees before the start of the exhaust stroke, i.e. in the power stroke itself and remains open for a few degrees in the suction stroke. The actual valve timing of a petrol engine is shown here, but the actual valve timing of a diesel engine is slightly different from that of a petrol engine. Similarly, in the exhaust valve, exhaust stroke, B.D.C. Opens 45° before T.D.C. Remains open till after 15°. In this way the inlet valve opens up to 235° of frank station and the exhaust valve remains open up to 240°.

The injection timing is also shown in the above diagram. As per the picture, fuel injection starts 5° before the power stroke and continues till 25° after. Thus the total fuel injection is 30°. It is clear from the above pictures that the inlet valve is at T.D.C. Opens before and B.D.C. Closes after. Similarly, exhaust valve B.D.C. Opens before T.D.C. Closes after.

Valve timing diagrams illustrate the timing of the opening and closing of the intake and exhaust valves in relation to the movement of the piston within the cylinder of an engine.

For a typical four-stroke engine, the valve timing diagram shows the following key events:

1 **Intake Stroke:** The intake valve opens as the piston moves downward, allowing the air-fuel mixture to enter the cylinder. The intake valve closes as the piston reaches the bottom of its stroke.

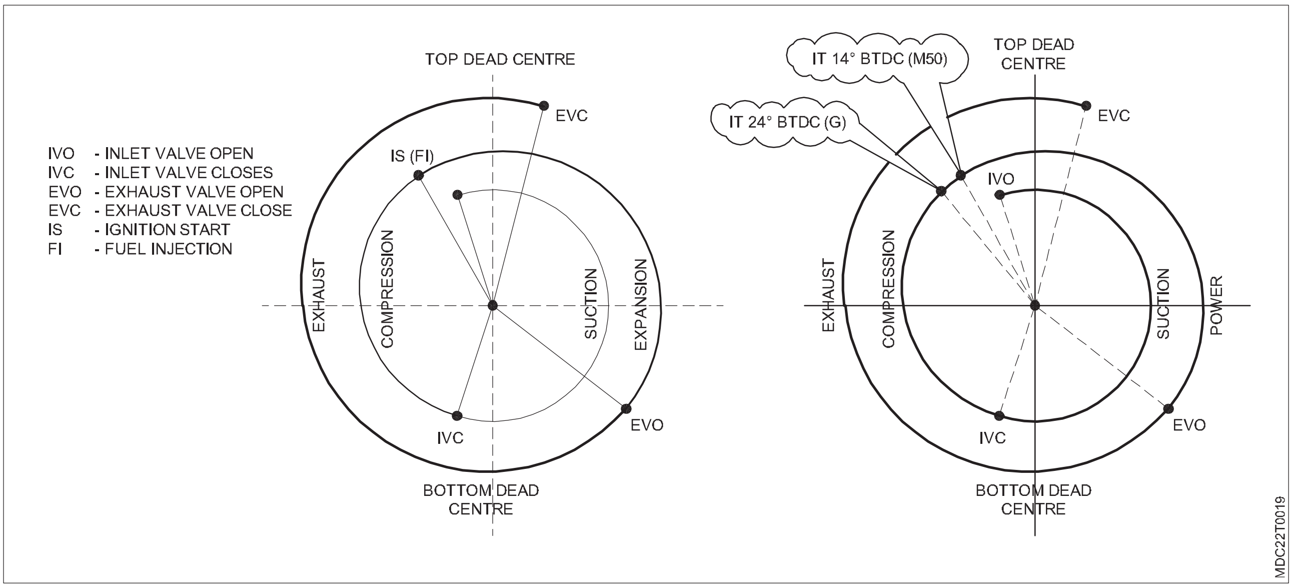
2 **Compression Stroke:** Both valves are closed as the piston moves upward, compressing the air-fuel mixture in preparation for combustion.

3 **Power Stroke:** The compressed air-fuel mixture is ignited by the spark plug, causing rapid expansion and pushing the piston downward. Both valves remain closed during this stroke.

4 **Exhaust Stroke:** The exhaust valve opens as the piston reaches the bottom of its stroke, allowing the burnt gases to exit the cylinder. The exhaust valve closes as the piston moves upward, pushing out the remaining exhaust gases.

The valve timing diagram visually represents these events, showing the position of the piston (usually in degrees of crankshaft rotation) along with the opening and closing times of the intake and exhaust valves....

The specific timing of these events can vary based on engine design, performance requirements, and other factors. Advanced engine designs may employ variable valve timing (VVT) systems to optimize performance and efficiency across a range of operating conditions.


IVO - INLET VALVE OPEN
IVC - INLET VALVE CLOSES
EVO - EXHAUST VALVE OPEN
EVC - EXHAUST VALVE CLOSE
IS - IGNITION START
FI - FUEL INJECTION
TOP DEAD CENTRE
EVC
IS (FI)
EXHAUST
COMPRESSION
SUCTION
EXPANSION
IVC
EVO
BOTTOM DEAD CENTRE
IT 14° BTDC (M50)
IT 24° BTDC (G)
TOP DEAD CENTRE
EVC
IVO
EXHAUST
COMPRESSION
SUCTION
POWER
IVC
EVO
BOTTOM DEAD CENTRE
MDC22T0019

LESSON 11 - 14: Importance of servicing cylinder Head- Precautions to be observed while servicing cylinder head

Objectives

At the end of this lesson you shall be able to

- explain importance of servicing cylinder head.
- precautions to be observed while servicing cylinder head

Importance of servicing cylinder head

- Servicing is important for cylinder safety, performance and long fuel mileage.
- Maintenance helps identify and fix problems such as leaks or wear, ensuring the cylinder is safe and functional.
- In addition, servicing can optimize performance, reduce the risk of wear and extend cylinder life. Damaged cylinder heads result in reduced cylinder pressure due to oil and water mixing.
- **Better Compression:** Servicing the cylinder head includes inspecting and protecting the valves, valve seats and valve guides for any problems. Ensures proper sealing and compression. Which is essential for the power and efficiency of the engine.
- **Leak Prevention:** Cylinder head gaskets wear out over time, which can cause coolant-oil leaks. Servicing the cylinder head includes inspecting and replacing the gasket as necessary, to prevent leaks that could cause engine overheating.
- **Enhanced Cooling:** The cylinder head plays an important role in dissipating heat from the combustion process. Cleaning and checking the coolant passages is important in cylinder head servicing to ensure efficient cooling, prevent overheating and engine damage.
- **Extended Engine Life:** By replacing problems such as worn valve elements, surfaces, or worn gaskets, servicing the cylinder head can increase engine performance over a longer period of time. Proper maintenance helps prevent costly repairs and premature engine failure.
- **Optimum Fuel Efficiency:** A proper cylinder head ensures optimum combustion chamber position and valve timing, thereby improving fuel efficiency and reducing emissions.
- **Smooth Engine Operation:** Cylinder head servicing resolves problems like valve noise, or misfire, resulting in smooth engine operation and an overall better driving experience

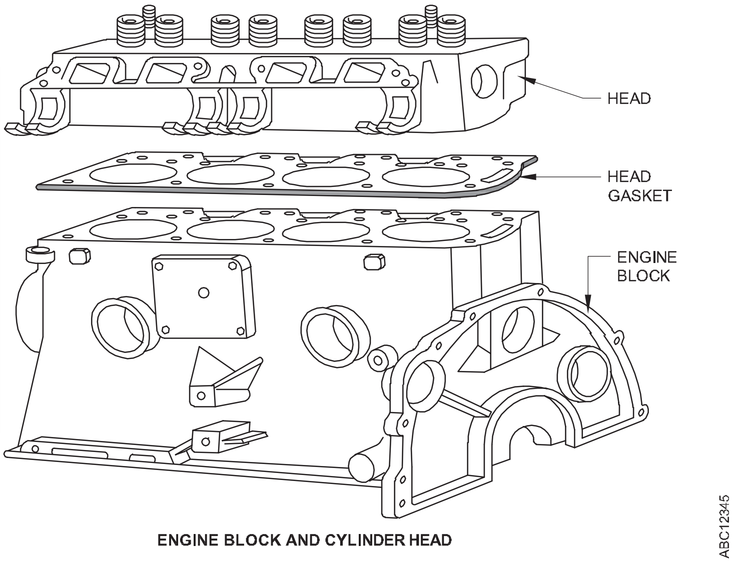
Precautions to be observe while servicing cylinder head

Cylinder Head: The cylinder head (Fig 1-13) is bolted to the machined surface on the top of the cylinder block. Its function is to enclose the top of the cylinders. Both the top of the cylinder block and the bottom of the cylinder head must be machined smooth to allow for an air-tight seal. The cylinder head fits directly over the cylinders and forms the combustion chamber of each cylinder. In these chambers, the engine burns air and fuel to produce mechanical energy.

You can also see that several small holes are cut into the bottom of the cylinder head When the cylinder head is bolted onto the cylinder block, the holes are aligned which allows oil and water to pass from the cylinder block into the cylinder head. The oil is then circulated back through the block while the water leaves the engine through the large holes on the front of the cylinder head.

Fig 1-14 shows the cylinder head in position to be installed on the cylinder block. A head gasket placed between the cylinder head and cylinder block ensures an airtight seal. Now that you have enclosed the cylinders and formed the combustion chambers, you must have a way to allow the air or air-fuel mixture to enter and exhaust (burned gases) to exit while keeping the combustion chamber closed as the air-fuel mixture burns. All this is done with the intake and exhaust valves.

Cylinder head assembly



ENGINE BLOCK AND CYLINDER HEAD

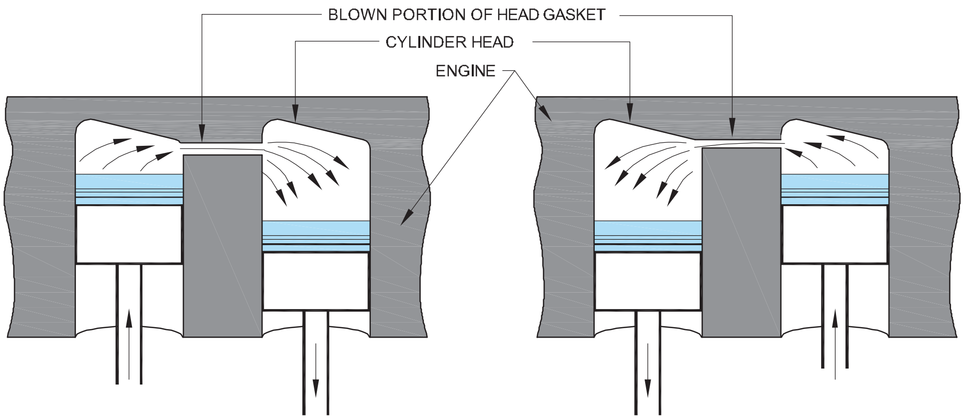
Valves: To have heat energy, you must burn air and fuel. After you have burned the fuel, you must get rid of the burned gases. Ports are provided in the engine for this purpose. In some engines, valves must open and close these ports at a given time to allow raw fuel to enter and burned gases to leave the combustion chamber. While the fuel is being burned, these valves help to seal the combustion chamber to allow the heat energy to move the piston.

The valve is a long-stemmed metal piece with a circular top known as the valve head. The mechanism required to operate the valve consists of a valve guide a valve spring, a valve spring retainer, valve spring locks, a camshaft, and timing gears or sprockets and chain. Figure 1-15 illustrates a portion of the valve mechanism.

On the underside of the valve head is the valve face. This face is machined smooth and when the valve is in the closed position, it seats firmly in the valve seat. The valve seat is a metal ring pressed into the cylinder block (or the cylinder head, depending upon the engine design) around the valve port. The valve face and the valve seat are machined smooth to ensure a pressure-tight fit. It is this portion of the valve mechanism that seals the ports while the fuel is being burned.

The valve must not be allowed to wobble while it is opening and closing or it will not seat properly and pressure will be lost. To prevent the valve from wobbling, a long tube called the valve guide is pressed or cast into the cylinder block and/or cylinder head. The valve stem travels up and down inside the valve guides as the valve opens and closes. A valve spring closes the valve. The spring seats against the cylinder block (or cylinder head) and the valve spring retainer.

Cylinder Head Malfunctions: A cracked cylinder head will produce the same results as a cracked engine block, and the same holds true for clogged oil passages in the cylinder head. A common problem in cylinder heads is a “blown” head gasket (fig. 3-9). This is usually indicated by two adjacent (side-by-side) cylinders failing to deliver power (misfiring)



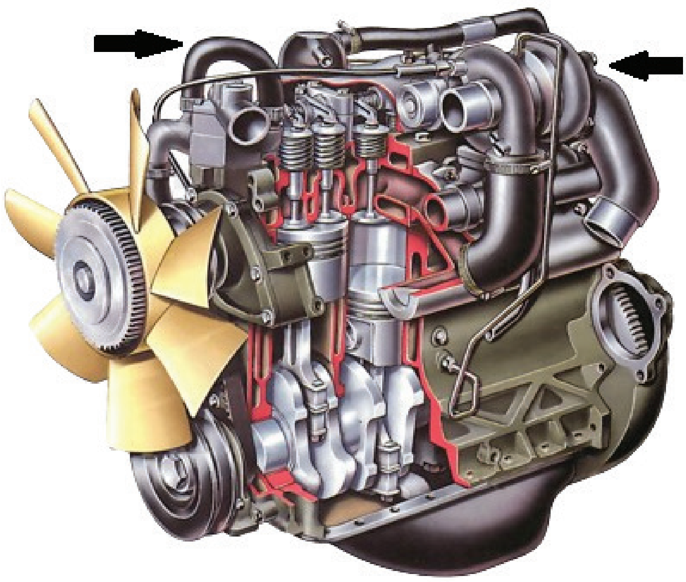
FLOW OF AIR DUE TO BLOWN CYLINDER HEAD GASKET

Carbon build-up is another problem encountered with heads. The carbon tends to hold heat which ignites the fuel prematurely. When pre-ignition is experienced in the engine and it cannot be remedied through the electrical system, the head is usually at fault.

Cylinder Head Troubleshooting and Remedies: If the two adjacent cylinders are misfiring, perform a compression test to verify the problem before removing the cylinder head (it could be faulty ignition). When a head gasket "blows," the break is usually between two adjacent cylinders, and air, instead of being compressed, simply moves back and forth between the cylinders (fig 3-9). A compression test would indicate little or no compression in either of these two cylinders to remedy this problem, the head gasket must be replaced. The cylinder head and block must be checked to ensure the surface has not warped. A perfectly flat surface is required to ensure an air-tight seal. If an uneven surface is detected on either the cylinder head or the cylinder block, it must be machined flat (commonly termed shaving or grinding the head or block).

If pre - ignition exists, and after troubleshooting electrical system, it is determined that the cylinder head is the cause, remedy the malfunction by removing the head and cleaning out all carbon deposits.

Valve Troubleshooting and Remedies: Let's return to the compression test for a moment. If a dry" test and a "wet" test result in the same low reading, this indicates an "open" combustion chamber (a blown head gasket, a cracked piston head, a valve adjusted too tightly, etc.). A visual inspection would eliminate the head gasket and you can eliminate a cracked piston if there is no sound to indicate it. You will probably have to remove the cylinder head, but first, let's adjust the valves to ensure that they are not too tight. Adjust the valves by inserting a feeler gage between the rocker arm and the valve stem and turning the adjusting nut until a slight drag is felt (fig 3-12).



Removing the cylinder head

Learning objectives

1 List the four procedures in preparing an engine for disassembly.

2 Identify the differences in removing the cylinder heads from the L-head engine and the I-head or F-head engine.

3 Identify the disassembly procedure for the rocker arm. The first engine component removed is the cylinder head assembly, but before any disassembly is started, you must prepare the engine. A good repair or rebuild job begins with engine preparation. Without good preparation, you may not only fail to locate unknown defects, but you may also cause further damage.

Engine Preparation: With the engine removed from the vehicle, you can begin your preparation. The first procedure is to cover all openings of the engine with clean, lint free rags. Look at figure 4-1. Note the arrows indicating typical openings to be covered. Now imagine yourself as a surgeon and the engine as your patient. If foreign matter enters your patient's body, infection may result, and your operation could be a failure.

Engine Cleaning: Now that all openings are covered, the second procedure is to clean the engine thoroughly to prevent foreign matter from entering the engine and causing internal damage during disassembly. First, take a high-pressure cleaning unit and steam clean the entire outer surface of the engine. If a cleaning unit is not available, use a high-pressure water hose to remove the dirt and loose matter. Next, with cleaning solvent and a stiff brush, remove any grease or oil that may be on the engine. The third procedure is to drain the engine Using two separate containers, one for oil and the other for the coolant, remove the oil pan drain plug and open the cylinder block drain cock and drain the engine completely (fig 4-2). While the engine is draining, you might use this time to make sure that your working area is thoroughly clean to prevent any chance of getting the internal parts of the engine contaminated with dirt.

With the engine thoroughly cleaned and drained, the fourth procedure is to conduct a good visual inspection of its outer surfaces for cracks and broken parts as you begin removing the accessories. If these conditions exist, you must get a decision from a machinist on the feasibility of repairing the defects. New or rebuilt parts are of no value if the engine block is damaged beyond repair.

At the point, you are ready to disassemble the engine. Mount the engine on the repair stand and begin the actual disassembly. Remember to lay the parts out in an orderly manner as you disassemble the engine.

Doing so will make assembly easier.

Note: The removal and installation of the intake and exhaust manifold are not covered in this course. It is essential, however, that these components be inspected and properly aligned for the engine to operate correctly.

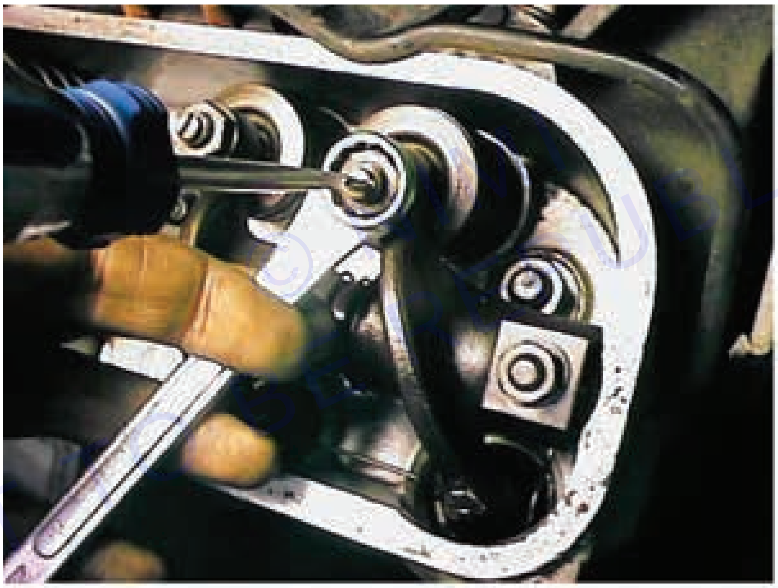
As you disassemble the engine, check each part to make sure it can be used in the repair of the engine. If you wait until reassembly, it will cause extra work and unnecessary time if you have to remove a part you earlier assumed was good without checking. The three most common cylinder head engine types will be taught. Let's begin with the L-head engine.

L-head Engine: You have already inspected the outer surfaces of the cylinder head along with the rest of the engine. The internal portion of the head must be cleaned before it can be inspected. When you remove the cylinder head, lay it aside and inspect it later in a separate area. To clean it now would result in carbon deposits flying through the air, possibly contaminating the rest of the engine.

The removal of the cylinder head from an L-head engine is very simple. Remove the cylinder head bolts from the head, lift the cylinder head from the engine, and lay it flat on a flat surface. To stand it on end or lean it against another object would result in the head warping which in many cases could require repairs that would not have been necessary. At this time, also remove the cylinder head gasket, inspect it for signs of leakage, and discard it. Any signs of leakage should be recorded so that you may concentrate on the cause during your cylinder head and cylinder block gasket surface inspection.

I- or F-head Engine: Removing an I- or F-head engine's cylinder head requires a little more effort. First, remove the rocker arm cover and discard the gasket and retaining seals. At this time, check the retainer seal surface of the cover for dents. Check for any other dents. Some mechanics have a tendency to over-torque the retaining nuts and bolts; this bends the retainer seal surface of the cover. If a dent exists, you may straighten it at this time or record the defect so that it is not forgotten.

With the cover removed, back off (loosen) the valve adjustment at least one complete turn to relieve the pressure on the rocker arms (fig 4-3). If the pressure is not relieved, damage to the rocker arm shaft could result when it is being removed.



Relieving rocker arm pressure

When the pressure is relieved, remove the rocker arm attaching bolts and nuts and lift the rocker arm shaft from the engine. If the engine does not have a rocker arm shaft, simply remove the rocker arm.

Once the shaft is removed, you might make a preliminary inspection by removing a couple of rocker arms and checking their pivot points on the shaft. If you find grooves worn into the shaft, discard both the shaft and the rocker arms, retaining all other parts.

To prevent damage to the pushrods when the cylinder head is removed, take them out of their holes (before removing the cylinder head) and lay them in order on your workbench or in the area you are storing the parts you have removed. You might as well take this opportunity to ensure that all the pushrods are perfectly straight. A bent rod will continue to bend when reinstalled in the engine. Discard any bent rods and make a note of the holes from which they were removed. Now, loosen the cylinder head bolts, lift the head from the engine, and lay it on a flat surface.

Cylinder head

The cylinder head from an L-head engine does not require major disassembly. Therefore, the disassembly portion of this study unit refers mostly to the I-head and F-head engines. The cylinder head is cleaned and inspected just as the engine block was; therefore, it is unnecessary to go into a detailed description. Let's get right to inspection and the repair of the cylinder head.

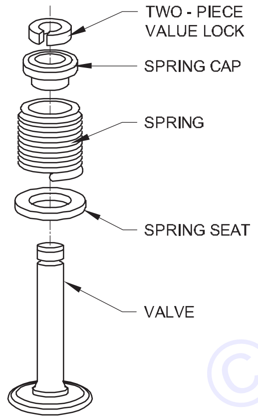
Cylinder Head Inspection and Repair

Begin disassembly by removing the valves. With a valve spring compressing tool compress the valve spring and remove the valve stem locks. There are various types of valve spring compressors.

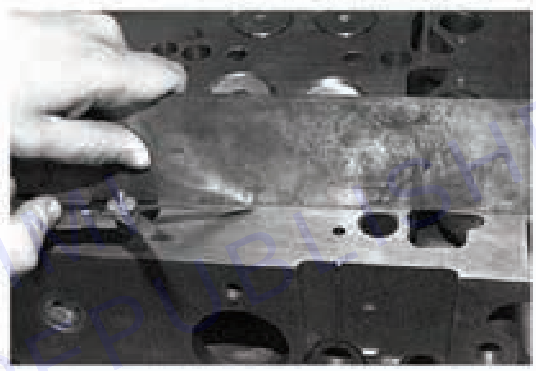
The one described is one of the more common. The spring is compressed by placing the solid end of the compressing tool on the valve head and the split end of the spring retainer, then compress it with the lever located on the tool.

Once this is accomplished, you can easily remove the valve stem locks with your fingers. Cup your hand over the end of the spring now and release the lever. The valve spring and its related parts are then removed by hand? The valve may also be removed from the bottom side of the cylinder head by hand.

Keeping each valve and its related components together, lay them out on a clean surface and carefully inspect each piece for damage.



VALUES AND RELATED PARTS



MDC22T0026

Now, remove the coolant outlet connection and check the thermostat operation. To remove the outlet connection, simply remove the cap screws retaining it and lift it from the head.

Remove the thermostat and drop it into boiling water to check its operation. The thermostat should open.

Remove the expansion plugs and replace them as you did in the engine block.

Check the head for nicks, burrs, and cracks. Smooth any nicks and burrs with oil stone. A cracked head may be sealed in some cases. The cylinder head is now ready for specification checks.

The flatness check is performed to ensure that the head is not warped. This check is made in the same manner as the cylinder head gasket surface of the cylinder block. A straight edge and a feeler gage are used to determine the amount of warpage. Fig 5-25 is a good illustration of how to perform the checks.

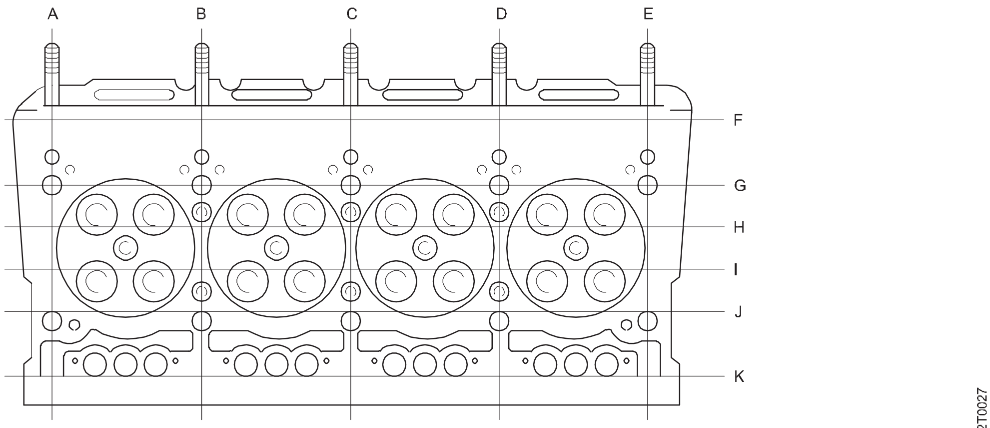
Checking cylinder head flatness

Fig 5-26 shows where these checks should be made. The lines drawn across the surface indicate the positions in which the straight edge should be placed for checking. If you were working on a cylinder head from an L-head engine, this is the only check you would be required to make.

If the results of the check reveal that the cylinder head warpage exceeds the tolerances listed in the TM, you must have the head ground to obtain a new, flat surface. In some cases, the head may have already been ground as far as allowed and in other cases, heads are manufactured in such a design that they cannot be ground at all. In these cases, discard the cylinder head and obtain a new one through the supply system.

Valve Seat Inspection and Repair

Your first step would be a visual inspection. It is important that the valve seat be of the proper width to ensure an air-tight seal and proper valve cooling. Although the entire surface of the valve seat is machined smooth, only a small portion of that surface is actually contacted by the valve when it is closed.



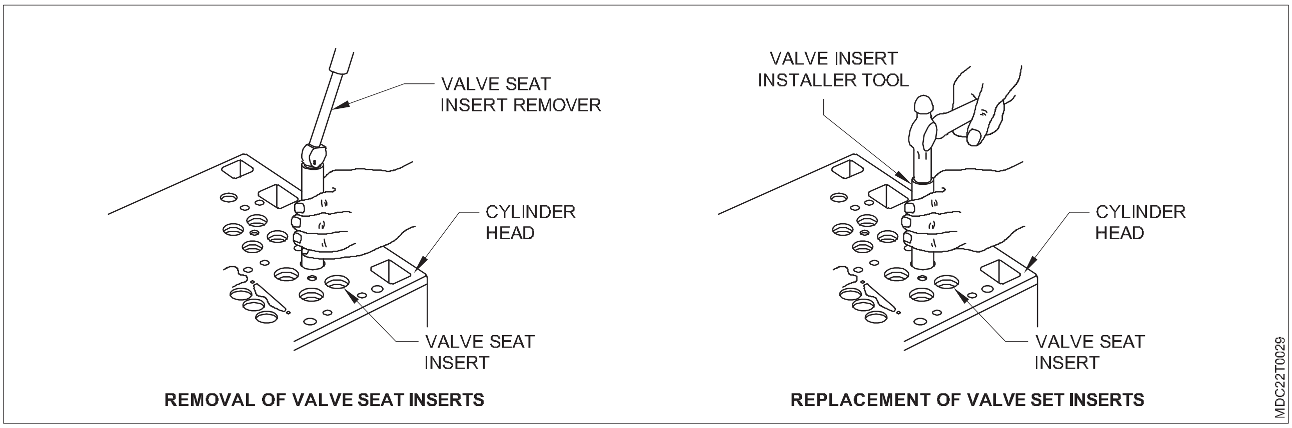
POSITION FOR CHECKING CYLINDER HEAD FOR FLATNESS

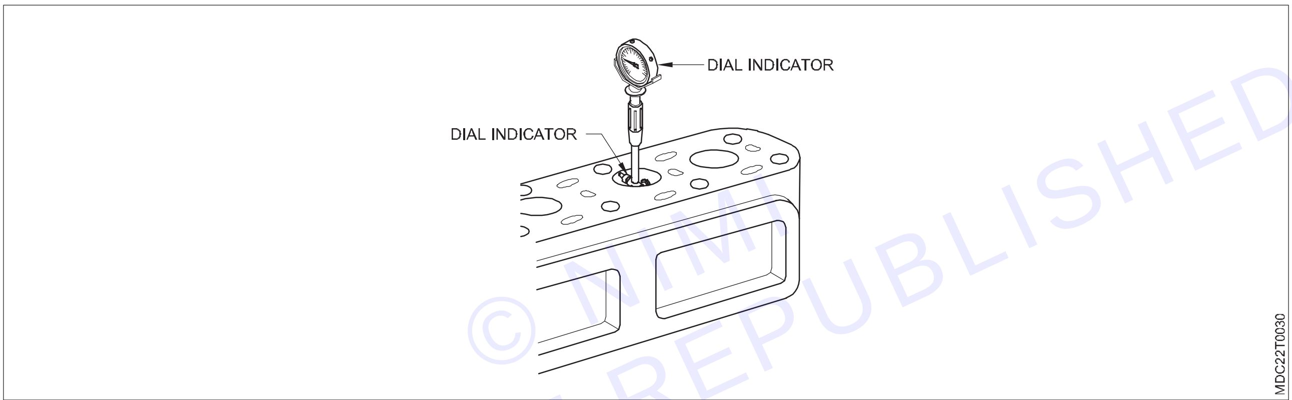
If the head is equipped with cast in seats, improper fit or damaged seats would need to be ground (refaced). Grinding requires the use of an electric drill motor (fig 5-27) and grinding stones of various degrees of angle. Consult the appropriate TM for the proper angle.

Care must be exercised to prevent the grinding of too much metal from the surface of the seat. Check contact surfaces between the valve and valve seat by applying a light coat of Prussian blue dye to the valve face. Lower the valve stem into the valve guide and let the valve drop against the valve seat. Apply pressure valve head until valve face makes good contact with valve seat, BUT DO NOT ROTATE. Push up on valve stem until valve face is about one inch above valve seat. Drop valve back into valve seat and reapply pressure to valve head. Repeat this procedure several times to get a good imprint in the Prussian blue dye. Being careful not to smear the dye, remove valve. The imprint in Prussian blue dye should have an even seat mark all the way around the center of the valve face.

If the head you are working on has replaceable seats (valve seat inserts), badly damaged seats must be replaced. Remove and replace valve seat inserts as illustrated in figure 5-28A and B.

After valve seats have been replaced, perform a runout check. The valve seat runout check ensures that the seat is perfectly round. This is accomplished by the use of a dial indicator type gage known as a runout gage. The gage manufacturer provides instructions for its use, but basically, you insert the base of the gage into the valve guide, adjust the measuring device to seat on the contact surface of the valve seat, and run the measuring device around the valve seat (fig 5-29). The maximum reading reached on the dial indicator tells what the runout is. The runout is then checked against the tolerance listed in the TM.





Valve Guide Inspection and Repair

Although you may have repaired or replaced the valve seats, the valves will not seat properly unless the valve stem clearance is correct. Check the valve stem clearance now to help ensure proper valve seating. Measure the inside diameter of the valve guide with a telescopic gage and the outside diameter of the valve stem with a micrometer. To obtain valve-to-guide clearance, subtract valve stem diameter from valve guide diameter. Check appropriate TM for proper specifications.

If the reading you have obtained is greater than the tolerance, either the valve or the valve guide must be replaced. Check the condition of both and determine which needs replacement. In some cases, both may have to be replaced. If the cylinder does not have replaceable guides, ream the guide and use an oversized valve.

If the engine is equipped with replaceable valve guides and a visual inspection reveals that the valve guide is damaged beyond repair, it must be replaced. To replace the valve guide, the old guide must be driven out of the cylinder head or cylinder block and a new one driven in. This is accomplished by placing the valve guide remover inside the valve guide and drive the guide out through the cylinder head with a ballpeen hammer.

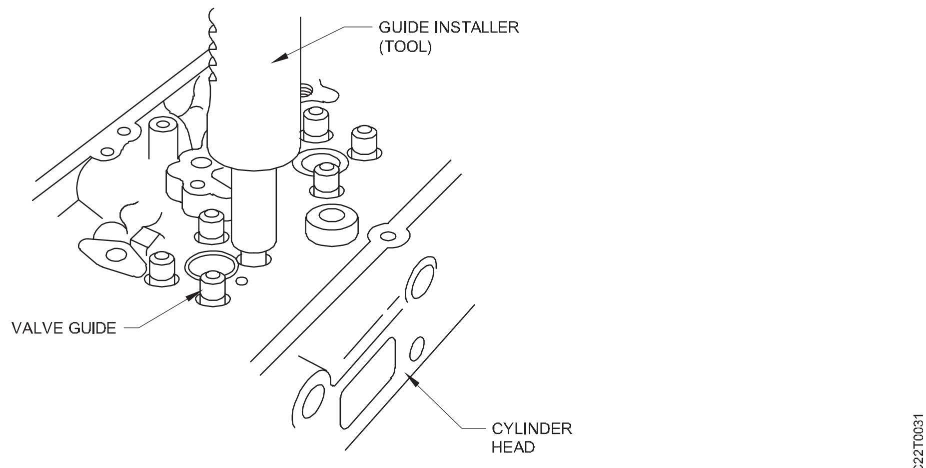
When installing valve guides, use the appropriate valve guide installer tool and press (fig 5-30). Position valve guide squarely on guide bore and gently press guide into bore. The installer will position guide to the correct depth.

This should complete the repairs of the cylinder head, or in the case of the L-head engine, the cylinder block. The final component to be repaired is the valve mechanism

Valve and cylinder head installation servicing objectives

1 Identify the correct procedure for installing each of the following components: the valves, pushrods, rocker arm shaft, and cylinder head.

2 Identify the correct tightening sequence for cylinder head bolts.



INSTALLING VALVE GUIDES

You already know that valves are located in the cylinder block of the L-head engine, in the cylinder head of the I-head engine, and in both the block and the head of the F-head engine.

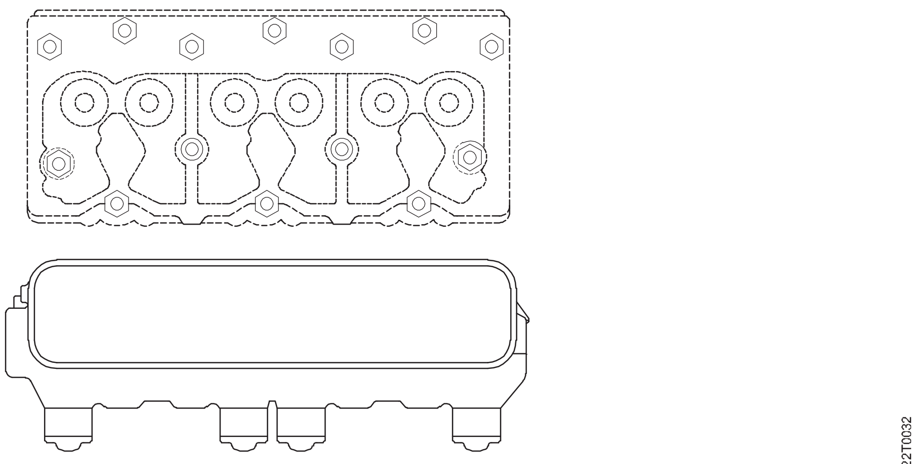
Valve Installation from constant use, valves shape themselves to the valve seat. When reusing old valves, be certain that you install each valve in its original location to ensure proper seating. This holds true for all valves, whether you are installing them in the head or in the block. Insert the valve stem first into the valve guide from the bottom of the head. If the valves are equipped with seals, place the valve spring and valve spring retainer over the valve stem and compress the valve spring into place with the valve spring compressing tool.

After compressing the valve spring, insert the valve stem locks However, in some cases you may find that a sleeve is used. This is placed on the valve stem before the locks. If a valve stem cap is used, it is placed over the end of the valve stem after the locks are in place and the valve spring released. Figure 6-14 is an example of valves and their associated components. You might note that the valve stem locks are sometimes referred to as keys. When all valves are installed in the cylinder head, the head is ready to be installed on the cylinder block.

Cylinder Head and Pushrod Installation

Now you are ready to install the cylinder head. Since the L-head engine is the simplest of heads to install, let's discuss it first. Inspect your cylinder head gasket. In many cases, you will find one side marked "TOP." Be sure to place the gasket on the cylinder block so that the word "TOP" may be seen. In cases where the gasket is not marked, inspect the alignment of the holes in the block with the holes in the gasket. If the holes are not aligned, you have the gasket inverted, or bottom side up.

Now, place the cylinder head in position over the gasket and insert the cylinder head bolts. Screw the bolts into the cylinder block until they are snug against the cylinder head. You must use a torque wrench to tighten the cylinder head bolts.



TYPICAL TIGHTENING SEQUENCE FOR CYLINDER HEADS

Check the TM for the proper torque specifications and sequence. Figure 6-8 gives examples of cylinder heads having two and three rows of head bolts. Note the tightening sequence for both.

The installation of the cylinder head on the I-head and F-head engines is the same as that for the L-head up to this point. However, before head installation is considered complete on these two engines, the rocker arms and pushrods must also be installed.

The pushrods are inserted through holes provided in the cylinder head. The bottom end of the pushrod must seat in the recess located in the tip of the valve tappet or the engine will not operate and the pushrod will be damaged.

Engine Diagnosis and Service: Cylinder Head and Valve train

Disassemble a cylinder head in the correct manner Clean and inspect a cylinder head for cracks and warpage Diagnose cylinder head and valve train wear problems and determine the correct repair procedure Understand machine shop repair processes for cylinder heads.

Objectives (cont'd.)

- Reassemble a cylinder head
- Understand camshaft and cam drive service procedures Introduction
- Valve job
- Cylinder head is removed for valve refinishing
- Leaking head gasket
- Removed for resurfacing and gasket replacement
- Timing chain or timing belt service
- Important maintenance procedures on today's long-life engines

Head Disassembly and Carbon Removal

- Cylinder heads: easier to work on if clean
- OHC heads with removable cam caps: verify caps are correctly numbered
- Removing valve springs: wear face protection
- Keep valves in order
- Measure and record valve stem and spring height
- Carbon removal
- Most OHC heads have oil galleries
- Carbon can be removed from necks of valves

Cylinder Head Inspection

Cylinder heads sometimes warp

- Warped heads are resurfaced
- Clean head before checking for flatness
- Rock the straightedge so one edge of it rests against the opposite side of the head
- A round, straight bar is also available for checking straightness
- Warpage
- Cast iron head warpage
- Aluminum head warpage

Resurfacing by Grinding, Cutting, or Sanding

- Resurfacing methods
- Fly-cutting

- Grinding the head
- Correct surface finish is very important
- Multilayered steel (MLS) gaskets
- Require a very smooth surface finish
- Head resurfacing
- Can increase compression.

Straightening Cylinder Heads

Warped aluminum OHC heads

- Commonly straightened
- Several methods for straightening cylinder heads
- Best: heating oven
- Straighten the head prior to surfacing
- Combustion chamber volumes will remain equal

Crack Inspection

- Cracks are sometimes found:
- In combustion chambers
- Between adjacent combustion chambers
- On the valve spring side of the head
- Ways to detect cracks
- Magnetic crack inspection
- Dye penetrant
- Pressure testing

Crack Repair

- Cracks are sometimes repairable
- Only practical if the cost of a bare head is more than twice the cost of the crack repair
- Cracks in iron heads
- Repaired with tapered, threaded plugs
- Welding heads
- Common method of repairing aluminum head cracks

Checking Valve Springs

- Springs are tested for:
- Tension
- Squareness
- Height
- Specifications are available in the service manual

Checking Valve Stems

- Valves wear: oil consumption results
- Measure the valve stem with a micrometer

Valve Guide Service

- Valve guides are checked for wear
- Wear in a bell mouth fashion
- Can result in oil consumption
- Valve seat has worn and is wider than usual
- Look for a worn valve guide as the cause
- Checking valve stem-to-guide clearance
- Split ball gauge and micrometer
- Dial indicator

Guide Repair

- Guides are repaired in several ways
- Worn integral guide bored out to accept a pressed-fit insert guide
- Worn insert guide pressed out and replaced with a new one
- Knurling
- Thin wall insert

Grinding Valves

- Valves are refinished on face angle using a valve grinder
- Stem tip is reground flat
- Grinding wheel is dressed with an industrial diamond
- Some machinists grind an interference angle
- Very little metal is removed from surface of the valve face

Grinding Valve Seats

- Valve guides must be refinished before refinishing valve seats
- Valve seats are refinished with a grinding stone or a seat cutter
- 45-degree seat angle that mates with valve face is machined until seat area is clean and free of pits
- 60-degree angle in the bottom of the seat (i.e., throat angle) is cut very lightly
- Head must be thoroughly cleaned of all grit before beginning assembly

Checking Valve Stem Installed Height

- Seat and valve are reground
- Stem moves further into the cylinder head
- Results in increased valve stem tip height and valve spring installed height
- After grinding the valve and seat
- Check installed height
- Shims may be installed under the springs when a head reassembled

Solvent Testing the Valve and Seat

- After the valve and seat have been ground:
- Install the spark plugs in their holes
- Turn head over so combustion chamber faces up

- Place head on head stands and put it on a shelf in solvent tank
- Install valves in the ports
- Fill the combustion chambers with solvent and check for leaks

Reassembling the Head and Valve Guide Seal Installation

- Clean head before reassembly
- Thoroughly clean the guides
- Lubricate all valve stems
- Valve guide seal installation
- Install guide seals before installing springs on all but O-ring seals
- Check instructions in gasket set regarding placement of seals
- Lubricate seals before installing them
- Positive seals: often supplied with a plastic sheath

Install the Valve and Spring Assembly

- Some springs have coils more closely spaced at one end than at the other
- End more tightly coiled IS positioned against the cylinder head
- Compress spring just enough to install keepers
- Inspect each keeper for wear
- Use grease to help hold keepers in place
- Newer engines may use been hive-shaped springs
- One end of coils smaller in diameter

Pushrod Engine Rocker Arm Service

- Stud-mounted rocker arms
- Not serviceable
- Replaced when worn
- Cast rocker arms that are shaft-mounted
- Can be reground
- Thoroughly lubricate rocker arms
- Before installing

Inspect Pushrods and OHC Camshaft

Inspect pushrod ends and surface of socket where it pivots on rocker arm

- Look for pitting or other unusual wear
- Roll pushrods on a bench to see if they are bent
- Overhead camshafts often have oil galleries and holes drilled in cam lobes for direct lubrication
- Small oil holes are prone to plugging
- Check that oil holes are clear before installing

Reassembling OHC Head

- Important steps
- Reinstall camshaft in the head
- Check to see camshaft cap alignment bushings are installed and positioned correctly

- Bucket-type OHC heads
- Lubricate buckets and install them in the head prior to installing the cam
- Adjust the valve clearance before installing the head on the engine
- Valve lash must be enough to allow heat to dissipate from valve to valve seat

Safety with Cylinder Heads and Valves

Keep these 10 safety precautions in mind when working with cylinder heads, valves, valve springs, camshafts, and rocker arms.

1 Always wear safety glasses around the shop. Wear the glasses at all times while in the shop, even while

looking up specifications, reviewing procedures, or working on cylinder head components. Get in the habit of keeping the safety glasses on at all times.

2 The edges of the cylinder head may be very sharp because of the machined surfaces. Be careful not to cut your fingers when handling the cylinder head.

3 During cleaning, pieces of carbon and soot are usually removed from the valves and cylinder heads. Be careful not to breathe in the carbon dust.

4 When valves and valve springs are being removed or installed, the valve springs are depressed and under high pressure. Make sure the valve spring compressor is secured correctly on the valve so the spring will not slip under pressure. Your eyes and face may be injured if you are hit by a spring that has slipped out of the grasp of the tool.

5 Make sure that any electrical tools used for cleaning valves or cylinder heads are grounded correctly.

Never use an electrical tool while standing in wet are as in the shop

Back to Safety

6 Often the top edges of used lifters are very sharp. This is caused by the cam lobe wearing on the top of the lifter. Be careful not to cut your fingers on these sharp edges when removing lifters.

7 When installing a camshaft, be careful not to pinch your fingers between the cam bearings and the cylinder block holes.

8 Make sure that all tools used for working on the camshaft and valves drive mechanisms are clean and free of dirt and grease.

9 When grinding valves or using other electrical equipment, never string an extension cord across the floor.

10 Many of the bolts and nuts require high torque specifications. Always use the correct Torque wrench, and know the torque specifications when working with cylinder heads.

Reasons for frequently occurring abnormal wear in cylinder head components and its Effects on engine performance

Objectives: At the end of this lesson you shall be able to

- demonstrate Reasons for frequently occurring abnormal wear in cylinder head components
- effects on engine performance due to abnormal wear.

Cylinder head defects, causes and solutions Faults, Causes and Remedies of Cylinder Head

i **Overheating of the engine:** The main reason for overheating of the engine is accumulation of excessive amount of carbon in the combustion chamber.

To protect the engine from overheating, the cylinder head should be de-carburized

ii **The face of the cylinder head becomes crooked:** The main reason for this defect is that the nuts and bolts of the cylinder head are not tightened properly.

To prevent the face of the cylinder head from getting crooked, the nuts and bolts should be tightened opposite to each other while tightening the cylinder head.

Overhauling of Cylinder Head

While overhauling the cylinder head, the carbon of the combustion engine should be properly cleaned. Additionally, when water is poured into a hot engine, the cylinder head may crack. Therefore, it is necessary that all the water passages in the cylinder should be sealed and then the cracks should be checked by creating water pressure in it.

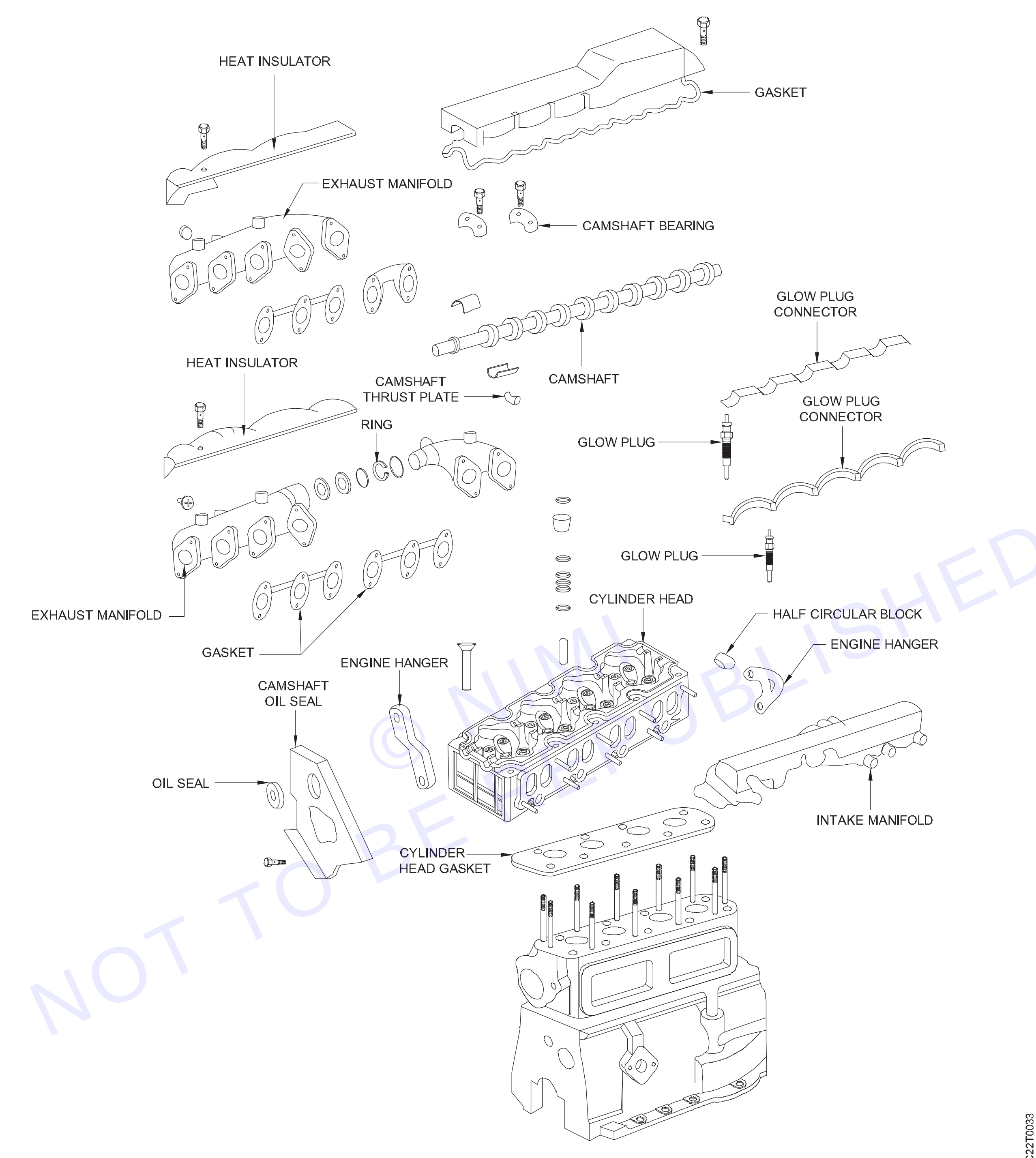
While cutting the valve seat, carbon should be cleaned from the seat surface. Apart from this, while fitting the valve guide, it should be cleaned properly. If the valve guide is loose, a new valve guide should be used.

The surface of the cylinder head should be flat. To check the surface of the cylinder head, its straightness and flatness should be checked with a straight foot rule and a feeler gauge as shown in the picture. This should be checked at least at 6 places. The feeler gauge of 0.05 mm should not go between the foot rule and the head. If the feeler gauge goes between the foot rule and the head, then grinding of the cylinder head should be done. (iii) Cracking of cylinder head. There are following reasons for crack in the cylinder head.

a Sudden falling of the cylinder head.

b Adding cold water when the engine is hot.

Prevention Cold water should not be added when the engine is hot. If due to some reason a crack appears in the cylinder head, then after welding the cylinder head, the face grinding should be done.



CYLINDER HEAD

1 Open Combustion Chamber

It is also known as direct combustion chamber. In this, the entire volume of the combustion chamber is located in the main cylinder and fuel is injected into this volume. The ignition of fuel can happen properly in the combustion chamber so that the efficiency of a detector can be increased, for this this type of chamber is made in the following designs.

a Shallow depth combustion chamber

b Semi-cylindrical combustion chamber.

c Cylindrical combustion chamber.

d Toroidal combustion chamber.

2 Close Combustion Chamber

It is also known as indirect combustion chamber. In this the combustion chamber is divided into two or more parts. These parts are connected to each other through restricted passages.

These are usually of the following types

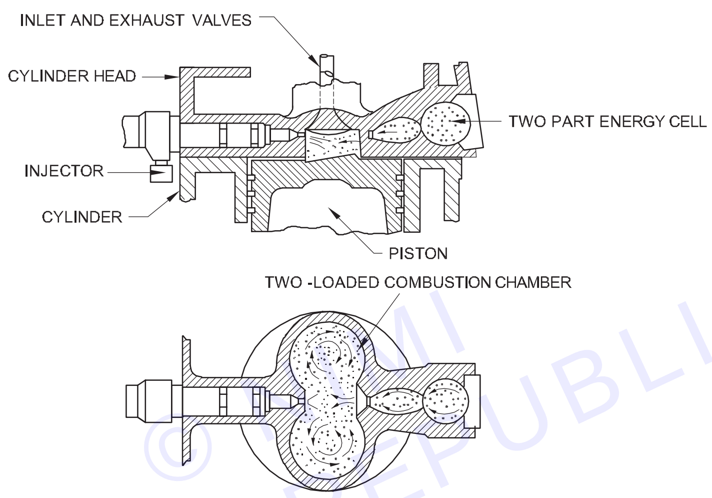
a Air cell chamber

b Re-ignition chamber

c Whirlpool chamber

a Air Cell Chamber

In this method, diesel is injected at a cylindrical place. Due to this, it immediately comes in contact with the full amount of air, due to which the diesel burns quickly and helps in spreading the gases.



AIR CELL CHAMBER

Constructional details, Advantages and disadvantages of variable valve timing

Objectives: At the end of this lesson you shall be able to

- demonstrate constructional details of Variable valve timing
- explain Advantages and disadvantages of Variable valve timing.

Variable Valve Timing (VVT) is an engine technology that alters the timing of the opening and closing of the intake and/or exhaust valves, optimizing performance and efficiency throughout the engine's operating range.

Construction details

1 **Camshaft Mechanism:** VVT systems typically involve a mechanism that adjusts the position of the camshaft relative to the crankshaft, allowing for precise control of valve timing.

2 **Actuator:** An actuator, often hydraulic or electronic, is responsible for adjusting the camshaft position according to signals from the engine control unit (ECU).

3 **Sensors:** Sensors monitor engine parameters such as RPM, throttle position, and load to determine the optimal timing adjustments.

Advantages:

1 **Improved Performance:** VVT enables engines to operate more efficiently across a broader range of RPMs, resulting in improved horsepower and torque.

2 **Fuel Efficiency:** By optimizing valve timing, VVT systems can enhance fuel economy by ensuring more efficient combustion.

3 **Reduced Emissions:** Enhanced combustion efficiency leads to lower emissions of harmful pollutants such as nitrogen oxides (NOx) and hydrocarbons (HC).

4 **Smooth Idle:** VVT systems can help maintain smoother engine operation at idle by adjusting valve timing for optimal combustion stability.

5 **Flexibility:** VVT allows for flexibility in engine design, enabling automakers to achieve a balance between performance, efficiency, and emissions control.

Disadvantages:

1 **Complexity:** VVT systems add complexity to engine design and can increase maintenance and repair costs.

2 **Reliability Concerns:** Some early VVT systems faced reliability issues due to the complexity of the mechanisms involved. However, modern VVT systems have improved significantly in reliability.

3 **Cost:** The additional components and technology required for VVT can contribute to higher manufacturing costs, potentially increasing the price of vehicles equipped with this technology.

4 **Oil Dependency:** Some VVT systems rely on engine oil pressure for operation, meaning they may be sensitive to oil quality and require regular maintenance to ensure proper function.

Overall, Variable Valve Timing offers significant benefits in terms of performance, efficiency, and emissions control, although it comes with some trade-offs in terms of complexity and cost. However, advancements in technology continue to improve the reliability and effectiveness of VVT systems.

LESSON 15 - 18: Importance of servicing cylinder Block- Precautions to be observed while servicing cylinder block

Objectives

At the end of this lesson you shall be able to

- explain Importance of servicing cylinder block
- demonstrate precautions to be observed while servicing cylinder block.

Importance of servicing cylinder block

Cylinder Block

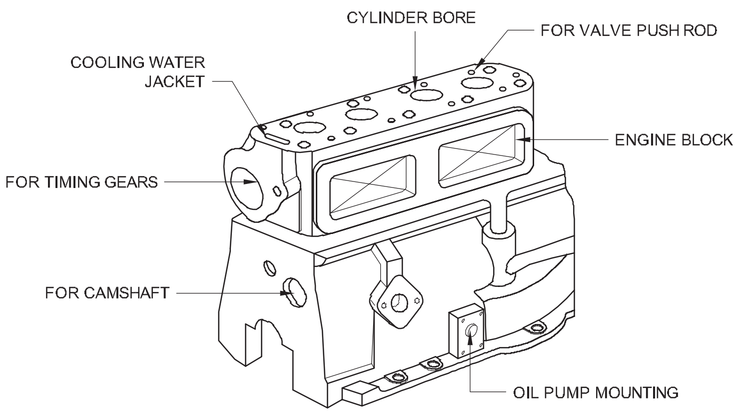
This is an important part of the engine, which plays a key role in integrating various useful parts related to the cylinder. The cylinder block is closed from above by the cylinder head with the help of a head gasket and from below by an oil sump. The piston completes its stroke inside the cylinder made in the cylinder block.

Importance for servicing cylinder block

Without servicing the cylinder block, it is not possible to maintain the success and life of the engine. Here are some important reasons for servicing cylinder block.

- For proper engine strength
- For checking engine misfire
- better performance.
- prevention of excessive wear.
- better lubrication.
- energy savings.
- less pollution.
- quiet running
- safe and smooth closing.
- good sound production.
- support and protection.
- For proper conveyance.
- better stress management.
- For improved drivability.
- specified better temperature.
- convenience of attention for proper performance.
- increase the life of the engine
- maintain a good standard by regular servicing.
- For checking / maintain overheating
- For better compression
- For checking leak

Precaution to observed while servicing cylinder block



Engine block mainly use for internal parts of fitting engine parts like piston, crankshaft, oil pressure chamber etc. Vibration and jerks on moving (working) and heat also. To be attained by the engine block and crankcase so these should be designed strong and hugely solid.

Let's understand about we should need to take **Precaution to observed while servicing cylinder block.**

Safety first: When you working as while servicing cylinder block you should know about of your own safety first. Before servicing cylinder block always wear appropriate safety gear including safety gloves and safety goggles, to protect yourself from injury. Don't use loose type wears and loose outfit.

Cleanliness: Before to start work please check very carefully about workplace. Ensure the work area and the components are clean to prevent debris from contaminating the engine. Clean all spanners and special tools also before start of servicing of engine block.

Use proper tools: Use correct tools for each and every parts or tasks too to avoid damaging the cylinder block and it is components.

Follow manufacturer guidelines: Refer to the manufacturers service manual for specific instruction as well as torque specification.

Inspect gasket and seal: Before assembly of cylinder block we should need to properly inspect of gasket seals for wear or damage and replace them as needed to prevent leaks. Also carry sealing tube for clear the fluid type minor fitment.

Proper disassembly: Follow the proper procedure for dismantling cylinder block to prevent damaging delicate components or causing leakages.

Keep track of parts: Put parts align in tray very carefully. Keep tracks all their position to ensure proper reassembly.

Check measurements: Measure critical dimension such as bore diameter, piston clearance and cylinder block upper surface to ensure they meet specification.

Inspect for damage: Before reassembly of cylinder block inspect it very carefully specially check in block cracks, warping or other damage.

Clean and lubricate: Clean all components thoroughly and lubricate moving parts as necessary during reassembly. Apply oil were need for lubrication.

Torque properly: Use a torque wrench to tighten bolts and fasteners to the manufacturers specifications to prevent over-tightening or under-tightening.

Pressure test: Perform pressure test on the cylinder block to check for leaks and ensure proper sealing.

Follow break-in procedure: If installing new components, follow the appropriate the manufacturers recommended break-in procedure to ensure proper performance and longevity.

Reason for measuring cylinder block for various parameters to find out its serviceability and suggestions for remedial measures. Reasons for frequently occurring abnormal wear in cylinder block components and its Effects on engine performance

Objectives: At the end of this lesson you shall be able to

- explain Reason for measuring cylinder block for various parameters
- suggest serviceability for remedial measure of cylinder block patys
- demonstrate Reasons for frequently occurring abnormal wear in cylinder block components and its Effects on engine performance.

Reason for cylinder block measuring various parameter to find out it's serviceability and suggestion for remedial parameter

Measuring various parameters of the cylinder block is essential to determine its serviceability and identify any issues that may affect its performance. Here's:

1 **Dimensional accuracy:** Checking dimensions ensures that the cylinder block can accommodate pistons and other components within specified tolerances. If dimensions are out of tolerance, it may indicate excessive wear or damage, requiring repair or replacement.

2 **Surface condition:** Assessing surface roughness and flatness helps identify areas prone to leaks or poor sealing, suggesting the need for resurfacing or machining to restore proper sealing surfaces.

3 **Tolearance verifications:** Ensuring that critical features such as bores and bolt holes meet specified tolerances is crucial for proper assembly and alignment. If tolerances are exceeded, it may indicate wear or distortion requiring corrective action.

4 **Wear analysis:** Measuring wear patterns and deviations from standard dimensions helps diagnose issues such as piston slap, cylinder wear, or bearing clearance problems. Remedial actions may include honing, boring, or installing oversized components.

5 **Sturctural integrity:** Checking for distortion, cracks, or other defects helps assess the structural integrity of the cylinder block. If defects are found, remedial measures such as welding, sleeving, or replacement may be necessary.

6 **Performance optimization:** Analyzing parameters like bore taper, out-of-roundness, and cylinder wall thickness provides insights into engine performance and potential efficiency improvements. Remedial actions may involve honing, decking, or cylinder sleeving to restore optimal conditions. Measuring various parameters of a cylinder block is crucial to ensure its serviceability and identify any potential issues. Here are 15 key points on why these measurements are important and some suggestions for remedial actions:

7 **Cylinder Bore Diameter:** Ensures proper piston fit and seals for efficient combustion.

Remedy: Honing or boring oversize if out of tolerance.

8 **Cylinder Bore Out-of-Roundness:** Ensures uniform piston movement.

Remedy: Honing or re-boring for roundness.

9 **Cylinder Bore Taper:** Ensures uniform piston movement throughout its stroke.

Remedy: Honing or re-boring to restore taper.

10 **Deck Surface Flatness:** Ensures proper head gasket sealing.

Remedy: Milling or resurfacing if not flat.

11 **Deck Height:** Affects compression ratio and piston clearance.

Remedy: Machining to desired height if too high or low.

12 Crankshaft Bore Alignment: Ensures proper alignment with crankshaft journals.

Remedy: Align honing if misaligned.

13 Main Bearing Bore Diameter: Critical for crankshaft support and alignment.

Remedy: Line boring if out of tolerance.

14 Main Bearing Bore Alignment: Ensures proper alignment with crankshaft.

Remedy: Align honing or line boring if misaligned.

15 Camshaft Bore Alignment: Critical for proper valve timing

Remedy: Align honing if misaligned.

16 Camshaft Bore Diameter: Affects camshaft support and bearing wear.

Remedy: Replace cam bearings if worn or oversized.

17 Water Jacket Integrity: Prevents coolant leaks and overheating.

Remedy: Pressure testing and repairing any leaks.

18 Oil Passages Cleanliness: Ensures proper lubrication to vital engine components.

Remedy: Thorough cleaning and flushing.

19 Head Bolt Hole Alignment: Ensures proper head bolt torque and sealing.

Remedy: Re-tapping or installing inserts if misaligned.

20 Head Bolt Hole Thread Condition: Prevents head bolt failure or stripping.

Remedy: Re-tapping or installing inserts if damaged.

21 Overall Structural Integrity: Prevents potential cracks or weaknesses.

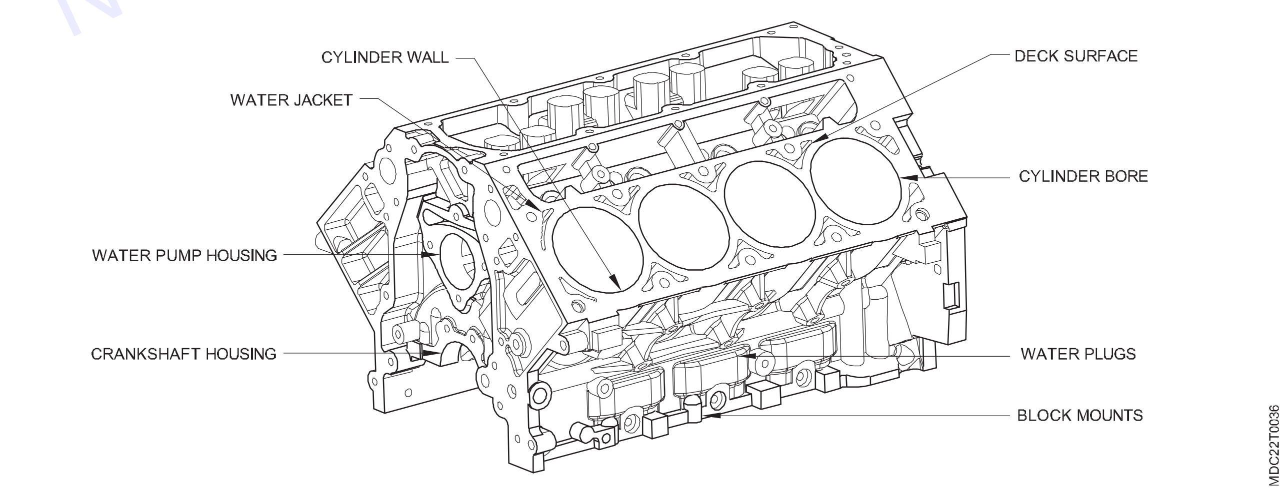
Remedy: Inspect for cracks and repair if necessary, or replace if beyond repair.

Regular measurement and maintenance of these parameters are essential for ensuring the longevity and reliability of the engine block.

Reasons for frequently occurring abnormal wear in cylinder block components and its effects on engine performance

Introduction: Cylinder block is that part of the engine block in which the engine cylinder or cylinder liner is located.

- The engine block is mainly made up of two parts: cylinder block and frank case.
- Crank case is the lower part of the engine block and cylinder block is the upper part of the engine block.



- When the engine block is cast in one piece, the cylinder block and the Crank case are cast together and are joined together.

Causes of cylinder bore wear

- Piston Side Thrust
- Applying continuous pressure on the cylinder liner through the piston ring.
- Cylinder overheating
- Lack of lubricating oil

Frequent abnormal wear in a cylinder block component can occur due to various reasons

1 **Poor Lubrication:** Inadequate lubrication or poor quality lubricants can lead to increased friction between moving parts, causing accelerated wear.

2 **Contaminants:** Dirt, debris, or metal particles in the lubricating oil can cause abrasive wear on the cylinder block surfaces.

3 **Incorrect Installation:** Improper installation techniques or incorrect assembly procedures can result in uneven stress distribution and premature wear.

4 **Overheating:** Excessive engine temperatures can cause thermal expansion, leading to distortion and accelerated wear in the cylinder block.

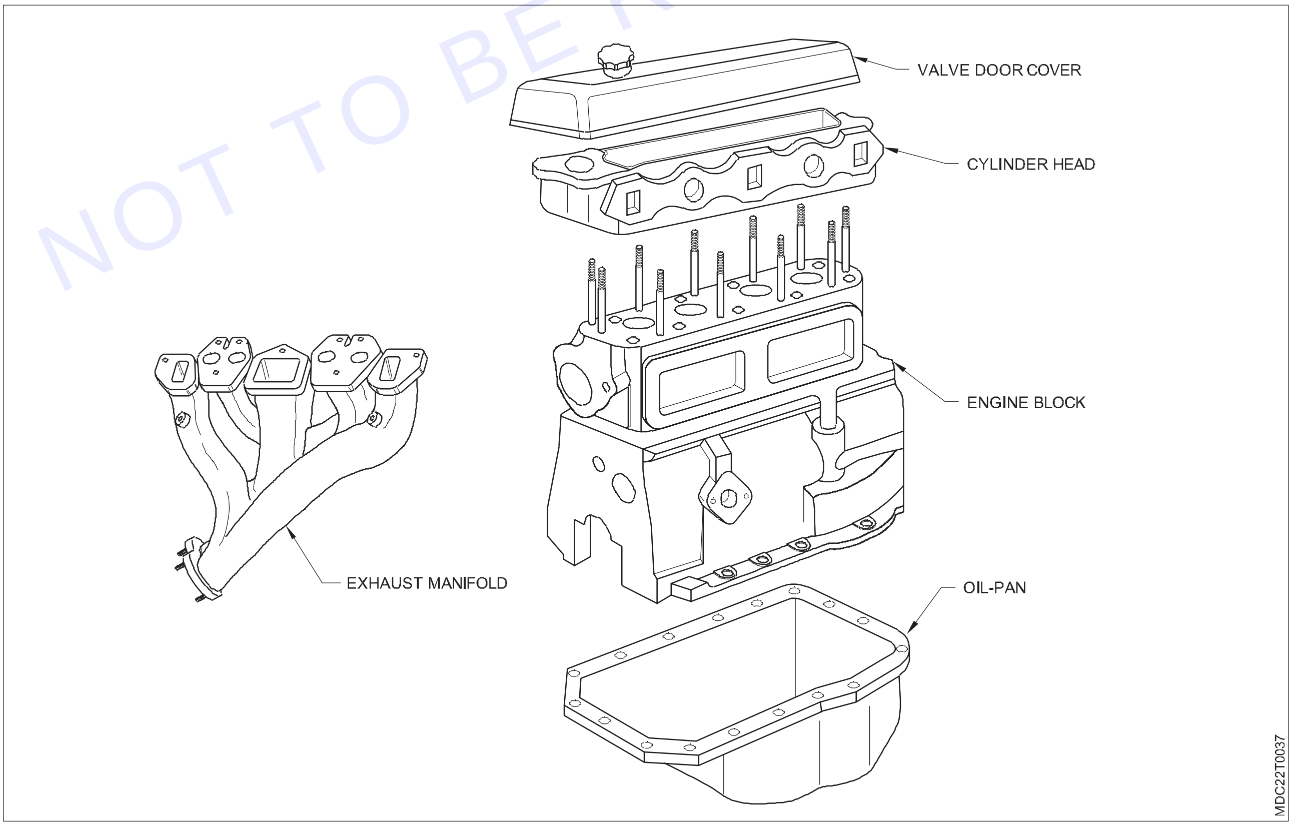
5 **Material Defects:** Manufacturing defects or substandard materials in the cylinder block can result in premature wear and failure.

6 **Poor Maintenance:** Neglecting regular maintenance, such as oil changes and engine inspections, can allow wear to progress unchecked.

7 **Combustion Issues:** Irregular combustion, such as detonation or pre-ignition, can cause increased stress on the cylinder block components, leading to abnormal wear.

8 **Operating Conditions:** Continuous operation under extreme loads or harsh environmental conditions can accelerate wear on cylinder block components.

Addressing these issues through proper maintenance, quality lubrication, and monitoring operating conditions can help mitigate abnormal wear in cylinder block components.



LESSON 19 - 24: Importance of measuring cylinder block components for actual wear to decide serviceability

Objectives

At the end of this lesson you shall be able to

- explain Importance of measuring cylinder block components
- decide Serviceablility of cylinder block components.

Importance of measuring cylinder block components: Measuring the wear of cylinder block components is important to determine their serviceability as it ensures that the engine operates efficiently. Excessive wear can cause poor performance, oil consumption, and even engine failure due to excessive oil consumption. By accurately assessing wear, mechanics can decide whether components need to be replaced or whether they can still perform adequately within specified tolerances. This helps maintain engine longevity and overall vehicle reliability.

Here is some important point for measuring a cylinder block Components

For Cylinder bore diameter: Measuring the diameter of the cylinder bore ensures that it remains within manufacturer specifications. Excessive wear can increase oil consumption and reduce compression.

For Cylinder taper and out-of-roundness: Checking taper (gradual increase in diameter from top to bottom) and out-of-roundness (variation in diameter around the cylinder) helps ensure uniform piston movement and proper sealing.

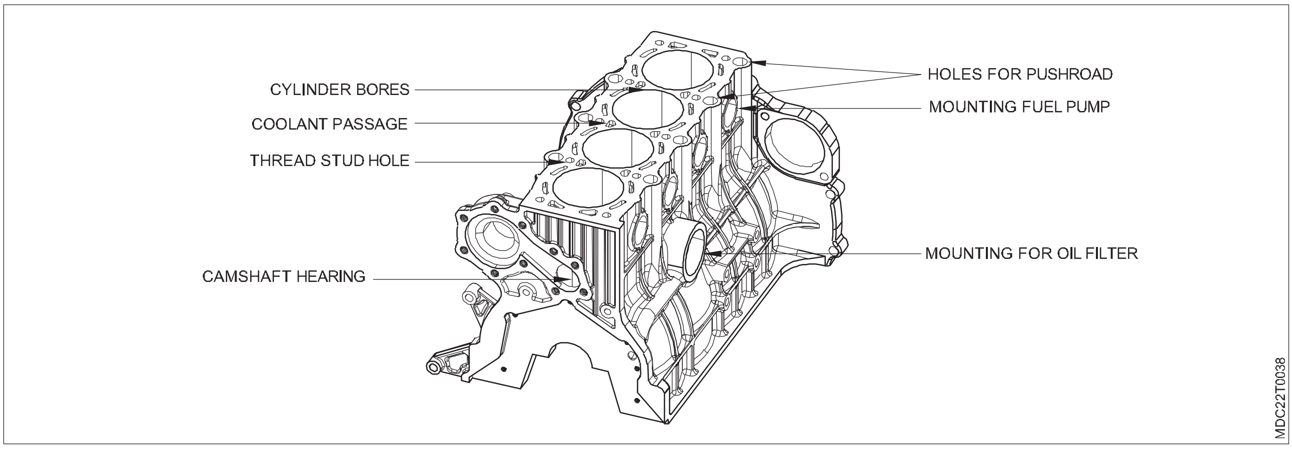
For Check Cylinder wall thickness: Assessing the thickness of the cylinder walls is important to detect thinning due to wear or corrosion. Thin walls compromise structural integrity and can lead to catastrophic failure.

For checking Surface finish: Inspecting the surface finish of the cylinder walls helps ensure proper lubrication and piston ring sealing. Rough surfaces can cause excessive friction and accelerated wear.

For Check Deck Height: Measuring the distance between the cylinder deck and the crankshaft centerline helps maintain proper piston-to-valve clearance and compression ratio.

Bearing Surfaces: Checking bearing surfaces for scoring or grooving helps determine the condition of main and rod bearings, ensuring proper lubrication and reducing the risk of bearing failure.

For checking Alignment: Checking for any misalignment or distortion of the cylinder block ensures proper mating with other engine components such as the cylinder head and crankshaft.



For Check Cracks and Defects: Thoroughly inspecting the cylinder block for cracks, pores or other defects is essential to identify potential points of failure and ensure structural integrity.

By carefully measuring these aspects, mechanics can accurately assess the condition of cylinder block components and make informed decisions about repair or replacement, ultimately ensuring engine reliability and performance.

Engine assembly procedure as recommended by manufacturers

Objectives: At the end of this lesson you shall be able to

- cleaning all the parts of the engine
- assembling all the engine parts
- using torque range

Hand Tools and Equipment's

1 Ring spanner set mm

2 Ring Expander

3 Ring Compressor

4 Double Ended Spanner Set mm

5 Feeler gauge mm

6 Torque Wrench

7 Bass Drift 30 × 160 mm

8 Socket set mm

9 Flat Screw Driver 10"

10 Hair Pin Hammer

11 Valve Lifter

12 Combination Plier 6"

13 Oil Can

Raw Materials

- Kerosene
- Cotton vest
- Emery paper
- Petrol
- Old dhoti
- Engine over hall gasket kit
- Ring Set

Procedure

1 Clean all engine parts with kerosene.

2 Clean all the engine parts again with petrol.

3 Place the engine block upside down.

4 Fit the cracked main bearing and thrust washer into the engine block and oil them.

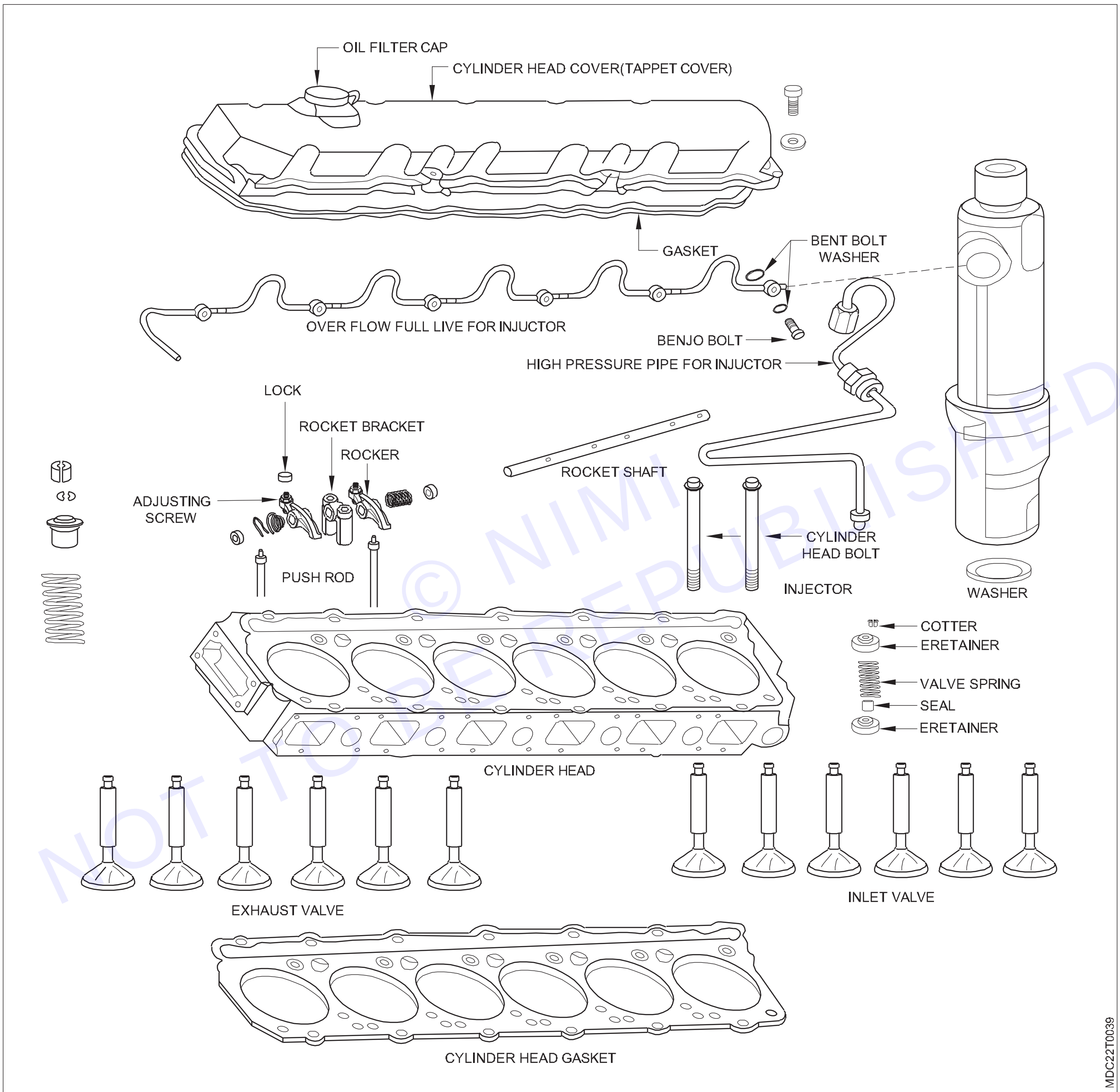
5 Fit thrust washers to the crank shaft on the engine block side and tighten their bolts with a torque wrench.

6 Check the cracked shaft by rotating it. The cracked shaft should rotate freely.

7 Fit the timing plate.

8 Fit the fly wheel onto the crank shaft and tighten its bolts with a torque wrench.

9 engine block



10 Insert the piston ring, including the cylinder by pressing it into the ring compressor and onto the crack shaft pin through the connecting rod and connecting rod cap.

Fit the torque wrench with assistance

11 Fitting the connecting rod cap sequentially, check by rotating the cock shaft. The cock shaft should rotate freely.

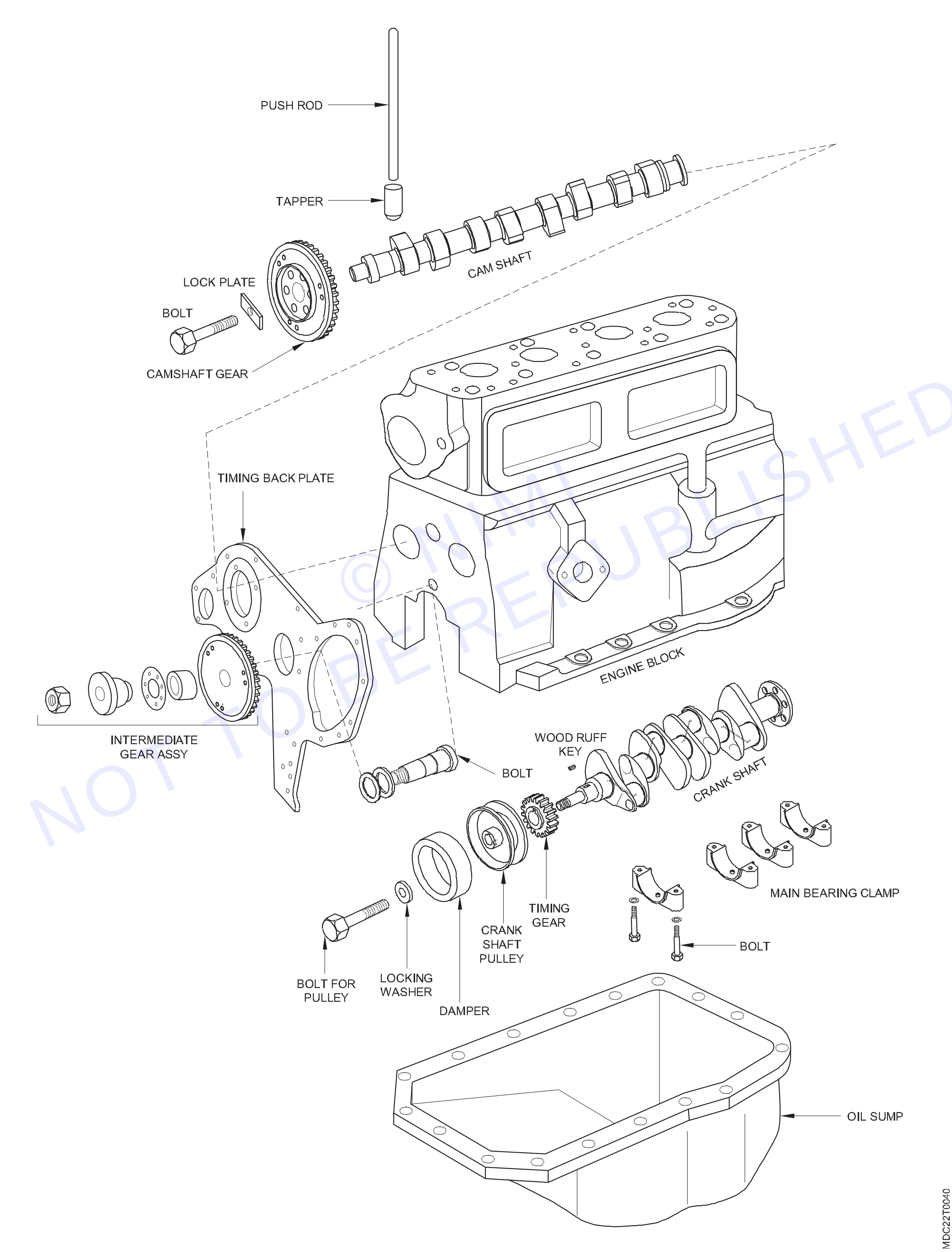
12 Fit the oil pump into the engine block.

13 Install new packing on oil sump and fit oil sump to engine block.

14 Fit the cam shaft to the engine.

15 Keep the engine in vertical position.

16 Fit the timing gear on the cam shaft.



17 Top center (T.D.C.) of the

- piston and set the valve timing with the help of Ider Gear by bringing the
- tappet of the cam shaft to the Over Lap Position.

18 Fit the timing cover by placing the gasket on the timing plate.

19 Fit the crank shaft pulley and tighten its bolt with a torque wrench.

20 oil to all tappets and fit them in the engine block.

21 The cylinder gasket correctly on the cylinder block.

23 Fit push rods.

22 Set the cylinder arm on the engine block and tighten all the bolts sequentially with the help of torque wrench nd socket.

24 Fit the rocker assembly.

25 Set the tappet clearance.

26 Fit the tappet side cover.

27 Fit the oil filter assembly.

28 Fit the exhaust manifold with gasket.

29 Fit the fuel injection pump (F.I. Pump).

30 Fit the high pressure pipes to the injector along with the fuel injection pump.

31 Fit the water pump with gasket.

32 Fit the water pump pulley and fan.

33 Fit the dynamo alternator.

34 Adjust the fan belt.

35 Fit the air cleaner

36 Fit the fuel filter

37 Fit the self-starter.

38 After completing the work, all the tools should be cleaned and kept in their proper place.

Importance and correct procedure of setting valve timing

Objectives: At the end of this lesson you shall be able to

- set valve timing, gear drive type
- set valve timing, chain drive type

Importance of valve timing: More power better fuel efficiency and even reduce emissions. It also offers greater torque at low speed Without engine knocking high speed without excess noise and vibration.

Hand tools and equipment's

1 Ring Spanner Set mm

2 Double Ended Spanner Set mm

3 Socket Set mm

4 Pipe Wrench 250 mm.

5 Screw driver 200mm

6 Two Tire levers 350mm

7 Well 100 mm

RAW MATERIALS

1 Cotton vest

2 Old dhoti

3 Chain Adjuster

Job Sequence

Valve timing gear drive type

1 Open the dog nut lock of bank bridges with the help of flat chisel and hair pin hammer.

2 Open the dog nut from the bank pulley with the help of a socket/pipe wrench.

3 Separate the bank pulley from the frank shaft with the help of pulley puller.

4 Open all the timing cover bolts and separate the timing cover from the front plate of the engine.

5 Open the nut of the cam shaft gear by straightening the lock leaf of the nut of the timing gear (cam shaft gear) with the help of a flat chisel and a ball pin hammer.

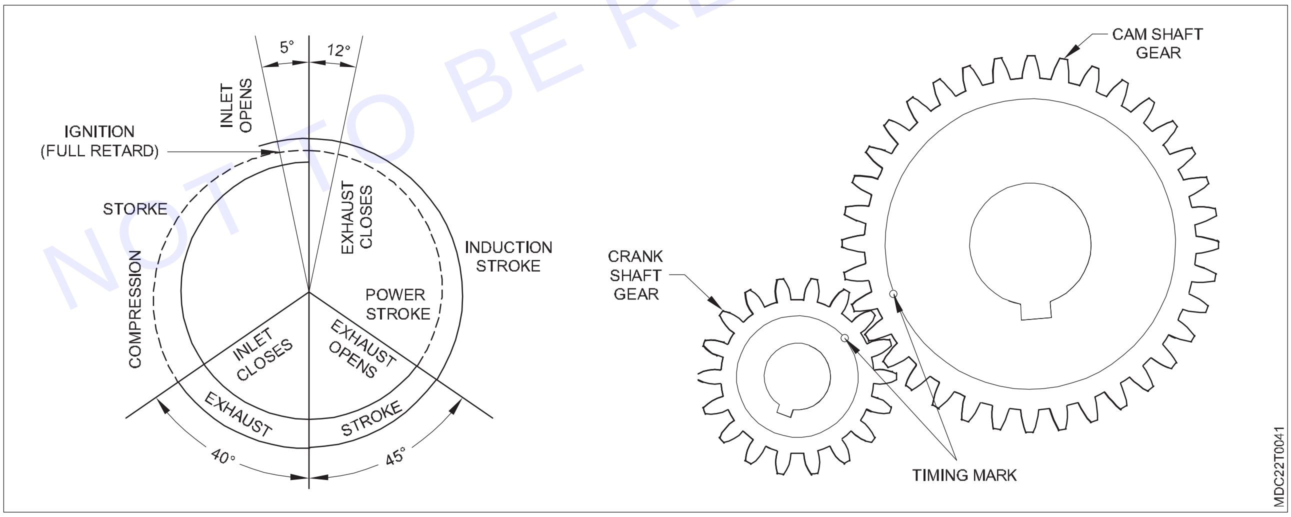
6 Take out the crank gear and cam shaft gear by pushing them equally from the crank shaft and cam shaft with the help of tire lever

7 Check the teeth of the cam shaft gear carefully to ensure that no teeth are damaged.

8 Open the tap side cover from the engine block.

9 Rotate the flywheel and bring piston 1 to T.D.C. Bring it on.

Note: Fly keel, pointer (A) given in the housing and TD given on the fly keel. C. Meet the mark when the piston reaches 1 TDC. Are setting on.



Valve timing on crankshaft rotation **Valve timing gear type**

10 Bring both tappets of cylinder 1 to upper lap period (dancing position) by prying the cam soft to the right/left.

11 Match the timing mark of the bank shaft gear and the timing mark of the cam shaper pin face to face.

Note: With the help of a hammered nail, rotate the bank shaft two revolutions and both the dung marks should be face to face. If the marks are not face to face, reset the tea timing.

12 Install the lock spring on the cam soft gear and tighten the nut and lock the nut with the help of a lock spring.

13 Fit a new gasket on the timing cover and fit the timing cover to the front plate of the engine block, tightening all the bolts.

14 Fit the bank pulley onto the bank flat.

15 Install the lock leaf on the dog nut and tighten the dog nut.

16 Lock with the lock leaf of the dog nut.

Valve timing chain drive type

1 Set the chain two valve timing as per the above procedure.

2 Open the dog worm from the pulley of the bank shaft.

3 Separate the crank pulley from the crank shaft with the help of a pulley puller.

4 Open all built-ins of the timing story.

5 Open the lock leaves of both the mounting bolts of the chain adjuster.

6 Unscrew both mounting bolts of the chain adjuster and the chain adjuster from the front plate of the chain and engine.

7 Open the lock bird of the cam shaft nut and separate the nut from the cam shaft gear.

8 Separate the chain from the cam shaft gear by pushing the cam shaft gear and bank shaft gear equally with the help of tire lever.

9 Check the bank shaft gear and cam shaft gear for wear.

10 Check the chain for slackness and wear.

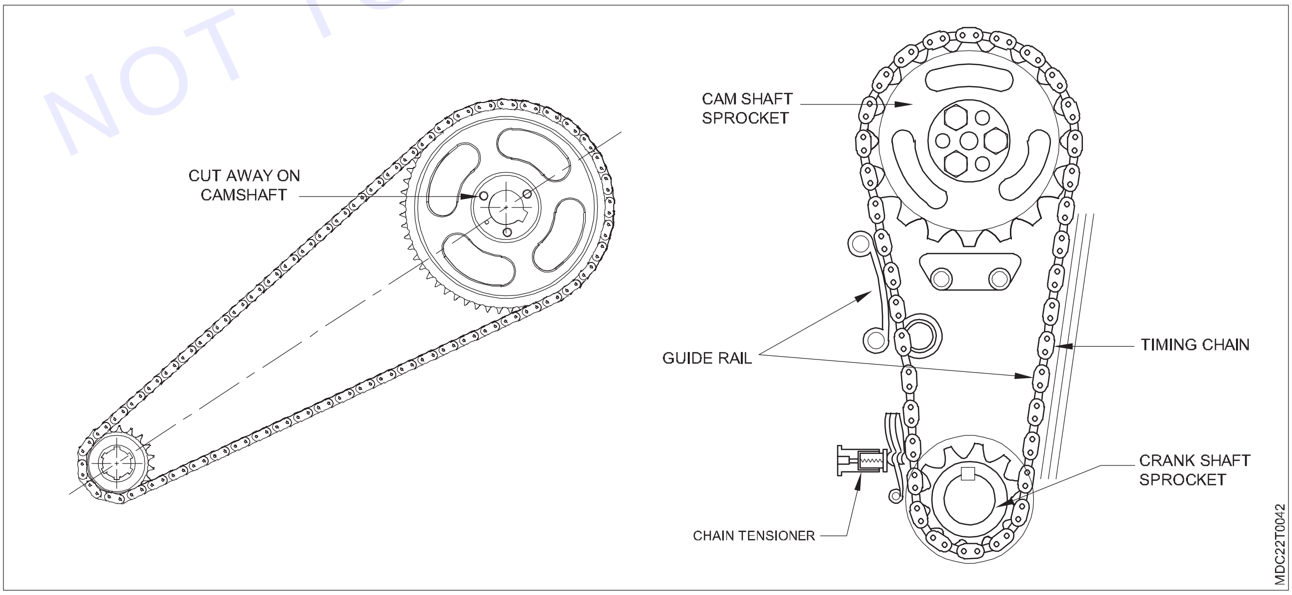
11 Open the tappet sight cover from the engine.

12 Turn the fly wheel and bring the piston 1 to T.D.C. Bring it on.

13 Bring the tappet of cylinder 1 to overlap period (dancing position) by turning the cam shaft left/right.

14 Mount the chain on the camshaft gear and cam shaft gear, match the timing marks of both the gears face to face.

Note: With the help of fly wheel, rotate the crank shaft two revolutions. The marks of both the gears should be face to face. If the marks are not face to face, then reset the valve timing.



Valve timing chain type | **view showing timing marks on gears and use small chain- no need of chain adjuster**

15 Install the lock leaf on the cam shaft gear and tighten the nut and lock the nut with the help of the lock leaf.

16 Install a new gasket on the timing cover and fit the timing cover to the front plate of the engine block, tightening all bolts.

17 Fit the frank pulley to the frank shaft.

18 Install the lock leaf on the dog nut and tighten the dog nut.

19 Lock the dog nut with the lock leaf.

Safety precautions

1 Dirty hands should be kept clean while working on the job.

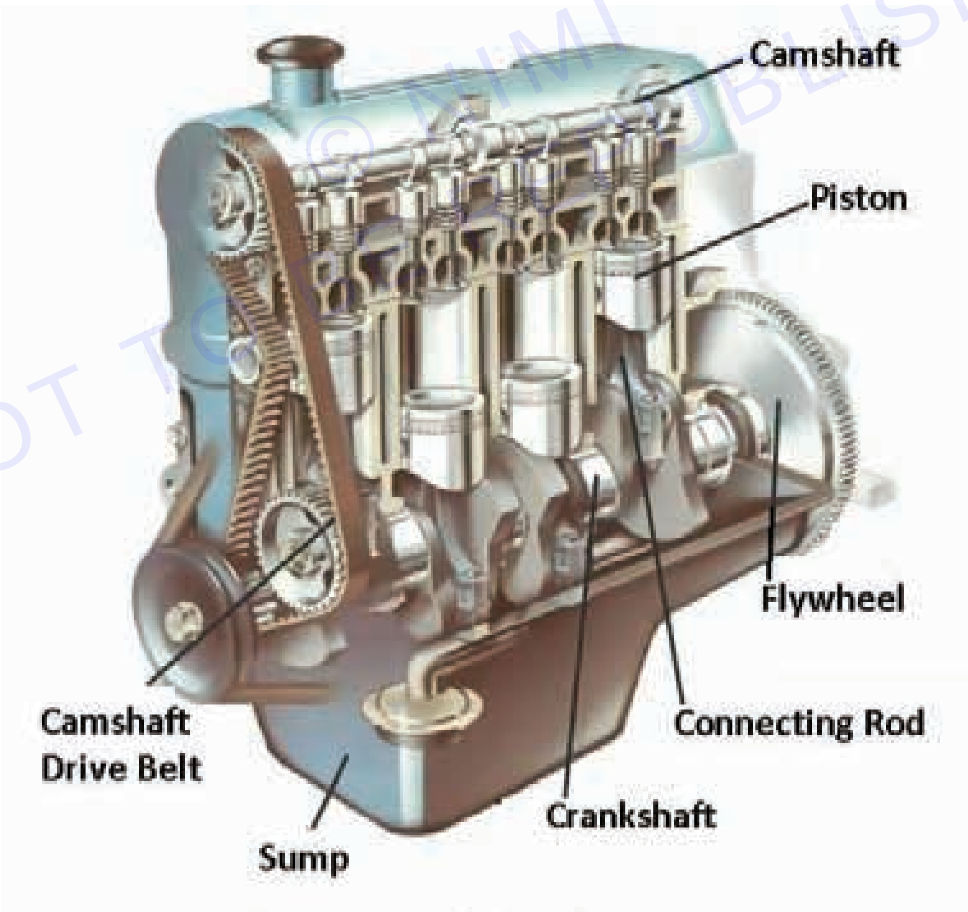
2 Piston No. 1 at T.D.C. But check after setting. Pointer (arrow) given in fly wheel housing and TDC given on fly wheel. The marks should be face to face. Correct if the marks are not face to face.

3 While setting the valve timing, both taps of cylinder no. 1 should be on the overlap period and piston 1 should be at T.D.C. must be on.

4 With the help of the fly wheel, rotate the crank shaft two revolutions. The marks of both the gears should be opposite to each other. If Mark face to face If not, reset the valve timing.

5 After setting the valve timing, the cam shaft gear nut should be locked with the help of lock leaf.

6 Before fitting the valve timing chain, its wear and slackness should be checked. If there is excessive wear and looseness, the chain should be replaced.



Four-stroke compression-ignition engines-ii (Perkins)

Timing arrangements and overhead-valve operating gear shown in relation to diesel engine.

7 Check the gear teeth of the crank gear and cam shaft, if excessively worn then the gear should be replaced.

8 After tightening the dog nut on the frank shaft pulley, it should be locked with the lock leaf.

9 If the gasket of the tap side cover or timing cover is damaged, it should be replaced.

10 If the chain adjust mouth is excessively worn, it should be replaced.

11 After tightening both the mounting bolts of the chain adjuster, both the bolts should be locked with the lock leaf.

12 After completing work on the job, all tools should be cleaned and kept in their proper place.

Importance of correct valve clearance Precautions to be observed while assembling engine components

Objectives: At the end of this lesson you shall be able to

- explain Importance of correct valve clearance
- demonstrate Precautions to be observed while assembling engine components.

Importance of correct valve clearance

Valve clearance refers to the space or gap between the camshaft and the top of the valve when the valve is fully closed. It's an essential measurement in the engine that ensures proper functioning of the valves. Having the correct valve clearance is crucial for the valves to open and close at the right time, allowing the engine to operate smoothly and efficiently. Adjusting the valve clearance is a standard maintenance procedure to keep the engine running properly.

Proper Engine Performance: Correct valve clearance ensures that the valves open and close at the right time, allowing the engine to operate efficiently. Incorrect valve clearance can lead to poor engine performance, including misfires, rough idling, and decreased power.

Prevents Engine Damage: If the valve clearance is too small, the valves may not fully close, leading to overheating and potential damage to the valves, valve seats, and cylinder head. On the other hand, if the clearance is too large, the valves may not open fully, reducing engine power and efficiency.

Noise Reduction: Correct valve clearance helps reduce valve train noise, which can be annoying and indicate potential issues with the engine if excessively loud.

Longevity of Engine Components: Proper valve clearance reduces wear and tear on the valves, rocker arms, and camshaft, leading to longer engine life.

Fuel Efficiency: Correct valve clearance ensures that the engine operates at its optimum efficiency, leading to better fuel economy.

Overall, correct valve clearance is essential for ensuring the smooth operation, performance, and longevity of an engine.

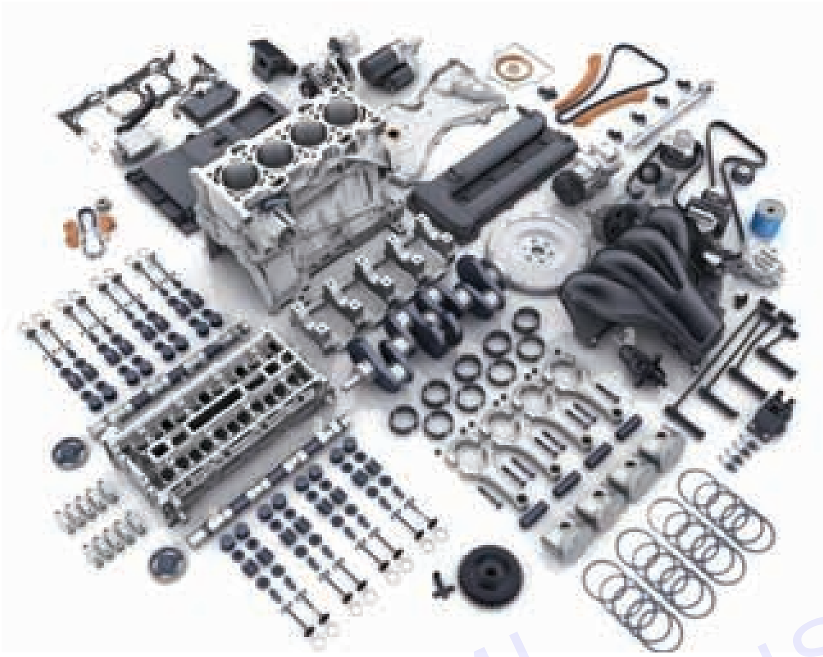
Precautions to be observed while assembling engine components

Assembly of Diesel Engine

The process of assembling and dismantling a diesel engine involves several important steps to ensure its functionality and safety. During assembly, various engine parts are fitted together based on their mechanical compatibility, such as the crankshaft and camshaft being installed into the engine block, and the tappet valve and timing gear being fitted onto the camshaft. Tools capable of opening and closing the engine assembly are used to facilitate this process.

On the other hand, dismantling a diesel engine from a vehicle is a crucial skill for trainees in the 'Mechanic Diesel' trade. This process involves parking the vehicle on a hoist, opening the bonnet, and disconnecting the brake linkage from the engine. Subsequently, the radiator fan belt is removed, and all pipes or hoses related to the fuel system are isolated by closing valves. Belts of the fuel pump and other pumps are then disconnected. With the assistance of a torque wrench, all engine bolts are loosened, and the engine is carefully lifted out of the vehicle using an engine hoist. It's essential to remove the engine from the vehicle without causing damage and ensuring safety throughout the process.

During engine removal, trainees should pay special attention to separating any parts of the engine and ensuring that the engine is removed from the vehicle in a completely safe condition. This involves disconnecting the engine from all devices that directly or indirectly connect it to the vehicle, while taking precautions to avoid accidents or damage.



Shortcoming

- Oil Leakage from The Engine.
- Engine Jerking to Stop.
- Making Engine Noise.
- Excessive Engine Smoke.
- Excessive Engine Vibration.
- Making Engine Noise.
- Engine Not Starting.
- Excessive Emissions from The Engine.
- Overheating of Engine Parts
- Excessive Engine Friction.
- Engine Valves Making Noise.

Precaution

- Tighten the nut-bolt or stud at the leaking point in the engine or replace the packing.
- Clean the engine’s fuel line.
- Provide proper lubrication to the engine.
- Get the engine repaired timely.
- Adjust the engine’s ignition timing.
- Have the engine’s crankshaft repaired or replaced.
- Have the engine’s fuel system repaired.
- Get the engine repaired.
- Get the engine cooling system repaired.
- Maintain a certain level of high quality lubricant in the engine.
- Adjust the engine’s valve timing.

MODULE 3 : Intake and exhaust systems

LESSON 25 - 28: Study about intake system components such as air cleaner, different types of turbo charger, super charger, throttle body, intake manifold etc

Objectives

At the end of this lesson you shall be able to

- explain Intake System components such as air cleaner
- demonstrate Turbo charger and super charger
- explain Throttle body and Inlet Manifold.

Study about air cleaner

Air cleaner and air cooler

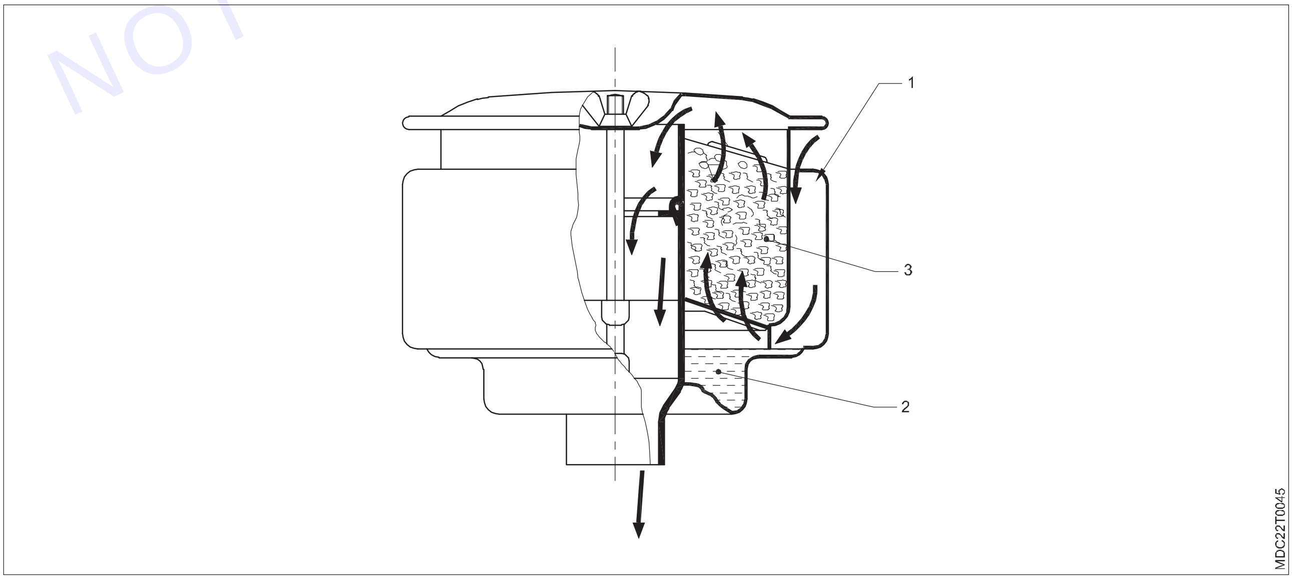
Atmospheric air consists of a large quantity of dirt and dust. Uncleaned air will cause faster wear of and damage to the engine parts, so air is filtered before entering inside the cylinder bore.

Purpose of air cleaner

- It cleans the intake air.
- It reduces the noise of the intake air.
- It acts as a flame arrester during engine backfire.

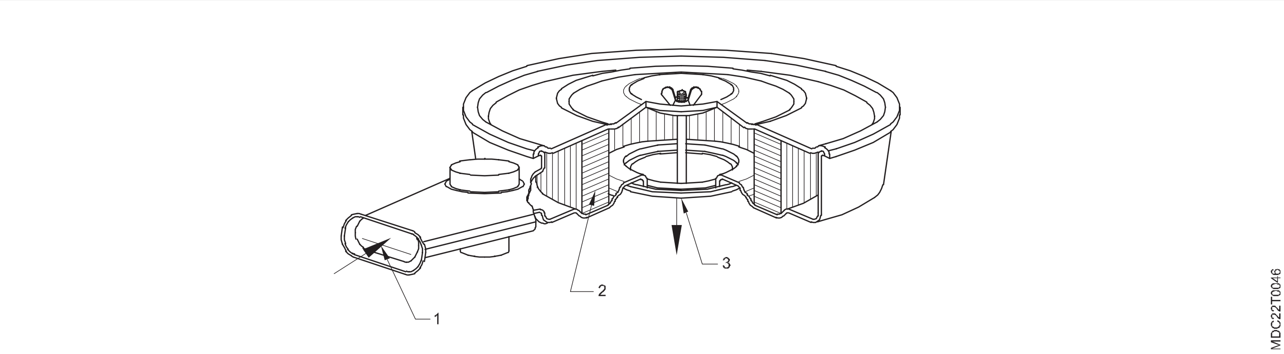
Location

It is mounted on the top of the air inlet manifold. Types Wet-type (Fig 1).Dry-type (Fig 2) Wet type air cleaner The atmospheric air enters the air cleaner through the side passage (1) and strikes on the surface of the oil (2). Heavy dust particles are absorbed by the oil. The partially filtered air, along with oil particles, moves upward through the filter element (3). Fine particles and oil particles are collected by the filtering element (3). Cleaned air then passes through the passage to the inlet manifold.



Dry type air cleaner

In this type of air cleaner, a specially treated paper element is used to filter the intake air.

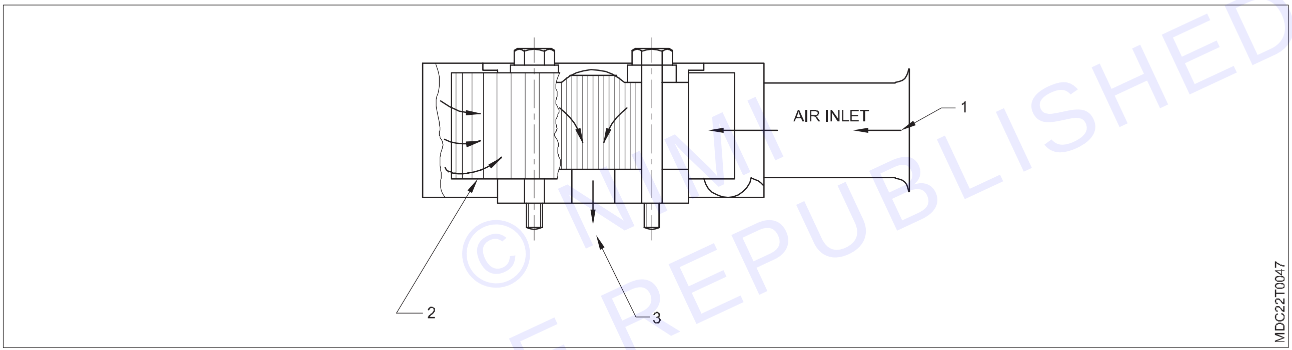


Function

The atmospheric air enters the air cleaner (Fig 3) through the air entrance (1) and passes through the paper element (2). The filtered clean air goes to the intake manifold entrance (3).

Intake manifold

The intake manifold is connected with air cleaner and cylinder head intake port of the cylinder head. It is allowing the fresh air to flow from air cleaner to cylinder through inlet valve. The intake manifold is made of a cast iron or aluminum.



1 Air supplied to an engine must be free from dirt as far as possible.

2 If any dirt entering the air it will act as an abrasive, hence abrasive wear there is will occur on piston rings, cylinder walls, vales, bearing and other relative moving parts.

3 Under extreme condition the wear may become very much greater.

4 An air filter also called air cleaner is always install at the entrance of the inlet manifold.

Air cleaner

In order to keep the abrasive wear at the minimum is necessary to regular clean the air to ensure only clean, dust free air is drawn into the engine further for optimum performance of the engine the air cleaner should be fully free from dust and dirt and should offer no resistance at all to the incoming air.

Remove the air cleaner once in every week (1000 kms) Dismantle and clean thoroughly the bowl and the wire mesh with the petrol (Use kerosene in absence of petrol). Fill in bowl with clean engine oil up to the mark and assemble.

While cleaning the wire mesh filter, if small broken metallic pieces are found getting dislodged replace the same with new one.

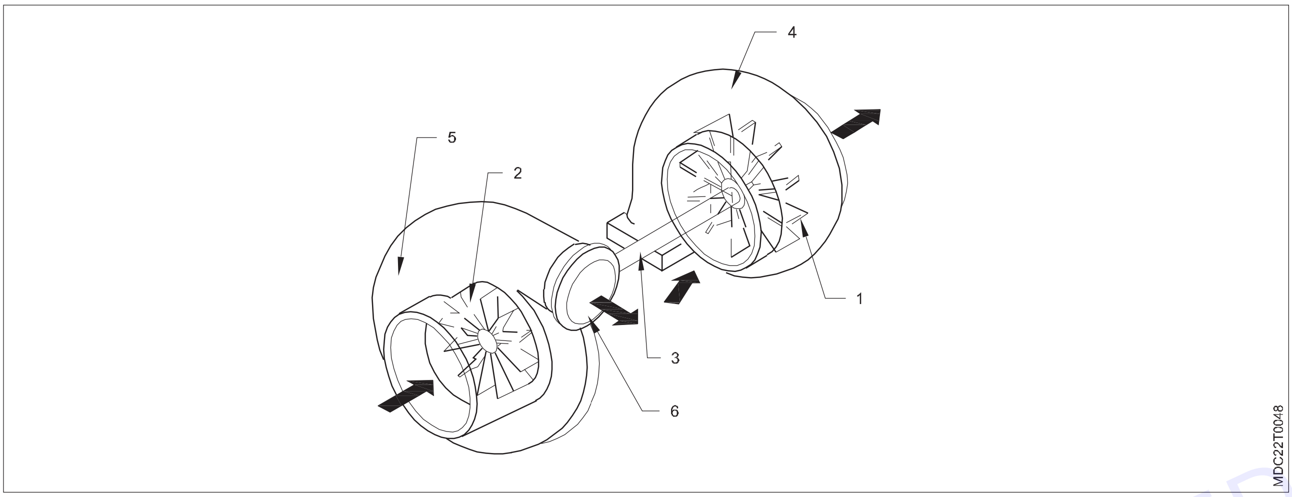
Do not overfill the bowl as this will result in smoky Exhaust

The air cleaner where need earlier attention if the operating condition are particularly dusty.

Turbo charger and its type

Turbocharger: Turbo charger is mounted on the engine. It increases the amount of air delivered to the engine cylinder, thereby more fuel can be burnt which increases engine power. Whenever the density of air is less than the density at atmospheric pressure specially at higher altitudes, turbo charges helps the engine to get the sufficient air. An engine may have one or more turbo chargers.

A turbocharger is mounted on the exhaust manifold. It has a turbine wheel (1) and a compressor wheel (2) on the same shaft (3). Exhaust gases enter in turbine housing (4) and rotate the turbine wheel (1). Compressor housing's (5) inlet is connected to the air cleaner and compressed air is discharged to inlet manifold through the outlet (6).



Types of Turbochargers

The following types of turbochargers are used in automobiles:

1 Single-turbo

2 Twin-turbo

3 Twin-scroll turbo

4 Variable geometry turbo

5 Variable Twin Scroll Turbo

6 Electric Turbo

1 Single-turbo

Single-turbo - types of turbochargers The most common type of turbocharger is the single turbocharger. Different torque characteristics can be obtained by changing the size of the components in the turbo. Larger turbos provide higher-end power, while smaller turbos can spool faster and produce better low-end power.

They are expensive to increase engine power and efficiency, and as they become more popular, they allow smaller engines to increase efficiency by naturally producing the same power as larger engines, but with less weight.

However, they work best in a narrow RPM range, and drivers will usually feel "turbo-lag" until the turbo begins to operate in its peak rev band.

2 Twin-Turbo

Twin-turbo - types of turbochargers in a twin-turbo turbocharger, the engine has a second turbocharger. V6 or V8 engines, this can be done by allowing a single turbo to operate in each cylinder bank. Alternatively, a smaller turbo can be applied at lower RPM, with a larger turbo for higher RPM.

The second configuration allows for a wider operating RPM range and gives better torque at low revs (reducing turbo lag), but also power at higher RPMs. This is known as twin sequential turbocharging. Unexpectedly, having two turbos greatly increases complexity and cost.

3 twin-scroll turbo

Twin-Scroll Turbo - Types of Turbochargers These types of turbochargers require a split inlet turbine casing and exhaust manifold that individually connects to the appropriate engine cylinder with each scroll.

For example, in a four-cylinder engine (with a 1-3-4-2 firing order), cylinders 1 and 4 may support one turbo scroll, while cylinders 2 and 3 feed a separate scroll. This layout gives efficient distribution of gas exhaust energy to the turbo and helps deliver dense, clean air to each cylinder.

More energy is sent to the exhaust turbine, meaning more power. Repeat, approaching the complexity of the system requiring complex turbine housings, exhaust manifolds and turbos comes at a huge cost.

4 Variable Geometry Turbo: - Variable geometry turbo

These types of turbochargers are also known as variable nozzle turbines. It is commonly used in diesel engines because the exhaust gases in diesel engines are low, heat does not damage the vanes.

A variable geometry turbo consists of a ring of aerodynamically shaped vanes in the turbine housing at the turbine inlet. It is complex in design and requires more cost than other types. VGTs are now limited by cost in petrol engine applications.

Due to their ability to vary the area-to-radius ratio, these types of turbochargers result in wider boost ranges and shorter gap times that match engine RPM. This design allows the ratio of the turbocharger to change when the position is changed.

5 Variable Twin Scroll Turbo

The variable twin-scroll turbo combines a twin-scroll turbo and a variable geometry turbo. This turbo allows for great high performance in any vehicle. This design provides exhaust airflow to be directed in only one scroll.

In addition, it also provides the amount of valves to open to split the gas between the two scrolls if necessary. The VTS turbocharger design offers a cheaper and more powerful alternative to the VGT turbo, which is a good choice for petrol engine applications.

6 Electric Turbo Electric Turbo

Types of Turbochargers Electric turbos are the latest and most recent addition to the turbocharger industry. It is completely different from other types of turbochargers. They reduce turbo lag and aid normal turbocharger operation at low engine speeds. This is done by connecting an electric motor that rotates the compressor at low revs from start until the exhaust volume is strong enough to operate the turbocharger. A disadvantage of this type of turbocharger is that they are quite expensive and complex. This turbocharger option also allows the recovery of used energy and use for power generation.

Study about super charger

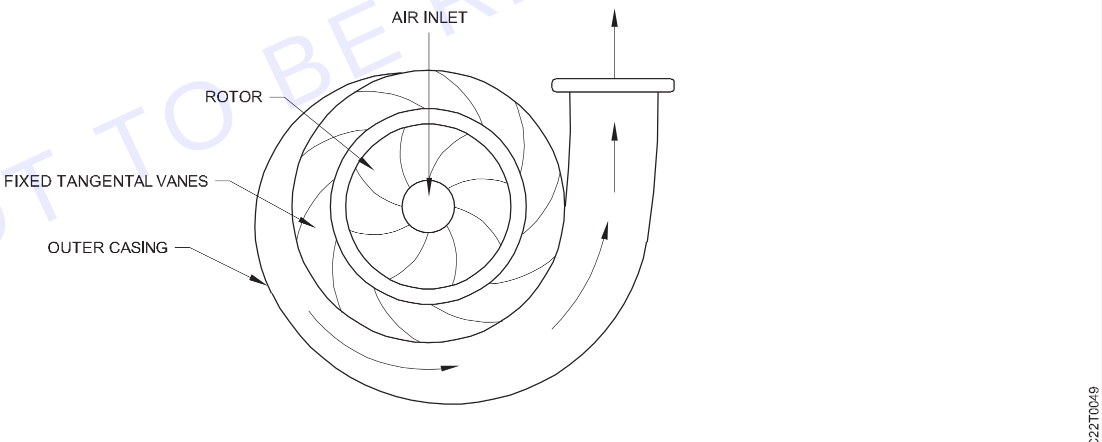
- **Supercharger:** A supercharger is a device that increases the pressure of the air fuel mixture from the carburetor before it enters the engine. It is connected to the intake manifold between the carburetor and the cylinder. It is usually driven by an engine through suitable gears and shafts. There are three general types of superchargers:

  1 Centrifugal type

  2 Pane type

  3 Roots Air-Blower Type

- **Centrifugal Type Supercharger**



CENTRIFUGAL TYPE SUPERCHARGER

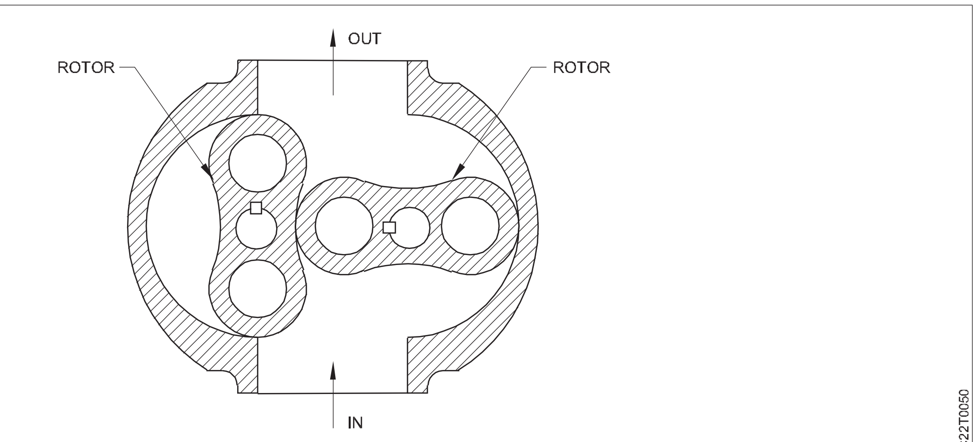
It consists of an actuator that rotates at a very high speed, approximately 10,000 rpm. The air-fuel mixture enters the impeller at the center and moves from the casing to the engine cylinder after passing through the impeller and diffuser vanes. Due to the high speed of the propeller,

The mixture is forced into the cylinder under high pressure.

- **Roots air-blower type supercharger**

It has two rotors of epicycloid shape. each rotor one Is connected to the shaft by a key. The two shafts are connected whether the same

The two rotors rotate at the same speed through shaped gears.

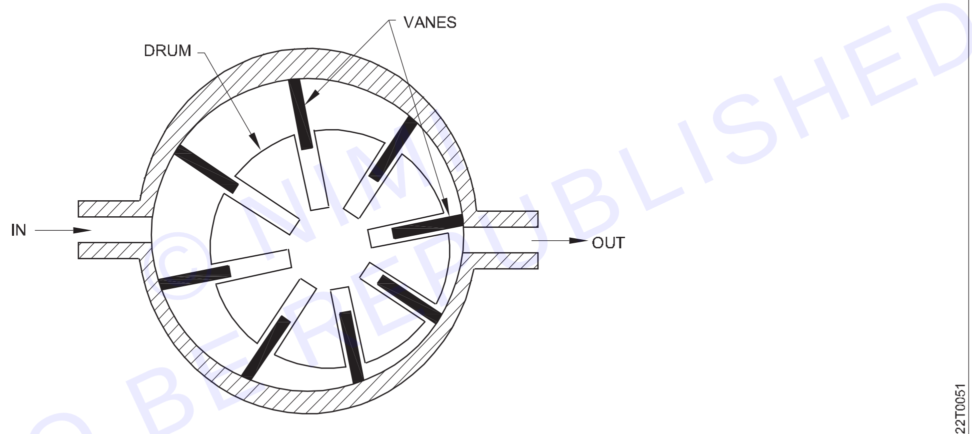


ROOTS AIR-BLOWER TYPE SUPERCHARGE

The working action of this type of supercharger is like that of a gear pump, so that

The mixture should be at high pressure on the outlet side.

- **Vane Type Supercharger**



VANE TYPE SUPERCHARGER

It consists of a drum on which a number of vanes are mounted in such a way that they can slide in or out against a spring force, so that at all times they are in contact with the internal surface of the supercharger body. The space between the body and the drum decreases from inlet to outlet. Thus, the air-fuel mixture trapped between any two vanes at the inlet goes

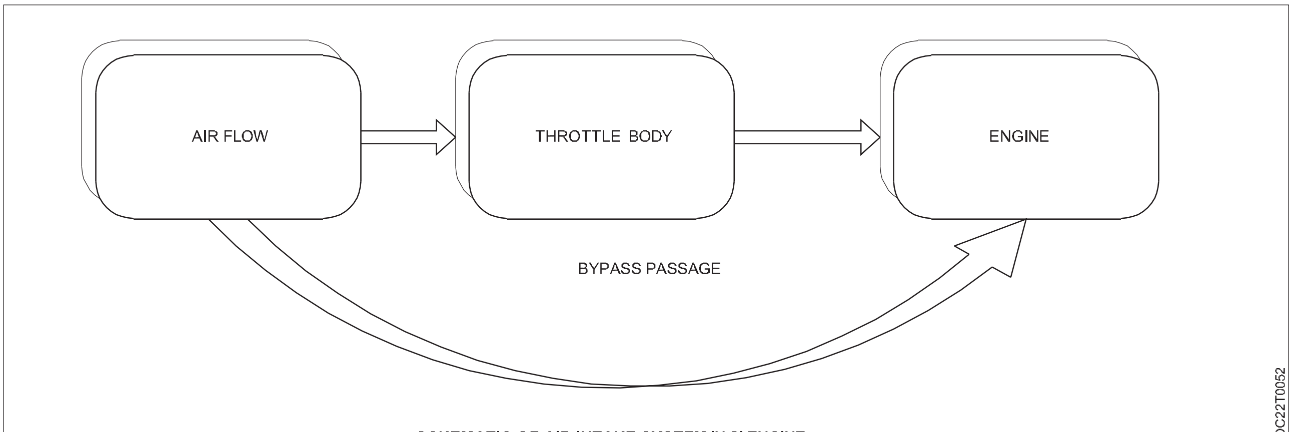
The volume decreases and the pressure increases as it reaches the outlet.

The Roots supercharger is simple in construction and requires minimal maintenance. It has a relatively long life. It works well even in low speed range. Centrifugal type superchargers have poor operating characteristics at low speeds. Vane type superchargers suffer from wear of vane tips.

The turbo charger sends compressed hot air to the inter cooler and it expands the heated air. The increase in pressure from the turbocharger is the result of heating the air before it goes into the engine. To increase engine power and get more air molecules into the cylinder.

Study about throttle body and intake manifold

Introduction of throttle body: Most of the spark-ignition internal combustion engines operate with an air-gasoline ratio since throttle body controls airflow and fuel intake level. To control engine power and the flow pressure and velocity, a throttle valve is used. The throttle valve's main objective is to control air and gasoline mass flow, flow pressure and flow velocity for changing the airflow ratio. For this case Computational Fluid Dynamics (CFD) analysis can be used. Main function of a throttle body is to control the air flow into the engine. Throttle body is mounted between the air cleaner and the engine. Throttle body has a plate to reduce the pressure of the air flowing through throttle valve opening condition. When the throttle body is closed, all the air is not entering into the throttle body, through the bypass passage into the engine. As the bypass screw is opened and closed, which it can control the airflow through the bypass circuit. So the throttle body main function is the changed the flow velocity and pressure during transient operation of the engine, which the throttle position is changed by per driver's demand. So the schematic of a throttle body describing air flow path is shown in Figure 1, Air flow enters into the throttle and move downstream, Throttle body restricts the amount of air flow into the engine based on throttle position.

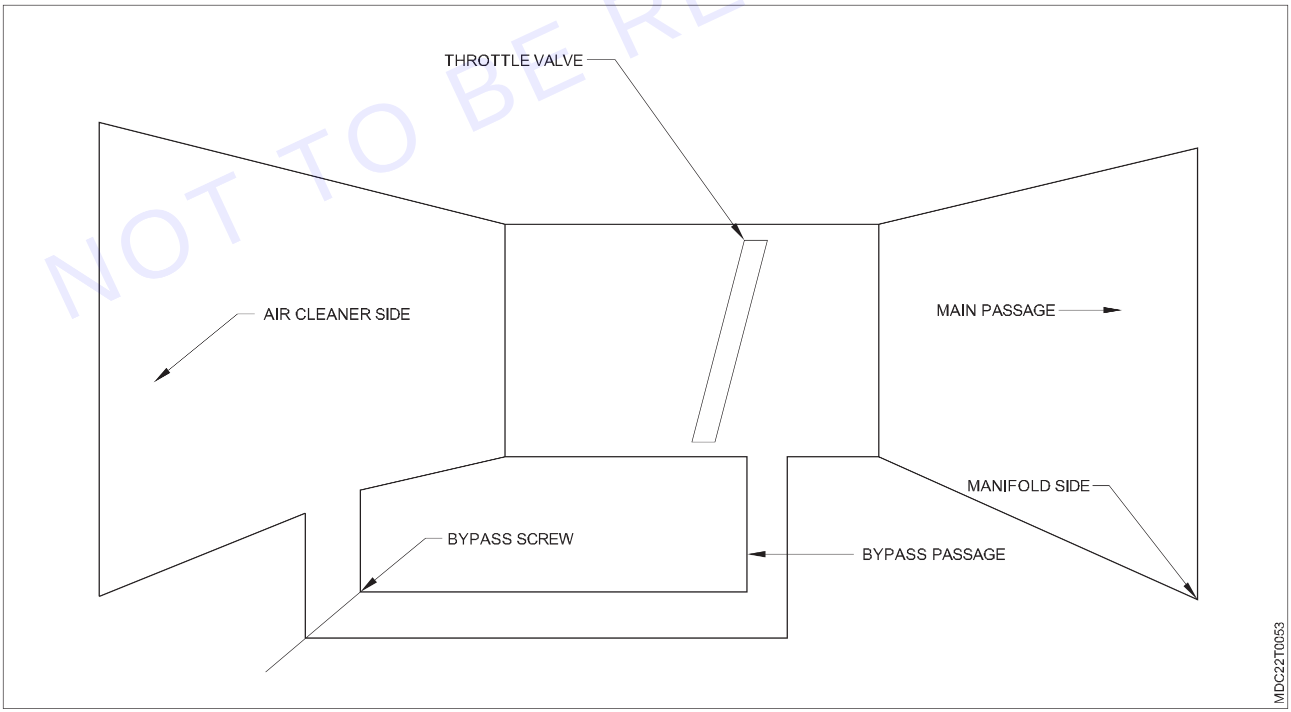


SCHEMATIC OF AIR INTAKE SYSTEM IN SI ENGINE

[1] have carried out simulation of time- dependent flow through throttle valve to determine flow mechanisms various throttle plate angles and compared the results with hexahedral and tetrahedral meshes. Chen and Chen [2] analyzed small airflow rate at engine idling by using CFD analysis to aid throttle body design and to study tolerance effect on the estimated airflow rate.

The limited studies are reported on numerical simulation of flow through the throttle body, it is proposed to analyze the flow through the throttle body assembly at different throttle valve opening and closing use CFD.

Design of the throttle body



Represents structure of a throttle body with important dimensions. Major dimensions of the throttle body are the throttle bore diameter and bypass passage diameter, the overall length of the throttle body is fixed based on the engine layout. Diameter (air cleaner side) and diameter (manifold side) are contacted with the air-cleaner side fitment and the intake manifold side respectively. After the overall length is known, manifold side length is determined considering the position of throttle valve at fully open condition. Length is chosen based on the air cleaner side mounting. [14] Air from the air-cleaner enters into the throttle valve and move towards the main passage. When the throttle plate is almost closed, the air flow into the throttle body cannot though the main passage, it though the bypass passage. So the throttle plate is opened, the air flows through the main passage and the amount of airflow through the passage increase when increase the throttle body opening conditions. Reverse, the amount of the airflow through bypass passage increase.

In this study, we can show the air flow through inside the throttle body that show the flow rate when the throttle valve opening conditions at the positions are 25, 50 75.100%, With increase in throttle opening conditions the air flow's velocity increase through the throttle valve. As the flow travels the throttle body at different conditions the airflow rate is different. The flow rate through the throttle valve increase with increase in the throttle body opening positions due to reduce the restriction by throttle body increase the air into the engine.

Intake manifold: An intake manifold is a series of tubes that sit atop the engine. As air enters the car, it travels through the throttle body, then into the intake manifold and then finally into the engine itself. Basically, the intake manifold is the last stop on the air's journey before it reaches the cylinder heads.

There are two basic parts to the intake manifold. There's the plenum, the large cavity at the top of the manifold, and the runners, the small tubes that run to each cylinder individually. An intake (also inlet) is an opening, structure or system through which a fluid is admitted to a space or machine as a consequence of a pressure differential between the outside and the inside. The pressure difference may be generated on the inside by a mechanism, or on the outside by ram pressure or hydrostatic pressure. Flow rate through the intake depends on pressure difference, fluid properties, and intake geometry. Intake refers to an opening, or area, together with its defining edge profile which has an associated entry loss, that captures pipe flow from a reservoir or storage tank. Intake refers to the capture area definition and attached ducting to an aircraft gas turbine engine or ramjet engine and, as such, an intake is followed by a compressor or combustion chamber. It may instead be referred to as a diffuser. For an automobile engine the components through which the air flows to the engine cylinders, are collectively known as an intake system [4] and may include the inlet port and valve. An intake for a hydroelectric power plant is the capture area in a reservoir which feeds a pressure pipe, or penstock, or into an open canal.

Importance of maintenance, diagnosis and Servicing intake systems

Objectives: At the end of this lesson you shall be able to

- explain Importance of maintenance
- diagnosis faults in Intakes System
- demonstrate servicing of Intake system.

- **Air intakes system:** In engine air is drawn into the cylinder from atmosphere through air cleaner, turbocharger, induction manifold, intake port and inlet valve. The induction manifold provides passage for the flow of fresh air from air cleaner via turbo charger towards the engine cylinder. The intake valve provides entrance for the fresh air charge into the combustion chamber and cylinder. The following air flow system is used in diesel induction system.

  Air cleaner → Turbo charger → Induction manifold → Intake port → Inlet value → Combustion chamber and cylinder

- **Importance of maintenance of system:** Maintaining the air intake system is crucial for optimal performance and efficiency. Regularly inspect and clean air filters to ensure proper airflow and prevent any kinds of damages. Check for any leaks or damage in the intake ducts and hoses is ensure that the system as good condition. Additionally, schedule periodic inspections to address any issues promptly and keep the system running smoothly.

Importance of diagnosis of system

1 **Performance Optimization:**

Identifying problems early can prevent decreased engine performance and fuel efficiency.

2 **Prevent Damage**

Finding issues like clogged filters or leaks early can prevent damage to the engine and other system components.

3 **Cost Savings**

Finding problems before big damaged it's can save money by preventing more significant repairs down the line.

4 **Emissions Control**

A faulty air intake system can be responsible for increased emissions, affecting environment. We can stop it by solving problems.

5 **Safety**

Ensuring proper air intake is important for engine combustion and overall vehicle safety.

6 **Long lifespan**

Regular diagnosis and maintenance can extend the lifespan of the engine and related components, reducing the need for repair and replacements.

Importance of servicing of system

regular servicing of the air intake system is essential for maintaining vehicle performance, efficiency, reliability, and safety.

Engine performance: A clean and properly functioning air intake system ensures the engine receives the right amount of air for combustion, optimizing performance and power output.

Fuel efficiency: A well-maintained air intake system helps achieve efficient fuel combustion, leading to better fuel economy and reduced fuel consumption.

Emissions control: Proper air intake system servicing contributes to lower emissions by ensuring optimal air-to-fuel ratios, helping vehicles meet environmental regulations and reducing their carbon footprint.

Preventing damage: Regular servicing helps identify and address issues like clogged filters, leaks, or damaged components before they lead to more significant engine damage or costly repairs.

Long lifespan: By preventing damage and ensuring proper engine operation, servicing the air intake system promotes the longevity and reliability of the engine and related components, potentially extending the vehicle's lifespan.

Safety: Maintaining the air intake system is essential for safe vehicle operation, as it ensures proper engine function and performance, reducing the risk of breakdowns or accidents caused by engine issues.

Causes of failure of the components of intake system

Objectives: At the end of this lesson you shall be able to

- explain Causes of failure of the components of intake system.

The intake system of an engine can fail due to following reasons

- **Air leak:** any leak of an intake system can effect on air-fuel mixture or an engine performance.
- **Clogged air filter:** a clogged or dirty air filter, it restricts airflow and effects on engine performance.
- **Throttle body issues:** malfunctioning throttle bodies can disrupt the air intake, affecting engine performance.
- **Vacuum leak:** leak in intake manifold gasket or vacuum hoses can cause air enter the engine without passing throttle body it is effect on air-fuel mixture or engine performance.
- **Mass air flow sensor (MAF):** its failure can lead to incorrect fuel-air mixture ratio because it measures the amount of air enter the engine.
- **Dirty intake manifold:** carbon built in the intake manifold and it resists the airflow and disrupts the engine performance.
- **Faulty PCV valve:** Positive crankcase ventilation (PCV) valve can to oil containment in the intake system, affecting engine performance.
- **Worn or Damaged component:** over time, components can wear out or damaged, leading to leaks and inefficiencies like intake hoses, seals, or gasket etc.
- **Water ingestion:** driving into deep water can cause water to enter the intake system, potentially causing hydro-locking and serve engine damage.
- **Incorrect installation:** improper installation can lead to lead to leaks or other issues, impacting engine performance and reliability.

Trouble shooting in an intake system. Study about exhaust system components such as exhaust manifold, muffler, types of catalytic converter etc

Objectives: At the end of this lesson you shall be able to

- demonstrate Trouble shooting in an intake system
- study about exhaust system components such as exhaust manifold & muffler
- explain types of catalytic converter.

Troubleshooting in an intake system

Check for air leaks: Check the air intake system for air leaks, such as: B. Broken hoses, loose connections, or damaged seals. Air leaks can cause incorrect air-fuel ratios and affect engine performance.

Check the air filter: A dirty or clogged air filter can restrict airflow to the engine, affecting performance. Check the air filter and replace if necessary.

Check the throttle body: The throttle body controls the amount of air entering the engine. If it's dirty or doesn't work properly, it can cause air intake problems. Clean the throttle body or replace as necessary.

Check the Mass Air Flow Sensor (MAF): The MAF sensor measures the amount of air entering the engine. A faulty MAF sensor may cause incorrect fuel delivery. If the MAF sensor is not working properly, have it tested or replaced.

Check the vacuum line: The vacuum line plays a vital role in the air intake system. Check the vacuum line for leaks or cracks and replace if necessary.

Check the fuel system: Fuel system problems such as: Other problems such as a clogged fuel filter, fuel pump problems, or injector problems can also affect the performance of your intake system. Check and correct any fuel system problems.

Check for fault codes: Use an OBD-II scanner to check for fault codes related to the air intake system or engine performance. This can provide valuable diagnostic information.

Test sensor: In addition to the MAF sensor, other sensors such as oxygen sensor (O2 sensor), throttle position sensor (TPS), and intake air temperature sensor (IAT) will also have an impact on the intake system. Test whether these sensors are working properly.

Check the intake manifold: Check the intake manifold for leaks, cracks or carbon deposits. Correct any problems found to ensure proper airflow.

Check ECU/PCM Operation: The engine control module (ECU) or powertrain control module (PCM) plays an important role in controlling the air intake system. Make sure the ECU/PCM Is working properly and update the software if necessary.

Study about exhaust system component such as exhaust manifold and muffler

System: Under this heading, such a components used in the engine have been described, which are used for various functions in the exhaust systems of the engine. The components of the exhaust system are as follows.

1 **Exhaust manifold:** This is also made in the same way as the inlet manifold. It is fastened to the block or engine head by studs or bolts. It is used to expel the burnt gases from the cylinders. Along with this, a silencer or muffler is added. Through this manifold, the burnt gases of all the cylinders are collected and sent to the silencer. Exhaust manifolds are often made from cast iron.

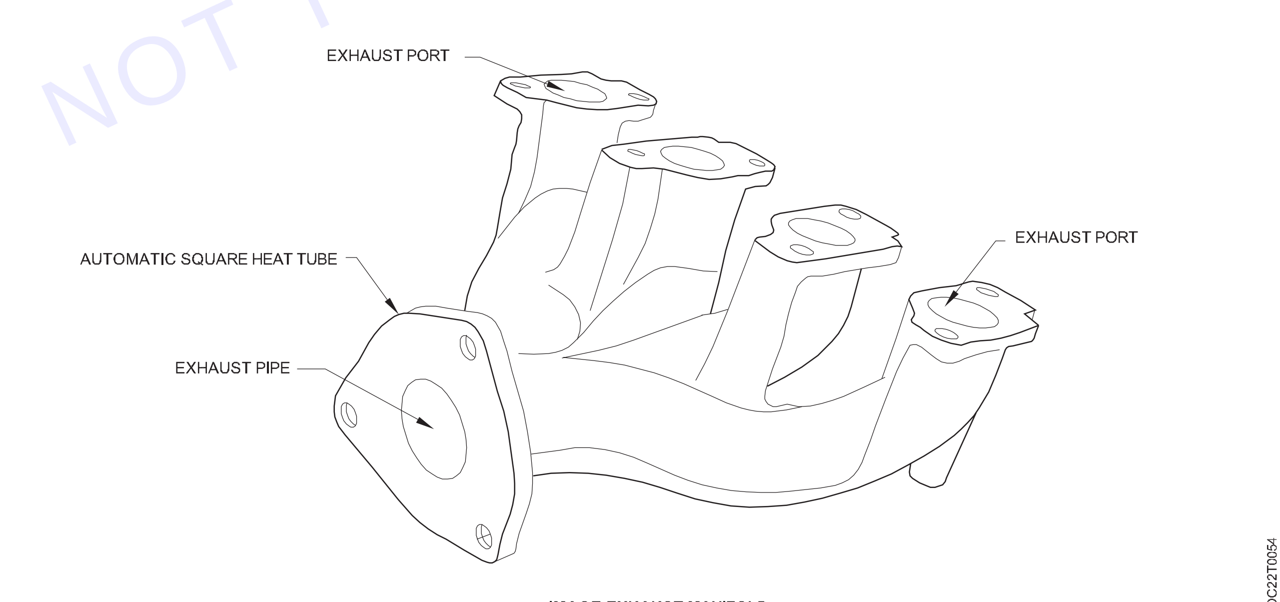


IMAGE EXHAUST MANIFOLD

V-8 engines use two, while the remaining engines use one exhaust manifold. They are designed in such a way that back pressure of exhaust gases does not build up. Some exhaust manifolds are equipped with a manifold heat control device to keep the inlet manifold at a certain temperature at all times, preventing the mixture in the inlet manifold from freezing when the engine is at rest.

Heat control valve or heat riser is used as a heat control device in which a thermostatically operated butter fly valve is installed. When the engine is cold, this valve is closed and when the engine warms up to operating temperature, this valve opens due to which the exhaust gases go directly into the muffler.

2 **Exhauster:** This is a type of vacuum pump. In this, the pipe is fitted in such a way that there is less bends in it and the exhaust is outside the engine. The exhaust pipe should always be installed in a horizontal direction, so that the exhaust pipe does not get clogged during rainy days. Exhausters are mainly of the following types.

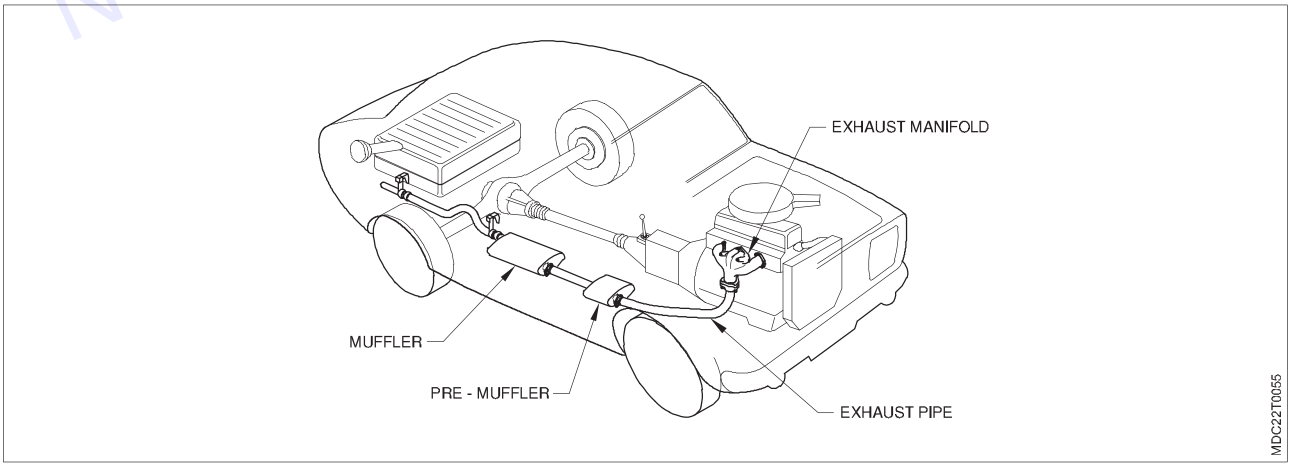
i **Vane type exhauster:** Exhausters are installed on the engine to develop vacuum with the help of the pneumatic governor of the fuel injection pump (FIP). Vane type exhauster is bolted on to the exhaust tract of the engine. It has a rotor which is rotated by a ‘key’ on the shaft It is applied. The rotor is mounted eccentrically on the body of the exhauster. The vanes are to be installed obliquely in the slots of the rotor. A shift valve fitted on the exhauster limits the vacuum to a predetermined pressure.

ii **Impeller type exhauster:** Impeller type exhauster has two spindles. One spindle is fitted with an impeller, which is driven by the auxiliary driving shaft and the other spindle is fitted with a rotor, whose vanes are attached to the vanes of the driven rotor.

iii **Fins Type Exhauster:** This exhauster works in the same way as a volume pump. It is installed at the inlet of the exhauster body or casing. It is driven by timing gear. A rotor is mounted on the shaft of this exhauster, which has four to six Blades are attached. Oil seals on both sides of shaft It is engaged. If the gasket of fins type rotor exhauster is bad, then they are unable to create a vacuum which causes the rotor to not function.

3 **Exhaust pipe:** The exhaust pipe receives hot gases from the muffler in the manifold. These are suitably sized steel tubes and are fitted under the chassis to carry the gases to the rear end of the vehicle. It is fastened with a flange or clamp. The exhaust pipe is used to connect the exhaust manifold to the silencer or muffler. This pipe is attached to the exhaust manifold and muffler by means of a flange and clamp. In this way, the gases coming out of the exhaust manifold are transported to the catalytic converter and muffler through the exhaust pipe itself. To keep the exhaust pipe and silencer away from chassis shocks, pieces of rubber or brick are installed.

4 **Muffler:** The muffler is usually mounted inside the body and attached to the body and chassis with flexible mounting. Some trucks with upward-directed exhaust gases have the muffler installed at the rear end of the cab and covered with a guard to prevent accidents. The muffler reduces the exhaust sound of the engine. It is a large cylindrical shaped container fitted with a passage and chamber and absorbs the sound of the exhaust gases. Sometimes mini and pre-muffler are also fitted in the exhaust system along with the manifold and main muffler.



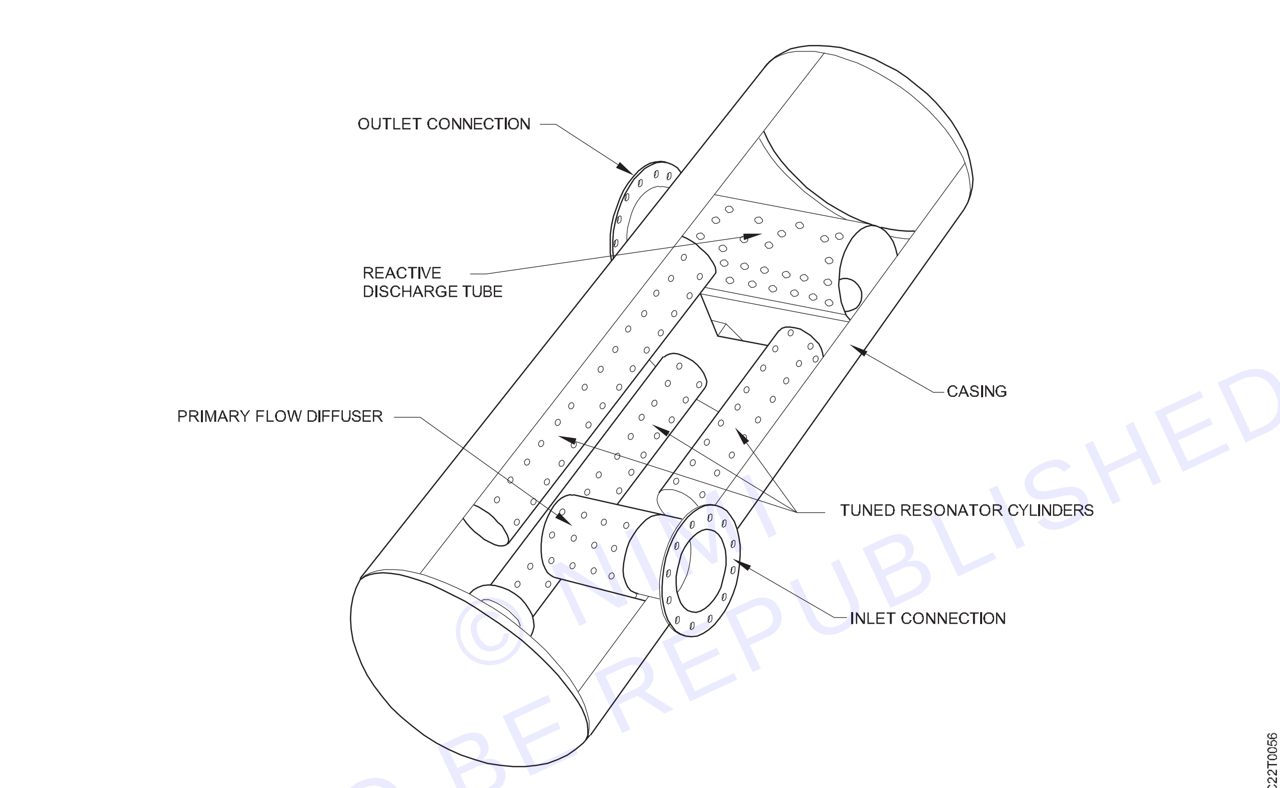
The frequency of sound emanating from the engine cylinder is mainly classified into

1 Low frequency sound (500 to 1500 per second)

2 High frequency sound (3000 to 10000 per second)

Thus, silencers that reduce low and high frequency noise should be used in vehicles. Following types of mufflers are used in vehicles as per requirement.

i **Reactive Muffler:** In this type of muffler, the inlet and outlet tubes extend towards the chamber, hence this muffler is also known as chamber muffler. Usually it consists of many types of pipe segments, which are connected together by a large chamber. These reduce the sound generated by combustion through destructive interference. In other words, these pipe segments divide the sound produced and reduce its value. These mufflers are very helpful in reducing low frequency sound; Such as Midas, Drift Tech, Full Bore etc. Nowadays only reactive mufflers are used in trucks.



PICTURE REACTIVE MUFFLER

ii **Absorptive muffler:** In this type of muffler, absorbing materials are used to reduce the noise generated by the combustion process. Due to this method, the sound waves are reduced and the energy in the absorbent material is converted into heat.

In absorbent muffler, two functions are accomplished, destruction of more energy due to higher coefficient and generation of less radiated sound waves.

Types of absorptive muffler

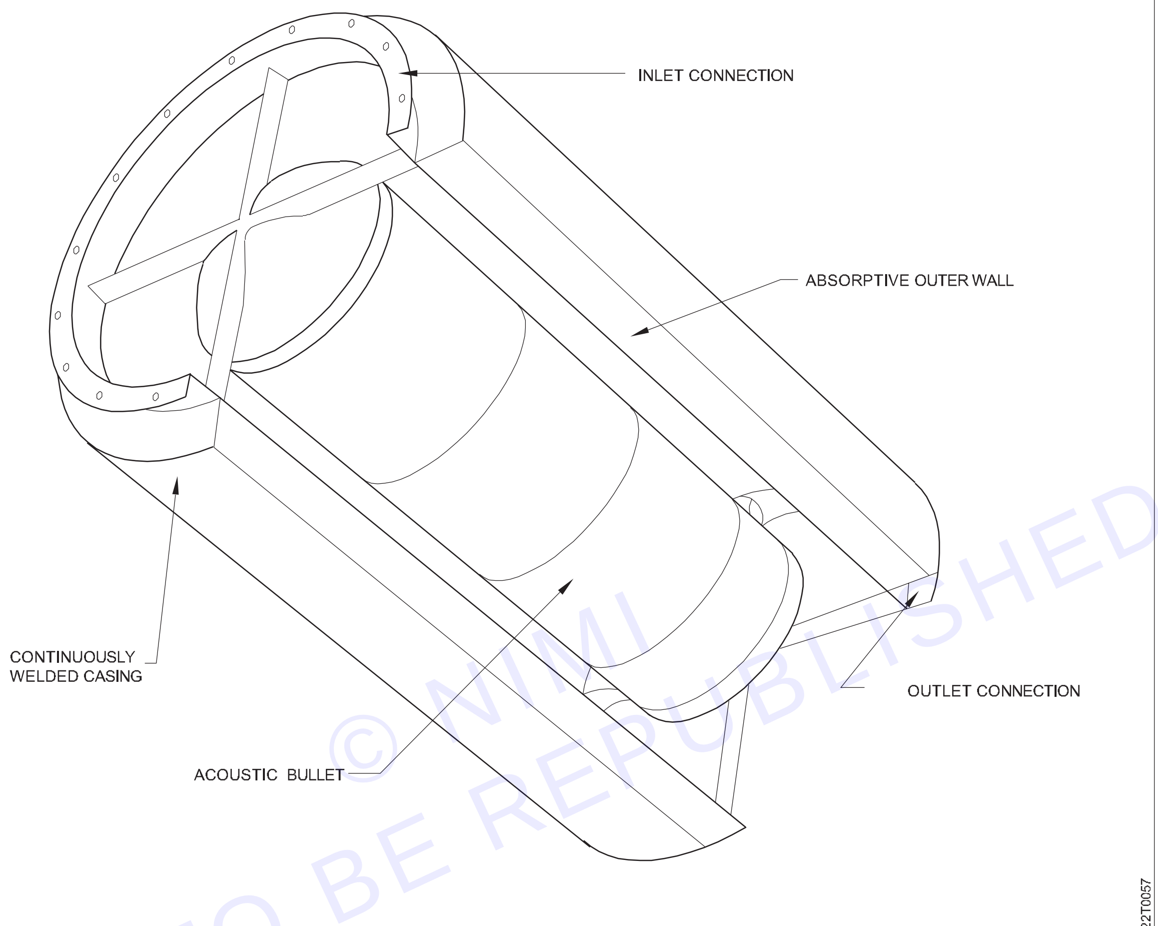
Three types of absorptive muffler

A **Straight thorough muffler:** This is the easiest way to reduce the sound generated by the gases coming out of the cylinder. In this, a pipe is fitted across the muffler housing. Holes are cut in it. This pipe is closed from the middle. the burnt gases from the exhaust manifold pass through this pipe and fill the housing. From this housing again these gases come out without any pressure and sound through the holes of the pipe at the other end. Due to the holes in this pipe, entry and exit of gases occurs slowly due to this, the velocity and pressure of these gases gets lost.

B **Reverse flow type:** In this type of muffler, separate compartments or chambers are made and each chamber is connected to each other, due to which the burnt gases in the muffler are taken out through many curved parts. Due to this rotation, the velocity and pressure of the burnt gases are lost and the gases come out without any sound.

C **Baffle plate type:** In this type of muffler, baffle plates with one or two holes are used inside the housing. When the gases coming out of these plates collide, their velocity and pressure reduce, due to which the burnt gases come out without any sound.

iii Combination muffler: - Some mufflers in vehicles combine absorbent and reactive elements, so that the broad spectrum of sound can be easily reduced. This type of mufflers are extensively used to reduce exhaust sound.



PICTURE JOINT MUFFLER

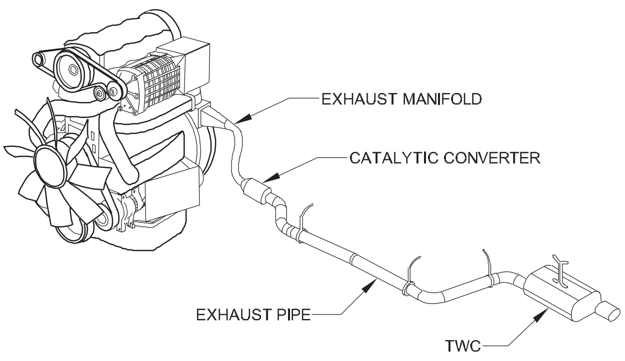
iv Electronic muffler: - This muffler is also called the 'Halm Holtz' muffler after its creator. These muffler resonators are connected in series with a pipe in between which has ports. With the help of these ports, sound waves come out without any obstruction. It is mainly used in electronic sound control system. This almost eliminates exhaust sound. In this system, a microphone is used to detect sound in a computer-controlled emitter. These exhaust sound waves are similar and opposite. Its application does not produce noise in the exhaust system.

In this type of muffler, a pattern is taken by observing the sound waves generated by the exhaust pipes with the help of sensors and microphones. This pattern is analyzed in a computer, generating a mirror image. This mirror image is sent to the speaker, as a result of which waves are generated and the noise stops. In this system, fuel saving and exhaust emission are done. Therefore, this type of muffler is used to obtain a specific sound.

Types of catalytic converter

Passenger cars and light trucks have been equipped with catalytic converters. A Catalytic converter is located (Fig 1) within the exhaust system and converts to convert harmful emissions as HC, CO, NOx, produced by an internal combustion engine, to less-harmful elements: H2O(Water), CO2 (Carbon Dioxide), and N2 (Nitrogen)

Modern vehicles are fitted with three-way catalytic converters (TWC). The term 'three-way' is in relation to the three regulated emissions the converter is designed to reduce:

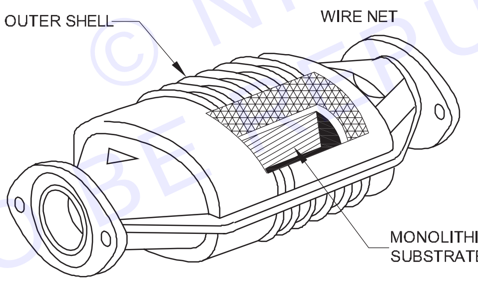


- Unburnt Hydrocarbons are oxidized into water/steam.
- Carbon monoxide is oxidized into carbon Dioxide
- Oxides are converted into Nitrogen and Oxygen

The converter uses two different types of catalysts to reduce the pollutants: a reduction catalyst and an oxidation catalyst. A honeycomb structure (Fig 2) as either ceramic or metallic is treated with a wash-coat of precious metals usually platinum, palladium and rhodium through which the exhaust gasses flow. The Surface of the honeycomb material has a rough finish such that it allows the maximum contacts are available to the exhaust gasses.

The exhaust gases first pass over the reduction catalyst in the converter. The platinum and rhodium coating helps to reduce the oxides of nitrogen, together known as 'NOX' emission.

The three - way Catalyst, which is responsible for performing the actual feed gas conversion, formed by coating the internal substrate with the following type materials.



Material	Conversion for
Platinum/palladium	Oxidizing catalysts for HC and CO
Rhodium	Reducing catalyst for NOx
Cerium	Promotes oxygen storage to improve oxidation efficiency

The electronic control unit, or ECU, monitors the air-fuel ratio by using an exhaust gas oxygen, or EGO, sensor, also known as a lambda sensor. This sensor tells the engine computer how much oxygen is in the exhaust and uses this information via the ECU to control the fuel injection system.

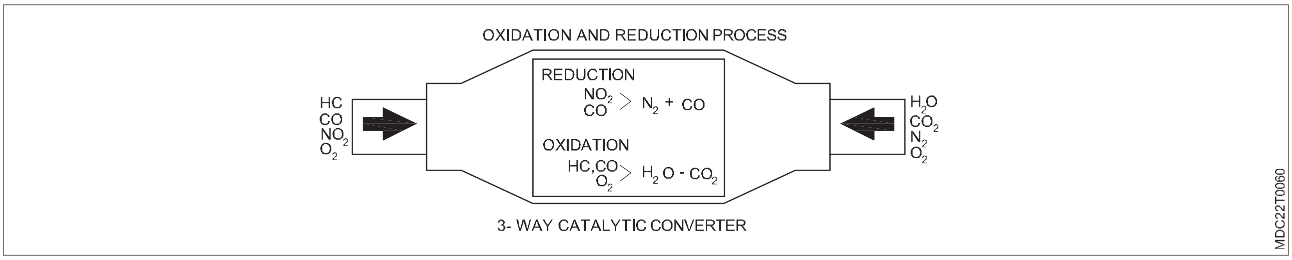
There are three main types of catalytic converters

1 **Two-way catalytic converter:** Converts carbon monoxide (CO) and unburned hydrocarbons (HC) into carbon dioxide (CO2) and water (H2O) ....

2 **Three-way catalytic converter:** Converts not only CO and HC but also nitrogen oxides (NOx) into nitrogen (N2), carbon dioxide (CO2), and water (H2O) ....

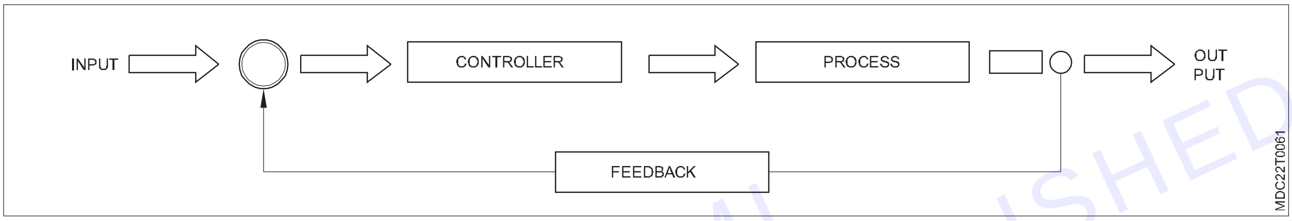
3 **Diesel oxidation catalyst (DOC):** Primarily focuses on reducing emissions from diesel engines by converting CO and HC into CO2 and H2O....

The ECU can increase or decrease the amount of oxygen in the exhaust by adjusting the air-to-fuel ratio. The system ensures that the engine runs at close to the stoichiometric point in normal driving conditions. It also ensures that there is always sufficient oxygen in the exhaust system to allow the oxidization catalyst to deal with unburned hydrocarbons and carbon monoxide.



Closed loop control system

Control system in which the output has an effect on the input quantity in such a manner that the input quantity will adjust itself based on the output generated is called closed loop control system in this way closed loop control system is called automatic control system.



Importance of maintenance, diagnosis and Servicing exhaust systems

Objectives: At the end of this lesson you shall be able to

- demonstrate maintenance, diagnosis and Servicing of exhaust systems.

Servicing of exhaust system

improve Fuel Efficiency

Keeping your vehicle's exhaust system in tip-top condition can help you improve fuel efficiency. After all, who doesn't love making their car more fuel efficient? If the components of your vehicle's exhaust system are failing for some reason, you may notice that your car is getting poor engine combustion and gas mileage. For example, a clogged catalytic converter can cause a significant decrease in fuel efficiency, potentially ranging from 10% to 25% or even more. Having your exhaust system repaired in a timely manner will ensure your vehicle will perform at its top miles per gallon ability.

1 **Leaking exhaust manifold:** The most common symptoms of a leaking exhaust manifold are ticking noises, a lit check engine light, odors in the exhaust, and clear damage on the manifold itself. The easiest and most effective way to fix a leaking exhaust manifold is to replace it entirely.

2 Exhaust Pipe reaper

3 Muffler replacement

4 Catalytic converter service

5 Oxygen sensor replacement

6 Exhaust manifold repair

7 Hanger and Mount replacement

8 Emission testing

Maintenance of exhaust system

1 Check for rust and corrosion

2 Look for damage

3 Clean the exterior

4 Remove carbon deposits

5 Listen for unusual noises

6 Check gaskets and seals

7 Check for efficiency

8 Use quality fuel

Causes of failure of the components of exhaust system

Objectives: At the end of this lesson you shall be able to

- explain causes of failure of the components of exhaust system.

- **Exhaust manifold**

  Exposure to extreme pressure and heat cycles can damage exhaust manifolds.

- **Oxygen sensor**

  Oxygen sensor failure can lead to incorrect reading of exhaust gases.

- **Catalytic converter**

  Catalytic converters can become blocked or choked, which can cause a noticeable lack of power, a smell of Sulphur, or heat from the floor of the vehicle.

- **Diesel Particulate Filter**

  DPFs can become clogged and may even need to be replaced in some circumstances. DPFs go through which helps clear out the soot. The danger is that it can become clogged beyond the engine management's capabilities to clean it.

- **Exhaust pipe**

  Checking for holes or signs of rust is required; any sign of rust may indicate a more serious problem within the silencer.

- **Silencer**

  Rust is the main culprit when it comes to exhaust damage or erosion.

MODULE 4 : Fuel Supply System (Petrol)

LESSON 29 & 30: Fuel supply system in petrol engine Gasoline Fuel: properties of Gasoline fuel - combustion processes

Objectives

At the end of this lesson you shall be able to

- explain Petrol Fuel Supply System
- elaborate properties of Gasoline fuel
- demonstrate Combustion processor.

Gasoline Fuel: properties of Gasoline fuel-combustion processes

Petrol or Gasoline Fuel

It is obtained by fractional distillation or cranking of petroleum. It is the lightest and most volatile liquid fuel. After refining petrol, desired properties are obtained by adding other desired substances (additives) to it.

mechanic motor vehicle It is used in different types of IC engines, such as cars, scooters, motorcycles, aircraft etc. It is a mixture of unrefined petrol, paraffin, naphtha and aromatic hydrocarbons. Generally, and highly flammable, yellow color is distilled and soot. This is hydrogen. Its relative gravity is about 0.73 and calorific value ranges from 42 to 44 mega joules/kg.

Characteristics of Gasoline Fuel Following are the main properties of gasoline fuel

i **Volatility:** Volatility refers to the ability of petrol to evaporate. Due to this property of fuel, it gets mixed with air in sufficient quantity for combustion. It blows at 90°C with a vapor pressure of 0.5 to 1.0 cm. This property is of great benefit when the engine is running, because the vaporized fuel burns easily.

ii **Purity:** Petrol should be pure i.e. it should not contain dust, dirt, grease and water

iii **The sulfur obtained during purification of sulfur:** free crude oil should be cleaned as much as possible, otherwise there is a possibility of rusting in the engine. Only a maximum of 0.1% of it is acceptable in fuel.

iv Due to the amount of gum in adhesion-free petrol. Piston rings and valves etc. start sticking and the manifold and The jets of the carburetor get blocked. Therefore, there should not be any amount of gum in petrol i.e. it should be stick-free.

v **Anti-knocking quality:** This quality of petrol depends on its octane number. Octane The higher the number, the less knocking the engine will have.

vi **Viscosity:** This is a physical property of petrol which depends on its rate of flow. The lower the viscosity of the petrol, the more easily the petrol will flow in the engine.

vii **Additive:** Some chemical additives are added to petrol to increase the anti-freezing capability of petrol as well as to increase its combustion capability and to reduce the harmful waste left after combustion. Detergent is used as an additive to clean critical parts of the engine.

viii **Stoichiometric ratio:** The ratio of fuel and air required for complete combustion of petrol is called stoichiometric ratio. For petrol this ratio is 14.7:1 which means that 14.7 liters of air will be required to burn 1 liter of petrol.

ix According to ISA (International Standard Atmosphere) the sea level density is also 1.235 K. Air mixture for the engine. The air used as fuel in petrol engine is 14.7 kg of air. If the air density in the fuel is low, the mixture obtained will be a rich mixture and if the air density in the fuel is high, the mixture obtained will be a lean mixture.

x **Pressure and vacuum:** In the compression stroke of the engine, both the valves (inlet and outlet) are closed due to which the fuel in the combustion chamber is compressed, that is, the pressure of the fuel in the combustion chamber is increased. As a result, fuel is atomized and complete combustion of fuel occurs successfully. Under suction stroke in the engine, only the inlet valve is open and the piston moves downwards due to which suction or vacuum is generated in the combustion chamber, that is, the internal pressure of combustion is less than the atmospheric pressure due to which the fuel automatically It starts entering the combustion chamber.

xi Fuel burning control Petrol fuel is a rapid ignition fluid. Its combustion can be controlled only by burning petrol fuel slowly. Due to rapid combustion of petrol, there is a possibility of explosion and knocking in the combustion chamber of the engine. Therefore, some additional substances are added to petrol to burn it slowly in the combustion chamber.

The combustion of fuel in the engine can be controlled in the following manner: Octane rating: By increasing the octane rating of petrol fuel, detonation in petrol is reduced.

Operational pressure: Combustion of petrol can be controlled by reducing the operational pressure in the combustion chamber.

Air-fuel ratio: A balanced ratio of air and fuel can control the combustion of petrol in the combustion chamber.

Spark timing: The proper timing of sparking of the compressed fuel in the combustion chamber controls the combustion of the fuel. Internal temperature: By reducing the internal temperature of the combustion chamber, the combustion of fuel is controlled. is done.

xii **Economic gain:** Petrol should be of such a type that the vehicle can be operated for maximum kilometers in one-liter quantity.

Study about carburetor fuel system and its components such as fuel tank, mechanical fuel Pump, electrical pump, fuel filters, carburetors and its circuits etc

Objectives: At the end of this lesson you shall be able to

- study about carburetor fuel system
- explain about fuel tank, mechanical fuel Pump & electrical pump
- demonstrate Circuits of Carburetor and Petrol filter.

Study about carburetor and its circuits

Carburetor: Carburetor is a device which takes petrol in liquid form from the fuel pump, vaporizes it with air, mixes it in appropriate quantity and sends it to the cylinder through intake stroke of the engine.

Carburetor usually has three functions

1 Mixing

2 Vaporization

3 Atomization

Mixing: Mixing of air and petrol in the mixing chamber of carburetor with different speeds and loads is called mixing.

Vaporization: The atomization of air and petrol which heats up and turns into vapor is called Vaporization.

Atomization: When a liquid is broken down into small particles it is called atomization and this helps in converting the fuel into vapor.

Carburetor Circuit:

1 Float Circuit

2 Idle slow speed Circuit

3 Cruising Circuit

4 High Speed or Full Throttle Circuit

5 Accelerating Pump Circuit

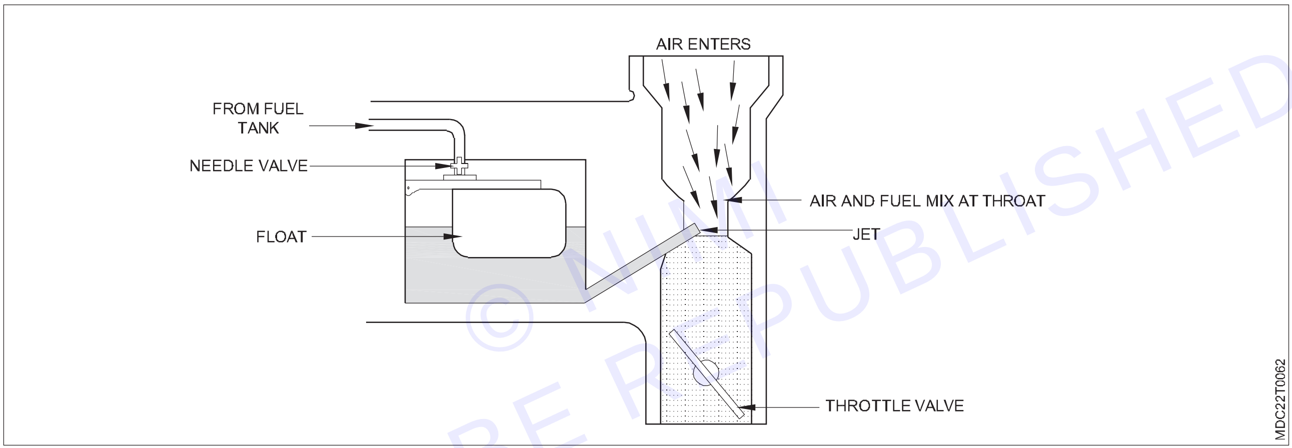
6 Chock Circuit

Float Circuit: It is very important to keep the level of petrol in the float bowl constant at all times. If the level increases too much, more petrol will go through the jet into the manifold, which will increase fuel consumption and if the level decreases, less petrol will come out of the jet, due to which the engine will not be able to develop full power.

A float ball and needle valve are installed to keep the level of petrol in the bowl full.

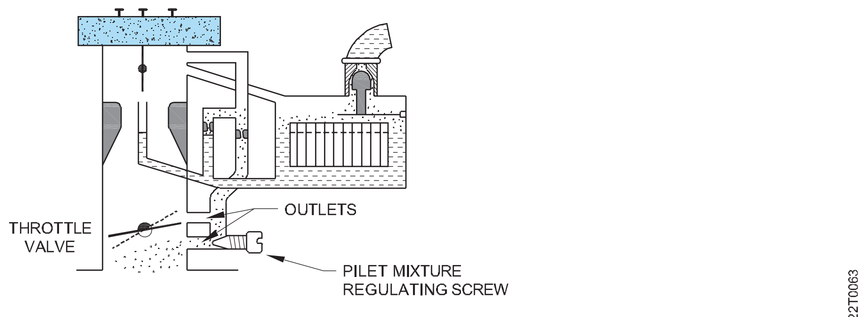
The fuel pump will keep supplying petrol with pressure while the engine is running, whether the carburetor needs less petrol or more. We have just read that we have to keep the level of petrol in the float bowl full. To keep the level of petrol constant, float ball and needle valve are installed which work in the following manner.

The float ball is a hollow ball from which the air is removed. It rises when the bowl is filled with more petrol. As it rises, the needle valve which is stuck with the bowl's lever, rises up. When it rises up, the needle valve sits on its seat, which closes the way for petrol to enter the float bowl.



When the float goes from the bowl to the carburetor through petrol jets, then along with the petrol level going down, the float ball also comes down, due to which the needle valve again falls on the lever and the way for petrol opens up and petrol starts coming into the float bowl. In this way, the level of petrol remains complete in the float bowl.

Idle and slow speed Circuit: To run the engine slowly, we close the throttle a little. By closing the throttle, less air can enter the venture, due to which less vacuum is created inside the venture. When the vacuum is less, the main jet is able to draw less petrol from the float chamber, due to which the engine does not get the supply of mixture to the entire surface and it stops. To run the engine at slow speed or idle speed, another circuit is required through which we can put petrol in the carburetor through a jet at slow speed.



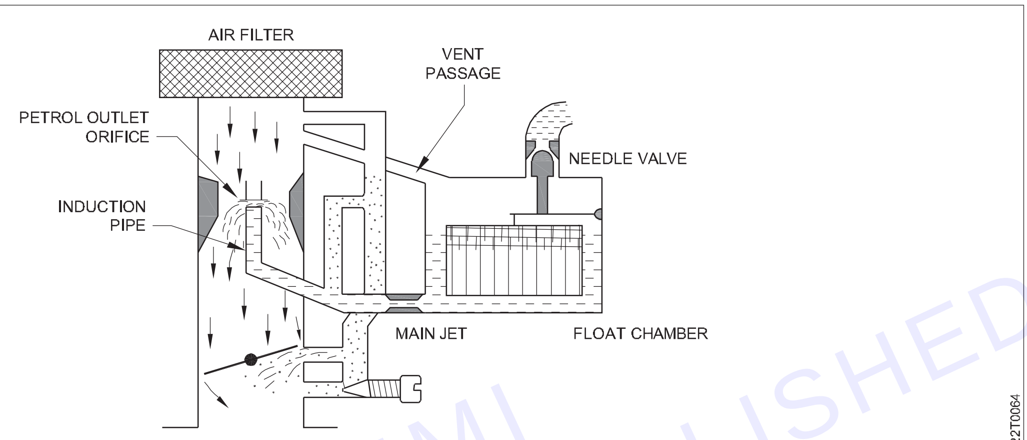
IDLEAND SLOW SPEED CIRCUIT

When the throttle is closed, a lot of vacuum is created below the throttle and inside the manifold. The jet or discharge port of the idle circuit remains below the throttle valve. As mentioned above, there is a lot of vacuum below the throttle valve and since this port is below the throttle valve, due to the vacuum on it, petrol keeps getting drawn from the chamber and goes into the carburetor. And even when the throttle is slightly open, the engine keeps running at idle speed.

There is an adjusting screw to open the idle port or jet more, so that we can increase or decrease the amount of petrol, or adjust it at idle speed.

Sometimes a hole is made in the idle circuit which opens above the venture, so that air is drawn in along with the petrol and is expelled by the jet. This is called air-bleeding of the carburetor

Cruising Circuit



CRUSHING CIRCUIT

Another disc type valve is fitted inside the carburetor but it is in the lower part of the carburetor. It controls the amount of mixture of air and petrol going into the engine

1 To increase or decrease the speed of the engine.

2 To maintain the speed when the load on the engine is less or more.

When the mixture of air and petrol goes in more quantity, more power will be generated. Similarly, when less mixture goes in, less power will be generated.

The throttle valve is connected to the accelerator pedal through a linkage and when the driver presses the pedal, this valve opens due to which more mixture goes into the cylinder and the engine gains speed. As the pressure on the pedal is reduced, the throttle valve closes and the engine starts running slowly.

In many engines, automatic governors are fitted between the throttle shaft and the accelerator pedal linkage which automatically opens the throttle wider when there is excessive load so that the mixture can enter and the engine speed does not decrease.

High Speed or Full Throttle Circuit

To run the engine at higher speeds or to get maximum power from it, a rich mixture needs to be supplied. For this, the ratio of air and petrol has to be 12:1 as compared to 16:1, when the engine is running at normal speed. The following methods are used to supply more quantity of petrol to the engine.

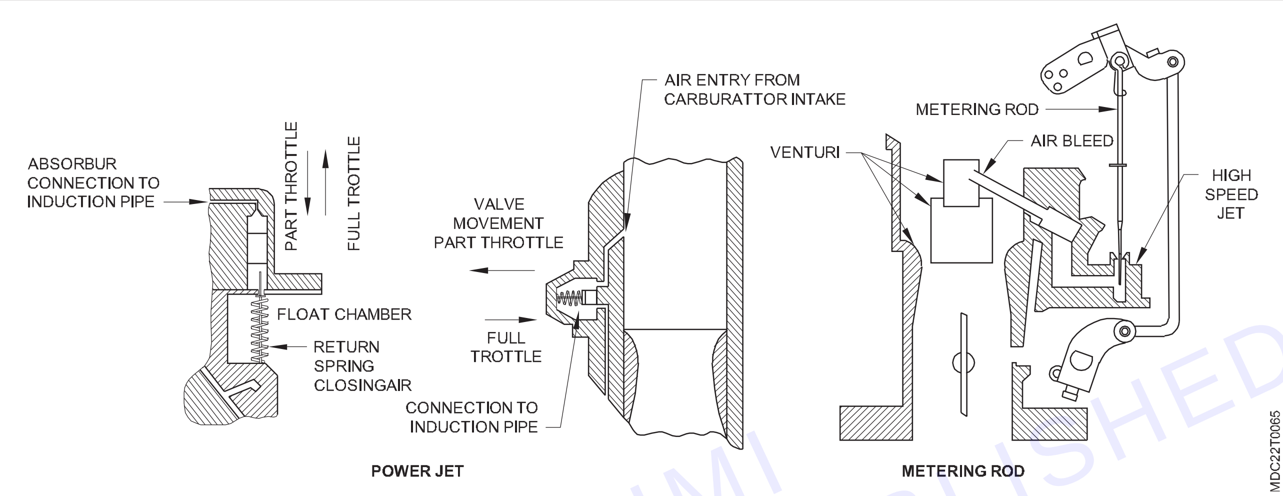
1 Power jet or vacuum set up,

2 Metering rod.

Power Jet: Power jet is operated in two ways. Its mouth opens and closes by a vacuum operated piston. When the throttle is closed, the vacuum in the manifold increases due to which this piston is pulled down and closes the valve. Due to this, petrol is not able to go out through the jet. When the throttle is opened, the vacuum inside the manifold reduces due to which the vacuum pressure on the piston also reduces and it opens the jet with the help of the spring. When the jet opens, more amount of petrol goes into the carburetor and a rich mixture is formed.

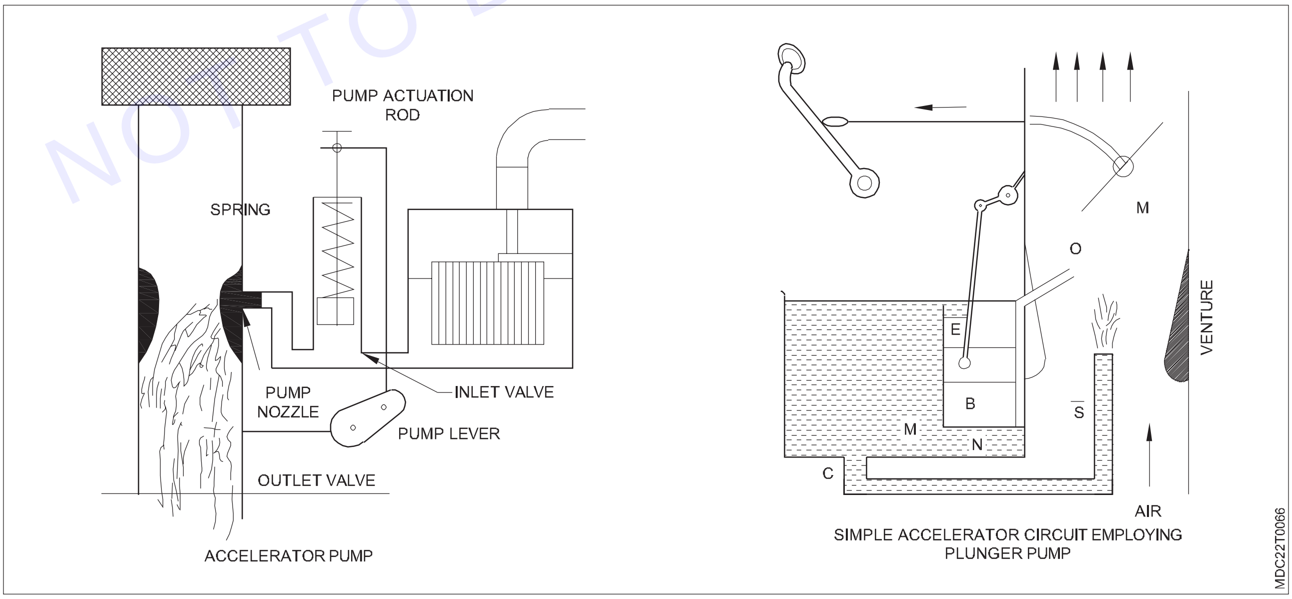
In the power jet, instead of the piston and needle valve, a diaphragm type disc valve is fitted. When the vacuum is high in this valve, it keeps the jet closed through the seat. And as soon as the accelerator is pressed and the throttle opens by pressing the accelerator, the effect of vacuum on the diaphragm reduces and it rises from its seat by pressing the spring, which opens the way for petrol and it can go more into the carburetor through the jet. A disc valve is fitted in the middle of such a diaphragm.

Metering rod: In many carburetors, a metering rod is fitted like a vacuum type power jet. It is in the shape of a needle and steps are made in its lower part. The upper part of this rod is connected to the accelerator lever through a lever. When the driver presses the accelerator, this rod is raised by the lever, which opens the mouth of the high speed jet and a large amount of petrol can go into the carburetor. As soon as the pressure of the foot is removed from the pedal, the metering rod keeps coming down and the path of petrol keeps closing.



Accelerating Pump Circuit: When the engine is accelerated, the main jet supplies the same amount of petrol to the carburetor, whereas the engine needs a little more petrol to pick up speed quickly. Until the power jet starts its work, the carburetor circuit fulfills this requirement.

A small pump is fitted in the accelerator whose plunger is connected to the accelerator links. On pressing the accelerator, this plunger pumps the petrol coming inside the cylinder and puts it in the carburetor through the jet, due to which the engine is able to pick up speed on accelerating. There is another reason for installing such a pump circuit.



When the throttle is opened quickly, a large amount of air enters the carburetor quickly. Before the power jet starts its work, it reaches the manifold without taking petrol vapor because it is lighter than petrol. The accelerator jet sprays petrol into the fast incoming air, which makes the engine pick up speed quickly.

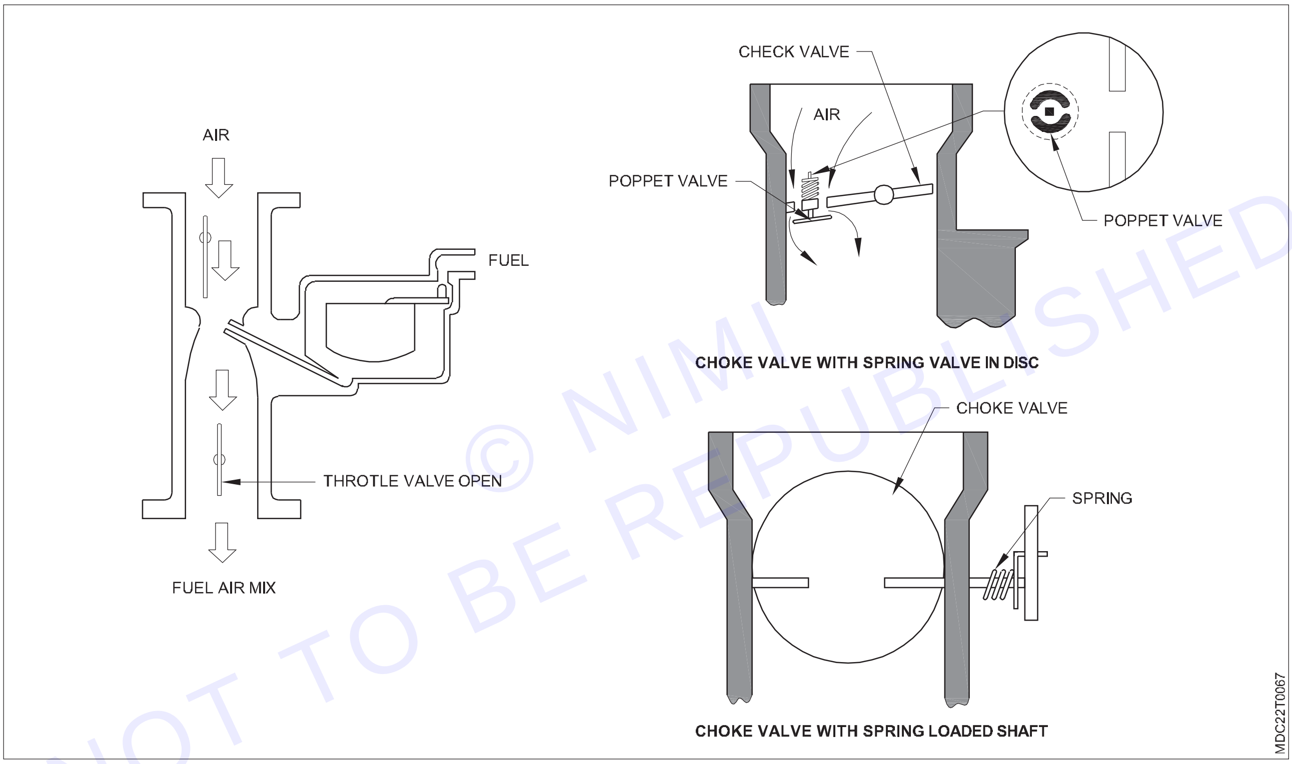
Choke Circuit: When the engine is cold, the engine needs mixture. A disc called choke valve is fitted in the front part of the carburetor from where the air enters. By closing it a little, less air from outside enters the engine through the carburetor. When the engine is rotated to start, a lot of vacuum is created inside the carburetor, due to which a lot of petrol comes out of the float bowl and goes into the inlet manifold and due to the rich mixture, it starts quickly.

The driver can open or close this choke from his seat itself with the help of a flexible cable.

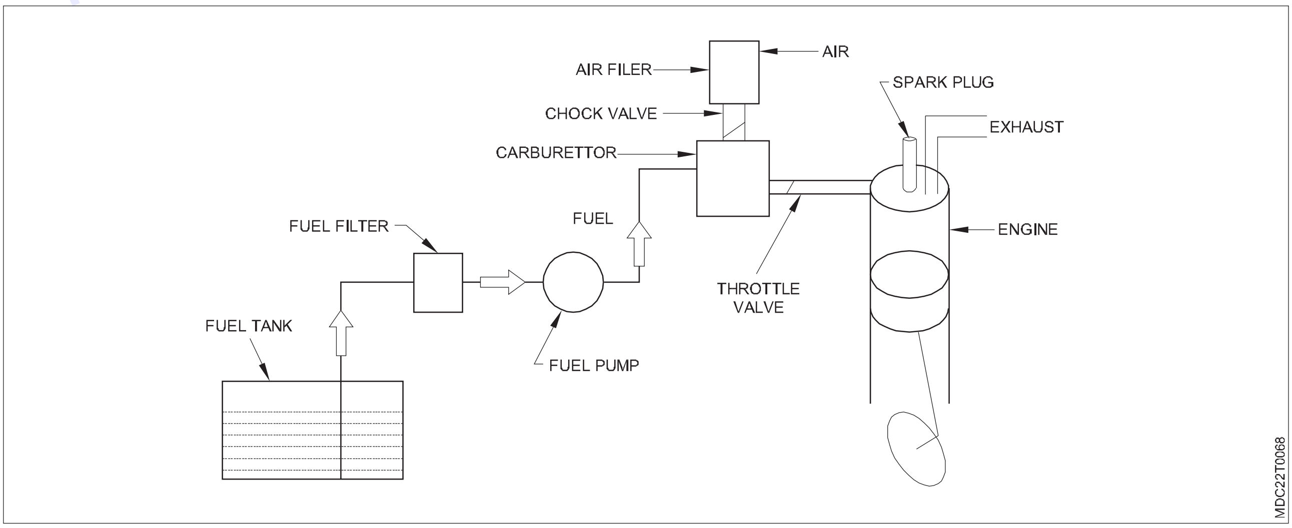
If this choke is accidentally left in the closed position, then combustion will not be complete due to the rich mixture going inside the engine. Therefore, the choke valve should be opened after starting the engine.

Sometimes a small spring loaded valve is fitted in the choke disc, which opens when the vacuum in the carburetor increases when the choke is closed. Through this some fresh air can enter the carburetor.

In another system there is a spring fitted on the choke shaft which keeps it closed in the full choke position, but as the engine speed increases the pressure difference exerts so much pressure on the choke valve that it opens the choke valve against the tension of the spring.



Petrol fuel system and its components such as fuel tank, mechanical fuel pump, electric pump, fuel filters



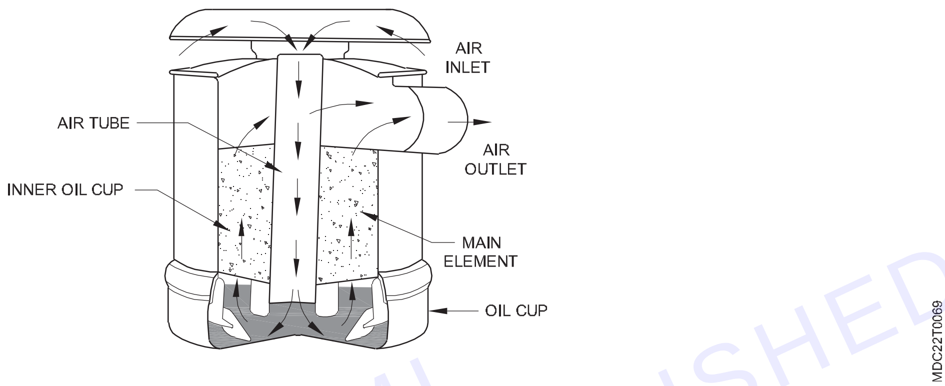
Petrol fuel supply system diagram

Introduction: In I.C (Internal Combustion) engine use a petrol engine for light motor vehicle. There are also use combustion due to the compact size of petrol engine there are also some different type use supply system of fuel in engine. Petrol fuel supply system typically consists of such kind a different types of components like fuel tank, fuel pump, fuel filter, fuel injector (in fuel-injected engines), spark plug and fuel lines. The pump drawn fuel from the tank and sends it to the engine, where it mixes with air and is ignited for combustion. The system ensures the proper amount of fuel is delivered to the engine at all times for optimal performance.

The fuel supply system in a petrol engine comprises various components that work together to transfer set amount of fuel from a car fuel tank to it is engine for combustion.

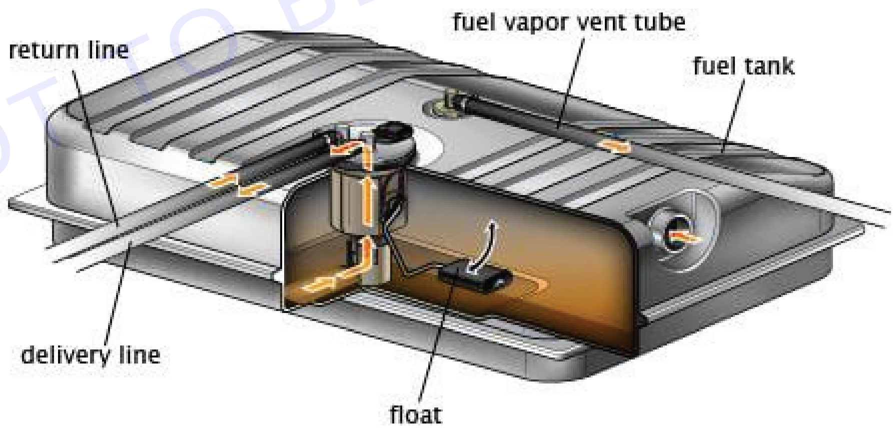
Petrol fuel supply system componentes

Air cleaner



Air cleaner cleans the air as we know that air contain lot of minor particles of dust and dirt so if these entre in the engine having contents of mud and sand etc. It will work as emery when entre in cylinder piston, piston rings etc. thus wear parts faster and make the life of engine shorter. Air filter traps the dust from incoming air and does not allow it to go to cylinder so parts of engine do not wear fast. It also reduces the hissing sound produced by fasting moving of air to intake pipe. In petrol vehicles, it does not allow the fine ball (flame) caused due to back-firing to come out of intake system and save from fire.

Fuel tank



It is a type of tank made of iron sheet which is fixed with chassis of motor vehicles with the help of nuts and bolts. From where the connection of petrol pipe is taken, many time a brass mesh in glass shape is fitted inside the tank so that petrol can be purified before going to pump through pipe. A small pit is designed below the tank to fix a plug inside it so that to transfer petrol as and when required and during cold season air inside the tank become water after condensing. Thus water assemble in this pit so water should be removed by opening the plug.

There are one or two compartments inside of the tank and these are connected with each other by holes. These are so fixed that are running of vehicle petrol tank should not strike with each other.

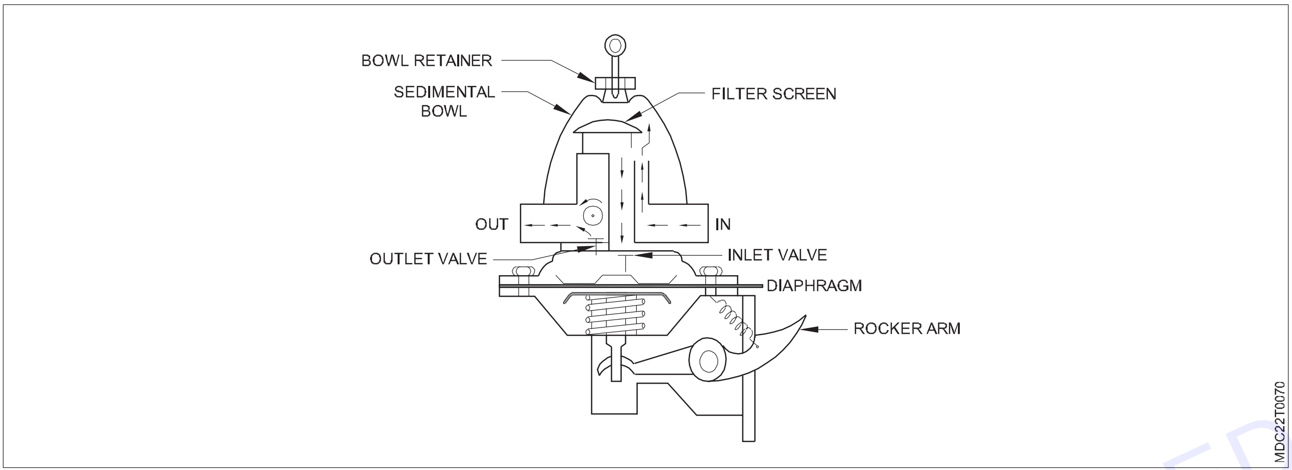
A mouth type shape is made over the tank by which an air is entered in that space thus a vent pipe is attached by which an air enters in the tank. Many vehicles have it is provision inside the tank cap.

Fuel pump: The function of fuel pump is to pump petrol and feed to carburetor. These pump can supply petrol in sufficient quality at all type temperature and make proper a pressure on petrol line. So that to avoid locking of vapors on heating of petrol called mechanical air lock. Generally, there or two types of pumps used in vehicles.

a Mechanical fuel pump

b Electrical fuel pump

Mechanical fuel pump



Mechanical fuel pumps are almost very common and of same type. Mechanical pump of design is fixed with engine by two bolts stud and nut. This is so fitted that eccentric cam on rocker cam on rocker cam shaft of fuel pump is always connected with it. The body of mechanical pump is made by two parts and all others parts fitted in it. It has following main parts:

1 Rocker arm with return spring

2 Lower body

3 Upper body

4 Diaphragm

5 Diaphragm return spring

6 Inlet and outlet valve

7 Filter

These pumps are very common and used in 90% of vehicles.

To the drive the pump a rocker arm in engine is attached with eccentric cam made on cam shaft. On moving the cam shaft of an engine this rocker arm starts to move up and down due to eccentric cam. Second side of rocker arm is hinged to the diaphragm with pin. On moving the rocker arm the diaphragm also start to move up and down. Two valves are fitted in upper side of diaphragm chamber known as inlet valve or outlet valves.

When diaphragm is pull down by rocker arm then vacuum is created in the upper part of chamber. This vacuum opens the inlet valve and petro from fuel tank is sucked in the chamber above diaphragm.

When diaphragms lift up then pressure is built up on petrol in chamber which closes the inlet valve and outlet valve and open the outlet valve and petrol which was filled in the chamber is pushed out to carburetor through pipe.

Now when petrol is filled up in float chamber fitted in engine then float lifted up as the connection of float is with needle valve that closes the passage and stop the supply of petrol in chamber.

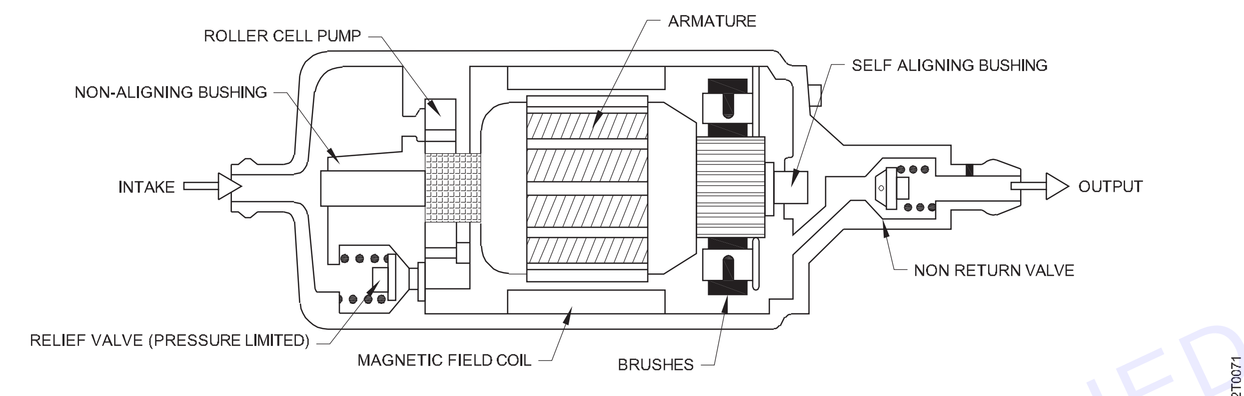
When due to closing of needle valve petrol does not moved forward in carburetor then petrol remains filled up in the chamber over the diaphragm and it remains pressed down and outer rocker arm don't have any connection with eccentric cam. As such as outer rocker arm goes on moving up and down, but as soon as petrol in float chamber of carburetor becomes low then needle valves open and pressure over the diaphragm become low because petrol through outlet valve due to low pressure starts to entre in carburetor. Diaphragm lifted up to pressure via spring and rocker arm again moves down. In these way fuel pump again starts to supply petrol.

In some fuel pumps hand priming lever are fitted with fuel line and carburetor is filled with petrol before starting the engine.

If such lever is out fitted then engine which is not used for long time or engine which is overhaul and carburetor open, to starts these first should be filled up the float bowl with petrol after opening the top cover of carburetor.

In mechanical pumps parts are normally damage after sometimes like returning spring and diaphragm crack, due to these condition sometimes valve is not work properly therefore it should check time to time. If they should need replaced, then replaced it.

Electrical fuel pump



ELECTRICAL FUEL PUMP

In some vehicles instead of mechanical fuel pump electrical fuel pump is fitted which is connected through ignition switch (key) as soon ignition switch is ON this pump starts to function. There are two types of pumps mostly use in automobile sector:

1 Diaphragm type

2 Bellow type

This pump is totally operated in electrically there only need current there are no any critical mechanical it is same pump as per as mechanical only it is drive make it is different

1 Diaphragm type electrical pump

There is a coil fitted in the body of pump, one wire of coil is connected to battery ignition switch while other is earthed. When electric current is passed then due to magnetic field, plunger in the coil is pulled up. This plunger is connected with diaphragm with the result it is also lifted up due to this vacuum is created in the chamber below the diaphragm, which open the inlet valve and sucks petrol from tank and the chamber gets filled up. Due to lifting of plunger the electric point connected with each other and thus break the connection of electric current and effect of magnetic field in coil diminishes. The spring fitted over the diaphragm pushes the diaphragm down along with the plunger and thus closes the inlet valve and therefore pushing the petrol out from the chamber throughout let valve to carburetor.

If carburetor don't required petrol, then diaphragm remains lifted up and pump chamber remains filled with close contact. But a chamber becomes empty then diaphragm comes down due to spring pressure and open the content and pump works in same way.

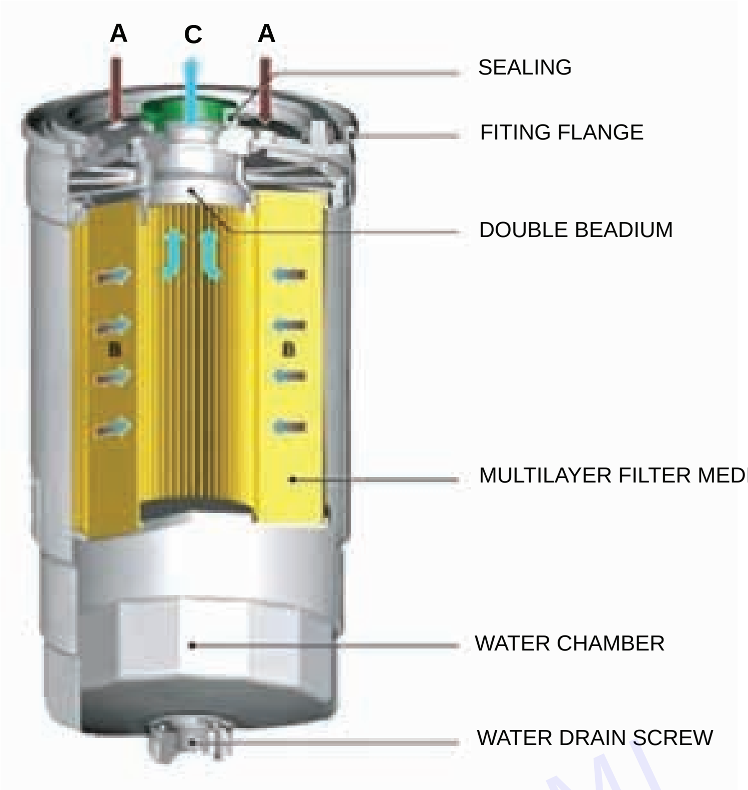
Sometimes diaphragm valve and contact points inside the pump are damaged and these can easily to be replaced, a strainer is fixed inside the pump which should be cleaned at proper interval of time and also insulation of wires should be good so that to avoid short circuit.

2 Bellow type electrical pump

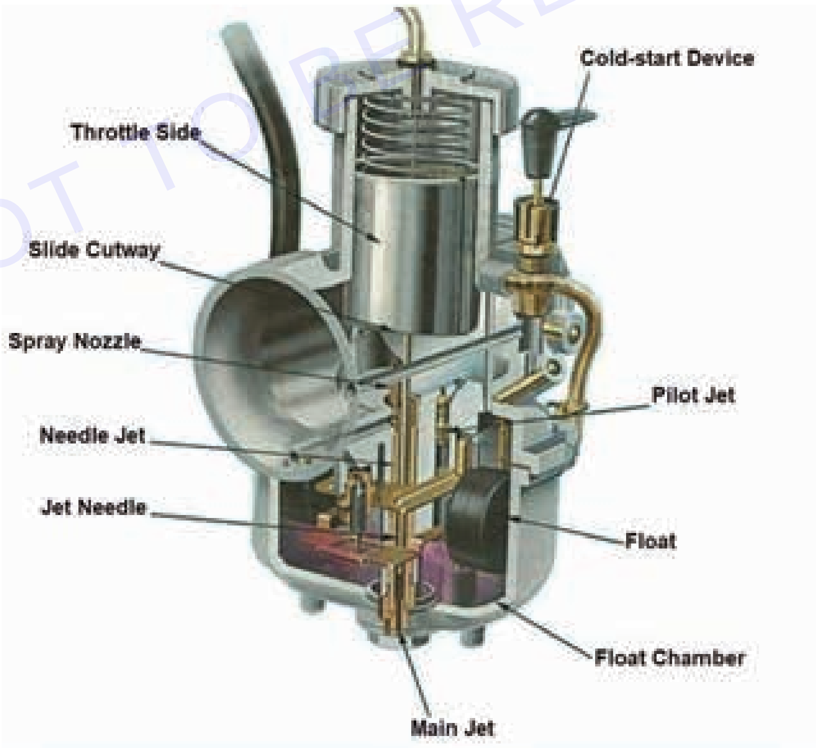
Bellow type pump is same as per diaphragm type pump. It works is also same only one part is different in bellow type pump a flexible metal bellow is used. Otherwise no any different, both pumps are same.

Fuel filter

In some of the mechanical pumps fuel filter is fitted inside it, a strainer is placed in the glass bowl. It requires cleaning at each service. Glass bowl is used to see dust and dirt if entered. Some engines have an extra fuel filter with glass bowl fitted over it and that should be cleaned.


A
C
A
SEALING
FITING FLANGE
DOUBLE BEADIUM
MULTILAYER FILTER MEDIUM
WATER CHAMBER
WATER DRAIN SCREW

Carburetor


Cold-start Device
Throttle Side
Slide Cutway
Spray Nozzle
Pilot Jet
Needle Jet
Jet Needle
Float
Float Chamber
Main Jet

Carburetor is a device which takes petrol from fuel pump in liquid form, converts it into vapors and mixes it with air in correct proportion in engine and enters the cylinder in the intake stroke. The mixture of air and petrol called a fresh charge. It is then compressed during compression stroke and at the end of compression stroke it is ignited with the help of spark plug which causes it to expand and produced force which push the piston down and move the engine.

Every good carburetor should have all above quality. The one of the difficult task which carburetor has to perform is to mix air and petrol in proper ratio at every speed. As some time engine move fast and then slow so when engine is running in slow speed then it does not have any load on it then engine require such type of mixture in which ratio of petrol should be less but engine on high speed then it have full load then engine require rich mixture having more petrol ratio. The air and petrol proper ratio is:

1 Mixing

2 Evaporation

3 Atomization

1 Mixing

The carburetor has to vary the supply of fuel, air and petrol to suit different running conditions. To mix up these in mixture chamber is called mixing.

2 Evaporation

The atomization of air and petrol. It converts into vapors from at certain temperature. This reaction is called evaporation.

3 Atomization

The term atomization means breaking a liquid into very tiny particles.

Importance of maintenance, diagnosis and Servicing carburetor fuel system and its components

Objectives: At the end of this lesson you shall be able to

- demonstrate maintenance, diagnosis and Servicing carburetor fuel system and its components.

Importance of maintenance, diagnosis, and servicing Carburetor

1 **Fuel Efficiency:** Proper maintenance, diagnosis & servicing ensures that the Carburettor provides the correct air-fuel mixture, thereby maximizing fuel efficiency and reducing fuel consumption.

2 **Engine Performance:** Regular maintenance, diagnosis & Servicing helps keep the engine running smoothly.

3 **Emission Control:** A well-maintained Carburettor contributes to reducing harmful emissions, promoting environmental sustainability.

4 **Preventive Maintenance:** Regular checks and adjustments prevent potential issues from turning into major problems, helping to avoid the risk of breakdowns and costly repairs.

5 **Engine Longevity:** Proper maintenance, Diagnosis & servicing prolongs the life of the engine by keeping it clean and free from damage caused by improper fuel mixture.

6 **Cost Savings:** Maintenance & Servicing helps avoid costly repairs, saving money in the long run.

7 **Safety:** Enhances maintenance, diagnosis and servicing safety, preventing engine malfunction that could lead to accidents or breakdowns.

9 **Reliability:** Regular maintenance & Servicing increases the reliability of the vehicle and reduces the chances of breakdown.

10 **Customer Satisfaction:** Solving Carburettor problems and providing a high performing vehicle increases customer satisfaction.

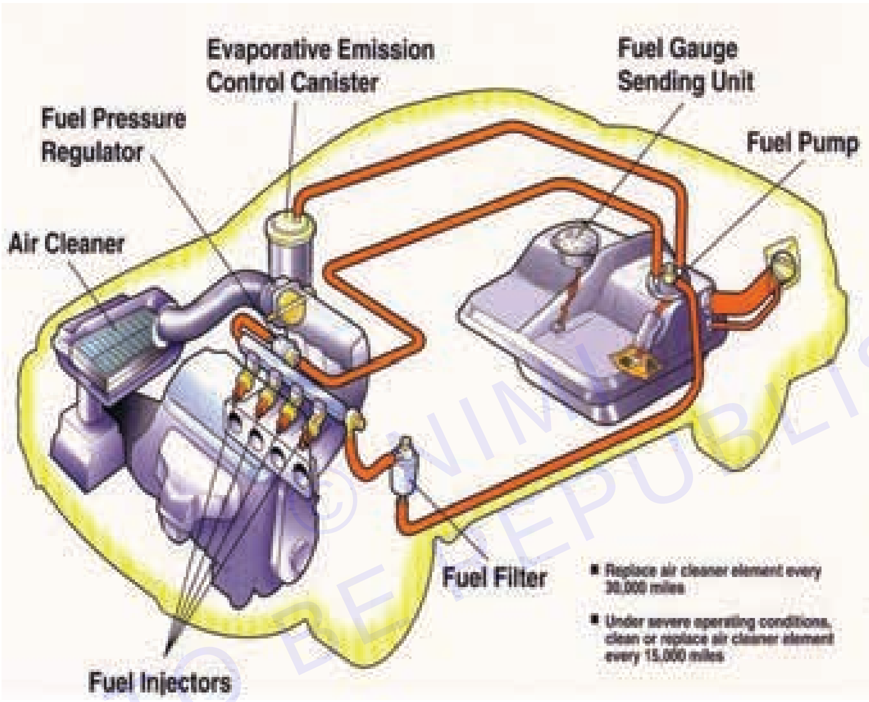
11 Noise Reduction: A well maintained and serviced carburettor contributes to reducing engine noise, making the driving experience pleasant.

12 Smooth Running: A well serviced carburettor helps the engine run smoothly which provides a better driving experience with consistent performance.

Carburettor maintenance, Diagnosis & Servicing is essential to maximize vehicle engine efficiency, performance and lifespan, as well as safety and environmental responsibility.

Servicing of fuel system and its component

Fuel System: The fuel system is made up of the fuel tank, pump, filter and injectors or carburetor, and is responsible for delivering fuel to the engine as needed. Each component must perform flawlessly to achieve expected vehicle performance and reliability.



Fuel system components

1 Injectors

2 Fuel Filter

3 Fuel pump

4 Fuel Tank

5 Fuel lines

6 Carburetor

7 Pressure regulator

8 Pump

9 Pressure system

10 Air cleaner

11 Fuel supply units

12 Gasoline

13 Fuel Gauge

Servicing of fuel system

Common faults and Solution causes

Engine not running normally: -

1 Adulteration in diesel.	i Fill good diesel of correct grade.
2 Filter inserts clogged (choked)	ii Insert new filter elements.
3 Air in the fuel system.	iii Bleed the diesel line
4 Looseness/disruption in accelerator linkage.	iv Remove the defects after seeing them.
5 Injection timing wrong.	v Reset the injection timing.
6 Incorrect phasing of pump/uneven delivery.	vi Do phasing and calibration Of the injection pump.
7 Wear of pump control rod/gear.	vii Replace rod and calibration pump.
8 Leakage in the joints of high pressure pipes.	viii Remove the defects after Seeing them.
9 Blockage in hi. pressure pipe.	ix Remove the faults after seeing them.
10 Nozzle holes clogged/. needle jammed/ spray not working properly.	x Clean the nozzle or insert a new one.
11 Low engine compression. /engine seizure.	xi Overhaul the engine
12 Valve sticky/valve spring broken/valve guide worn.	xii Reset or replace.

Causes of failure of the carburetor fuel system and its components

Objectives: At the end of this lesson you shall be able to

- explain Causes of failure of the carburetor fuel system and its components.

1 Carburetor leaking after filling with petrol (Flooding of carburetor)

1 High pressure of fuel pump

2 The level of the float is high.

3 Puncture of the float ball.

4 Obstruction of movement of float ball up and down.

5 The gasket of the float ball is cut or moved from its place.

6 The needle seat of the Carburetor becomes loose.

7 Burst of needle seat gasket.

8 Wear of seat and needle valve.

9 Soil or garbage getting into the ball seat.

10 Tighten the bank carrier and main gate.

2 Loss of petrol due to low speed and idle speed circuit (Low Speed and Idle Speed Circuits sending Lean Fuel

1 Clogging of the threading hole.

2 Clogging of the hole by the economizer.

3 Horse by pumping low speed jet from idle screw to become closed.

4 Shutdown of the jet installed on the idle port.

5 Leaking of the gasket below the Carburetor.

6 Entering the intake manifold. (For those vehicles which have wipers fitted on vacuum operatic wings).

3 Idle and slow speed go of rich mixture (Rich Mixture on Idle or Slow Speed)

1 opening of low speed jet opening or Keep flowing.

2 The bypass smells like garbage and the amber-bleed smells like garbage.

3 The idle port gets damaged.

4 Idle screw clutches cut off.

5 Improper fit of throttle valve.

4 Less petrol consumption in high speed circuit (High Speed Circuit-Lean Condition)

1 low fuel pressure.

2 blockage in fuel line.

3 float ball level set low.

4 Needle seat not working properly or needle seat being fitted wrongly.

5 Metering rod accidentally set too long.

6 Shortening of metering rod jet.

7 Poor connection between metering rod and throttle opening.

8 Clogged opening from metering jet to nozzle.

9 Throttle or throttle shaft or bushing wear.

5 Rich fuel going into high speed circuit (Rich fuel in High Speed circuit)

1 Excessive pressure in the fuel pump.

2 Level of float ball being set high.

3 Looseness of the gasket or screw of the float ball cover.

4 Spring of metering rod coming out.

5 Spring of metering rod coming out.

6 Metering rod becoming banded.

7 Choke valve slightly closed.

8 Air-bleed hole closes up to main nozzle.

6 While accelerating, the accelerator pump does not send enough petrol or the engine does not pick up quickly. (Accelerator Pump Sending Lean Mixture on Acceleration)

1 Weakening of the spring of the plunger.

2 The washer inside the plunger becomes dry, cut or loose.

3 Leaking valve in feed pump.

4 The petrol pipe coming from the feed pump gets clogged or choked.

5 Slight closure of accelerator jet.

6 Stroke of the pump not being complete.

7 Accelerator pump sending more petrol while accelerating (Accelerate Pump Sending Too Rich Mixture on Acceleration)

1 Increase in stroke of accelerator pump.

2 Enlargement of the hole of the accelerator jet.

8 Cold engine not starting quickly

1 The choke is left open.

2 Jamming of the flexible cable running the choke.

3 Less oil reaching the carburetor.

9 Engine not starting quickly when warm

1 Closing of choke.

2 Flooding the carburetor.

3 Vapor locking in the pipe.

10 Engine stall attempt (Engine Stalz)

1 Idle speed not adjusted properly.

2 Idle fuel mixture not correct.

3 Choke not working properly.

4 Incorrect setting of float ball.

5 Water or garbage getting into petrol.

6 Throttle leak and accelerator pump not working properly.

Parts of the carburetor

1 Venturi

2 needle valve

3 float

4 float chamber

5 throttle valve

6 accelerating pump

7 Body

8 choke valve

Trouble shooting in carburetor fuel system and its components

Objectives: At the end of this lesson you shall be able to

- demonstrate Trouble shooting in carburetor fuel system and its components.

a Leakage of petrol from carburettor

1 If the float is punctured it fills with petrol and sits down in the float chamber. Therefore, the needle valve on it is pulled down and the fuel pump continues to supply petrol, overflowing the float chamber and causing petrol leakage.

2 High float level. Due to this, the petrol level goes above the mouth of the nozzle in the float chamber and petrol leakage starts. For this, the petrol level in the float chamber is two mm below the mouth of the nozzle. It should be set as much.

3 If the float chamber top cover gasket is broken, there will be petrol leakage from that place.

4 Malfunction of needle valve. These include loose fitting of the needle valve seat due to wear or sticking during its up-and-down movement. Due to this, the function of stopping the petrol supply is not properly done by the needle valve and float Petrol level increases in the chamber and petrol starts leaking.

5 Supply of main jet, since the petrol level in the float chamber is up to the main jet, 3. If the main jet is loose, petrol starts flowing through it.

6 Exceeding fuel pump pressure. If the diaphragm return stroke in the fuel pump is too hard, the fuel pump will supply more fuel to the carburetor and the fuel level in the float chamber will be higher than normal, causing fuel leakage.

b Decrease in petrol supply to engine at slow speed

1 Having the pilot jet choked up.

2 Having the hole choke up where the volume control screw is fitted.

3 The gasket below the carburetor is broken or damaged, causing air to be drawn into the suction from that point.

4 Keeping the slow speed adjusting screw tight causes the throttle valve to open too wide and draw in too much air.

5 If the inlet manifold is loosely seated, air is drawn from the side of the inlet manifold.

c supply of lean mixture to engine at high speed

If the engine is supplied with a lean (lean or weak) mixture at high engine speeds, the carburetor mouth mixture fires. This is called “popping-up” or back firing. Poor mixture supply to the engine at high speed can be due to the following reasons -

1 If the fuel pump diaphragm is weakened or due to other defects in the fuel pump and if the fuel pipe is choked up, the petrol supply to the carburettor is not proper.

2 Float level should be slightly adjusted. Therefore, the level of petrol in the float chamber remains low.

3 Choking up of orifice of main jet or emulsion tube.

d Supply of rich mixture at high engine speed

1 High pressure fuel supply from fuel pump.

2 Float level setting too high.

3 Float chamber cover loose.

4 Enlarged main jet orifice,

5 Choke valve partially closed.

6 Inadequate air supply due to air cleaner choke up.

e When the engine speed is increased, the engine does not accelerate quickly

When the engine speed is increased, it decreases without increasing the engine speed first happens This tendency of the engine is called “Flat Spot” in the carburetor.

This error can occur due to the following reasons.

1 Defective accelerator pump diaphragm assembly.

2 Having non return valve or pump jet choke up.

3 Having pump injector choke up.

4 Improper setting of pump control rod.

f Starting the engine and stopping immediately

1 Containing garbage in petrol or having petrol mixed with water.

2 Malfunction of throttle if there is play in throttle shaft bush. Also throttle not opening properly due to accelerator linkage not set properly.

3 Float level not set properly.

4 Addling not set properly.

5 Addling should be set very low.

Components

1 Air Intake

2 Venturi

3 Float Chamber

4 Main Jet

5 Idle Circuit

6 Throttle plate

7 Choke

8 Accelerator pump

9 Butterfly valve

10 Fuel inlet

11 Mixture screws

Importance of testing of fuel pumps

Objectives: At the end of this lesson you shall be able to

- explain Importance of testing of fuel pumps.

Fuel Pump: The purpose of the fuel pump is to measure the right amount of fuel according to the load and speed and deliver it to the cylinder at the right time. A C.A.V fuel pump is shown in Figure, its plunger is operated by a cam and tappet system. This plunger moves up and down in a barrel. The number of plungers in the engine.

Depends on the number of cylinders. There is a rectangular straight groove on the circumference above the plunger which is connected to a helical groove at the bottom. The delivery valve rises up on its seat against a spring due to pressure. Fuel goes to the injector from the delivery valve. Injector injects into the cylinder.

Importance of testing of fuel pump

1 **Performance Verification:** The test ensures that the fuel pump operates efficiently, delivering the correct fuel flow rate and pressure to meet engine demands. It helps maintain optimum engine performance and fuel efficiency.

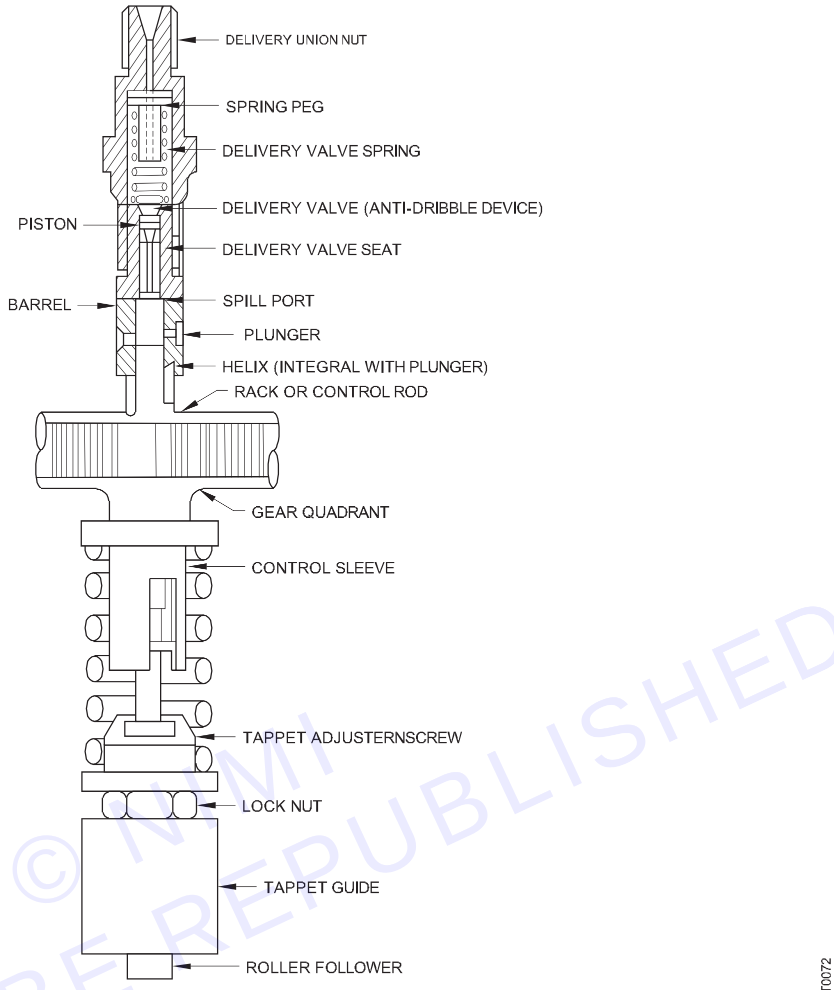
2 **Safety Assurance:** Properly functioning fuel pumps prevent fuel leakage and potential hazards such as fire or explosion. Testing helps identify any issues that could compromise safety.

3 **Preventive maintenance:** Regular testing enables early detection of wear and tear or potential failure, enabling timely repair or replacement. This helps prevent unexpected breakdowns and costly repairs.

4 **Compliance:** Fuel pump testing ensures compliance with regulatory standards and environmental regulations regarding emissions and fuel efficiency. Meeting these standards is essential for vehicle manufacturers and operators.

5 **Customer Satisfaction:** Reliable fuel pump performance contributes to overall vehicle reliability and customer satisfaction. Testing helps ensure that vehicles deliver the expected level of performance and durability.

In short, testing of fuel pumps is critical to ensuring vehicle safety, performance, compliance and customer satisfaction.


DELIVERY UNION NUT
SPRING PEG
DELIVERY VALVE SPRING
DELIVERY VALVE (ANTI-DRIBBLE DEVICE)
PISTON
DELIVERY VALVE SEAT
BARREL
SPILL PORT
PLUNGER
HELIX (INTEGRAL WITH PLUNGER)
RACK OR CONTROL ROD
GEAR QUADRANT
CONTROL SLEEVE
TAPPET ADJUSTERNSCREW
LOCK NUT
TAPPET GUIDE
ROLLER FOLLOWER
MDC22T0072

FUEL PUMB

MODULE 5 : Fuel Supply System (Diesel)

LESSON 31 - 38: Fuel supply system in diesel engines

Objectives

At the end of this lesson you shall be able to

- explain fuel sypply system in diesel engine.

Introduction Fuel supply system in diesel engines

The main function of the diesel fuel injection system is to inject the appropriate amount of fuel into the engine cylinders at the right time and at a predetermined rate. Diesel fuel injection system is classified into solid injection system and air injection system. In solid injection system only liquid fuel can be injected, whereas in air injection system only liquid fuel can be injected.

Liquid fuel can be injected with compressed air. Air injection systems are less reliable and efficient and require a compressor to deliver air at a pressure of 7 mpa or more, which consumes 10% of the power output. Therefore, air injection system is not used at present.

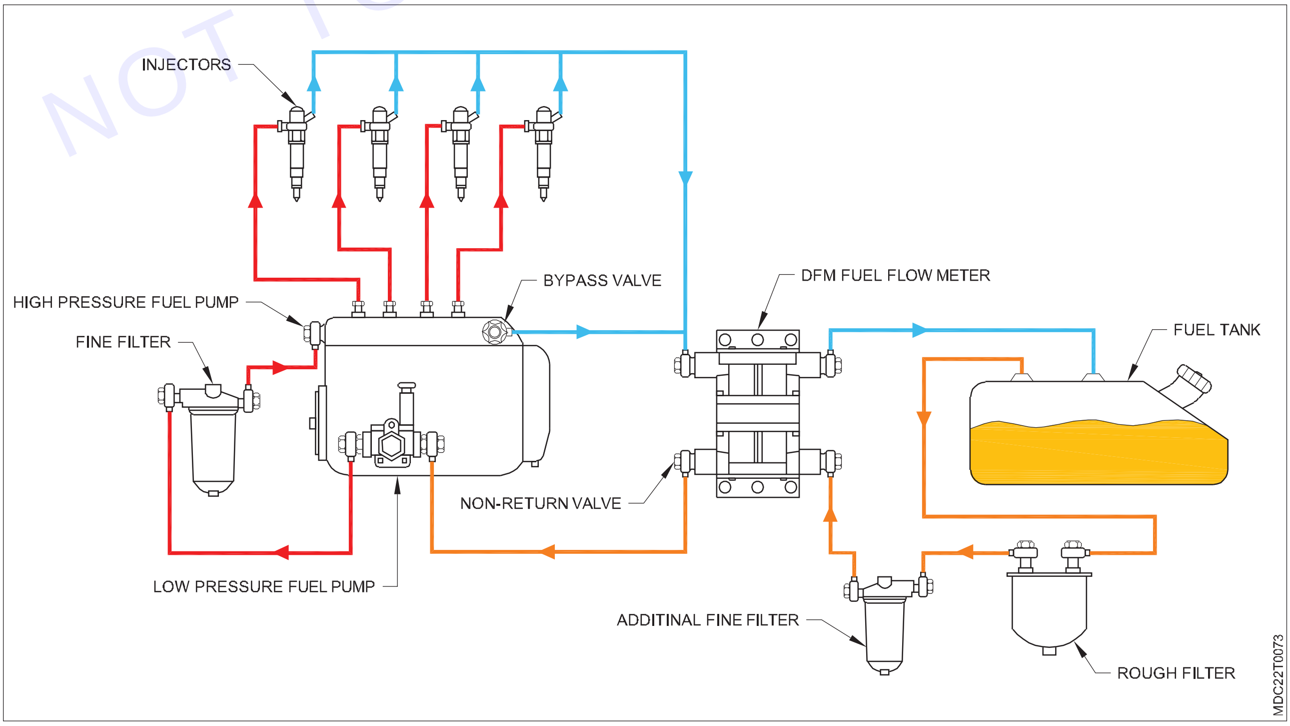
Gravity Feed

- A fuel tank is more than a rectifier or a FIP.
- Mounted slightly higher than the pump.
- So when the cock is released, the fuel automatically descends under its own weight.
- This is called gravity feed.
- This method was used on older cars.
- Now this method is used on scooters, motorcycles.

Pressure feed system

In this method, the fuel feed pump draws the fuel water through the fuel water separator ferrofilter in the fuel tank and delivers it to the fuel injection pump FIP at low pressure through the primary pre and secondary e2micro filters. And the FIP delivers high pressure fuel to the injectors (fuel valves, fuel nozzles, atomizers) as per engine requirements. And the injector works to spray into the combustion chamber.

Water Separator - Ferrofilter



This separates the water content of the fuel. it is a transparent bowl made of glass or plastic. since water is heavier than diesel in this, it stays at the bottom and the top diesel moves forward. a drain plug is provided to drain the water

Feed Pump/Lift Pump

A vacuum is created in the pump and the fuel is drawn from the tank and delivered to the fuel injection pump at low pressure through the primary and secondary filters. When FIP does not consume fuel. At that time the feed pump is working in idling state. A priming pump is provided to remove air from the fuel system when the engine is shut down (air lock).

Which delivers the fuel in this tank to the FIPs when the engine is off.

Fuel Filter

A fuel filter is installed to ensure that pure diesel is supplied to the diesel engine. Feed pump, f.i. clearance between moving parts in pump and injector is very less. If dirt or debris gets stuck in the four microns, the part cannot function properly.

Fuel due to which filters come in two types, single and double. A no hole fuel filter is mounted on the chassis or bolted to the engine. Which should be planted in four microns. Filtering

Fuel injection pump

This pump is used to supply diesel to the injectors before the piston reaches TDC at the end of the compression stroke. This pump supplies diesel to each injector as per engine requirement and firing order at a pressure of about 200 bar. This also shuts down the engine.

Fuel injector

F. A fuel injector is mounted on the cylinder head to spray high pressure fuel from the eye pump into the combustion chamber. Diesel is sprayed uniformly throughout the combustion chamber by the fuel injector. This completes the combustion by mixing with sufficient oxygen and thereby reducing the amount of carbon.

Diesel fuel & its properties combustion processes

Objectives: At the end of this lesson you shall be able to

- explain properties of Diesel fuel
- explain Cumbustion process.

Diesel Fuel Properties

1 **Chemical Composition:** Diesel fuel is composed of hydrocarbons obtained by fractional distillation of crude oil.

2 **Density:** It is denser than petrol, meaning it contains more energy per unit volume.

3 **Energy Density:** It has higher energy density than petrol, so it is more efficient for heavy duty uses.

4 **Viscosity:** Diesel fuel is more viscous or thick, which affects its flow.

5 **Combustion Temperature:** Diesel fuel requires a high temperature to catch fire because of its low volatility.

6 **Sulphur Content:** Diesel fuel used to have a high Sulphur content, but regulators have reduced Sulphur levels for environmental reasons.

7 **Cetane Number:** Cetane number is a measure of the flame quality of diesel fuel. Higher Cetane numbers indicate better flame quality.

8 **Flash Point:** Diesel fuel has a higher flash point than petrol, which means it requires a higher temperature to burn.

9 **Colour:** Diesel fuel ranges from light to dark brown.

10 **Storage Stability:** Diesel fuel has good stability during storage, but if not handled properly, it can degrade over time due to the growth of contaminants or oxidation.

Combustion process of Diesel fuel:

1 In a diesel engine, air is compressed under high pressure and temperature in the combustion chamber.

2 Diesel fuel is injecting directly into the combustion chamber.

3 The high temperature and pressure of the compressed air ignites the diesel fuel without the need for a spark.

4 The combustion of diesel fuel releases energy, which pushes the piston down, thereby propelling the vehicle.

5 Diesel fuel is produced in the form of carbon dioxide (CO2), water vapour (H2O), nitrogen oxides (NOx), and particulate matter.

Study about conventional diesel fuel system and its components such as fuel tank, fuel feed Pump, electrical pump, fuel filters, water separators, fuel injection pumps, governors, injectors etc. Importance of maintenance, diagnosis and Servicing diesel fuel system and its components. Causes of failure of the diesel fuel system and its components

Objectives: At the end of this lesson you shall be able to

- understand about conventional diesel fuel system and its components
- explain Importance of maintenance, diagnosis and Servicing diesel fuel system and its components
- demonstrate Causes of failure of the diesel fuel system and its components.

Study about conventional diesel fuel system

A conventional diesel fuel system typically consists of components like the fuel tank, fuel lines, fuel filter, fuel pump, fuel injectors. The system delivers diesel fuel from the tank to the engine's combustion chambers, where it mixes with air and ignites under compression to generate power. The fuel filter ensures that the fuel entering the engine is free from contaminants, while the fuel pump pressurizes the fuel for efficient injection into the combustion chambers via the fuel injectors. Additionally, modern diesel engines often employ electronic control systems to optimize fuel delivery for improved performance and emissions.

Components of conventional diesel fuel system

- **Fuel tank:** The Fuel tank is provided for storing diesel required for running the engine. It is constructed of either pressed sheet metal with welded seams and special coating to prevent corrosion or fiber glass reinforced plastic materials. It may be round or rectangular in shape. It is mounted above the engine assembly.

- **Fuel pipe:** Fuel pipe between the fuel tank and the feed pump is called suction pipe, the pipes between F.I.P. and the injectors are called high pressure pipes. An over flow pipe is provided on fuel filter bowl and injectors to supply excess fuel back to fuel tank.

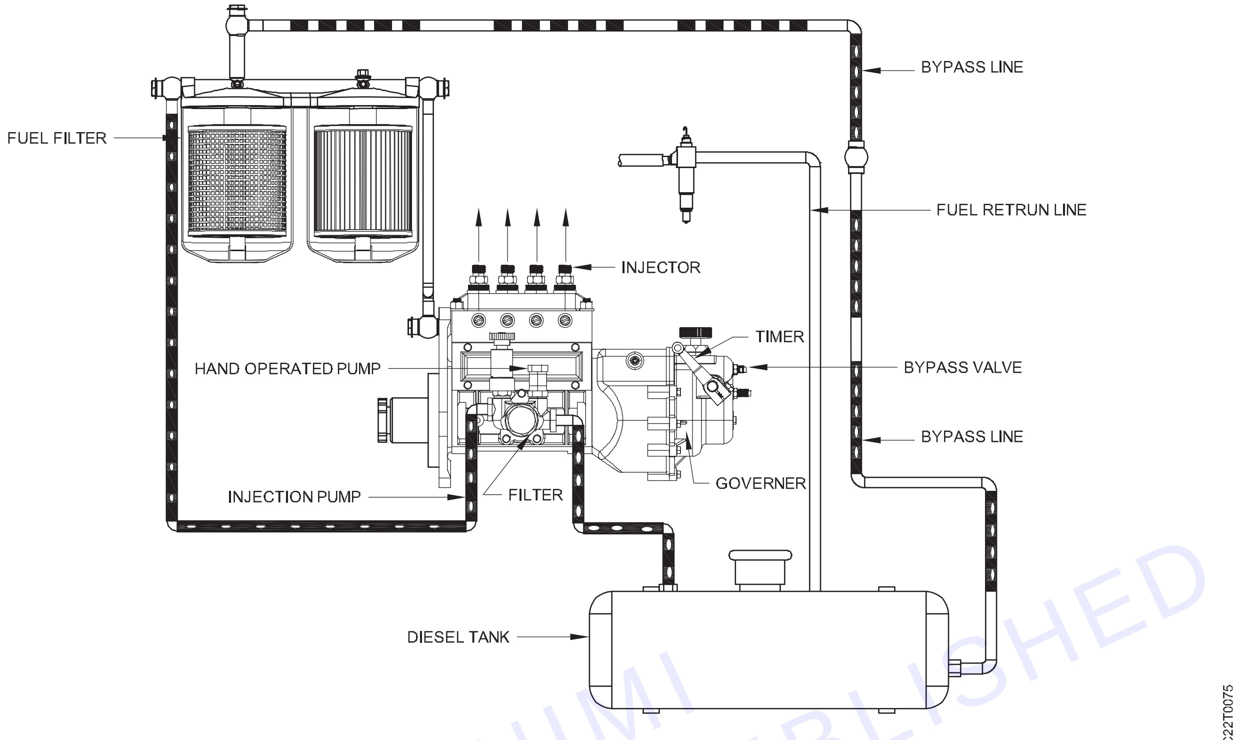
- **Fuel filter:** Fuel filter assembly is used in between feed pump and fuel pump. It's used for cleaning diesel fuel and separate the water from the fuel.

- **Fuel feed pump:** A feed pump is usually mounted on the F.I.P. and is driven by the camshaft of F.I.P. It sucks fuel from fuel tank and supplies it to fuel filters.

- **Fuel injection pump:** Fuel Injection Pumps are designed to deliver specific quantity of fuel to the combustion chamber through an injector at a specific time.

- **Governors:** The governor is a device for holding any speed steady between idling and maximum speed. The fuel injection pump operates in conjunction with a governor, which is required to control the injected quantity of fuel so that the engine neither stalls when idling nor exceeds the maximum speed for which it is designed.

- **Fuel injector:** The function of the fuel injector is to deliver finely atomized fuel under high pressure to the combustion chamber for the engine.



FUEL DISTRIBUTION SYSTEM IN DIESEL ENGINE

Diesel fuel tank, fuel feed pump and electrical pump.

Fuel Tank

The Fuel tank is provided for storing diesel required for running the engine. It is constructed of either pressed sheet metal with welded seams and special coating to prevent corrosion or fiber glass reinforced plastic materials. It may be round or rectangular in shape. It is mounted above the engine assembly.

Parts of the fuel tank

- Filler neck and cap
- Baffle
- Fuel gauge sensing unit (Float)
- Filter
- Sediment bowl and drain plug

Filler neck is provided for pumping diesel into the fuel tank. A cap is provided for closing the tank tightly. A vent hole Is provided either in filler neck or in cap to maintain Atmospheric pressure in the tank above the fuel. Baffles are provided in the fuel tank to minimize the Slushing of fuel due to movement inside the tank. Fuel gauge sensing unit is provided to know the level of fuel Available in tank. It consists of a float resting on the surface of the diesel in the tank. The float with the help of the Electrical sensing system indicates the level of the fuel Available in the tank, on the dash board fuel-gauge. Filter is provided at the lower end of the suction pipe. It Filters heavy foreign particles. At the bottom of the fuel tank a drain plug is provided to Collect sediments and drain it out of the tank.

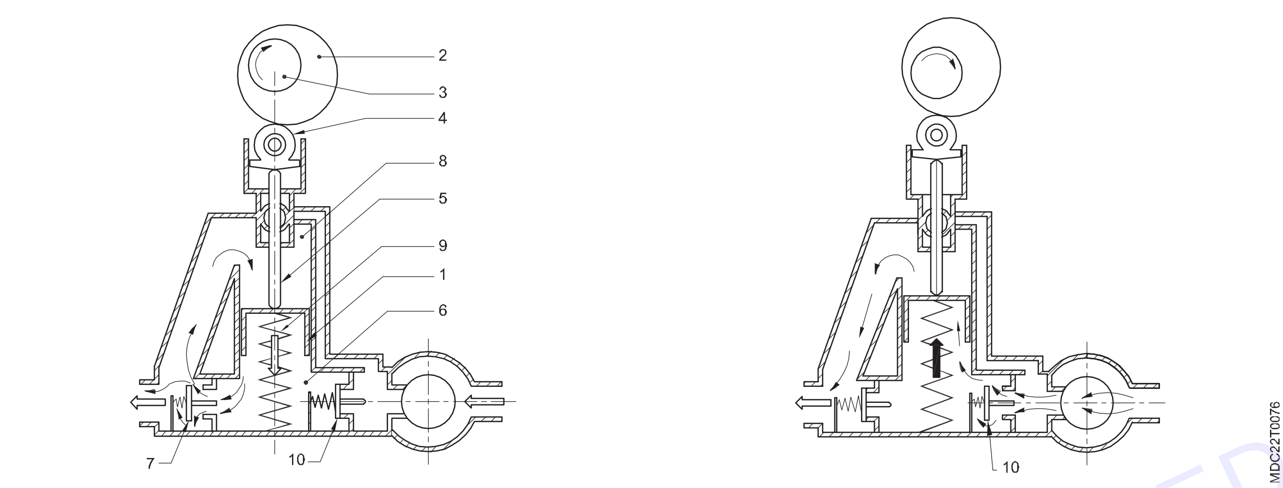
Function: A feed pump is usually mounted on the F.I.P. and is driven by the camshaft of F.I.P. It sucks fuel from fuel tank and supplies it to fuel filters.

Construction

The fuel feed pump consists of a barrel, a plunger, a plunger return spring, spindle, roller tappet, suction and delivery valves, hand primer and pre-filter.

Working

The feed pump plunger (1) (Fig 1 & Fig 2) is driven by the cam (2) provided on the F.I.P. camshaft (3). When the plunger moves “downwards” by means of roller tappet (4) and pressure spindle (5) a portion of the fuel present in the suction chamber (6) is delivered through the pressure valve (7) to the pressure chamber (8) and the plunger spring (9) compressed in an intermediate stroke. Towards the end of this stroke the spring loaded pressure valve closes again.



As soon as the cam or eccentric has passed its maximum stroke, plunger, pressure spindle and roller tappet move “upward” due to the pressure exercised by the plunger spring. A portion of the fuel present in the pressure chamber is thereby delivered to the fuel injection pump through filter. However, fuel is sucked simultaneously from the fuel tank to the suction chamber through the primary filter provided in the feed pump and suction valve (10). When the pressure in the feed pipe exceeds a specified, pressure the plunger spring lifts the plunger only partially. The quantity of fuel delivered per stroke in this is comparatively smaller. When the fuel pipe line is full and the F.I.P. does not need further fuel the feed pump should be put out of action. Due to the excess fuel in the fuel outlet line the pressure in the pressure chamber, holds the plunger in the top position putting the feed pump out of action. During this period only spindle works. The moment the pressure falls down the spring forces the plunger down and the pumping action is resumed. This action during which fuel is not supplied by feed pump is known as idling of feed pump.

Hand priming device

The hand priming device is screwed into the feed pump above the suction valve. When the engine is at rest, with the aid of the hand priming device fuel can be pumped from the fuel tank through the filter to the F.I.P. In order to operate the primer, the knurled knob is screwed out until the plunger can be pulled upwards causing the suction valve to open for fuel to flow into the suction chamber. When the plunger is pressed down the suction valve closes while the pressure valve opens and fuel flows through the feed pipe and the filter to the F.I.P. After the use it is essential to screw the knob again in its original position.

Preliminary strainer

The preliminary strainer is usually attached to the feed pump. The function of the preliminary strainer is to prevent the coarser impurities at a very early stage. It consists of a housing with a nylon/wire gauge insert or a wire mesh sieve

Types

There are two types of fuel feed pumps.

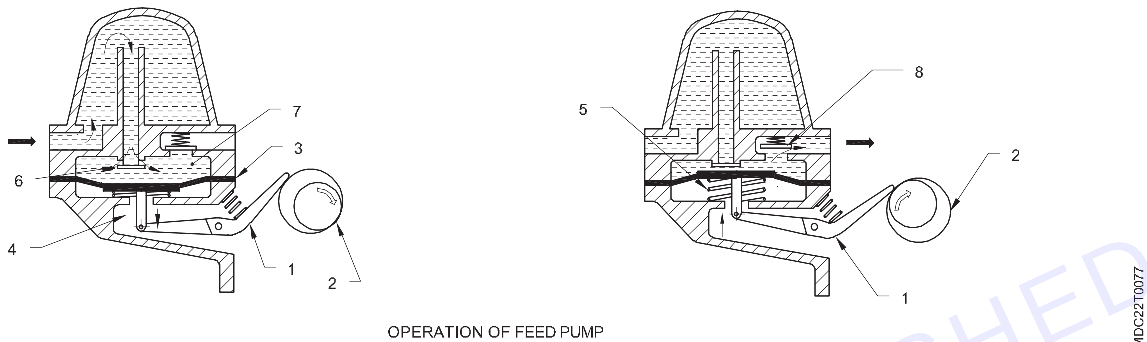
- Mechanical
- Electrical

Mechanical type feed pump

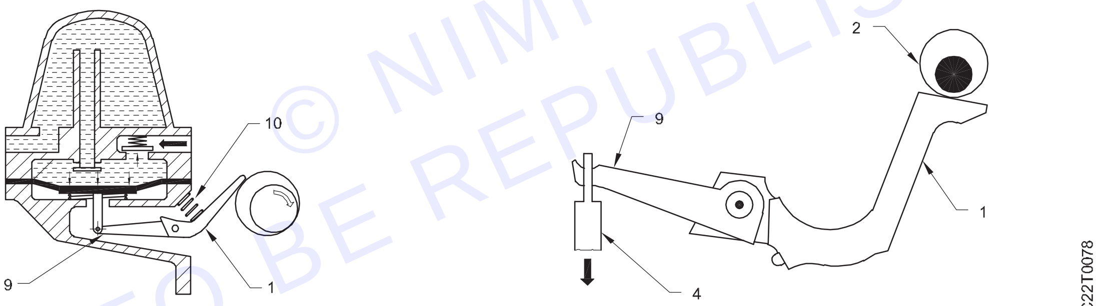
A mechanical pump is mounted on the engine and is operated by a camshaft. This pump consists of an air chamber divided in the Centre by a flexible diaphragm. Operation of feed pump (Fig.1) The rocker arm (1) is actuated by the camshaft (2) and moves to and fro. This makes the diaphragm (3) to move up and down along with the spindle (4) and the spring (5). During the downward motion of the diaphragm, a partial vacuum is created and the inlet valve (6) opens, allowing the fuel to be sucked into the top chamber (7). When the diaphragm moves upward, the inlet valve (6) closes and the fuel is forced through the outlet valve (8) into the pipe line to the carburettor float chamber. The pressure developed is 0.18 kg/cm2 to 0.3 kg/cm2.

Idling action (Fig 2 &3)

When the carburettor float chamber is full, the pumping action has to be stopped, to avoid flooding of the carburettor. At this condition the needle value in the float chamber remains closed and a back pressure develops in the pipeline. This pressure keeps the diaphragm depressed and the link (9) remains in the downward position. The rocker arm (1) moves without affecting the motion of the diaphragm. A spring (10) is provided between the rocker arm (1) and the pump body to avoid any rattling noise of the rocker arm (1) during the idling operation.



OPERATION OF FEED PUMP



IDLING ACTION

IDLING ACTION

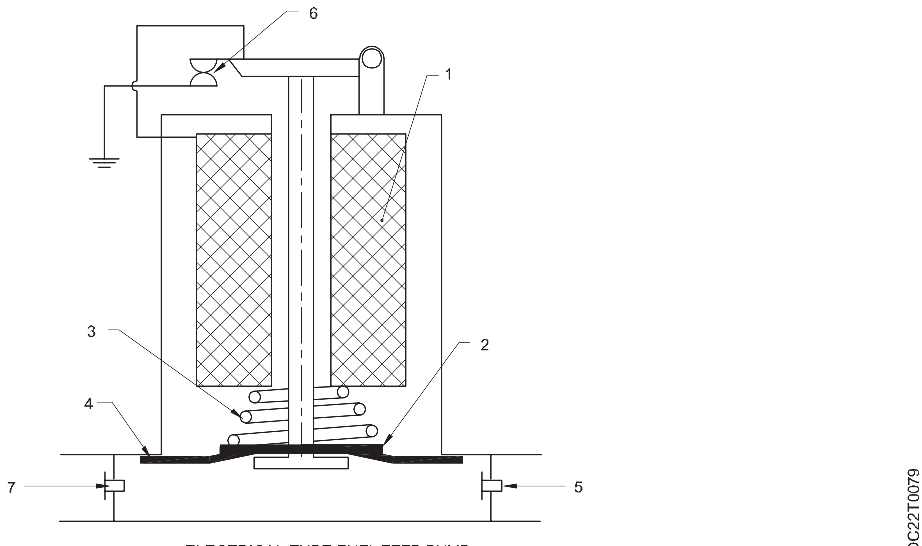
Electrical type fuel feed pump (Fig 4)

A battery operated fuel feed pump can be mounted at any convenient position. These are of two types.

- Diaphragm type
- Bellow type

When the ignition is switched on, the solenoid (1) of the pump is energized and the armature (2) is attracted to the magnetic core against the spring's (3) tension. This causes the diaphragm/bellow (4) to flex. It creates a partial vacuum in the pumping chamber. Petrol is sucked in the pump chamber through the inlet valve (5) from the petrol tank. When the armature (2) reaches its stop position, the bronze plunger opens the contact points (6) and cuts off the electric connections to the solenoid (1).

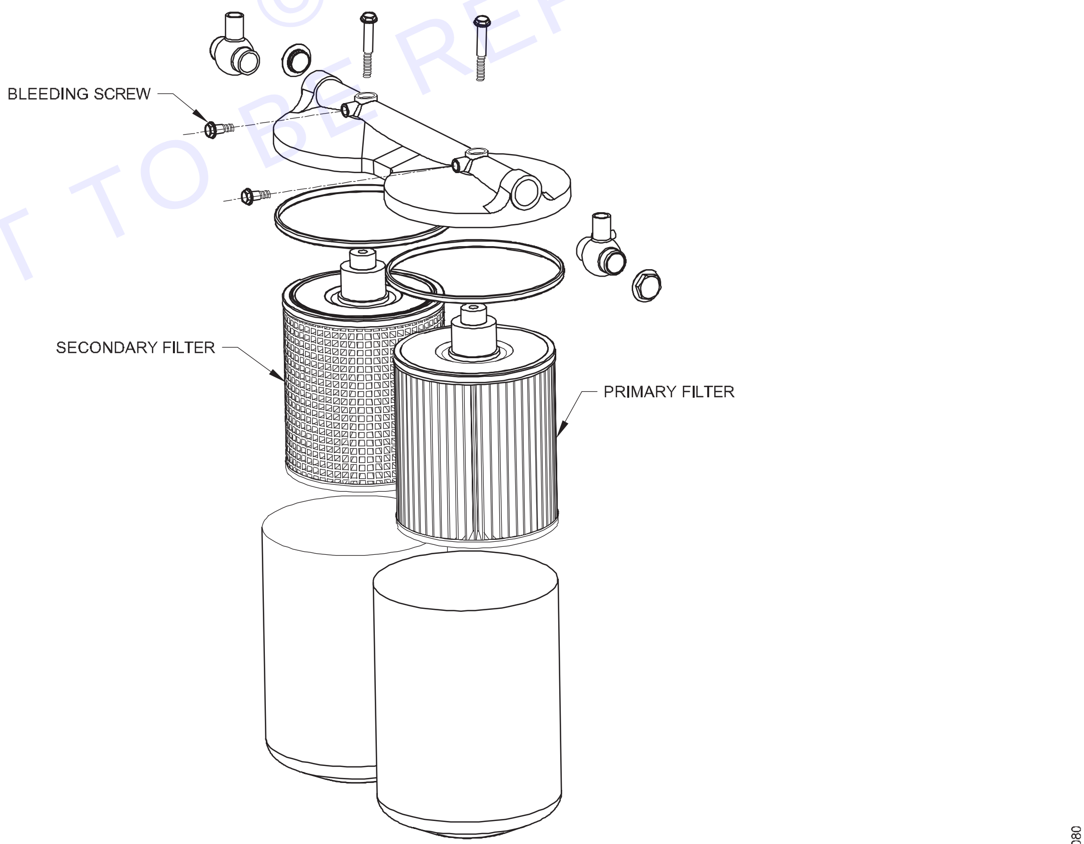
This results in de-energization of the solenoid (1). Now the spring's (3) pressure moves the armature along with the diaphragm/bellows (4) downwards, and the fuel in the chamber flows out to the carburettor through the outlet valve (7). This movement of the armature makes the contact points close and again the cycle is repeated at the rate of 50 to 60 times per minute till the float chamber is filled up. Idling action of the pump Once the float chamber is full, the needle valve in the float chamber closes the inlet passage of the carburettor. This results in back pressure being developed in the pipeline. Due to this back pressure, the armature is always pressed in the upward position which keeps the contact points open. This keeps the pump out of action till the fuel level in the float chamber goes down.



ELECTRICAL TYPE FUEL FEED PUMP

Diesel fuel filter and water separator

Diesel fuel filter - Various types of measures are taken to purify the fuel during production, yet some dirt still remains in the fuel. Apart from this, the dirt of the means used to transport diesel from one place to another also gets mixed in the diesel, hence it is necessary to clean the diesel properly before delivering it to the injectors. Diesel itself is a heavy oil and if dust, soil particles etc. get mixed in it, it creates blockage while going to the transfer pump, fuel injection pump and injector etc. used in the fuel system. There are very narrow passages in these parts, in which dirt gets stuck or freezes and closes those passages. Therefore, filters are used to purify fuel in diesel engines. There are arrangements at many places to filter diesel, but two main filters are definitely used. In these, paper, cotton and fine wire mesh etc. are used as elements to filter diesel.

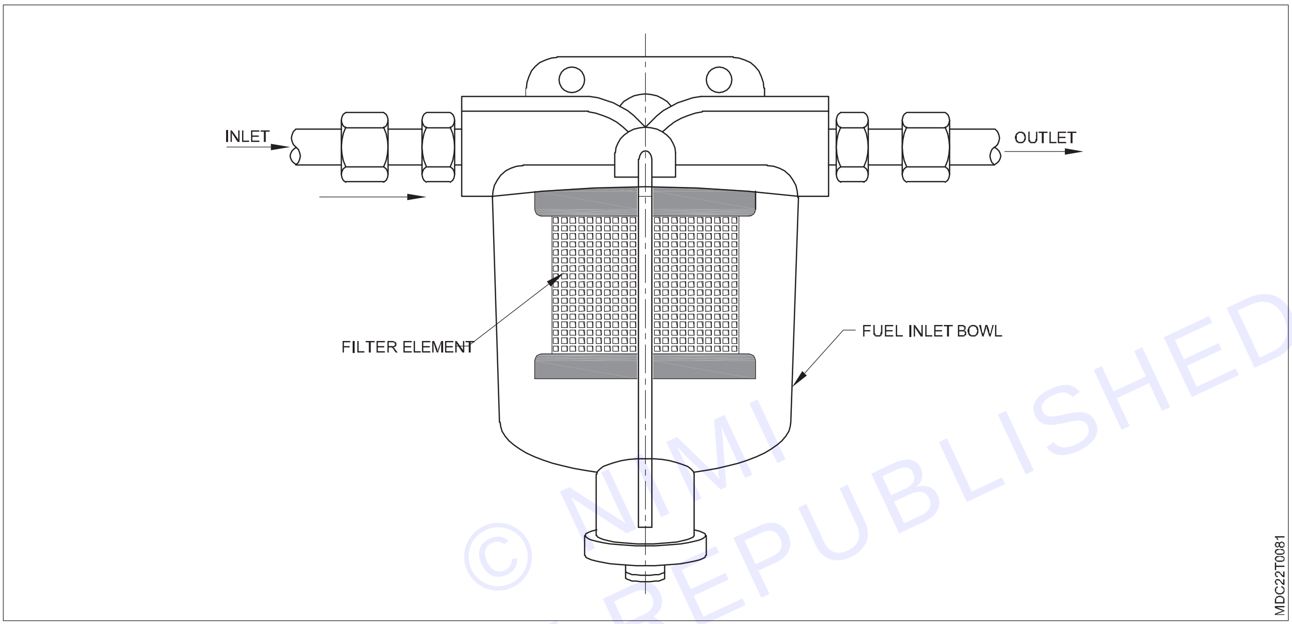


DIESEL FUEL FILTER

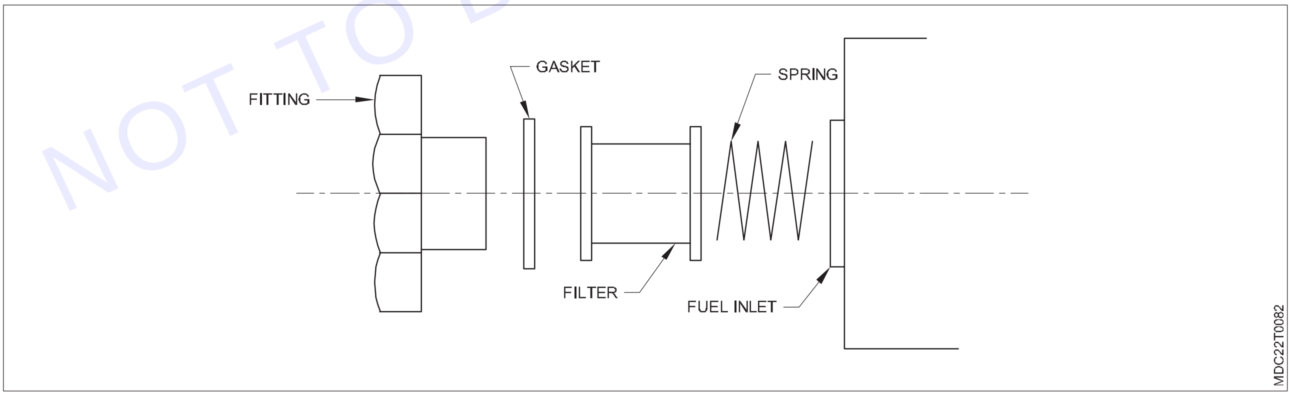
Filters are made in the shape of round boxes, which are closed with a lid. In this lid, there are passages for entry and exit of fuel. Diesel comes from the entry path on the sides of the element and gets cleaned and comes out through the exhaust path through a pipe fitted in the middle. Whatever be the type of diesel filter, it is very important to clean it from time to time, because the dirt mixed in diesel blocks the diesel passages in the filter. Due to this, proper amount of diesel does not flow into the filter.

Types of fuel filter

Ceramic type fuel filter - This type of filter is installed between the carburetor and the fuel pump or tank. It consists of a glass bowl, inside which there is a ceramic filter and strainer. The fuel first comes from the inlet into the glass bowl, then passes through the strainer and is filtered and goes to the carburetor from the outlet. This type of filters are also used in some motorcycles

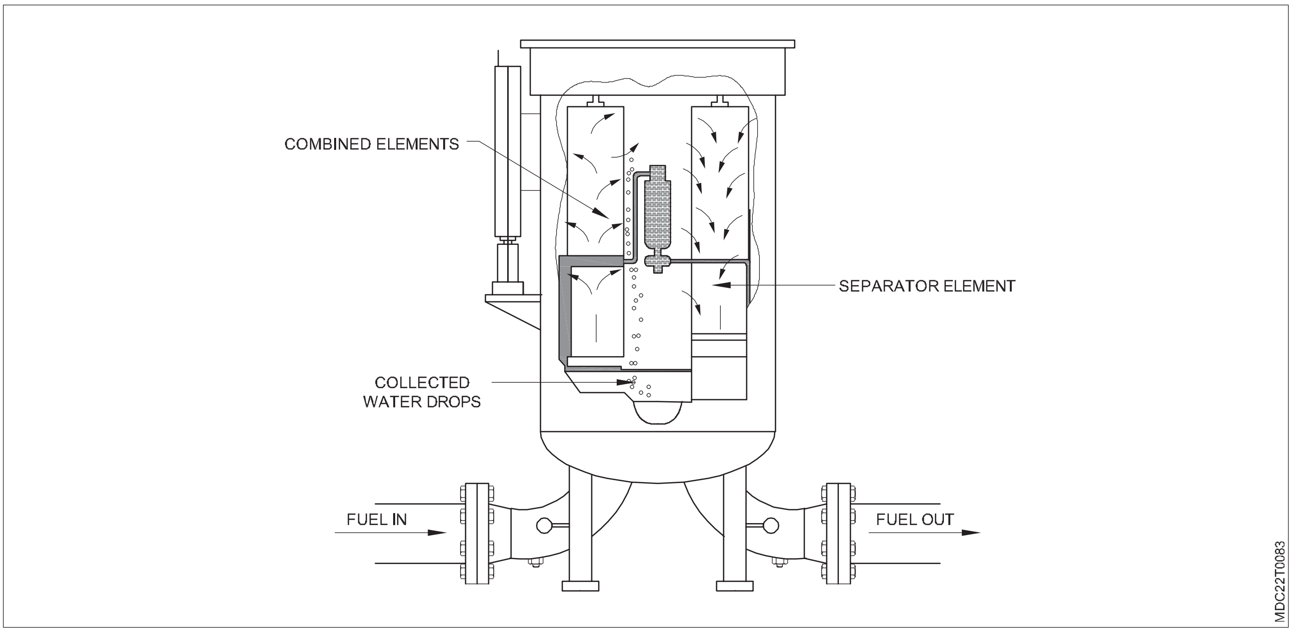


Carburettor fuel filter - This filter is installed in the fuel inlet passage of the carburetor. There is a filter made of pleated paper inside it, which is tightened by a brass union. In-line filters are also used in some places



Water separator - The water separator is installed between the diesel tank and the fuel pump. Diesel in vehicles quickly becomes contaminated by water, because diesel absorbs water more than petrol. For this reason, water separator is used in diesel engines. Water separator is a device to separate water from diesel. It keeps collecting water mixed with diesel inside itself. It is installed near the fuel filter. This filter is made of paper element. It has a transparent bowl at the bottom, which has a drain plug. Diesel water keeps forming in the separator.

From here the water mixed with diesel keeps collecting in the bowl and the diesel goes into the fuel filter. Water is drained from the bowl from time to time through the drain plug



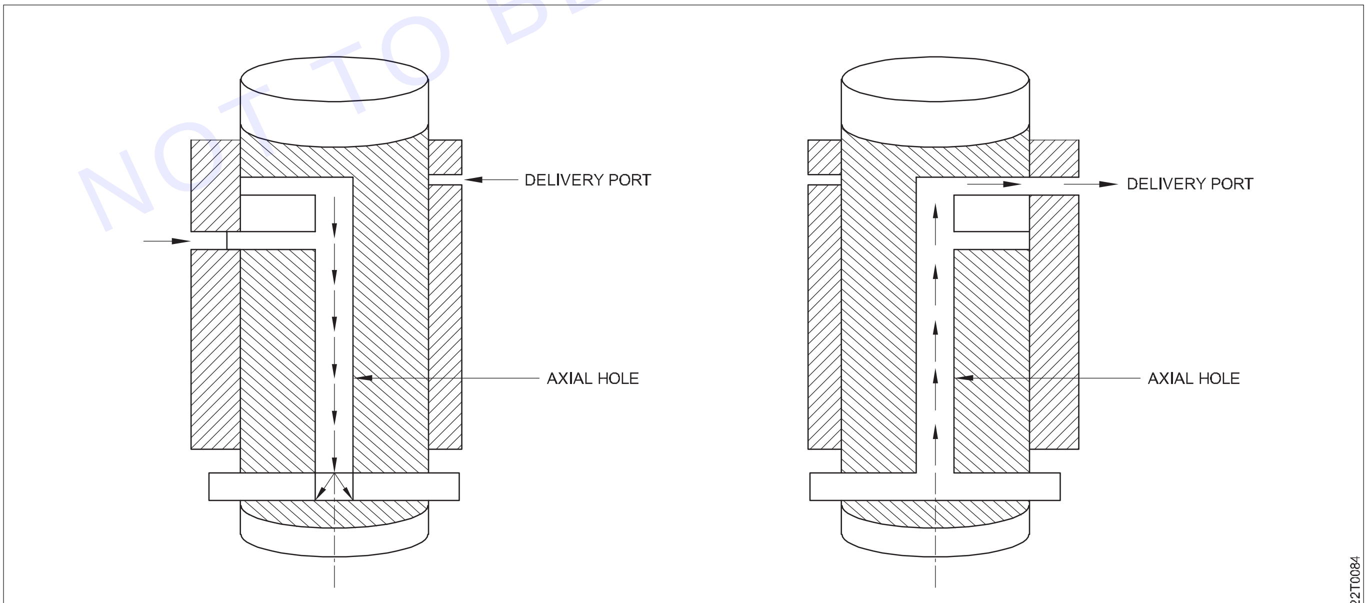
Fuel injection pump and its type

Fuel injection pump is an important component in a diesel engine, which works to transmit the appropriate amount of fuel in the diesel engine at high pressure (120 to 200 bar) through an injector connected to the cylinder with pressure in the cylinder. Fuel injection pumps are generally of two types.

i Distributed type fuel injection pump

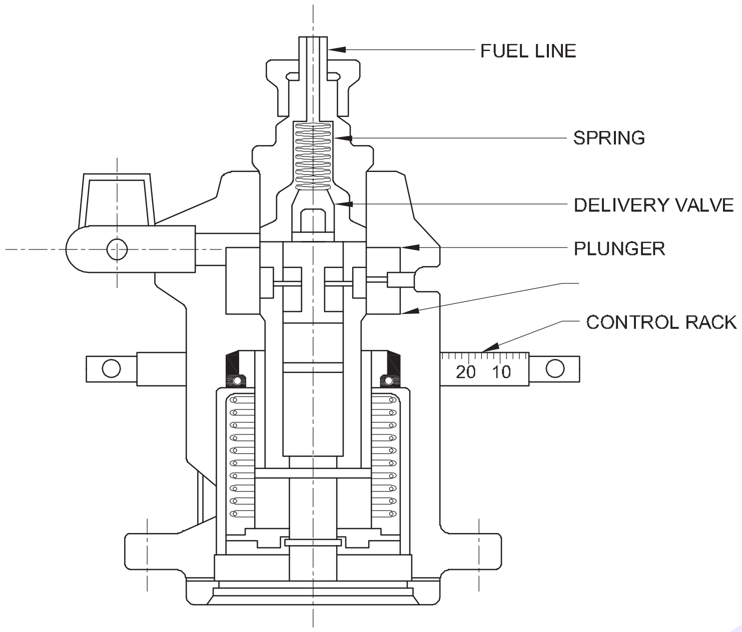
ii In-line fuel injection pump

i Distributed type fuel injection pump: This type of pump has a pumping element and in this the fuel is distributed to each cylinder with the help of a rotor. The rotor has a central longitudinal passage and two pairs of radial holes located at different heights. Out of these, one pair is connected to the inlet of the pump through the central passage and the other pair is connected to the delivery lines of the injectors of different cylinders. Such pumps are usually small in size and light in weight.



TYPE OF FUEL INJECTION PUMP

ii In-line fuel injection pump: This type of pump is fitted in the fuel line. It is a high pressure pump, which supplies diesel at high pressure to all the injectors sequentially and firing at the appropriate time. When the plunger is in its bottom position, fuel from the feed pump enters through the barrel inlet port. In this, the nozzle rotates one by one and delivers diesel to the pipe of each injector. This pump has a pumping element, through which equal quantity of diesel passes through the pump to the injectors. This pump is driven by the camshaft. From this pump, the diesel gets filtered and goes to the metering valve and from here the diesel goes to the injector through the injector pipes. In this pump the pressure increases from 400 to 700 bar.



IN-LINE FUEL INJECTION PUMP

Types of governors

Governor: Governor is used to regulate the maximum and minimum speed of any engine. In diesel engines a governor is used for this purpose in conjunction with the fuel injection pump. These governors control the minimum and maximum speed of the engine by controlling the amount of diesel supply.

There are mainly four types of governors

1 Mechanical or Centrifugal Governor

Centrifugal ball weight or fly weight is used in this type of governor. These weights are mounted on the camshaft of the fuel injection pump.

When the engine runs at slow speed, their expansion is less and when the engine runs at high speed, the weights also rotate faster and expand outwards more. Therefore, the control rods related to them also move more or less outwards according to the spread of weight.

Type

The control rod in the fuel injection pump controls the maximum and minimum speed of the engine by moving back and forth and rotating the plunger through the control sleeve, increasing or decreasing the amount of diesel in the diesel supply.

In other words, it can be said that the governor controls the quantity of diesel in the diesel supply as per the requirement of the engine.

- **Pneumatic Governor**

In this type of governor, a diaphragm is used, which is the basis of the system. This is affected by the depression created in the inlet manifold during the suction stroke. This governor consists of two main (ii) hydraulic units – inlet manifold unit and diaphragm unit.

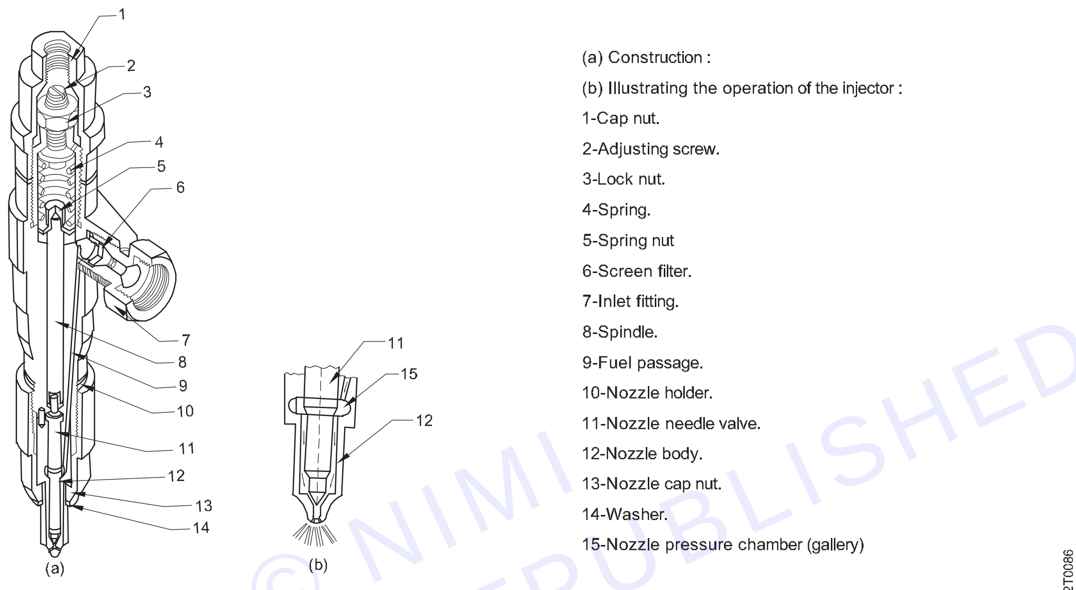
There is a butterfly fitted in the inlet manifold, which is connected to the accelerator. There is also a venture arrangement in the inlet manifold, which is directly connected to the diaphragm unit through a pipe. When the engine runs, there is a suction effect in the inlet manifold during the suction stroke. This creates a vacuum in the venture, which has its effect on the diaphragm. This diaphragm, which is attached to a spring, is also connected to the control rod.

Therefore, when the butterfly is opened by the accelerator pedal, the diaphragm is pulled outward against the spring pressure by the suction generated by the corresponding vacuum. A governor is a device used to regulate the speed of engines or machines. There are two main types:

1 **Centrifugal governor:** Uses rotating weights driven by the engine to control the throttle or fuel supply, adjusting the engine speed based on centrifugal force.

2 **Fly ball governor:** Utilizes a linkage system connected to a spinning flywheel. As the speed increases, centrifugal force causes the fly balls to move outward, which then adjusts the throttle or fuel supply to regulate the speed.

Fuel Injectors



FUEL INJECTOR

The function of the fuel injector is to deliver finely atomized fuel under high pressure to the combustion chamber for the engine. All component parts of the injector are carried in. nozzle holder (10.) The main part of the injector is the nozzle comprising nozzle body (12) and nozzle valve (11) The nozzle body and needle valve are fabricated from alloy steel. They are thoroughly machined and have high surface harness necessary for operation in condition of high temperatures and elevated pressures. The bore in the nozzle body and the nozzle needle valve are lapped to a close tolerance and are a matched set, so that neither the nozzle body nor the needle valve may be replaced individually. The needle valve is pressed against a conical seat in the nozzle body by spring (4) acting through the 212 intermediary of stem 8. The spring pressure is adjusted by adjusting screw (2). The adjusting screw is screwed in the bottom of the injector spring cap nut which in tum is screwed in the nozzle holder. Lock nut (3) is used to prevent the adjusting screw from unscrewing spontaneously. The screw is covered by nozzle holder cap nut (1) provided with a threaded hole to connect the leak-off pipe through which the leak-off fuel (used to lubricate the nozzle valve) filling the pressure spring and adjusting screw area is returned to the fuel tank or the secondary fuel filter. In operation, fuel from the injection pump enters pressure chamber (gallery) (15) in the nozzle body through supply passage (9) and a high-pressure pipe. When the fuel pressure in the pressure chamber becomes so high that the force acting on the pressure taper of the needle valve from below exceeds the set spring force on the stem, the needle valve lifts off its seat and comes to rest with its upper shoulder against the face of the nozzle holder. Fuel is then forced out of the nozzle spray holes into the combustion chamber in a spray pattern which depends on the type of nozzle used. After the injection of fuel has been ended, the fuel delivery from the injection pump ceases, the pressure in pressure chamber 15 of the nozzle drops instantly, and the pressure spring snaps the needle valve onto its seat, preventing unpressurized fuel from leaving the nozzle. The fuel injector is installed in a brass injector tube, or sleeve, which is fitted in a hole in the cylinder head, and is held in place by a special clamp Injectors are provided to atomize the fuel into engine cylinder. This is done to achieve complete combustion.

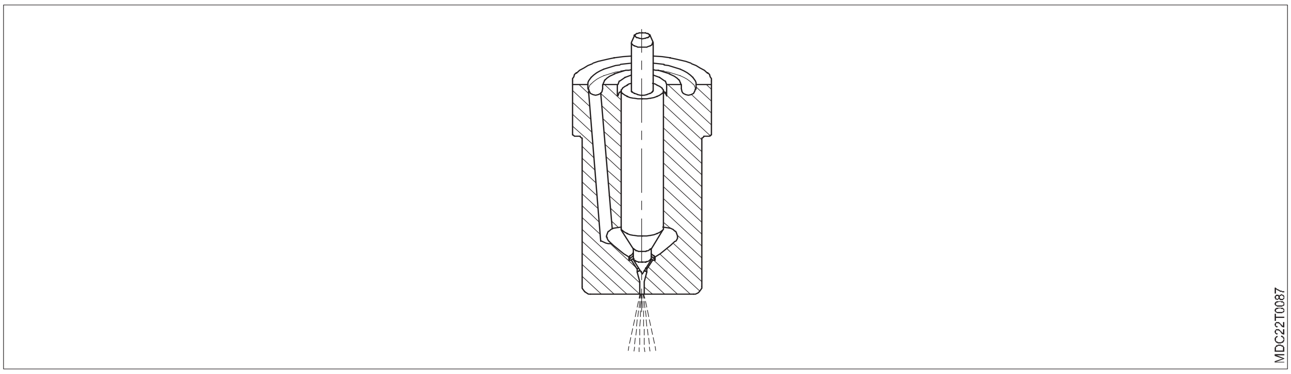
Following types of nozzles are used in engine.

- Single hole type
- Multi hole type
- Long stem type

- Pintle type
- Delay nozzle
- Pintaux nozzle

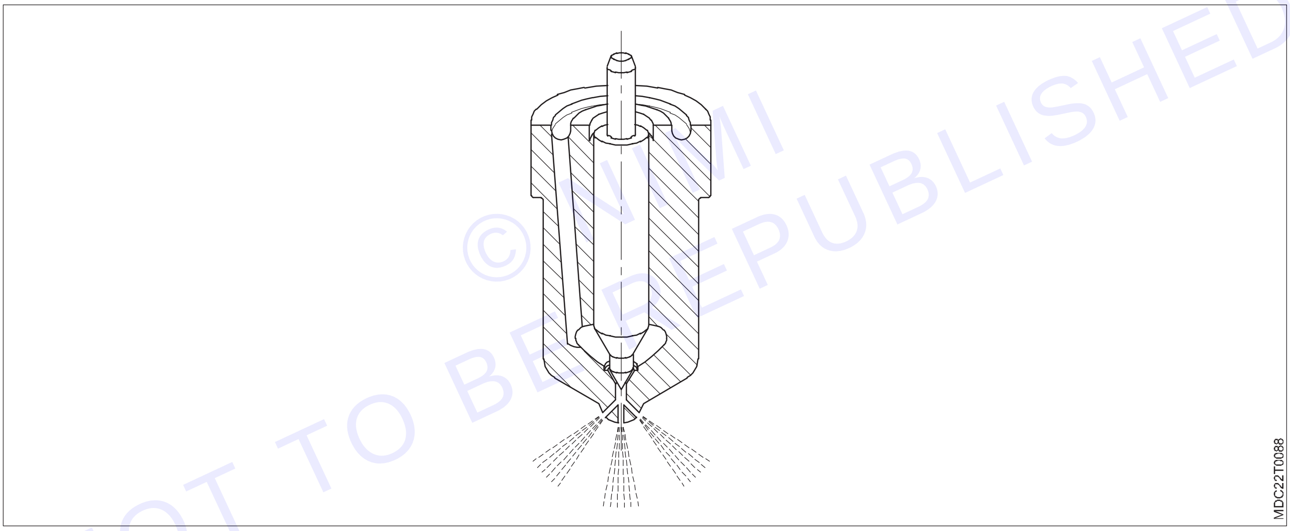
Single hole type

In this type, one hole is drilled centrally or in an angle through its body which is closed by nozzle valve.



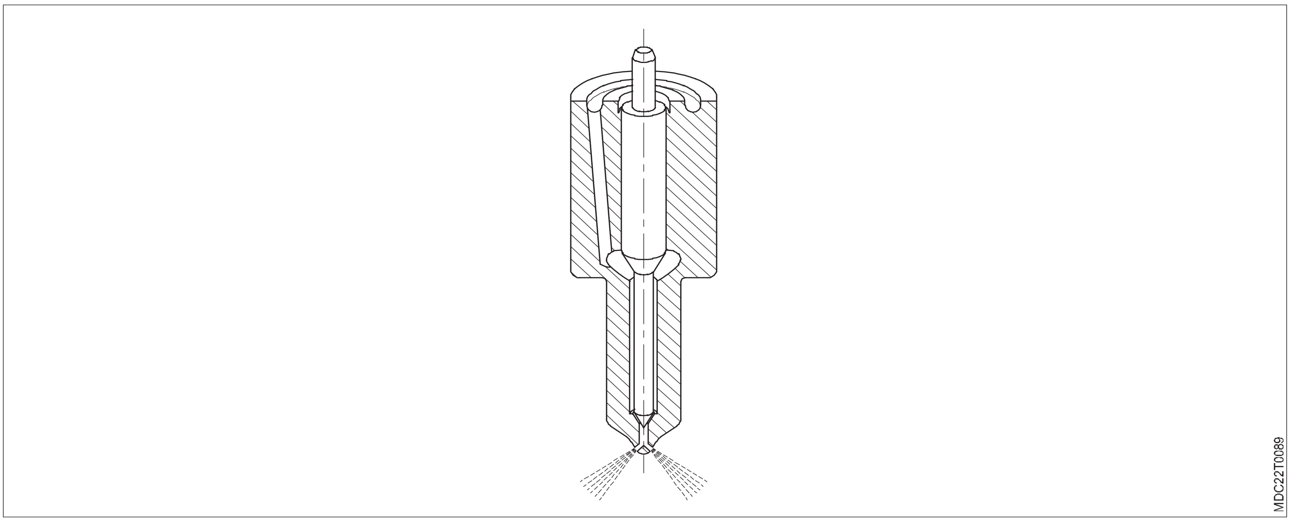
Multi hole type

In this type varying number of holes are dolled at the end of the body. The actual number of holes depend upon the engine requirement



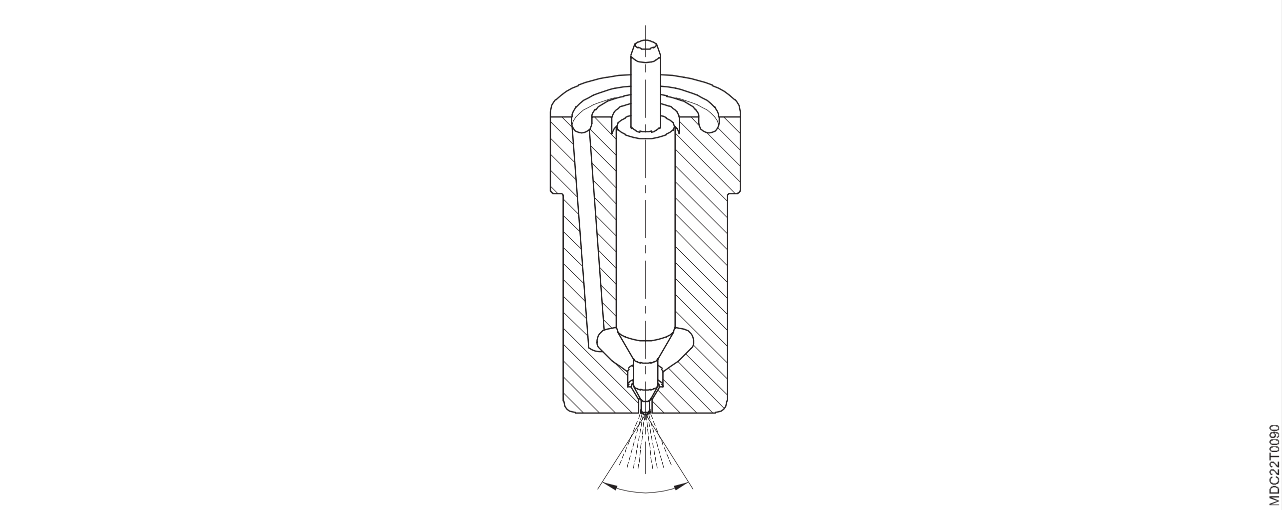
Long stem type

For providing adequate cooling for the standard short stem nozzle, a different type of nozzle with a small diameter extension has been developed. This is called long stem nozzle



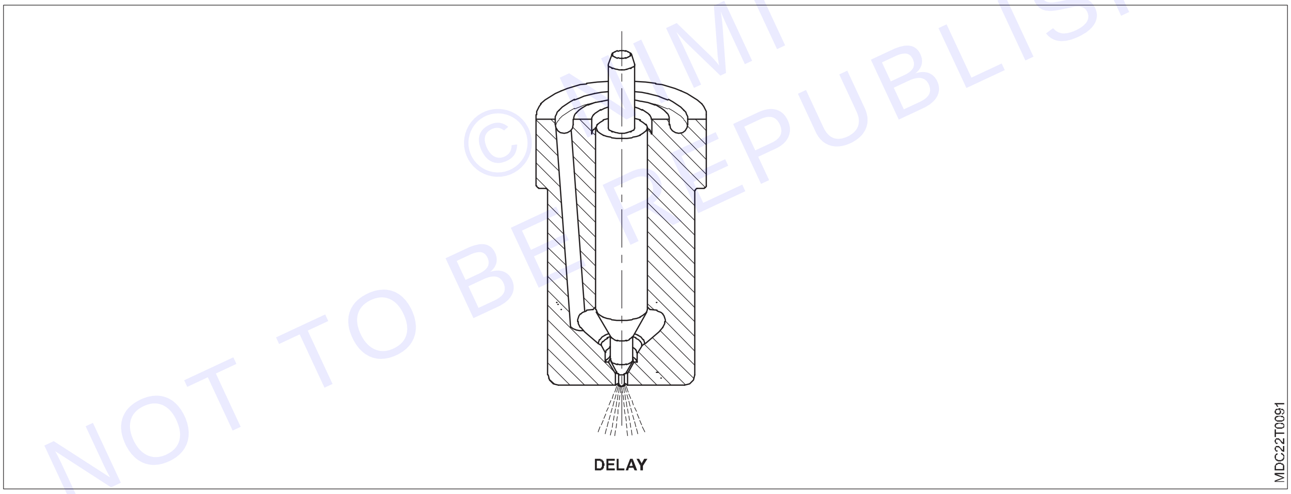
Pintle type

In this type the valve stern is extended to form a pin or pintle which protrudes through the month of the nozzle body.



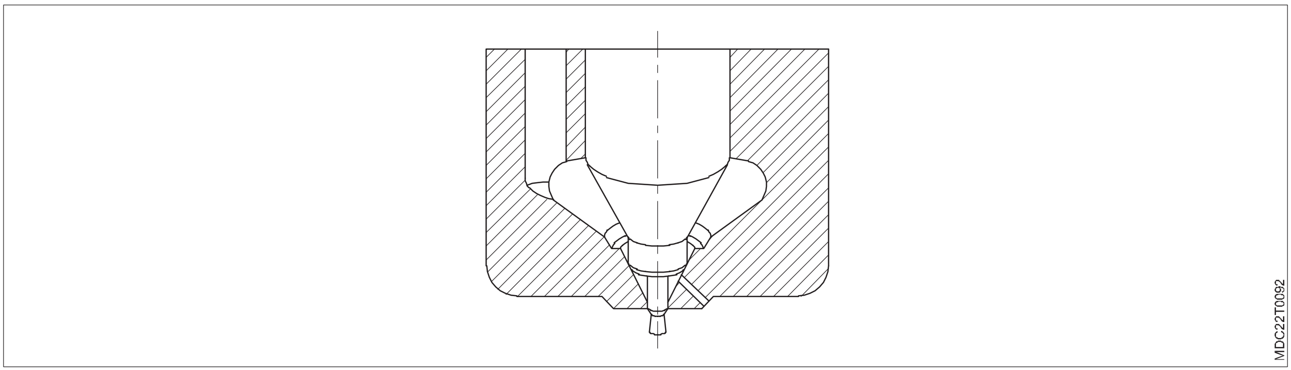
Delay nozzle

In this type spray pattern is controlled by the modification in pintle design. This will reduce the amount of fuel in combustion chamber, when the combustion begins. This modified nozzle is known as delay nozzle.



Pintaux nozzle

This is the further development of pintle type nozzle, having an auxiliary spray hole to assist easy starting under cold condition.



Importance of maintenance, diagnosis and Servicing diesel fuel system and its components

1 **Performance Optimization:** Regular maintenance ensures optimal fuel delivery and combustion, increasing engine performance.

2 **Fuel efficiency:** Properly maintained systems increase fuel efficiency, saving costs over time

3 **Preventive Maintenance:** Routine servicing helps identify and fix potential problems before they escalate, preventing breakdowns.

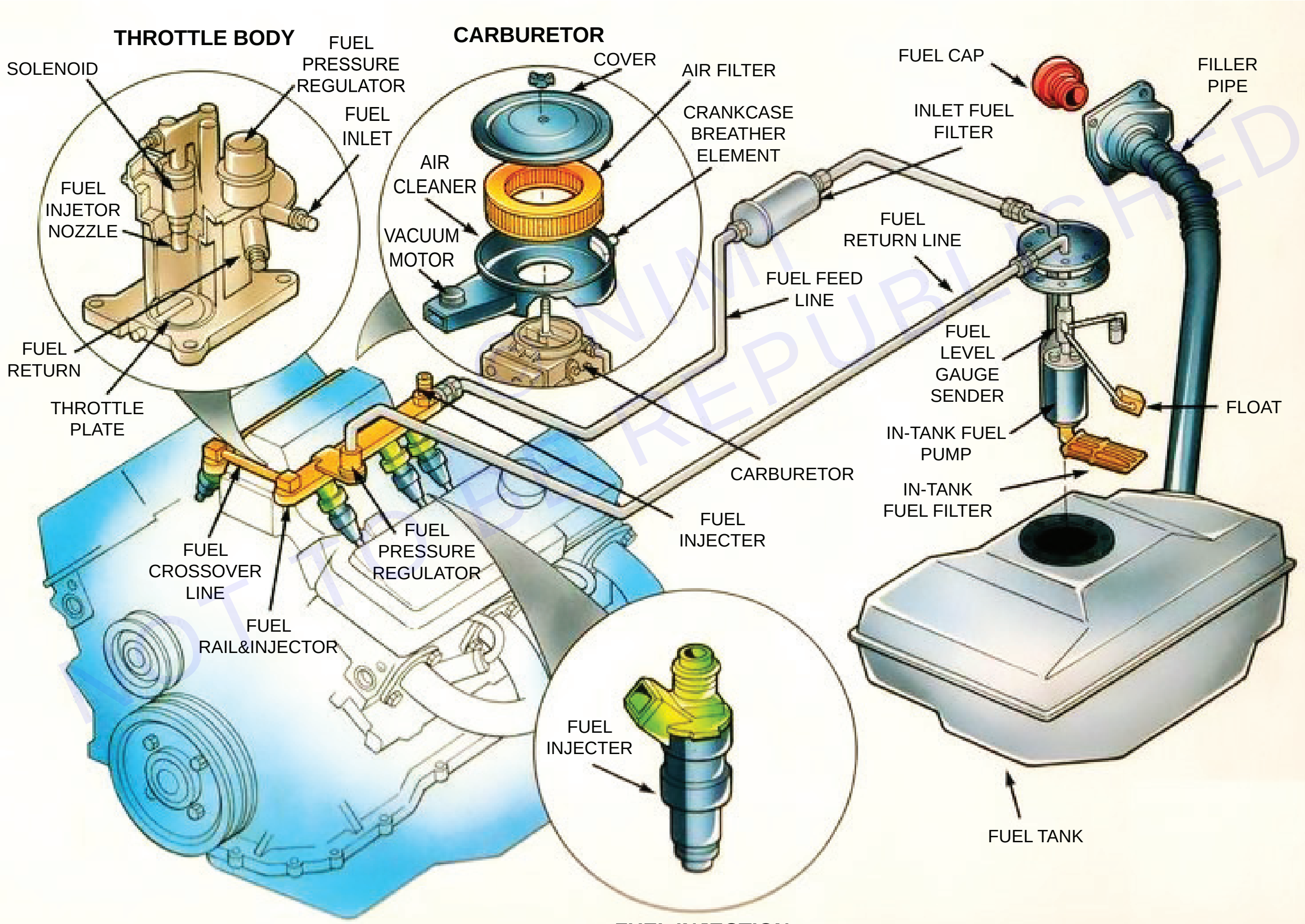
4 **Cost savings:** Proactive maintenance reduces the need for costly repairs and replacements.

5 **Safety Assurance:** Regular inspection reduces the risk of fuel leakage and associated hazards, ensuring safe operation.

6 **Environmental impact:** Streamlined systems reduce emissions, reducing environmental pollution.

7 **Legal Compliance:** Compliance with emission standards and regulations is ensured by a well-maintained fuel system.

8 **Engine Longevity:** Properly serviced components contribute to engine longevity, extending its life.



FUEL INJECTION

9 **Resale Value:** Regular maintenance increases the resale value of vehicles equipped with a well-maintained diesel fuel system.

10 **Reliability:** Reliable operation is ensured through regular maintenance, reducing the chance of unexpected failure.

11 **Optimized Combustion:** Clean fuel injectors and filters promote efficient combustion, improving engine performance.

12 **Diagnostic Efficiency:** Understanding the fuel system allows faster and more accurate diagnosis of problems, reducing downtime.

13 **Reduced Downtime:** Proactive maintenance reduces vehicle time for repairs.

14 **Component Longevity:** Increases servicing Reduces the life of individual components, the frequency of replacement.

15 **Operational Efficiency:** Well-maintained fuel systems contribute to overall efficiency and productivity.

16 **Manufacturer Recommendations:** Adherence to manufacturer recommended maintenance schedules ensures optimal performance and warranty compliance.

17 **Personnel Safety:** Properly maintained equipment contributes to a safe work environment for operators and technicians.

18 **Risk Reduction:** Regular servicing reduces the risk of catastrophic failures that could lead to accidents or injuries.

19 **Customer Satisfaction:** Reliable operation and reduced downtime lead to greater customer satisfaction with vehicle performance.

20 **Peace of mind:** Vehicle owners and drivers have peace of mind knowing that the fuel system is well maintained.

Causes of failure of the diesel fuel system and its components

The diesel fuel system can fail due to following reasons.

Engine not running normally

- Filter insert choke closed
- Air in fuel system
- Looseness/blockage in accelerator leakage
- Injection timing incorrect
- Pump phasing incorrect/delivery not equal
- Pump control rod/gear worn out
- Leakage in high pressure pipe joints
- Blockage in high pressure pipe
- Diesel adulteration
- Nozzle hole blocked/needle jammed/spray not working properly
- Engine compression low/engine seizing
- Valve sticky/valve spring broken/valve guide worn out

Starting problems

- Blocked air vents in tank lid
- Blocked low pressure pipe
- Clogged filter inserts (choked)
- Overflow valve/leakage
- Air in fuel system
- Governor stop lever pulled
- Looseness/blockage in accelerator linkage
- Wrong pump injection timing
- More diesel equipment defective
- Worn fuel injection pump/feed pump parts
- Leakage in high pressure pipe joints

- Leakage in injector and cylinder head sealing
- Nozzle holes blocked/needle jammed/spray not working properly
- Air filter/exhaust system blocked

Knocking sound in engine

- Pump injection timing incorrect
- Pump phasing incorrect/ delivery not equal
- Pump delivery valve jammed/ spring broken
- Injector opening pressure too high
- Nozzle jammed in open position/ nozzle holder spring broken
- Nozzle hole blocked/ needle jammed/ spray not working properly
- Engine compression low/ engine seizing
- Valve sticky/ valve spring broken/ valve guide worn out
- Big end/ main bearings worn out
- Excessive carbon deposits in combustion chamber.

Excessive smoke

- Wrong pump injection timing
- Diesel equipment malfunctioning
- Pump delivery valve jammed/spring broken
- Full load/course of delivery too high
- Injection timer automatic advance wrong
- Nozzle position in cylinder head wrong and use of washers
- Injector opening pressure low
- Nozzle jammed in open position/nozzle holder spring broken
- Nozzle hole blocked/needle jammed/spray not correct
- Nozzle needle lift too high
- Air filter/exhaust system choked
- Engine compression low/engine seizure

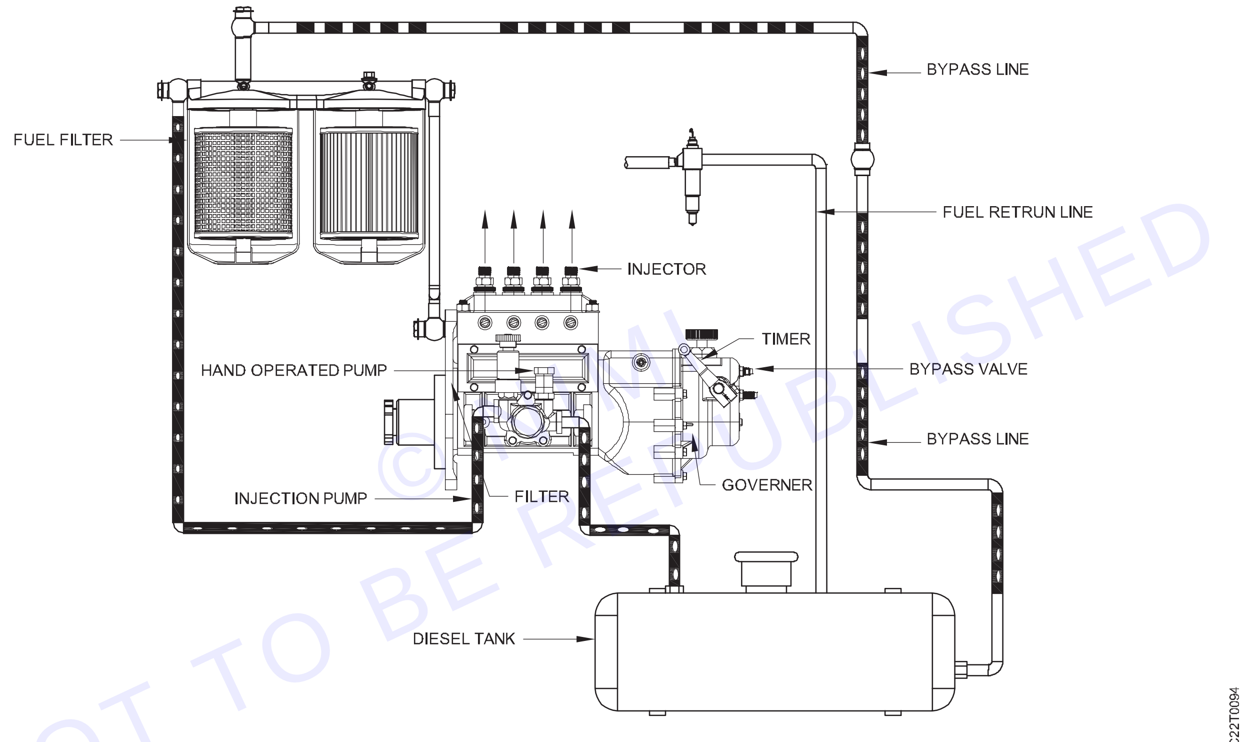
Engine overheating

- Pump injection timing incorrect
- Full load/course of delivery excessive
- Nozzle holes clogged/needle jammed/spray not working properly
- Engine compression low/engine seizing
- Valve-sticky/valve spring broken/valve guide worn
- Excess carbon build-up in combustion chamber
- Cooling/lubrication system malfunctioning

Some Important Components of diesel fuel system & it's position

- Bypass line
- Fuel return line
- Fuel filter

- Injector
- Bypass valve
- Timer
- Hand operated pump
- Governor
- Injection pump
- Bypass line
- Filter
- Diesel tank



FUEL DISTRIBUTION SYSTEM IN DIESEL ENGINE

Importance of testing of fuel feed pumps, FIP and injectors

Objectives: At the end of this lesson you shall be able to

- explain Importance of testing of fuel feed pumps
- importance of testing of fuel FIP
- explain Importance of testing of fuel Injector.

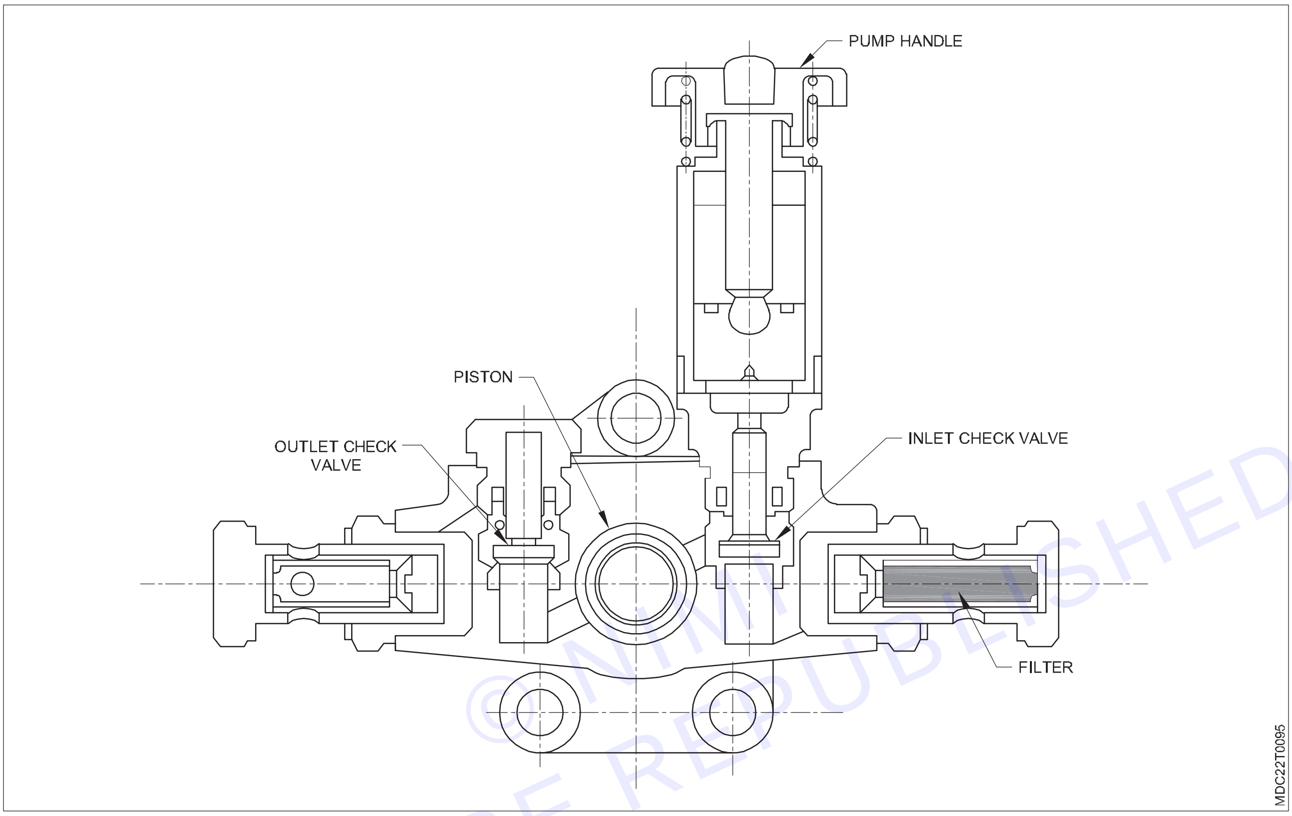
Introduction

Air inside the diesel engine through inlet valve is compressed in cylinder. In compression stroke due to high compression ratio the pressure and temperature increase and when piston is just to reach on compression stroke, then by injectors diesel spray applied in combustion chamber which is in atomized form. Compressed air and atomized diesel ignited with the diesel inject and get power stroke, for this big process done in Diesel I.C Engine but for these process also need another system process for these system need work as diesel fuel supply system. In these system include major three parts and its name is FIP, Injectors, Feed pump.

Let's understand about FIP, Injectors and fuel feed pump importance

Fuel feed pump

A low pressure feed pump ensures that the injection pump receives a continuous flow of filtered fuel. The fuel feed operates only when the engine is running. Fuel is injected form the fuel feed pump directly into the intake pipe at the point where it is mixed with the air.



The fuel feed pump plays a crucial role in delivering fuel from the tank to the engine at the correct pressure and flow rate. It ensures proper combustion, engine performance and overall efficiency by maintaining a steady supply of fuel to engine system. Without it, the engine might not receive enough fuel, leading to poor performance or even failure.

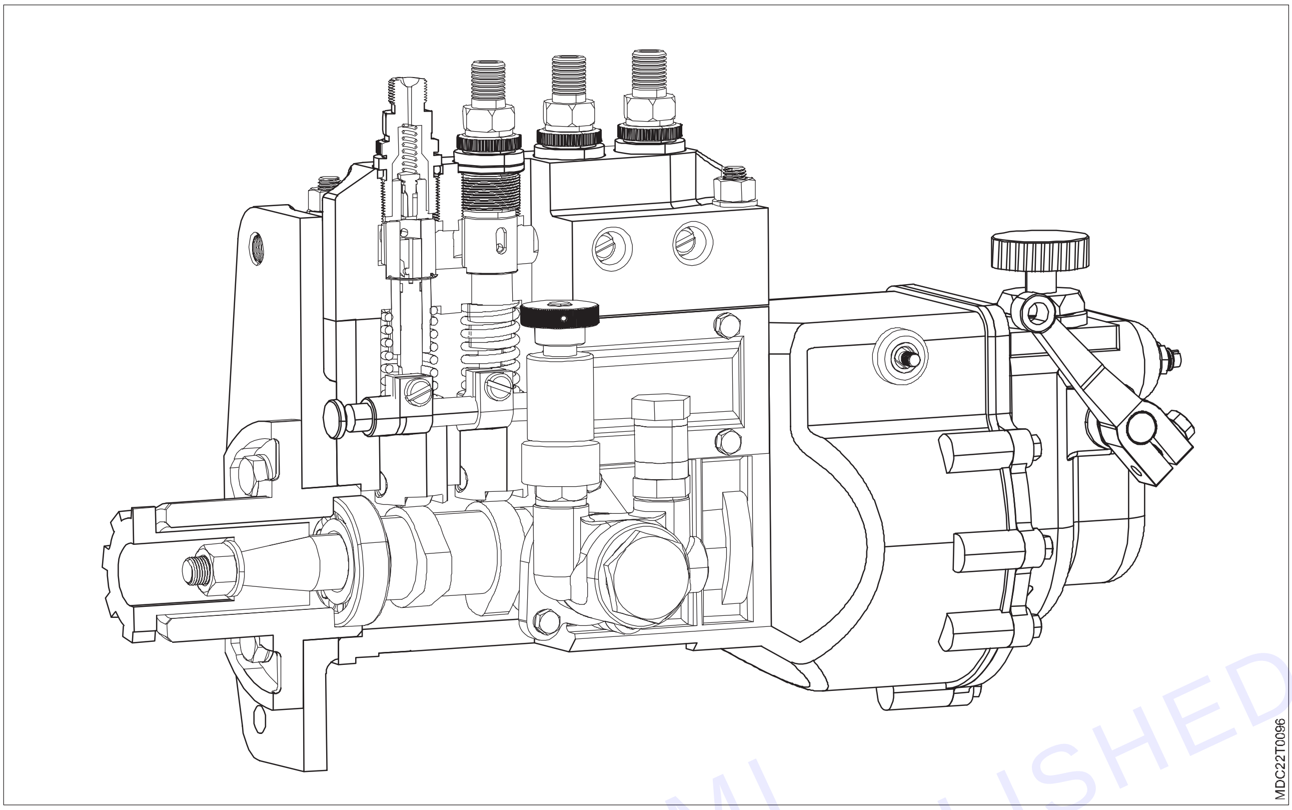
The mainly purpose of fuel feed pump is to convey the required quantity of fuel form the tank to the engine at the necessary pressure. A lift pump supplies low pressure fuel from the tank to the injection pump on the engine, providing roughly 8 psi - 15 psi of pressure supply. The injection pump or injectors then pressurizes the fuel into the cylinder at somewhere between 15000 psi – 30000 psi. It pressure is normal engine operation. Literally 30 psi – 50 psi range can be vary depending on the make and model of the vehicle.

FIP (Fuel Injection Pump)

Pump tests can also use to validate new pumps or repair. A pump could be machined imperfectly; the pump could be mounted incorrectly or it could simply be the wrong impeller in the pump.

The fuel injection pump regulates the amount of fuel that is delivered to the engine order to regulate the engine speed. When the engine is the running at higher speed, more is being injected into the cylinder. When the engine is running at lower speed, less fuel is being injected into the cylinders.

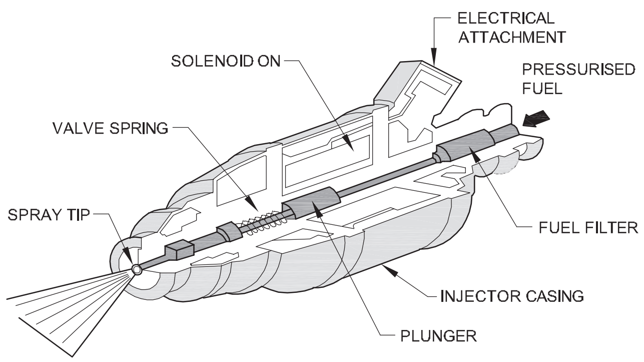
Function of the diesel fuel injection pump test bench testing and calibrating the fuel supply amount of each cylinder and fuel supply uniformity of mechanical injection pump. Testing the fuel supply spacing of each cylinder and fuel supply starting point in the static state.


MDC22T0096

Test were conducted according to following scheme

- Testing of high pressure pump on a test bench.
- Disassembly of high pressure pump into components.
- Analysis of individual high pressure pump units under a microscope.
- Determination of causes of defects in the tested object.
- Testing of the components which could be damaged as a result of pump damage.

Injector



For better performance of engine injector role is very important therefor for testing also we have to advance check it. With better fuel efficiency and emission control in vehicles:

1 **Performance optimization**

Injectors deliver fuel to the engine cylinder in precise amount and at the right time. Testing ensures they are operating within specification, preventing issue like poor acceleration misfire rough idling.

2 **Fuel efficiency**

Functioning injectors spray fuel in fine mist for efficient combustion. Testing help identify any leaks, clogs or irregularities that can lead to fuel wastage, reducing fuel efficiency and increasing operating costs.

3 **Emission control**

Malfunctioning injectors can cause incomplete combustion leading to increase emission of harmful pollutants like hydrocarbon, carbon monoxide and nitrogen oxides. Testing insure compliance with emission regulation and minimized impact.

4 **Preventive maintenance**

Regular testing of injectors can help detect problems early, allowing for timely repair or replacements before they escalate and causes more significant damage to the engine or other components.

5 **Longevity of engine**

Properly functioning injectors contributes to the overall health and longevity of the engine by delivering the right amount of fuel for combustion, reducing wear and tear on engine components.

Overall testing injectors is essential for maintaining vehicle performance, efficiency and environmentally friendliness while also ensuring the longevity of the engine and its components.

Importance of setting correct FIP timing. Importance of bleeding the fuel system. Trouble shooting in diesel fuel system and its components

Objectives: At the end of this lesson you shall be able to

- demonstrate Importance of setting correct FIP timing
- explain Importance of bleeding the fuel system
- demonstrate Trouble shooting in diesel fuel system and its components.

Importance of Setting Correct FIP Timing

1 Setting the correct FIP timing increases engine productivity, providing faster engine speed.

2 It helps save fuel by reducing fuel consumption, thereby lowering the running cost of the vehicle.

3 Correct timing ensures smooth and stable engine operation, resulting in improved sound and performance.

4 Proper service and care of the engine are ensured, helping to increase its lifespan.

5 Correct FIP timing enhances engine performance and longevity.

6 It aids in generating engine power, ensuring smooth engine operation.

7 Correct timing reduces engine emissions, benefiting the environment.

8 It is crucial for engine longevity and maximum productivity.

9 Prevents adverse effects of incorrect timing, such as engine damage and reduced performance.

10 Correct timing reduces the vehicle's noise level, minimizing the risk of noise pollution in the environment.

11 Correct FIP timing results in optimal performance at different temperatures, providing a better driving experience for the driver.

12 It safeguards the engine's mechanical components, ensuring mechanical efficiency.

13 The correct FIP timing prevents potential engine misfires, which could diminish the engine's lifespan and performance.

14 This allows the engine to be appropriately adjusted based on the vehicle's type and usage.

15 FIP timing adjustments can reduce potential losses and expenses.

Importance of bleeding the fuel system

Fuel Tank

The Fuel tank is provided for storing diesel required for running the engine. It is constructed of either pressed sheet metal with welded seams and special coating to prevent corrosion or fiber glass reinforced plastic materials.

It may be round or rectangular in shape. It is mounted above the engine assembly.

Parts of the fuel tank

- Filler neck and cap
- Baffle
- Fuel gauge sensing unit (Float)
- Filter
- Sediment bowl and drain plug

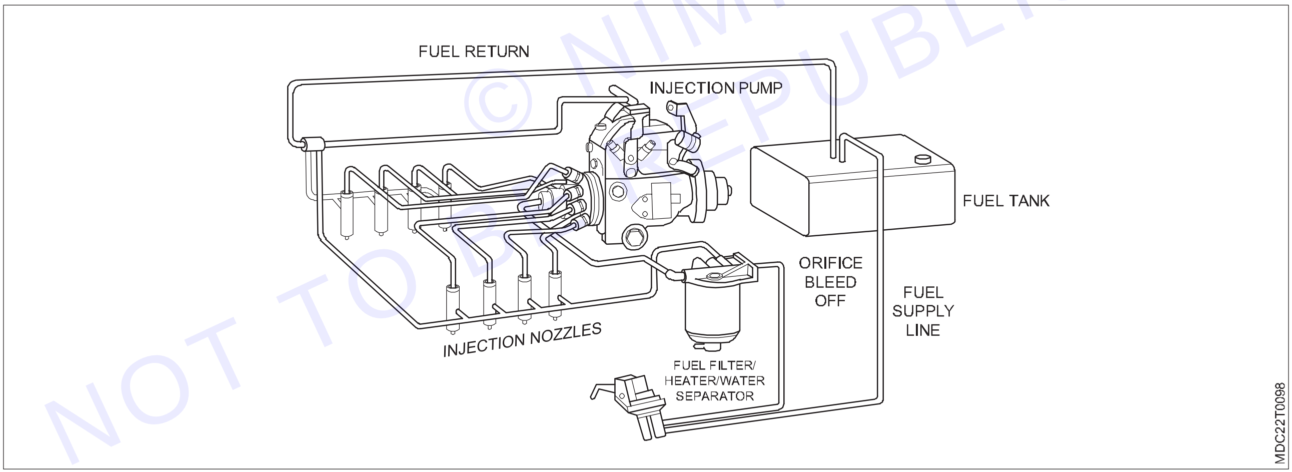
Filler neck is provided for pumping diesel into the fuel tank. A cap is provided for closing the tank tightly. A vent hole is provided either in filler neck or in cap to maintain atmospheric pressure in the tank above the fuel.

Bleeding of the fuel system

Bleeding is the process by which air, which is present in the fuel system, is removed. Air locking in the fuel system will result in erratic running of the engine and may result in stopping of the engine. Bleeding is carried out by priming the filter.

A slight loosening of the bleeding screw allows locked air to escape as bubbles along with the fuel.

When locked air escapes and the system is free of air, the screw is tightened finally.



Importance of fuel system

When you maintain your vehicle, it is important to have parts and components checked regularly. The function of the fuel system is to store and supply fuel to the engine and cylinder chambers. There, it can be mixed with air, vaporized, and then burned to produce the energy. The fuel pump will draw the fuel from the tank, have it travel through the fuel lines, and then is delivered through a fuel filter to the injectors. It is then delivered to the cylinder chamber for combustion. When your vehicle accomplishes this process, then your engine will run.

Trouble shooting in diesel fuel system and its components

faults occurring in diesel fuel system and their solutions are shown in the table below.

1 Fuel Tank

Causes	Remedy
Leakage of fuel	Repair the fuel Tank
Blockage EVAP system	Clean EVAP vapor line
EVAP system not working	vapor canister purge valve blockage

2 fuel line

Causes	Remedy
Leakage of fuel line	Repair the fuel line
fill air into fuel line	Bleeding the fuel line

3 diesel fuel Filter

Causes	Remedy
Filter insert closed choke	Insert new filter elements.
Block bypass valve	Clean bypass valve

4 water separator

Causes	
water separate elements is not working	Replace the element

5 Fuel Feed pump

Causes	Remedy
Wear of fuel feed pump parts.	Repair or replace.
pump delivery valve is block /breakage of spring.	Clean the delivery valve. Change the spring.

6 Fuel Injection pump

Wear of fuel injection pump parts	Replace or repair
Incorrect pump phasing/uneven delivery	Perform pump phasing calibration.
Delivery valve jamming of pump/breakage of spring.	Clean delivery valve/replace spring.
Full load/course of delivery exceeding	Calibrate the pump

7 injector

Causes	Remedy
Clogged nozzle hole / jammed needle / spray not working properly	Clean the nozzle.
Nozzle jammed in open position/nozzle holder rim spring broken	Replace nozzles, replace rings.
Leakage of injectors sealing	replace the washer.

8 Glow Plug

Causes	Remedy
Heater Plugs Circuit Malfunction	Check circuit, replace heater plug.

Common faults – problem in starting

Causes	Remedy
finished diesel in tank	Replenish diesel
adulteration in diesel	Add good diesel of right grade.
air hole in tank lid clogged	Open the hole in the tank cap.
blockage in low pressure pipe	Clean the pipes.
Filter inserts clogged (choked)	Clean or replace the filter element.
overflow valve jam/leakage	Bleed air from the diesel line.
air in fuel system	Correct the lever
governor stop lever pulled	Set the timing correctly

Looseness/disruption in accelerator linkage	Correct the faults after seeing them.
Pump injection timing wrong	Replace or repair faulty equipment
More diesel equipment malfunctions	Stop leakage
Wear of fuel injection pump/feed pump parts	Repair or replace
Leakage in joints of high pressure pipes	Clean the seat and replace the washer
Leakage in sealing of injector and cylinder	Clean the filter and remove any defects
Nozzle holes clogged/needle jammed/spray not working properly	Clean the hole and replace the nozzle
Air filter/exhaust system clogged	Overhaul the engine
Low engine compression/engine seizure	Battery weak/starter malfunction
Valve sticky/valve spring broken/valve guide worn	Replace defective parts.

Common faults– knocking sound in engine

Causes	Remedy
Pump injection timing wrong	Reset the timing
Incorrect pump phasing/uneven delivery	Perform pump phasing calibration
Jamming of pump delivery valve/breakage of spring.	Clean delivery valve/replace spring
Injector opening pressure is high	Adjust injector pressure
Nozzle jammed in open position/nozzle holder spring broken	Replace nozzle, replace spring
Clogged nozzle hole / jammed needle / spray not working properly	Clean the nozzle
Low engine compression/engine seizure	Overhaul the engine.
Valve sticky/valve spring broken/valve guide worn	Open valve and replace spring and guide
Wear of big end/main bearings/excessive force on the crankshaft	Do engine overhauling.
Excess carbon deposits in the combustion chamber	Decarbonize.
adulteration in diesel	Add good diesel of right grade

MODULE 6 : Engine Lubricating System

LESSON 39 - 46: Engine lubrication system Lubricant, types, application and its properties. Study about lubrication systems and its components such as oil sump, oil strainer, oil pump, relief valve, filter, bypass valve, oil cooler etc

Objectives

At the end of this lesson you shall be able to

- define Engine lubrication system.
- explain types of lubricants and properties of lubricants
- identify and locate differents parts of lubrication systems.

Lubricant, type, application, and its properties

Lubricants: - lubricants are substances typically used to reduce friction between parts in contact. Depending on the type, lubricants also perform various other functions such as heat regulation, power transmission, sealing against dust or dirt, as well as reducing oxidation and preventing corrosion. Lubricants are typically in liquid or semi-solid form, but they may exist in different forms.

Types of lubricants

Lubricants are mainly of following three types:

1 **Liquid lubricants**

2 **Semi-solid lubricants**

3 **Solid lubricants**

1 **Liquid Lubricants:** Liquid state lubricants are not fixed in size, so they can be transported by flowing from one place to another. Due to this quality, they are used the most. The following four types of oils are used as liquid lubricants.

 ı **Mineral oil:** Mineral oil, is extracted from petroleum. These oils are waxy (paraffin) and naphthenic. Waxy oils are more stable at higher temperatures because they contain a large amount of wax dissolved in them, which gives the oil more stability at higher temperatures than naphtha-based oils.

These are of the following types

* Circulating oil
* Gear oil
* Mobil, oil or engine oil
* Refrigeration grade oil
* Spindle oil
* Steam cylinder oil
* Wire rope oil

Gear oil and Mobile oil are mainly used in modern engines, which are described below

Gear Oil (Gear Oil) Gear oil is a light thick oil, which is used in the gear box, steering and differential parts of vehicles. SAE 90 gear oil is used in gear box and SAE 140 gear oil is used in other parts.

Mobil oil or engine oil (Mobil oil or engine oil) Mobil oil is a light thin oil, which is used in engine, dynamo, air cleaner, brush etc. parts of motor vehicles.

SAE (Society of Automotive Engineers) uses SAE 30 in cold weather and SAE 140 in hot weather. The SAE system assigns numbers to identify these experiments based on viscosity.

Like – SAE 30, SAE 40, SAE 50 etc.

ii **Organic Oils:** These oils are obtained from animals, plants and fish etc. These oils are easily broken down into their constituents by heat and tend to oxidize to a paste at low temperatures, as all organic oils contain alcohols and fatty acids.

Therefore, it is likely that free amount of acid is present in it. The molecules of castor oil are quite large. So, it can be used as a lubricant. For use for heavy loads, some amount of mineral oil is added to the organic oil and this mixture is called compound oil.

iii **Synthetic Oils:** Because synthetic oils are expensive, they are rarely used. These are of two types: polakaline glycols and silicon's. Silicon carbide is converted into silicon and oxygen by suitable chemical means. Synthetic oils combine with some other ingredients to form silicone lubricants. These oils maintain their properties for a very long time, so they are used for lubrication of precision tools.

iv **Blended Oils:** To make mineral lubricants heavier and increase their viscosity, 5 to 20% fatty oils are added to them. These oils are also called compound oils.

2 **Semi-solid Lubricants: -** This oil, which does not flow due to its high viscosity, is called a semi-solid lubricant. thickeners in mineral oil or organic oils to make it; Compounds like calcium, sodium, aluminum, barium, lithium, strontium, grease etc. are added. Semi-solid lubricants are mainly grease and Vaseline. Grease is mostly soft and hard type. Soft grease is usually used to lubricate those parts. Parts on which it is impossible for lubrication oil to stop; Like wheel axle assembly, rear axle, front axle etc. It is also used to lubricate bush bearings that transmit more power. Conversely, use hard grease with sharp cutting tools; For example, milling cutters etc. are done to protect them from corrosion for a long time.

3 **Solid Lubricants: -** Lubrication by grease and oil cannot be successful at very high temperatures and pressures; Like Power Hammer or Power Jais working in forging shop. Solid lubricants are used at such places. These solid lubricants are effective in lubrication even at high temperatures. As a solid lubricant, most of the graphite powder is mixed with grease or oil and is broken down into components. Solid lubricants are used to control the heat and pressure generated by friction between machine parts. Sometimes soap stone, talk, wax, mica etc. are used as solid lubricants.

Application

Application of liquid lubricant oil: Liquid lubricants are commonly used in various applications to reduce friction and wear between moving parts, such as in engines, machinery, and industrial equipment. They're applied by pouring, spraying, or using specialized lubrication systems to ensure smooth operation and prolong the lifespan of mechanical components.

Application of semi-solid lubricant oil: Semi-solid lubricants, like grease, are used in various applications where traditional liquid lubricants might not be suitable. Common applications include automotive wheel bearings, chassis components, industrial machinery, and gears. They provide long-lasting lubrication, resist water washout, and can withstand heavy loads and extreme temperatures.

Application of solid lubricant oil: Solid lubricants are solids applied to friction surfaces to reduce friction and wear and prevent surface damage. They may be in the form of powders, films or composite materials. They include substances with layered structures such as molybdenum disulphide and graphite. These solid lubricants are highly anisotropic, with weak bonding between particular crystal planes or molecules. Their self-lubrication properties provide low-friction coefficients.

PROPERTIES OF LUBRICANTS

The main properties of lubricants are as follows

i **Oiliness:** It is the property of the lubricant that a thin surface of the lubricant is maintained between the two moving parts, due to which the two parts move easily by sliding against each other.

ii **Viscosity:** A measure of the internal resistance of a lubricant is called its viscosity. This is an important property of lubricating oils, as viscosity determines the oil's ability to flow. If a substance flows easily, its viscosity is low. Conversely, if a liquid flow with difficulty, its viscosity is high. A viscometer is used to determine the viscosity of the lubricant to be tested. This quality of lubricants is expressed by numbers. This number is given by the Society of Automotive Engineers (SAE). The table below shows the different types of lubricating oils along with their viscosity numbers and applications.

Table

Expected Atmospheric Temperature	Single Viscosity Lubricant	Multi-Viscosity Lubricants
Below -10°F	SAE 5W	SAEFW-20
Above -10°F	SAE 10W	SAE10W-20 OR SAE10W-30
Above +10°F	SAE 20W	SAE20W-30 OR SAE10W-30
Above 32°F	SAE 20 or 20W SAE 30 (some manufacturers)	SAE10W-20 OR SAE10W-30
Above 90°F	SAE 30 SAE 30 (some manufacturers)	SAE10W-20 OR SAE10W-30

iii **Fire and Flash Point:** For a lubricant, the temperature at which it ignites in the form of a flame is called the flash point. Similarly, for a lubricant, the temperature at which it begins to vaporize is called the flash point. While selecting the lubricant it is necessary to keep in mind that the operating temperature of the machine should be less than the flash point and combustion point of the lubricant.

iv **Pour Point:** Pour point is the lowest temperature at which an oil can flow or be dropped. Pour point is an important specification for lubricants used in machines operating at low temperatures; Like- there were ice factories, refrigerators etc. A good lubricant should have a low pour point so that it can work smoothly even at low temperatures.

v **Carbon Residue Content:** The amount of residual carbon powder in an oil indicates its amount of waste material and its lubricity. In order to achieve high efficiency of an engine, the amount of residual carbon in the lubricating oil used in it should be minimum. For internal combustion engines and compressors, this amount is even more essential.

vi **Acidity:** The oil should not contain acidity or acid content, if it does, it will adversely affect the bearing metal.

vii **Emulsification and Distinctively of Water:** Miscibility is the property of a lubricating oil, due to which it can mix rapidly with the gel and form a uniform and almost permanent mixture. Similarly, water-separation is the property of a lubricating oil due to which water can be quickly separated from the water-oil mixture.

viii **Specific Gravity:** It is the property of the lubricant that compares the load of the lubricant with the load of the leaves at 30°F.

ix **Neutralisation Number:** The neutralization number is the amount in milligrams of potassium hydroxide that can be dissolved in one gram of lubricating oil.

The neutralization number has no significant relationship with the acidity present in the lubricating oil. The main thing is that during the use of lubricating oil, the depression should not increase. A sudden increase in its value means that the oil is oxidized (oxidise).

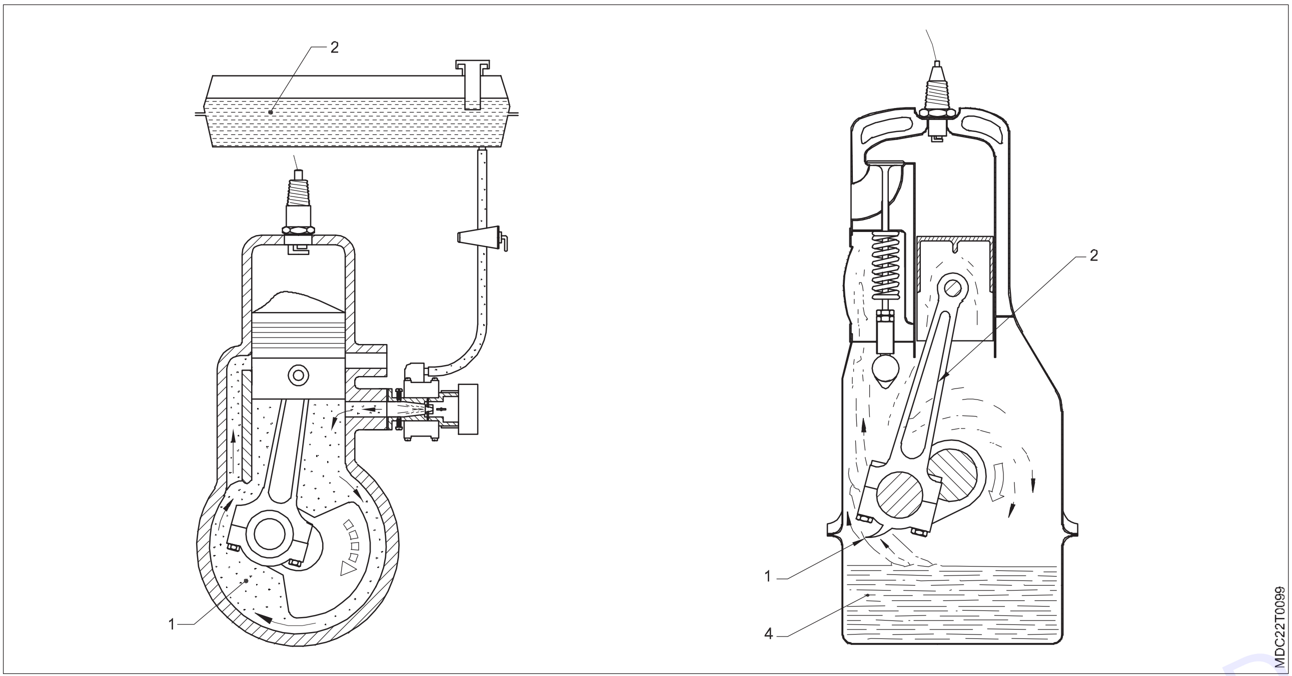
This number is less than 0.01 in well-cleaned lubricating oil. If this number starts to increase suddenly in a working machine, the oil should be taken out and new oil should be added.

x **Chemical stability:** Chemical stability is the characteristic of lubricating oils, due to which they are adopted. They maintain organization and existence and do not disintegrate under the influence of work.

Types of lubrication systems

Wet Sump Lubrication System: In Method

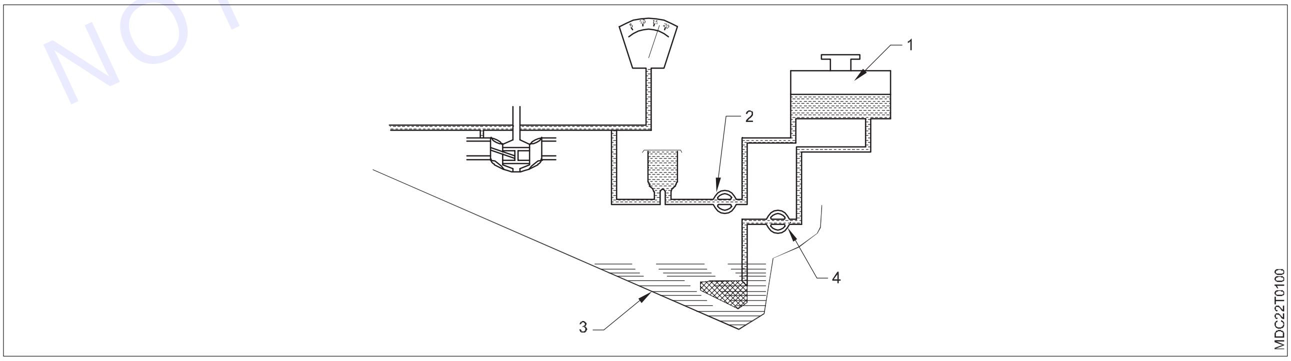
Oil is stored in the sump. or oil contacts the sump or crankcase.it is of the following points



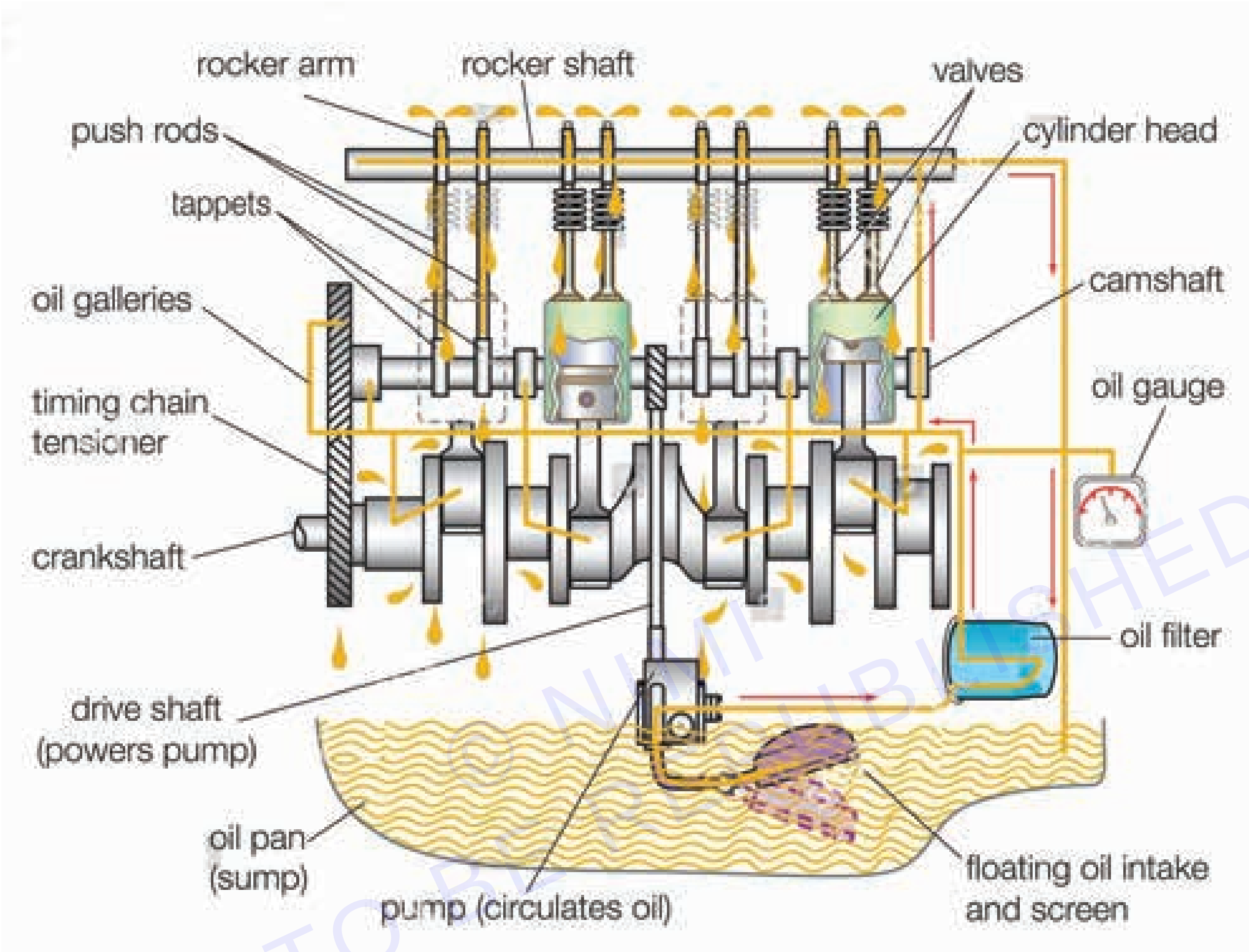
Petrol Mix Lubrication System: This method is used in two stroke engine of two wheelers is done. An oil sump is not used to store the lubricating oil in this system. Lubricating oil is mixed with petrol in a suitable ratio of 20% to 50%. Lubricating oil along with petrol enters the crankcase and combustion chamber to lubricate the piston, piston ring, piston pin, cylinder liner, bearing and crankshaft.

- **Splash lubrication system:** This Lubrication Oil in the system is stored in a sump. A spoon-like scoop is provided on the big end of the connecting rod. So when the engine rotates, it dips into the oil and as it rises, it acts to blow the oil onto the cylinder liner. Also crankshaft, bearing, piston they also have lubrication. But the valve mechanism, timing gear and external parts of the engine do not get lubrication. So this method is not used in automobiles

- **Dry sump lubrication system:** In this method oil is not stored in the sump. Hence it is called dry sump lubrication system. There is a separate tank for oil storage and an oil pump is used to deliver the oil from the sump to the tank and another pump is used to supply the oil from the tank to the engine. Even if the engine reverses, there is no interruption in the supply of lubrication oil. This method is used in airplanes, racing cars and ships. Pumps that draw oil from the sump are also called scavenging pumps.



- **Pressure Lubrication System:** Pressure Lubrication of engine parts are done by sending lubricant under pressure in the system. Oil is stored in a crankcase. The oil pump in the oil sump draws it through the strainer and sends it to the filter at the correct pressure through the pressure relief valve. The pressure of the oil sent by the oil pump is 2 kg. / cm to 5 kg. / cm There is so much. From the main gallery, the oil enters the crankshaft main journal and crankpin. The big end of the connecting rod is mounted on the crankpin. Lubrication of the piston also takes place through the connecting rod. Some of the oil splashes from the crankshaft main journal fly onto the cylinder wall to lubricate the cylinder wall. Also a separate internal passage is provided for conveying the oil from the main gallery to the rocker arm. Pressured oil through these passages supplied each rocker arm goes Some of the oil dripping down provides lubrication to the valve stem and guide. Also, a separate pipe line is provided for lubrication of timing gear and chain. An oil pressure gauge is mounted on the dashboard to measure the oil pressure in the system. The connection of which is connected to the oil gallery after the crankshaft main journal. Some vehicles have an oil pressure indicator mounted on the dashboard. Also, a separate oil pipe line is connected to the engine on which the turbocharger is installed.



Combine Lubrication System: This method combines flash and A combination of pressurized lubrication systems. Both these methods have been used in this system.

components in lubrication system oil sump, oil strainer

The main components in lubrication system.

Oil Pan or Sump: A reservoir that holds the engine oil.

Oil Pump: used for pumping the oil from the sump to other parts of the engine.

Oil Filter: Removes contaminants from the oil.

Oil Cooler: Helps to maintain the temperature of the oil, especially in high-performance engine.

Connecting Rod Bearings: Bearings that support the connecting rods and are also lubricated by the oil.

Camshaft Bearings: Bearings that support the camshaft and are lubricated by the oil

Valve Train Components: Components such as cam lobes, lifters, and valve stems that are lubricated by the oil.

Piston Rings: Rings that help seal the combustion chamber and are also lubricated by the oil.

Oil Galleries or Passages: Through which the oil flows to reach various engine components.

Main Bearings: Components that support the engine's crankshaft and are lubricated by the oil.

Oil sump

An oil sump is fitted on the bottom side of the engine block and stores the lubricating oil and this oil is arranged to lubricate each part of the engine. A drain plug is provided at the bottom of the sump to drain the oil from the sump. This drain plug has magnetism. As the oil lubricates each moving part of the engine and enters the sump, if the oil contains any iron particles from the part, they are attracted by the magnetism on the drain plug and are not allowed back into the oil.

Components

Pan Body: It usually made of steel or aluminum, which holds the engine oil.

Drain Plug: A plug at the bottom of the sump that can be removed to drain the oil during an oil change.

Gasket or Seal: A gasket or seal that ensures the sump is sealed against the engine block to prevent leakage in oil

Baffles: Internal structures within the sump that help prevent the oil from sloshing around excessively during vehicle movement, ensuring a steady prevent of oil to the pump.

Oil strainer: - An oil strainer is a fine wire mesh filter. The strainer is fitted to the suction pipe of the oil pump in such a way that it is always submerged in the oil in the oil sump. Due to the strainer, the carbon particles, garbage, metal particles in the oil are blocked and the clean oil is sent to the oil pump.

Components

Filter Element: This is the primary component that captures and holds the contaminants present in the oil. It is usually made of paper, synthetic fibers, or metal mesh.

Filter Housing: The filter element is housed inside a casing or housing, which is typically made of metal or plastic. The housing provides support and protection to the filter element.

Gasket: A gasket is used to create a tight seal between the filter housing and the mounting surface to prevent oil leaks.

Pressure Relief Valve: Some oil strainers have a pressure relief valve that allows oil to bypass the filter element if the pressure differential across the filter becomes too high. This helps prevent damage to the filter and ensures adequate oil flow.

Anti-Drain Back Valve: This valve prevents oil from draining out of the filter when the engine is not running, ensuring that oil is readily available when the engine is started.

Mounting Plate: The mounting plate is used to secure the oil strainer to the engine or hydraulic system. It often contains the threads or bolts used to attach the strainer.

Oil Pump and its types

Oil pump

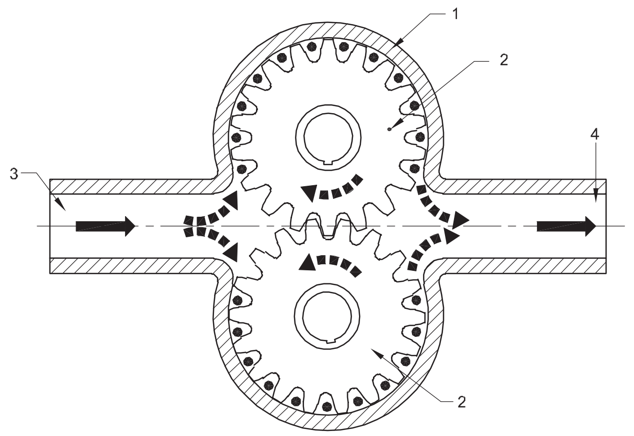
The oil pump is used to pump oil from the oil sump to the Oil galleries at a certain pressure. It is located in the crankcase and is driven by the camshaft. Four types of oil pumps are used.

Types of oil pumps used in lubrication system

- Gear type
- Plunger type
- rotor type
- Ven type

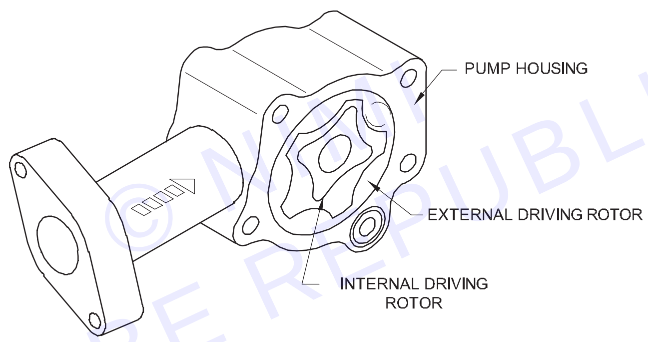
Gear type oil pump

This pump, two gears are mounted in a housing with very little clearance. One of these gears is given a drive. So when it starts rotating, the other gear connected to it also starts rotating. Both gears rotate in opposite direction. Therefore, a vacuum is created in the gear and the oil in the sump is drawn. And on the other side pressure is sent to the oil gallery through the pressure relief valve to the filter at the appropriate pressure



Rotor Type Oil Pump

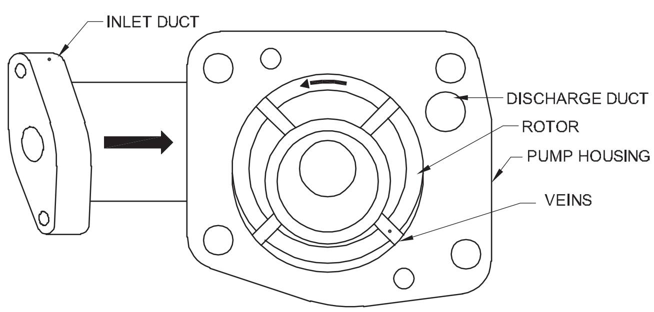
This type of pump two rotors is mounted in one housing. The number of teeth of the outer rotor is one more than there is after the inner rotor receives the drive, it starts rotating in the outer rotor. As the rotor rotates, the oil is drawn in from the high clearance portion of the teeth due to the vacuum created and is expelled from the low clearance portions



ROTOR TYPE OIL PUMP

Vane Type Oil Pump

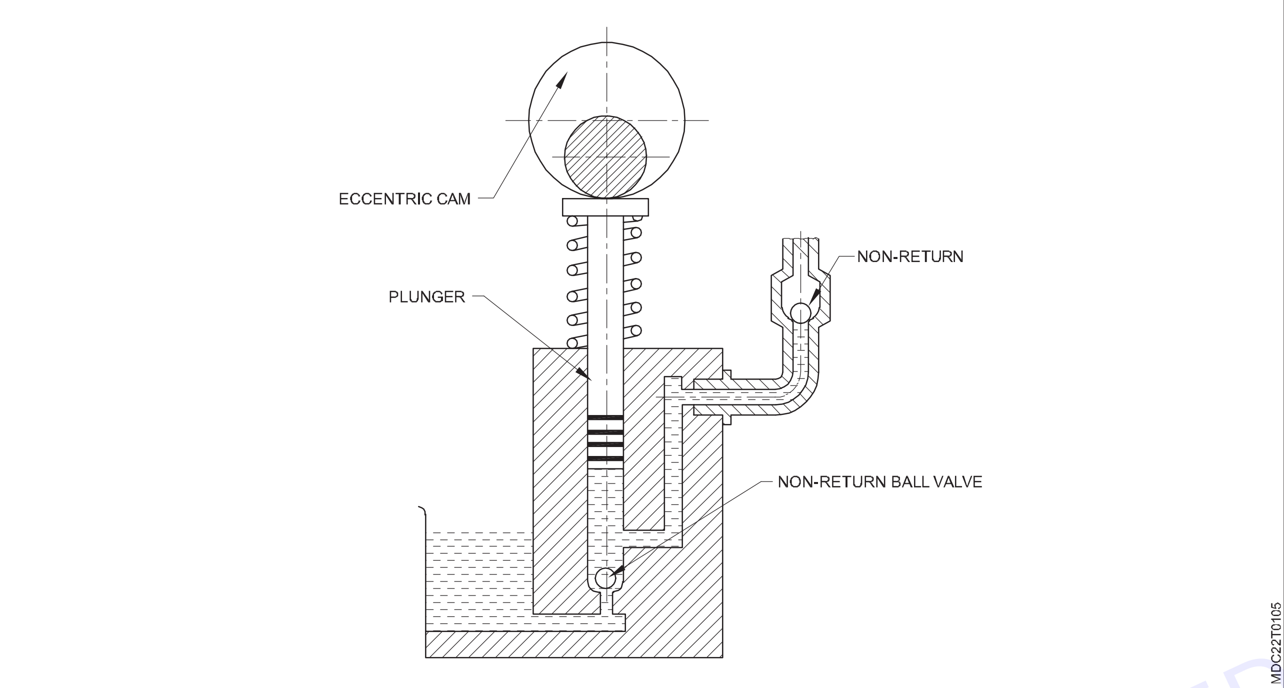
A rotor is eccentrically mounted in the pump. And spring loaded vanes are mounted on it. As the rotor rotates in the housing, a vacuum is created through the vanes and the oil is drawn in and comes out under pressure through the discharge tube.



VANE TYPE OIL PUMP

Plunger Type Oil Pump

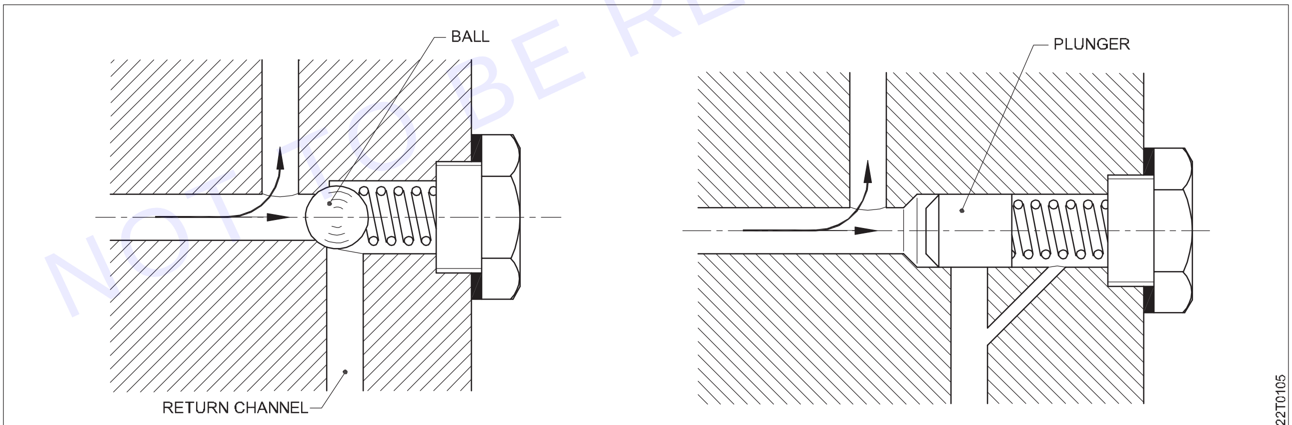
In this pump Includes cylinder, plunger, non-return valve and eccentric cam etc. A plunger is mounted in a cylinder and is operated by a cam. As the plunger moves up in the upward stroke, the ball valve at the inlet opens and the oil enters. At this time the ball valve on the outlet is closed. In the downward stroke, the ball valve at the inlet closes and the ball valve at the outlet opens and the oil escapes under pressure.



Pressure relief valve, bypass valve and oil cooler

Oil pressure relief valve: Oil pressure relief valve is used to maintain oil pressure at maximum limit. When the oil pressure exceeds the expected limit, the relief valve opens and the oil flows back into the oil tank. Generally, there are two types of pressure relief valves.

1 **Ball Type Pressure Relief Valve:** In this type of pressure relief valve, a spring loaded ball opens the return channel. When the oil pressure exceeds the spring force, the oil flows into the oil sump through the return channel.



BALL TYPE PRESSURE RELIEF VALVE

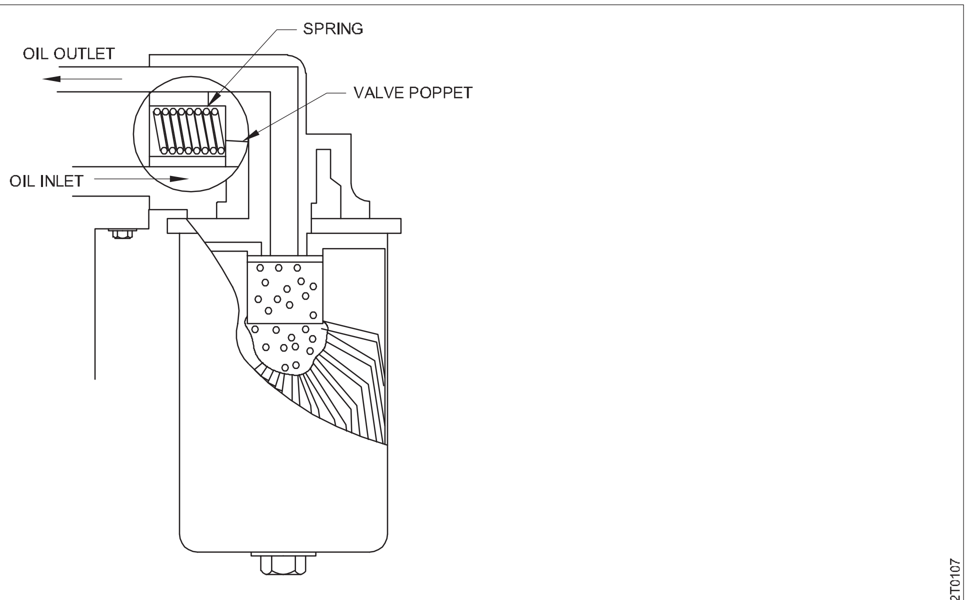
PLUNGER TYPE RELIEF VALVE

2 **Plunger Type Relief Valve:** In this type of pressure relief valve, a plunger is installed in place of the ball.

Bypass Valve: This valve is mostly installed in the filter body (see Figure 21.31) and it is also a spring loaded valve. As we have read above, the oil filter goes from the oil pump to the oil gallery. If the filter gets clogged, then it is possible that the oil will not be able to reach the gallery. Due to filter choke, the pressure inside the pipe coming from the pump increases and due to increase in pressure, the valve gets lifted from its place due to which the oil goes directly from the pump into the gallery and the filter gets cut-off and the engine seizes. Is saved.

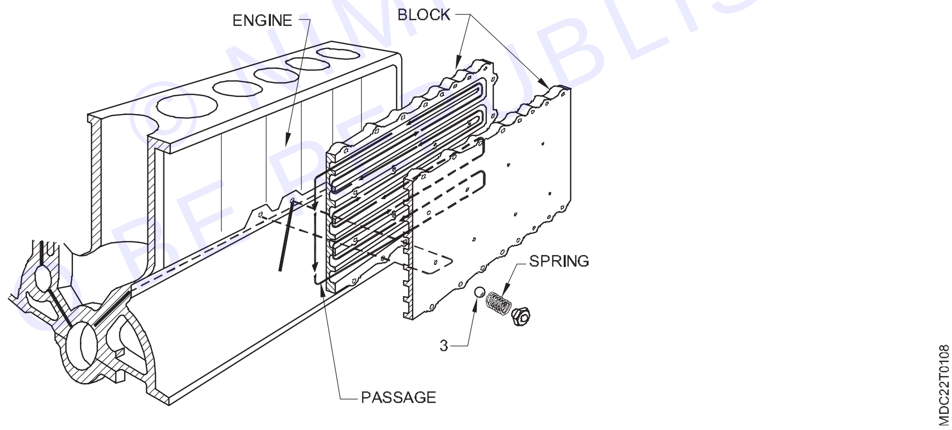
Oil Cooler:

In heavy engines where the oil temperature is likely to be very high, an oil cooler is installed to cool the lubricating oil. The oil cooler is made by combining two parts. Passage for oil circulation is provided in the middle of the cooler. To maintain the desired oil pressure, a ball valve is used, which is made of cast iron. The purpose of the oil cooler is to transfer heat from the engine oil to the cooling water and cool the engine oil.



BY PASS VALVE IN MOUNTING PAD OF FILTER

The inner walls of the oil cooler are in contact with the cooling rotor. The engine oil that is to be circulated through the passage is directed to the oil cooler. The oil cooler transfers heat from the engine oil to the cooling water and circulates the water between the engine block and Circulates through the internal walls. Thus it maintains the temperature of the engine.



Study about oil filtering systems

Objectives: At the end of this lesson you shall be able to

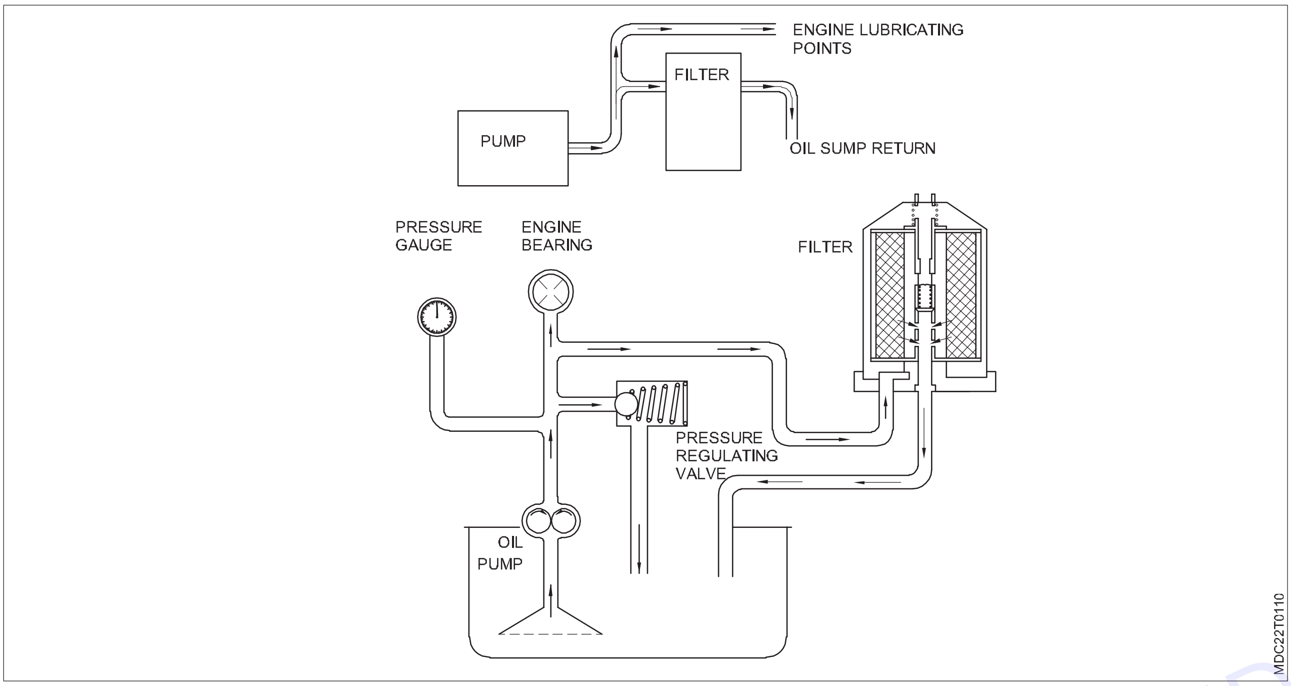
- explain about oil filtering systems.

Oil filter: The oil filter helps remove contaminants like dirt, particles from engine's oil.

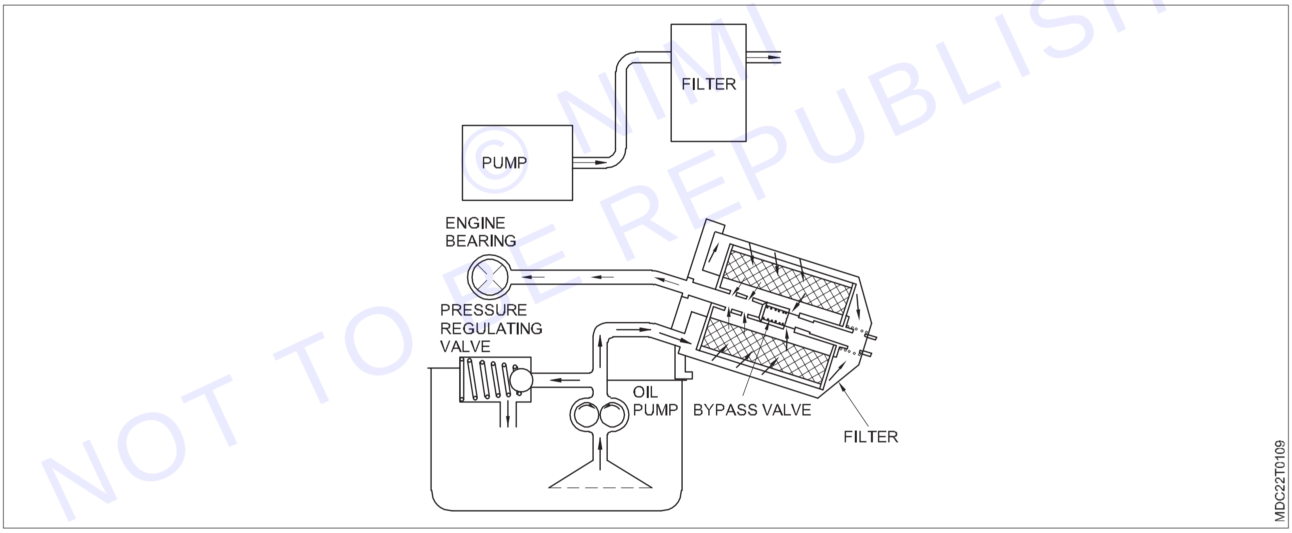
Types of oil filters

Full flow oil filter system: In this system all the oil passes through the filter before reaching the main oil gallery. One bypass valve is provided in the filter which allows oil to reach the main oil gallery directly if the filter is choked.

Bypass oil filter system: In this system only a part of the engine oil enters the filter. After filtering, the oil goes to the oil sump. The remaining oil goes directly to the main oil gallery.



Filter elements: Filter elements are made of felt, cotton waste, cloth and paper. Oil filters are replaced after certain kilometers of running of the engine as specified by the manufacturer.



Importance of maintenance, diagnosis and Servicing lubricating system and its components

Objectives: At the end of this lesson you shall be able to

- explain Importance of maintenance in lubricating system and its components
- explain Importance of diagnosis and Servicing lubricating system and its components.

Maintenance, diagnosis and servicing lubrication system and its components are crucial for maintain smooth operation and longevity of machinery.

- **Preventive maintenance:** continues maintenance helps to prevent breakdowns by identifying and fixed the issues before they break, save time or money on repair.

- **Optimal performance:** proper lubrication makes sure that moving parts operate smoothly, prevent frictional wear and buildup, which can prevent equipment's for the failure.
- **Extended lifespan:** continues maintenance helps to extend the lifespan of machinery by reducing wear and tear on components, preserve their functionality over time.
- **Efficiency:** for operate more efficiently, of any system that are well-lubricated for consuming less energy and reducing operational cost.
- **Safety:** properly lubricated system contributes to a safer work environment by decreasing the risk of accident and malfunction caused by equipment failure.
- **Diagnosis of issues:** continues inspection and diagnostics allow for the early deduction of problems such as leak, contamination or improper lubricated, preventing more serious issues down the line.
- **Component integrity:** servicing lubrication system components such as filters, pumps, hoses, and reservoirs ensure their integrity, preventing failures that could disrupt operations.

In summary investing maintenance, diagnosis, and servicing of lubrication system is essential for maximizing equipment performance, longevity, efficiency, and safety in industrial setting.

Causes of failure of the lubricating system and its components

Objectives: At the end of this lesson you shall be able to

- demonstrate causes of failure of the lubricating system and its components.

Causes of failure in lubricating system

1 Lack of oil in the sump.

2 Oil is too thin

3 Main and big end bearings are worn out.

4 There is leaking in the oil routes.

5 Pressure relief valve is faulty.

6 Oil pump is faulty.

7 Main oil gallery is closed.

8 Oil pressure gauge is faulty

9 There is more thick oil in the sump.

10 Relief valve is not arranged properly.

11 Wear of piston ring.

12 Engine bearings are worn.

13 Wear and tear in the cylinder.

14 Engine oil seal is leaking.

Causes of failure in lubricating system components

1 In oil pump

- **Oil pump wear:** over time the inner parts of oil pump like gears, bearings, etc. wear due to normal use every day which results in oil pump wear
- **Sludge Formation:** oil can't be thin and viscous every time and it losses it's viscosity which then accumulated and create a sludge resulting in clogging of oil pump.

- **Faulty pressure relief valve:** when the pressure relief valve not working properly then it causes the oil to come in excess or not enough oil which is required for lubrication.

2 **In Oil filter system**

- **Clogged Filter:** The most common cause is dirt, debris, and contaminants in the oil causing a clogged filter. This reduces oil flow and may cause engine damage.
- **Poor maintenance:** Irregular or inadequate maintenance (such as not replacing your oil filter at recommended intervals) can cause it to become less effective over time.
- **Inferior quality filters:** Using inferior or counterfeit oil filters can lead to premature failure as they may not filter oil effectively or have a shorter lifespan.
- **Extreme Conditions:** Operating in extreme temperatures or harsh environments can accelerate oil filter wear and lead to failure.

3 **In Oil pressure relief valve**

- **Wear:** Over time, valve components can wear out from continuous use, resulting in reduced effectiveness or failure.
- **Corrosion:** Contact with corrosive substances or environments can damage valves and cause failure.
- **Incorrect pressure settings:** If a safety valve is set to incorrect pressure specifications, it may not work as expected, leading to malfunction.
- **Mechanical Damage:** Physical damage to a valve such as: B. Impact or excessive force may cause malfunction or failure.
- **Lubrication issues:** Insufficient lubrication of valve components can lead to increased friction and wear, which can lead to failure

4 **In Oil pressure gauge**

- **Extreme Temperatures:** Operating at extremely high or low temperatures can affect the accuracy and reliability of your meter, especially if the meter is not designed for such conditions.
- **Component wear:** Wear of other components in the lubrication system, such as: B. Pump or pressure regulator, can indirectly affect the performance of the oil pressure gauge.
- **Age and use:** Like any mechanical or electronic device, oil pressure gauges will deteriorate with age and frequent use, eventually leading to failure if not properly maintained or replaced when necessary.

5 **In Oil cooler**

- **Clogging:** Accumulation of debris, dirt, or sludge in the oil cooler can restrict oil flow, resulting in less efficient cooling and possibly causing the lubricant to overheat.
- **Corrosion:** Exposure to corrosive elements or improper maintenance can cause the oil cooler to corrode, causing leaks or structural damage that affects its functionality.
- **Overheating:** Operating the engine or lubrication system at high temperatures for extended periods of time can put excessive stress on the oil cooler and cause it to fail prematurely.
- **Pressure surges:** Sudden changes in oil pressure, such as excessive pressure surges or spikes, can overload the oil cooler and its connections and cause cracks, leaks, or other failures.
- **Poor Maintenance:** Inadequate maintenance practices, such as: Other issues, such as infrequent cleaning or failure to replace worn parts, can cause oil cooler failure over time.

Importance of testing of oil pumps

Objectives: At the end of this lesson you shall be able to

- demonstrate importance of testing of oil pumps.

- As the two moving parts must be supplied with oil in proper quantity
- So that the oil can be supplied in the right quantity to the required place
- To check if the oil pump is not working properly or if the relief valve opens at low pressure.
- If the oil pressure in the engine is less than normal
- If the inlet passage to the oil pump is choked up
- To check oil pipeline leakage
- To check whether the rotation of the pump gear creates a torque in the pump body due to centrifugal force and pulls the oil from the oil sump by the pump into the oil pump body.
- To check if the oil in the pump body is pressed against the gear side due to the rotation of the gear and the oil is forced out of the outlet port adjacent to the pump housing by pressure.
- To check if the pressure of the oil coming out of all pumps is 0.6 to 1.4 PSI at normal idling speed.
- To check if the oil pressure is between 2.5 to 4.0 kg sq cm in high speed

Importance of servicing oil filter

Objectives: At the end of this lesson you shall be able to

- demonstrate importance of servicing oil filter.

In this system all the oil passes through the filter before reaching the main oil gallery. One bypass valve is provided in the filter which allows oil to reach the main oil gallery directly if the filter is choked.

Bypass oil filter system: In this system only a part of the engine oil enters the filter. After filtering, the oil goes to the oil sump. The remaining oil goes directly to the main oil gallery.

Filter element: Filter elements are made of felt, cotton waste, cloth and paper. Oil filters are replaced after certain kilometers of running of the engine as specified by the manufacturer.

Importance of Servicing the oil filter is

1 **Cleanliness:** The oil filter removes contaminants such as dirt, metal particles, and sludge from the engine oil, ensuring that only clean oil circulates through the engine. This helps prevent wear and damage to engine components.

2 **Efficiency:** A clean oil filter allows the engine oil to flow freely, ensuring proper lubrication of engine parts. This helps maintain optimal engine performance and fuel efficiency.

3 **Longevity:** Regularly servicing the oil filter prolongs the life of the engine by reducing wear on critical components. Clean oil also helps prevent corrosion and extends the lifespan of the engine.

4 **Preventing Engine Damage:** Contaminants in the oil can cause damage to engine components over time if not filtered out. Servicing the oil filter helps prevent this damage, leading to a smoother and more reliable engine operation.

Overall, regular servicing of the oil filter is essential for maintaining the health and performance of the engine, as well as ensuring its longevity and reliability.

Importance of checking and setting correct oil pressure

Objectives: At the end of this lesson you shall be able to

- explain about the importance of checking and setting correct oil pressure

In this system all the oil passes through the filter before reaching the main oil gallery. One bypass valve is provided in the filter which allows oil to reach the main oil gallery directly if the filter is choked.

Bypass oil filter system: In this system only a part of the engine oil enters the filter. After filtering, the oil goes to the oil sump. The remaining oil goes directly to the main oil gallery.

Filter element: Filter elements are made of felt, cotton waste, cloth and paper. Oil filters are replaced after certain kilometers of running of the engine as specified by the manufacturer.

Importance of Servicing the oil filter is

1 **Cleanliness:** The oil filter removes contaminants such as dirt, metal particles, and sludge from the engine oil, ensuring that only clean oil circulates through the engine. This helps prevent wear and damage to engine components.

2 **Efficiency:** A clean oil filter allows the engine oil to flow freely, ensuring proper lubrication of engine parts. This helps maintain optimal engine performance and fuel efficiency.

3 **Longevity:** Regularly servicing the oil filter prolongs the life of the engine by reducing wear on critical components. Clean oil also helps prevent corrosion and extends the lifespan of the engine.

4 **Preventing Engine Damage:** Contaminants in the oil can cause damage to engine components over time if not filtered out. Servicing the oil filter helps prevent this damage, leading to a smoother and more reliable engine operation.

Overall, regular servicing of the oil filter is essential for maintaining the health and performance of the engine, as well as ensuring its longevity and reliability.

Importance of checking and setting correct oil pressure

Objectives: At the end of this lesson you shall be able to

- explain importance of checking oil pressure.
- demonstrate how to setting correct oil pressure.

1 To reduce friction in the contact surfaces of the parts so that the motion of the parts is maintained.

2 Forms a fine film or oil film on the surfaces of engine moving parts.

3 To prevent gases from leaking out, oil fills the spaces.

4 Works as a cooling agent by absorbing the heat of moving parts.

5 Cleans the part by flushing out dust, metal particles etc.

6 This oil film reduces the noise of parts colliding.

7 Reduces shocks on the surfaces of engine moving parts.

8 Do not drop the viscosity to the maximum heat limit.

9 Produce with less carbon.

Reasons for sludge formation and its prevention Troubleshooting in lubricating system and its components

Objectives: At the end of this lesson you shall be able to

- explain reasons for sludge formation and its prevention
- demonstrate troubleshooting in lubricating system and its components.

Reasons for sludge formation and its prevention

Sludge

The piston rings prevent the burnt gases from entering the oil pump. But after some time when the rings get worn out, these gases enter the oil pump in some quantity and in addition when we turn off the engine at night, its temperature drops after some time. The cold air from outside enters the sump through the bead and we also know that there is moisture in the air. When it gets even colder at night, that moisture condenses and turns into water droplets. When water droplets mix with the engine oil and enter the sump, it turns the oil into a paste due to which the oil loses its proper quality. This paste is called sludge.

To prevent sludge, we should do the following things -

1 Start the engine and run it fast to bring its temperature to about 60° and while working, its temperature should be kept above 60°.

2 In cold weather, a shutter or sack should be put over the radiator.

3 Carburetor injector etc. should be checked to see if the rich mixture is not going.

4 Whether any cylinder is missing. In case of failure of the spark plug, the fuel will go inside the sump in liquid form. Similarly, in a diesel engine, if any injector is not working properly, then instead of spraying, it will pour a stream of oil on the piston and this oil will go into the sump through the ring.

5 The nuts of the cylinder head should be checked properly so that the water leaking through the gasket does not go into the sump.

6 The engine should not be run at idle speed for a long time.

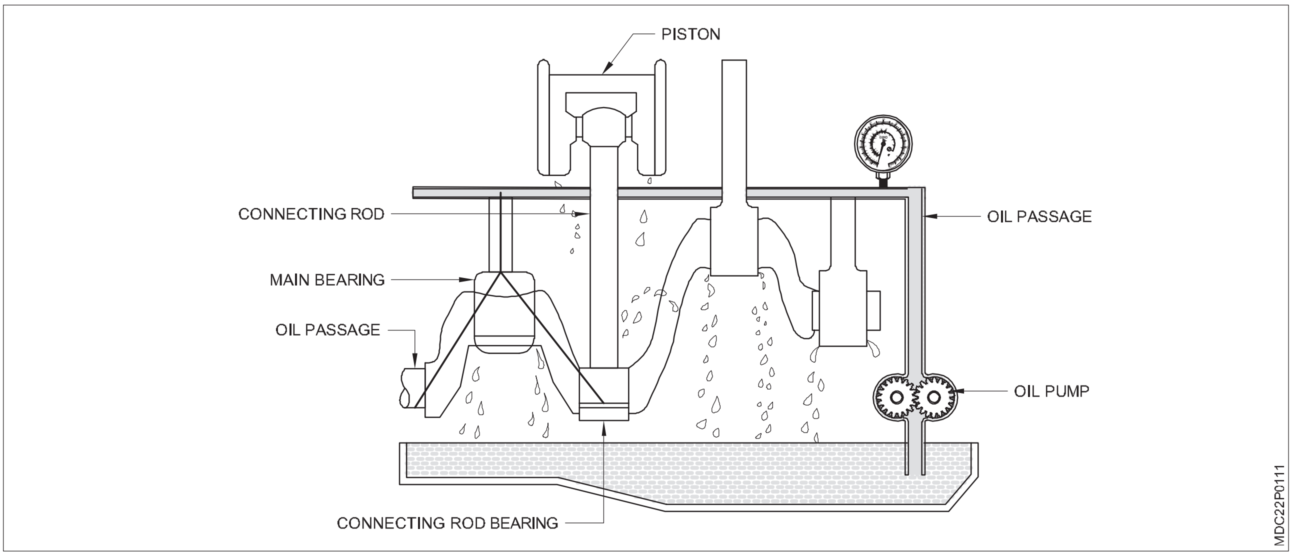
7 The breathing system of the engine should be kept clean.

8 Engine oil should be changed on time.

9 Oil filter should also be changed or cleaned at regular intervals.

Remember that whenever sludge is formed inside the engine, in this case not only the sump should be opened and cleaned but also the mesh fitted in front of the oil pump and the oil galleries should be cleaned.

Troubleshooting in lubricating system and it is components



Introduction: In I.C engine or E.C engine both engine have work crucial at high speed or low speed. Inside of engine so many metallic parts also move in quick second of time, but there are also create a strong heat by a friction as well as some parts also damage due to poor lubrication, for proper moving and crucial work there are use lubrication system used in engines (in I.C and E.C). It is median of lubrication is oil. Due to high rpm engine have need a strong lubrication in quick times therefore, at high rpm there are also construct some types of components in system. These systems also known as lubrication system.

Lubrication system is mechanical system of lubricating internal combustion engines in which a pump forces oil into the engine bearings.

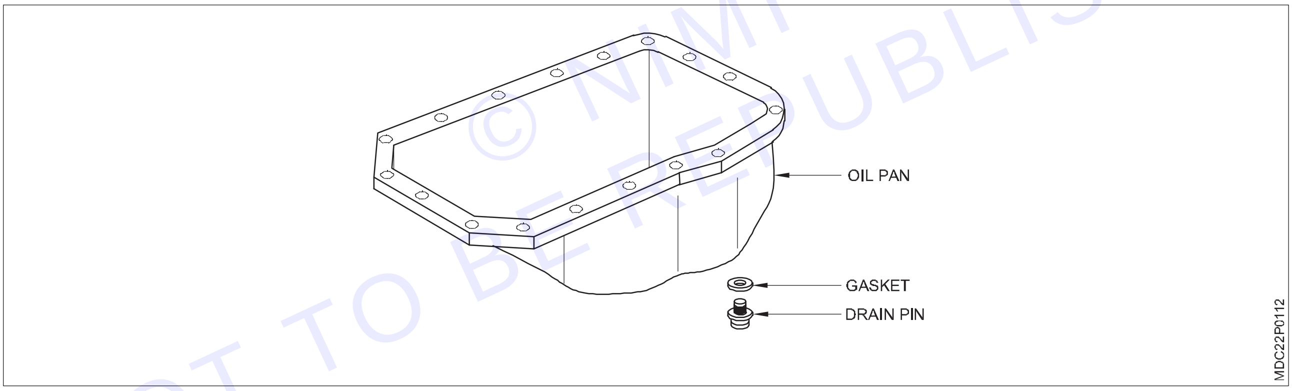
Engine parts that are required quick lubrication

1 Cylinder piston or piston rings
2 Main bearings
3 Crank shaft
4 Crank pin or piston pin
5 Big end or small end of connecting rod
6 Camshaft
7 Valve and valve trains and timing gear assembly
8 Turbo charger (if diesel engine)

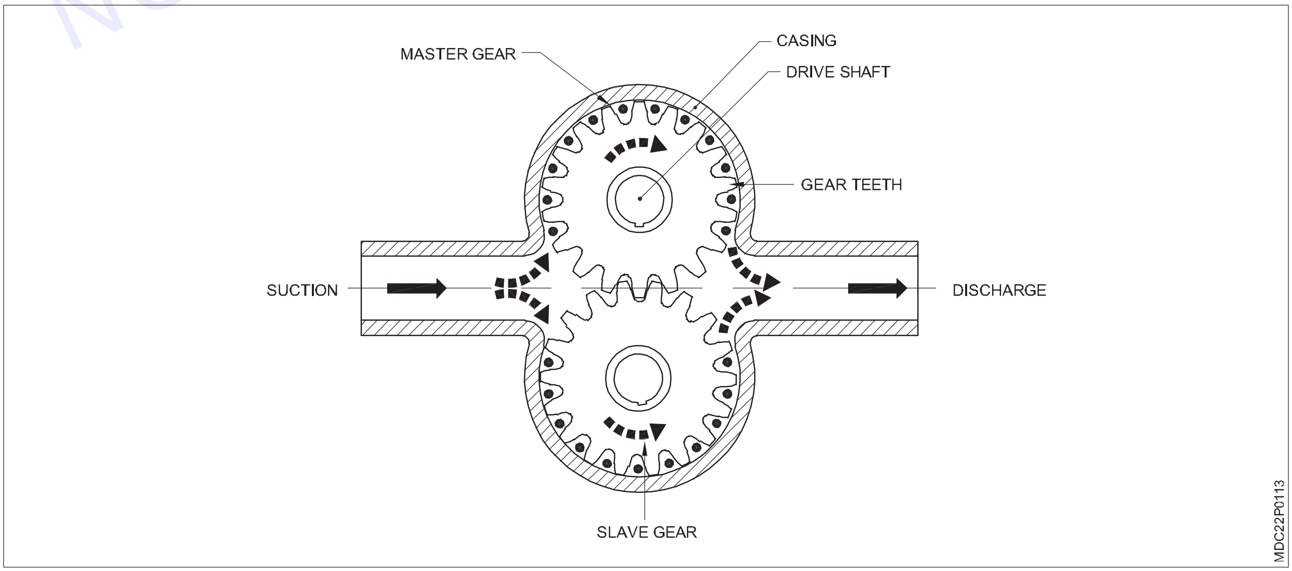
Components of Oil Lubrication System:

Oil sump (reservoir)

Oil sump is used for stores the engine oil and provides a reservoir for lubrication. Engine oil is kept in an oil sump, which also serves as a conduit for it is circulation inside the engine. It has a drain plug for changing the oil and often found underside of the crankcase.

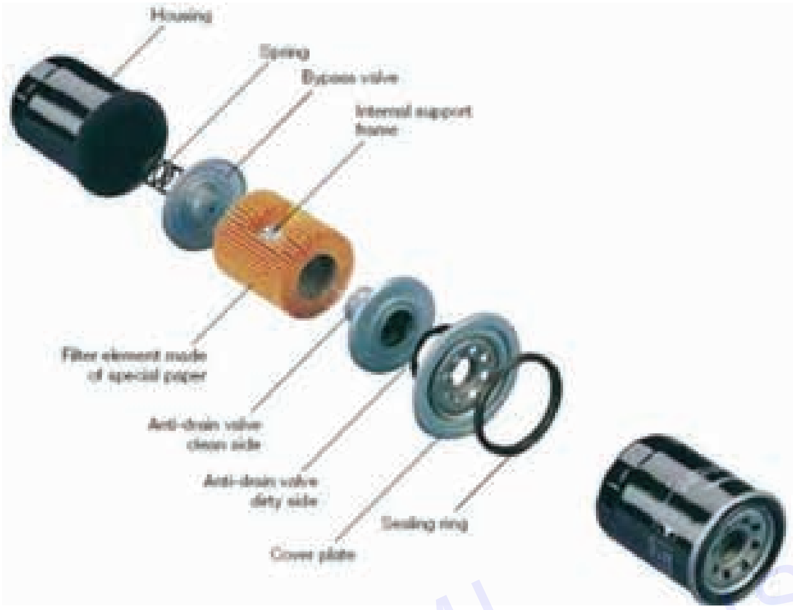


Oil pump



Oil pump is most important part of oil lubrication system because of it is main unit to which pressure create on oil. It is drive by a timing gears. It is construction is simple, inside of these pump only two gears rotate inside. The housing of a unit called drive gear which drive the cam shaft and another one is driven gear as shown in given diagram.

Oil filter



Due to movement of engine some metal dust carbon or breathing system dust and dirt mix with lubricating oil. To remove these dust from oil the oil filter is used. It is also main filtration unit in oil lubrication system. It may be full flow system or by pass system. A full-flow system filters all of the oil, flow whereas a bypass system simply filters some of it.

Oil strainer

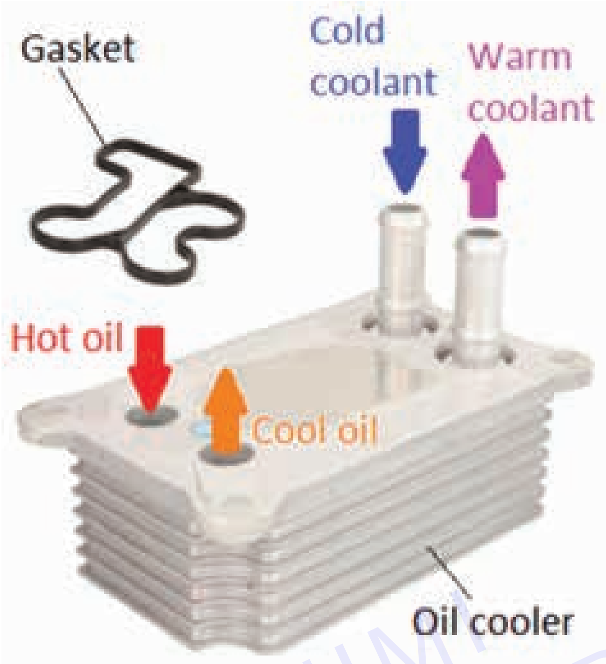
A mesh or screen that stops big particle from blocking the oil pump by keeping them from entering the oil pump. It is often fastened to the oil pickup tube or the oil sump. Oil strainer is first filter or starting filtration unit of oil lubrication system.

Oil cooler plates

Due to the lots of frication inside of engine every time oil also absorb a heat from which to produce from an engine. After absorbing of heat oil also start to highly boil these oil also need some cooling, for these cooling done by oil cooler plates. A device that reduces oil temperature by dissipating heat into air or coolant. It serves as a safeguard against engine overheating and oil deterioration. It comes both water-cooled and air-cooled varieties.

As water circulated in engine to suck heat similarly by circulating oil in engine becomes hot and viscosity decrease so oil becomes then thus not lubricate the parts of engine so it is necessary to keep it cool. Some of the engines has second radiator behind the main radiator known as heat exchanger. The oil going towards engine block passes through it and cool the oil when comes in contact with air of fan.

The second system is cool the oil by water as we known the temperature of water less than oil. Oil rotates around the water tube and becomes cool.

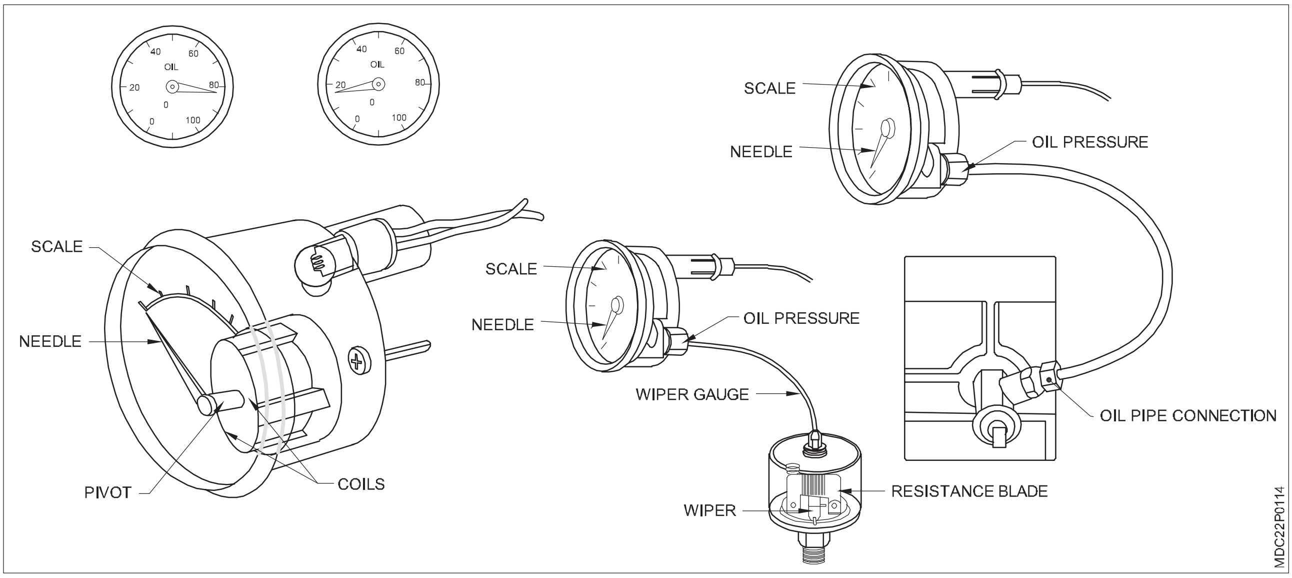


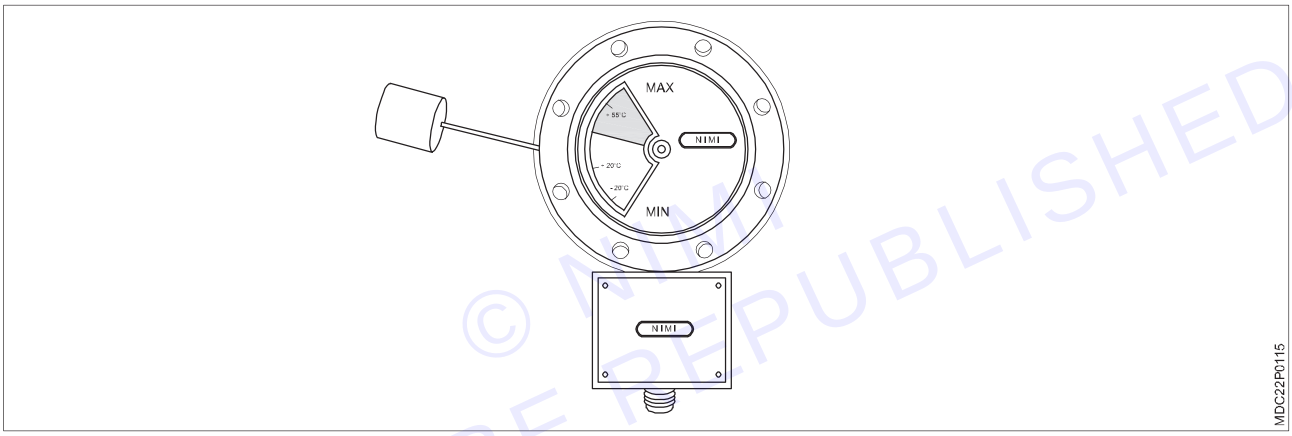
Oil level indicator

An instrument that displays the oil level in the oil sump is known as an oil level indicator. Either a dipstick, shows the minimum and maximum oil levels. A dashboard gauge or light receives a signal from an electric sensor.

Oil pressure gauge

An instrument that gauges the pressure of the oil in the lubricating system is known as an oil pressure gauge. It can be mechanical or electrical in nature. A fluid filled tube drives a moving needle on a dial in mechanical gauge. Using a sensor, an electrical gauge transform pressure into a signal that moves the needle or display a digital readout.





Oil pressure indicating light

A dashboard indicating light warning light the flashes when the oil pressure is abnormally high or low to notify the driver.

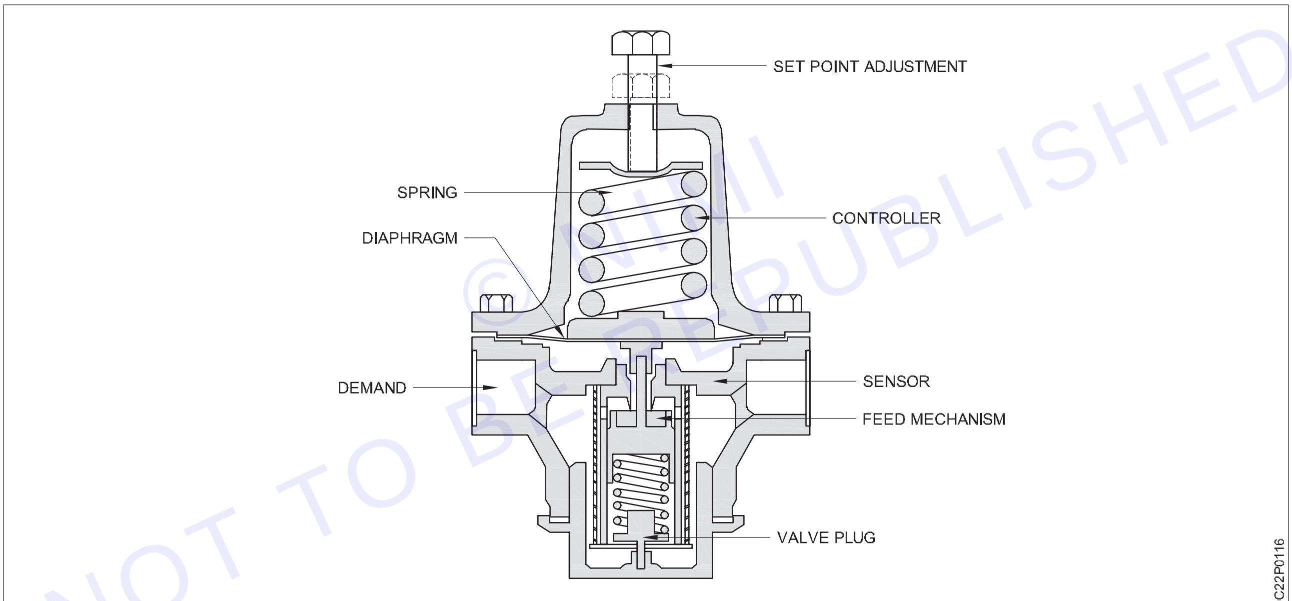
Oil pressure indicating light

A dashboard warning light that flashes in yellow it means engine lubricating system have minor issue.

A dashboard warning light that flashes in red it means engine lubricating system have a major issue.

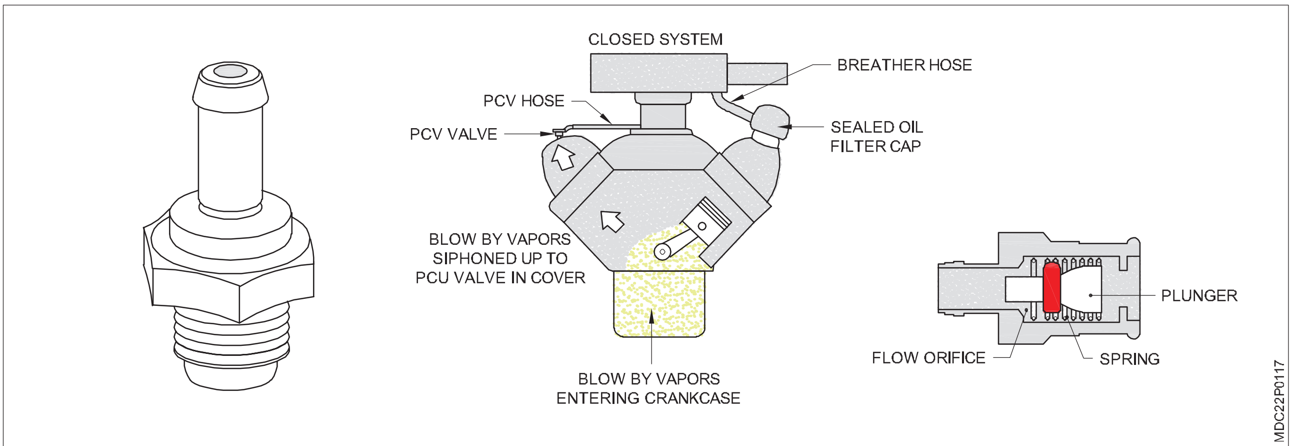
Oil pressure regulating valve

It is spring loaded valve and fitted in oil gallery. When oil pressure increases then this valve press the spring against it is tension (opposite direction) and some quantity of oil falls o sump thus oil pressure decreases then pressure from valve lifted and spring comes to it is seat back.



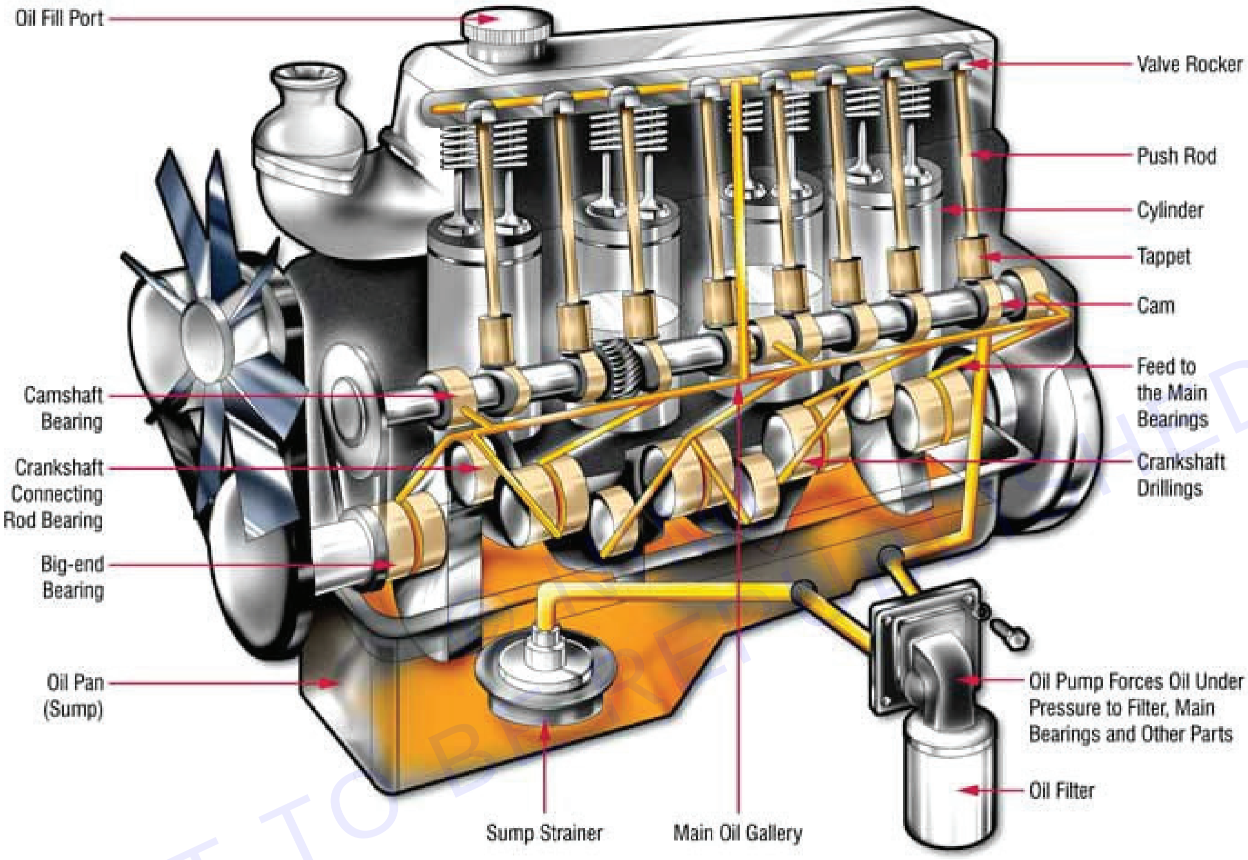
OIL PRESSURE REGULATING VALVE

Air breather



When engine runs and get heat up, air in empty space in sump also get heated up and expands. In olden engine some sumps also heated up and expands. In olden engines some sump press combustion gases leak in sump. If these pressure is not let off, then this will increase further and damage the oil seal etc. and gases leak from there is to save from this the pipe of engine block is connected with inlet manifold so that gases of block can be sucked and again burn out.

Must due to strong circulation of oil in system also sometimes failure therefore let's study about troubleshooting in lubrication system with causes and with its remedies



S.No	Troubleshooting	Causes of failure	Remedies
1	Low oil pressure	1 Less oil in crankcase 2 Use of low viscosity oil	1 Oil top-up 2 Use proper grade of oil
2	Worn out main and big end bearing	Low oil pressure	Replace the bearings and set the proper oil pressure
3	Leaky oil filter, oil pipe	Seal loose, pipe loose	Replace the seal
4	Low oil pressure	Chocked suction oil strainer	Remove old oil and flushing the system
5	High oil pressure	• Use of high viscosity oil • Defective oil pressure gauge • Sticky regulating valve incorrect setting of pressure regulating valve	Setting the proper oil pressure adjustment and check the wiring harness of gauge

6	Oil consumption	Causes of leakage oil	Check all pipe line of oil supply and check the drain plug also
7	Engine found oily	Tappet cover packing loose	Change the tappet cover packing

Internal leakage of engine and burning oil

	Troubleshooting	Causes of failure	Remedies
1	Piston pin poor lubrication	Opening of passage in combustion chamber due to broken gasket of cylinder head	Replace the gasket
2	Poor pickup	Oil burn in cylinder	Turbocharger check
3	Strong gases out through breather pipe	Piston rings worn out	Service your engine
4	Oil leak from rear side and front side of engine	Seal broken	Replace it
5	Oil mix with water	Damage of head gasket oil cooler plate broken	Check head gasket and oil cooler plate
6	Engine overheat	Cavitation	Check play between gear pump
7	Oil found in air tank	Air compressor gasket leak	Service air compressor and drain all air tank
8	Oil leak through alternator	Pipe broken vacuum motor fail	Change pipe and vacuum motor

MODULE 7 : Engine Cooling System

LESSON 47 - 56: Engine cooling system Coolant, types, and its properties

Objectives

At the end of this lesson you shall be able to

- explain properties of coolent
- explain types of coolent
- explain cooling system.

Introduction of cooling system

Introduction

As a result of the thermal energy generated during the operation of the engine, the temperature of the engine keeps increasing continuously. Therefore, there is a need to control the temperature of the engine. To eliminate unnecessary heat of the engine or to control the temperature of the engine, cooling systems are used, which are of two types – air cooling and water cooling.

Need of cooling system

The cooling system in engines is arranged to protect the engine from the ill effects of the heat generated in it. In the absence of a cooling system, the following defects are likely to occur inside the engine:

1 Pre-ignition

2 Detonation

3 Knocking

4 Burning of valves and

5 Damage to bearings etc. due to lack of oil.

Technical terminology related to cooling

The technical terminology related to cooling of vehicles is as follows:

1 Boiling Point

The fixed temperature at which a liquid starts converting into gas is called the boiling point or vapor point of the liquid and this process is called boiling; For example, the boiling point of water is 100°C and the boiling point of diesel in a diesel engine is 180°C-360°C.

2 Heat Transfer

Transfer of heat from one place to another can be done mainly through three methods – conduction, convection and radiation. In the first two methods, a medium is required for heat transfer, whereas it is not necessary for the radiation method.

Radiation method is the fastest method of heat transfer, in which heat is transferred from one place to another in the form of electromagnetic radiation. A brief description of these three methods of heat transfer is given below.

i Conduction

The process of heat transmission, in which the particles of the object do not move from their place, but allow heat to pass from one place to another. conduction process is called

ii Convection

In this process, heat transfer occurs due to the particles of the substance of the medium moving from one place to another. This process happens in two ways

- natural convection
- Ford Conviction

iii Radiation

Heat (energy) from a hot source is transmitted in the form of electromagnetic waves, this is called 'radiation'. There is no need of medium for this. Earth receives heat from the Sun only through radiation.

3 Pressure

The magnitude of the perpendicular force acting on the unit area of a plane is called the pressure acting on that plane.

that is

Pressure = vertical force / area

$p = F/A$

Where, F = force, p = pressure and A = area.

4 Centrifugal force

When an object moves in uniform circular motion, a force acts on it. The force which tries to push an object outward from the center is called centrifugal force.

Centrifugal force = mv^2/r

$= mrw2.$ $(V=rw)$

where,

m = mass of the object,

V = velocity of the object,

@ = angular velocity

r = radius of the circle

Properties of coolant used in vehicles

The ideal coolant to be used in an engine should have the following properties

i **High thermal capacity:** The thermal capacity of the coolant should be high, that is, heat should be absorbed by the coolant with great efficiency.

ii **Low viscosity:** A good coolant is one in which viscosity is almost negligible. Coolants with low viscosity flow faster.

iii **Low cost:** coolants should be available in the market at low prices, so that they can be purchased easily.

iv **Non-toxic:** Coolants should be non-toxic, otherwise when they come in contact with heat, they react chemically and release toxic gases, which can prove fatal for human health.

v **Chemical inertness:** Coolant should not be a chemical reagent, otherwise the coolant reacts chemically with the engine parts, resulting in problems like rusting etc.

vi **Electrical insulator:** The coolant should be a bad conductor of electricity. If the coolant is a good conductor of electricity, there is a possibility of spark in the engine.

Recommended change of interval of coolant

Coolant is one of the most overlooked fluids in vehicle maintenance. When coolant gets old, its pH value changes which can damage various engine parts, gaskets and seals. Therefore, for smooth operation of the internal parts of the engine, the coolant should be changed every 3 years, but some vehicle manufacturers recommend changing the coolant after 10 years or 10,000 miles.

Types of cooling system

The following cooling systems are used to cool the internal combustion engine or keep it at normal temperature.

1 Air cooling system (direct cooling system)

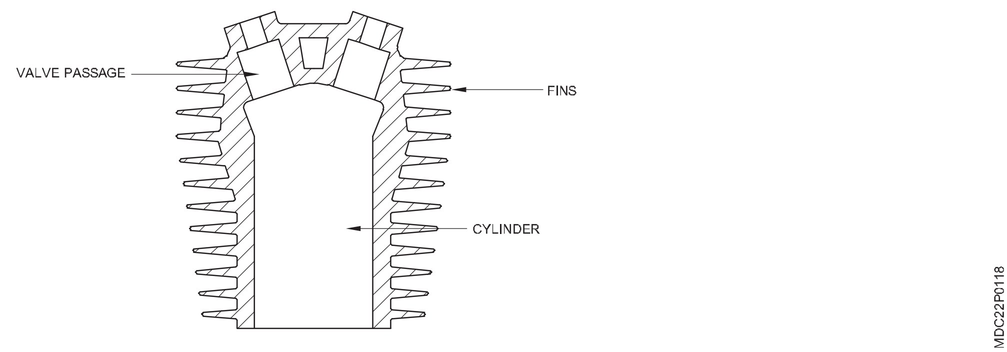
2 Water cooling system (indirect cooling system)

A Thermo syphon system

B Pump circulation system

1 AIR COOLING SYSTEM

In the air cooling system, air is used to cool the engine to normal temperature. In this system only air cools the cylinder head and block with the help of fins and blower. In this, many tapers and thin fins are made around the cylinders of the engines to be cooled. Due to these fans, the area of air accumulated around the cylinder increases. Due to these feathers being thin at the edge, they cool down quickly in contact with air. The efficiency of the air cooling system depends on the surface area of the fans used in the engine, the amount of air, its velocity and the temperature to be cooled. This system is used in two or three wheeled vehicles, airplane engines and small stationary engines.



Advantage

1 This cooling system is easy to maintain.

2 There is no possibility of water freezing in this system.

3 In this system, there is no additional weight of water pump, radiator and fan etc. in the weight of the engine.

4 In this system, casting of the cylinder can be done easily, because water jacket does not have to be made in it.

5 In this system the engine quickly comes to its normal temperature.

Disadvantages

1 Due to this the engines make more noise.

2 This reduces the efficiency of engines.

3 Under this system, larger fins have to be made in larger engines.

4 Under this system the engines are able to cool down gradually.

2 Water cooling system

Under the water cooling system, water is used to eliminate unnecessary temperature of the engine. Water is filled in the radiator ray to collect water around the engine cylinder.

Water jackets are made. The water from the radiator goes into these water jackets through rubber hose pipe and the heat from the cylinder is transferred to this water.

The water takes the heat from the cylinder and returns to the radiator, where it cools down and then goes back into the water jackets of the engine. Similarly, this cycle of water remains continuous while the engine is running and the engine continues to run at its normal temperature.

Water cooling systems are used in water cooling systems based on conveying water from the radiator to the water jacket and back to the radiator.

Advantage

Following are the main advantages of water cooling system

1 The engines in this system are of compact design.

2 Fuel consumption in engines of this system occurs at high compression.

3 Through this system, the temperature of the cylinder head and valve seat of the engine can be easily reduced.

4 The design of this system does not depend on the size of the engine.

Disadvantages

Following are the main disadvantages of water cooling system

1 In this system it would be necessary to make the radiator very large. So that the water can cool down quickly.

2 If for some reason there is an obstruction in the waterway, then this system is not able to perform its function.

Types of water cooling systems

Water cooling system is of following types

i Thermo-siphon system

ii Pump circulation system

1 Thermo-siphon system

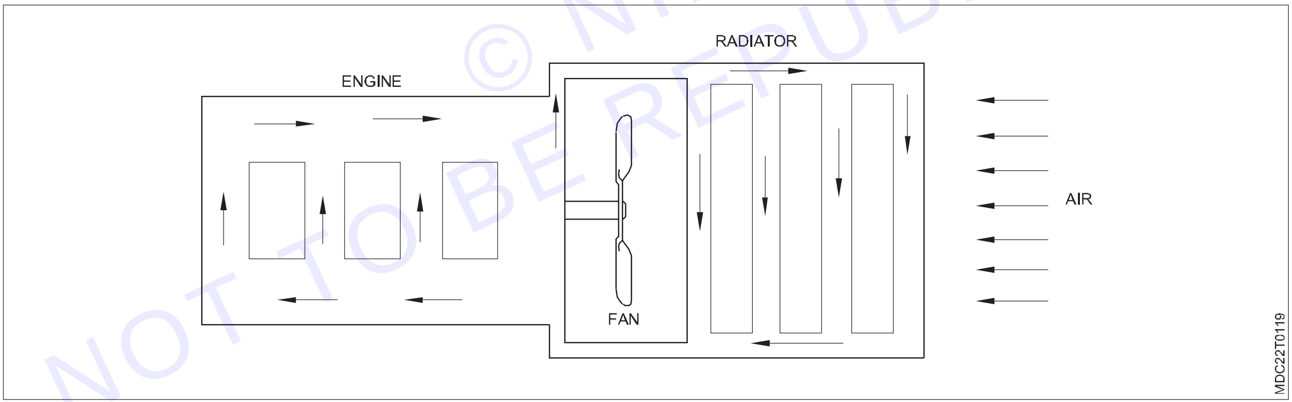
The thermo-siphon system is similar to the Forced circulation system and the radiator is filled with water. This radiator is made almost like the radiator of Ford Circulation system, but in this system a pump is not used. Generally, a thermo-siphon system is installed in front of the engine with a radiator. The cold water from the radiator goes to the engine block through the reservoir prime below it. From here, the water gets heated through the water jacket or water passage in the engine head and enters the heat tank of the radiator through a pipe from the engine head.

The air coming in contact with the radiator fins reduces the temperature of the water and the cooled water from the tubes installed in the radiator enters the lower tank of the radiator by gravity.

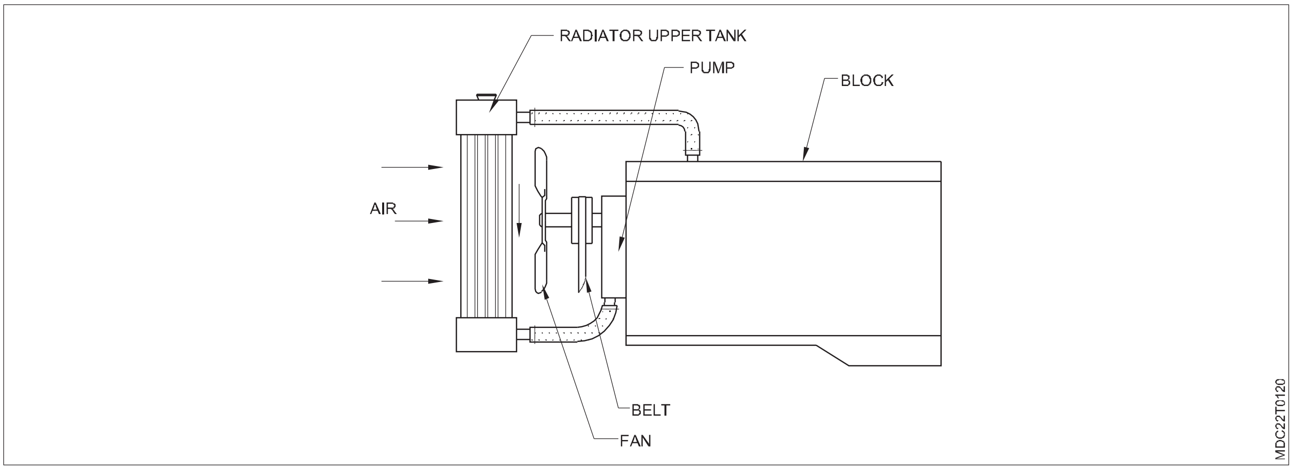
1 Water circulates self-due to density.

2 Top → bottom (in radiator)

3 Bottom → Top (in engine)



2 Pump circulation system



In this system, water is filled in the radiator, in which there is an upper tank at the top and a lower tank at the bottom. Both the tanks are connected by thin copper tubes. Zig-zag fans are installed around the tubes, in which the area increases due to the flow of air. There is a space made in the upper tank to fill water, on which a water tight cap is used. It is also called 'Ford Feed System'. In this tank, a rubber hose pipe is fitted to return the hot water coming from the water jackets. The lower tank is connected to the water inlet through a rubber hose pipe. A special type of water pump is installed at this place.

Basic components of cooling system

1 Radiator

2 Thermostat

3 Thermo-Switch

4 Coolant reservoir

5 Water Pump

6 Cooling Fan

7 Radiator pressure cap

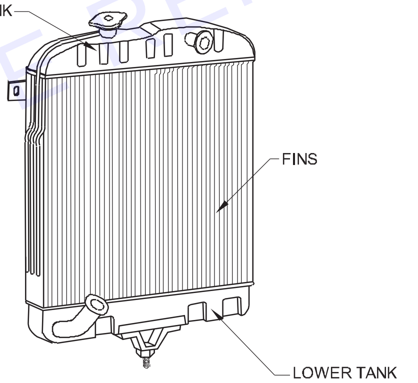
8 Water jacket

9 Radiator Shutter and Cowl

1 Radiator: The radiator is fitted at the front of the engine. Its main function is to cool the hot water coming from the engine. For this purpose, thin tubes are used in the radiator. These tubes are surrounded by fin lays.

Due to this type of structure, the cooling surface (cooling surface) becomes larger, due to which the water gets cooled quickly. The radiator has an upper tank and a lower tank. In the middle of which the radiator core is installed.

The upper tank is connected to the engine drain by a rubber hose and the lower tank is connected to the water pump by a rubber hose.



Main part of radiator

1 Upper tank

2 Lower Tank

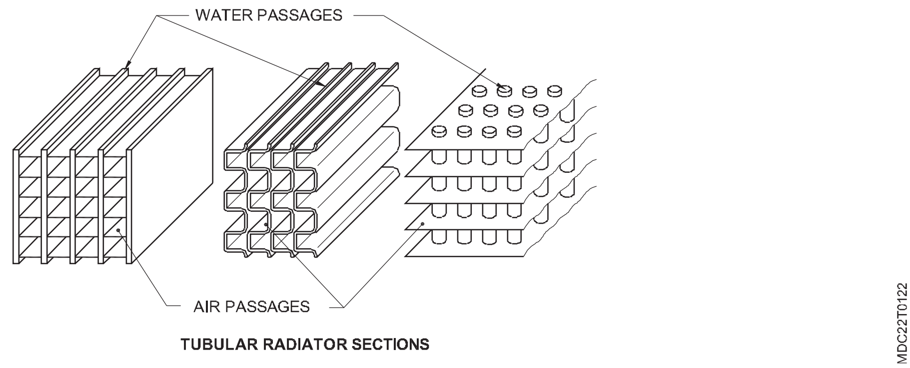
3 Radiator core

4 Radiator cap

Radiator core: When air is passed through a shorter path, it becomes cool. The radiator core is made by soldering the upper and lower tanks or connecting them with nuts and bolts. The radiator core is made up of tiny tubes. Fins are fitted on top of these tubes, which work to cool the water flowing inside the tubes.

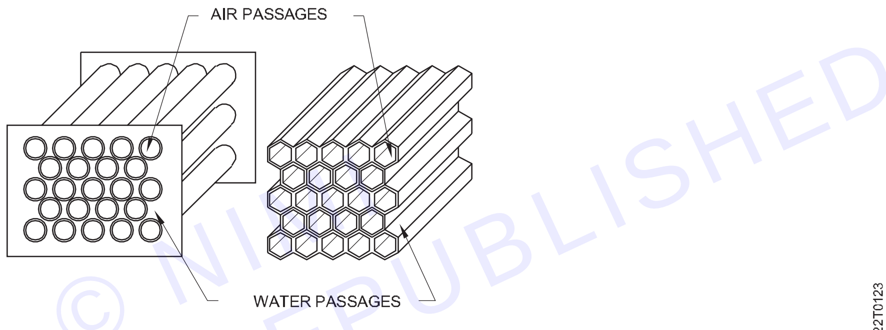
The radiator core is classified into two parts

a **Tubular type radiator core:** In tubular type radiator core the upper and lower tanks are connected by tubes. Water passes through these tubes. Cooling fans are installed around the tubes, which absorb the heat of water and spread it into the atmosphere. If the tube gets blocked for some reason, the cooling of the water stops



TUBULAR RADIATOR SECTIONS

b **Honeycomb type radiator core:** It is also known as cellular type core. In this type of core, air flows across the tubes and water remains on the outside. This core is made up of many air cells. Radiators are usually made of copper or brass, because these Metals have the property of cooling quickly. All its joints are joined by soldering, so that they can be easily opened by heating for repair. This type of radiator core looks as if it is a beehive, hence it is called also called 'honeycomb'.



CELLULAR RADIATOR SECTION

Thermostat: A thermostat is a device that opens automatically at a predetermined temperature. It is installed in the water pipe going from the engine to the radiator. As shown in the figure, when the engine is cold, the thermostat closes and the water pump normally pumps water around the cylinder block. When the engine reaches the correct temperature, the thermostat opens and water is circulated through the radiator to cool the engine.

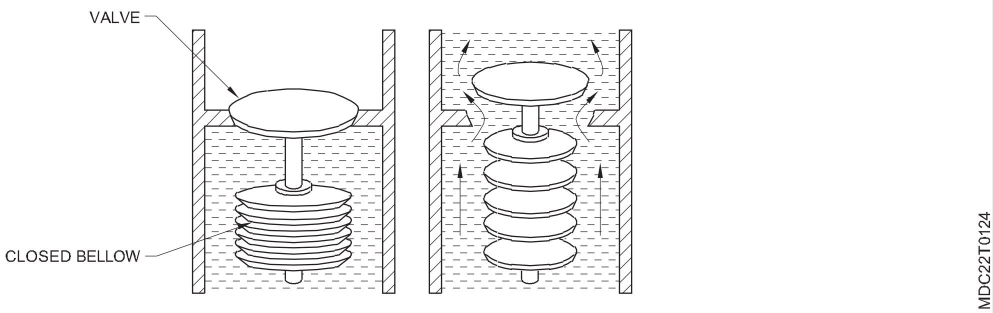
Types of Thermostat

There are two types of thermostat

i Bellow type thermostat

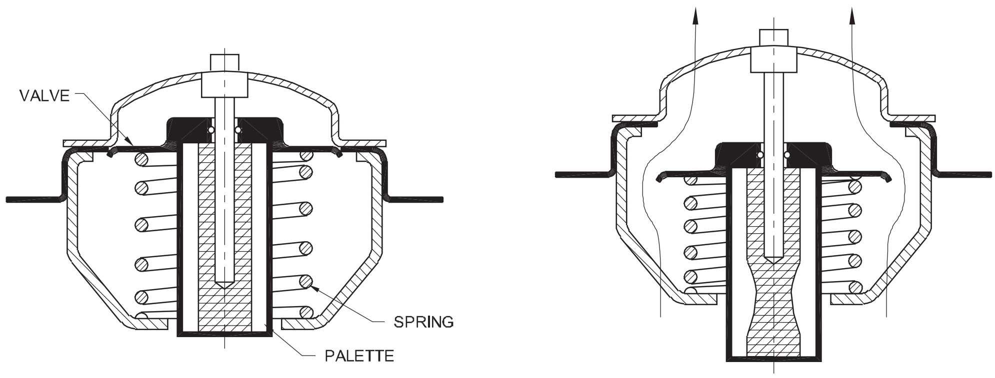
ii Wax pellet thermostat

1 **Bellow Type Thermostat:** consists of a flexible metal bag, both the ends of which are closed. This metal bag is filled with ethyl with low boiling point temperature. When the engine is cold, the valve closes its outlet passage and does not allow water from the engine to reach the top tank of the radiator. But water circulates through the bypass port of the engine.



2 Wax pallet type thermostat

This type of wax pellet is used like a heating element. When the temperature of the circulating water is below the operating temperature, the spring holds the valve in the closed position and water is not able to reach the top tank of the radiator from the engine. As the water reaches operating temperature the wax pellet expands and forces the valve open against spring tension. Now water reaches the top tank of the radiator from the engine. In this situation the bypass port remains closed by the valve.



(a) CLOSED POSITION OF THERMOSTAT VALVE (b) OPEN POSITION OF THERMOSTAT VALVE

MDC22T0125

Radiator pressur cap

increase the boiling point of water. In normal atmospheric conditions, water boils at 100°C. At the highest altitude, atmospheric pressure is less and water boils at temperatures below 100°C. To increase the boiling point temperature of water, the pressure of the cooling system has to be increased. This is achieved by sealing the system with a pressure cap.

Cooling losses due to evaporation can also be reduced by using a pressure cap. This allows the engine to run at higher temperatures resulting in higher engine efficiency. The pressure cap fits onto the filler neck portion above the radiator tank. If the pressure increases by 15 PSI, the boiling point temperature increases by 113°C.

There are two valves in the pressure cap

i Pressure valve

ii Vacuum valve

Clean of water cooling system

Pressure Flushing: In this method, water and air are used with sufficient pressure through the compressor to clean the cooling system. This method is done in two ways

i **Straight flushing:** To clean the cooling system, air and water are sent under pressure from the radiator to the water pump and water jackets.

ii **Reverse flushing:** In this method, air and water are released from the outlet pipe of the radiator by removing the thermostat valve.

It is sent into the water jacket with pressure.

Coolant, Types and Its properties

Coolant: Coolant (also called antifreeze) is a special fluid. It is made of either ethylene glycol or propylene and is usually green, blue, or pink colour. It is used to reduce the temperature of a system by removing heat to control or reduce heat.

Types of Coolant

There are many types of coolants that are used for different purposes.

1 **Water:** Often used to prevent corrosion and maintain temperature.

2 **Ethylene Glycol Based:** Commonly used in automotive applications, it is mixed with water to make antifreeze.

3 **Propylene Glycol Based:** It is similar to ethylene glycol, but less toxic, used in food processing and environmental uses.

4 **Polyalkylene Glycol (PAG):** Used in some industrial uses.

5 **Hydrocarbon based:** It is used in some special uses.

6 **Glycol based:** A mixture of water with ethylene or propylene glycol, chosen in various industries for their antifreeze and heat dispersing properties.

Each coolant has its own benefits and is used based on temperature requirements, environmental concerns and cost.

Properties of Coolant:

a **High thermal capacity:** The thermal capacity of the coolant should be high, that is, heat should be absorbed by the coolant with great efficiency.

b **Low viscosity:** A good coolant is one in which viscosity is almost negligible. Coolants with low viscosity flow faster.

c **Low cost:** Coolants should be available in the market at low prices, so that they can be purchased easily.

d **Non - toxic:** Coolants should be non- toxic, otherwise when they come in contact with heat, they react chemically and release toxic gases, which can prove fatal for human health.

e **Chemical inertness:** Coolant should not be a chemical reagent, otherwise the coolant reacts chemically with the engine parts, resulting in problems like rusting etc.

f **Electrical insulator:** The coolant should be a bad conductor of electricity. If the coolant is a good conductor of electricity, there is a possibility of spark in the engine.

Importance of maintaining correct coolant-water ratio

Objectives: At the end of this lesson you shall be able to

- explain Importance of maintaining correct coolant-water ratio.

Maintaining the correct coolant-water ratio in your vehicle's cooling system is crucial for several reasons:

1 **Temperature Regulation:** Coolant helps regulate the engine's temperature, preventing it from overheating or freezing. The right ratio ensures optimal heat transfer and efficient cooling.

2 **Corrosion Protection:** Coolant contains corrosion inhibitors that protect the cooling system components, such as the radiator, water pump, and hoses, from rust and corrosion. The proper ratio ensures adequate protection for these parts.

3 **Freezing and Boiling Point:** The ratio affects the coolant's freezing and boiling points. Too much water lowers the boiling point, risking overheating, while too much coolant raises the freezing point, potentially causing damage in cold weather.

4 **Heat Dissipation:** Water has better heat transfer properties than coolant alone, but coolant provides corrosion protection and prevents freezing. The right balance optimizes both heat transfer and system protection.

5 **Longevity:** Maintaining the correct ratio prolongs the life of the cooling system components by preventing corrosion and minimizing the risk of overheating or freezing, reducing the likelihood of costly repairs or replacements.

Overall, the correct coolant-water ratio ensures efficient cooling, protects the cooling system from damage, and contributes to the vehicle's overall longevity and performance.

Coolant water ratio: Maintaining the correct coolant-water ratio in your vehicle's cooling system is crucial for optimal performance and preventing overheating or freezing. Typically, a 50/50 mix of coolant and water is recommended for most vehicles. You can use a hydrometer or a refractometer to measure the coolant concentration and adjust as needed. Regularly checking and maintaining this ratio helps ensure your engine stays cool and protected.

Study about cooling systems and its components such as radiator, pressure cap, types of hoses, types of water pump, electric fan, thermostat, fan belts, temperature gauge, temperature sensor etc

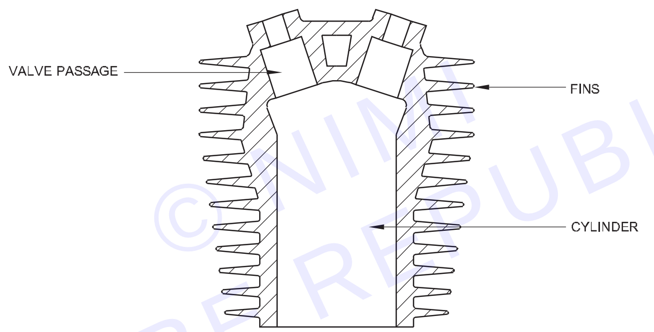
Objectives: At the end of this lesson you shall be able to

- explain about cooling systems and its components.

Types of cooling system and its component

The following cooling systems are used to cool the internal combustion engine or keep it at normal temperature.

1 **Air Cooling System:** In the air-cooling system, air is used to cool the engine to normal temperature. In this system only air cools the cylinder head and block with the help of fins and blower. In this, many tapers and thin fins are made around the cylinders of the engines to be cooled. Due to these fans, the area of air accumulated around the cylinder increases. Due to these feathers being thin at the edge, they cool down quickly in contact with air. The efficiency of the air-cooling system depends on the surface area of the fans used in the engine, the amount of air, its velocity and the temperature to be cooled. This system is used in two or three wheeled vehicles, airplane engines and small stationary engines.



2 **Water Cooling System:** Under the water-cooling system, water is used to eliminate unnecessary temperature of the engine. Water is filled in the radiator and water jackets are made to collect it around the engine cylinder. The water from the radiator goes into these water jackets through a rubber hose pipe and the heat from the cylinder is transferred to this water.

The water takes the heat from the cylinder and returns to the radiator, where it cools down and then goes back into the water jackets of the engine. Similarly, this cycle of water remains continuous while the engine is running and the engine continues to run at its normal temperature. Water cooling systems are used in water cooling systems based on conveying water from the radiator to the water jacket and back to the radiator.

Types of water-cooling systems

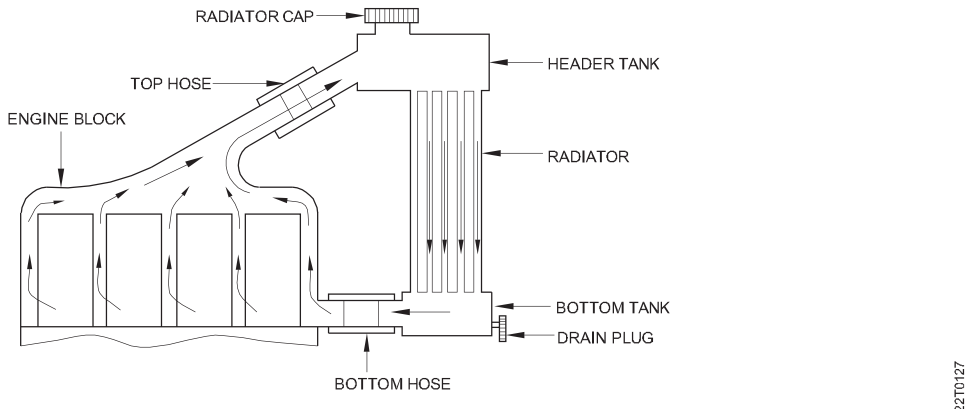
Water cooling systems are of the following types:

i Thermo-siphon system

ii Pump circulation system

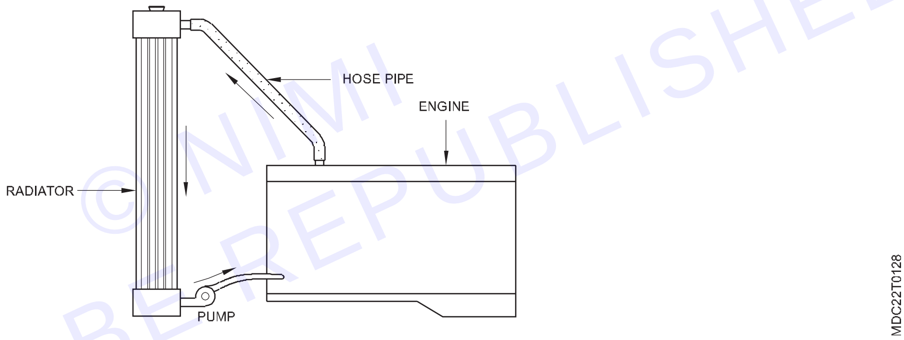
i **Thermo-syphon System:** In the thermo-siphon system, the radiator is filled with water, just like the Ford circulation system. This radiator is made almost like the radiator of Ford Circulation System, but water pump is not used in this system. Generally, in the thermo-siphon system, a radiator is installed in front of the engine, the cold water from the radiator goes to the engine block through the hose pipe below it. From here, the water gets heated and enters the upper tank of the radiator through a pipe from the engine head through the water jacket or water passage. and control

The air coming in contact with the radiator fins reduces the temperature of the water and the cooled water from the tubes installed in the radiator enters the lower tank of the radiator by gravity.



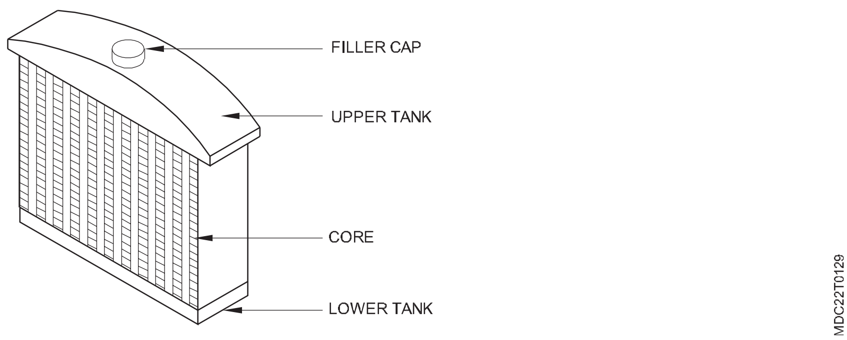
THERMOSYPHON COOLING SYSTEM

ii **Pump Circulation System:** In this system, water is filled in the radiator, in which there is an upper tank at the top and a lower tank at the bottom. Both the tanks are connected by thin copper tubes. Zig-zag fans are installed around the tubes, in which the area increases due to lack of air flow. There is a space made in the upper tank to fill water, on which a water tight cap is used. It is also called ‘Ford Feed System’. In this tank, a rubber hose pipe is fitted to return the hot water coming from the water jackets. The lower tank is connected to the water inlet through a rubber hose pipe. A special type of water pump is installed at this place.



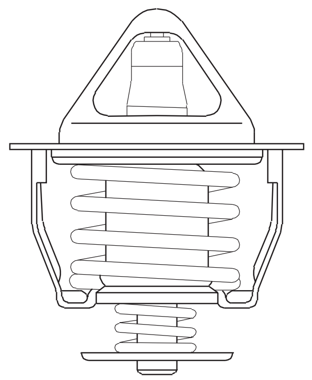
Basic Components of Cooling System: Various auxiliary components are used in engines to make the cooling system work smoothly and systematically. Details of such auxiliary components are given below:

1 **Radiator:** The radiator is fitted at the front of the engine. Its main function is to cool the hot water coming from the engine. For this purpose, thin copper tubes are used in radiators. Fins are fitted around these tubes. With this type of structure, the cooling surface becomes larger, due to which the water gets cooled quickly. The radiator has an upper tank and a lower tank, between which the radiator core is fitted. The upper tank is connected to the water drain of the engine by a rubber hose and the lower tank is connected to the water pump by a rubber hose.

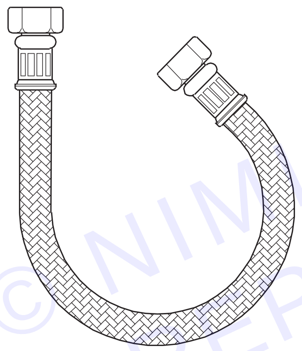


2 **Thermostat:** A thermostat is a device that opens automatically at a predetermined temperature. It is installed in the water pipe going from the engine to the radiator. As shown in the figure, when the engine is cold, the thermostat closes and the water pump normally pumps water around the cylinder block. When the engine

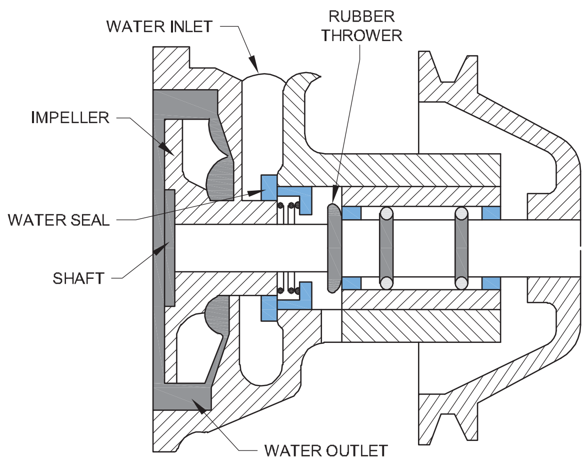
reaches the correct temperature, the thermostat opens and water is circulated through the radiator to cool the engine.



3 **Coolant Hose:** Coolant hose or coolant pipe is used to connect the water pump to the radiator and the radiator to the engine block. It is made of rubber and cotton threads. This hose pipe is tightened by hose clamps. PVC is used to make hose pipes.

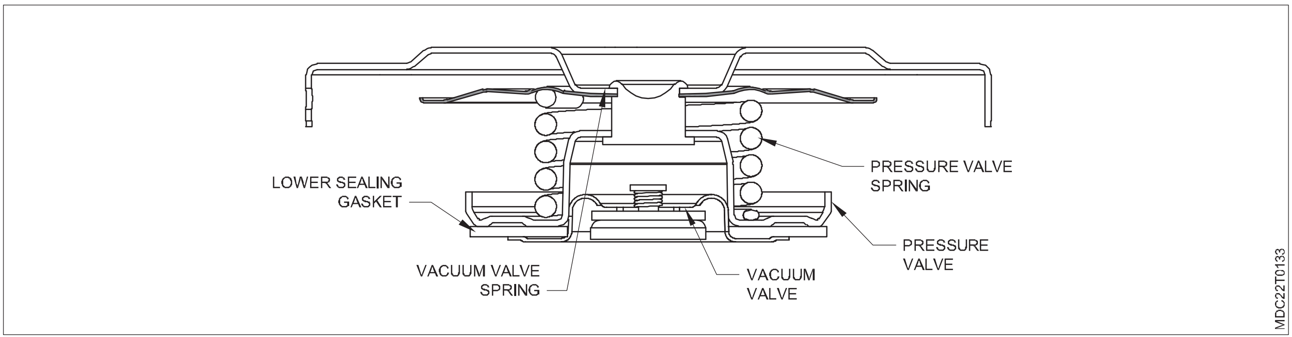


4 **Water pump:** Centrifugal type water pump is used in engines. It is located towards the front of the cylinder block or head. The water pump fan is driven by a belt from the camshaft pulley. The Impeller is fitted at one end of the water pump shaft. low gains the shaft is fitted with a bearing in the pump housing. A water seal is installed in the pump to prevent water from entering the bearings and to prevent water leakage. When the propeller rotates, it draws water from the lower tank of the radiator and delivers the water under pressure to the engine block through centrifugal force.

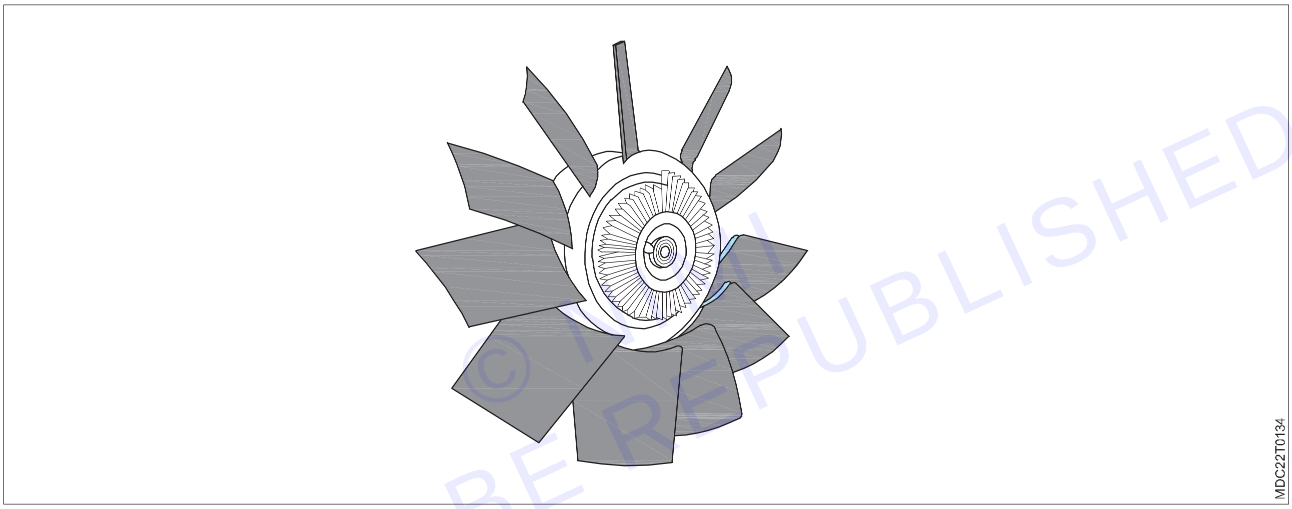


5 **Radiator pressure cap:** Water boils at 100°C in normal atmospheric conditions. At the highest altitude, atmospheric pressure is less and water boils at temperatures below 100°C. To increase the boiling point of water, the pressure of the cooling system has to be increased. This system is pressurized Obtained by sealing with a cap. Cooling loss due to evaporation can also be reduced by using a pressure cap. This allows

the engine to run at higher temperatures resulting in higher engine efficiency. The pressure cap fits onto the filler neck portion above the radiator tank. If the pressure increases by 15 PSI, the boiling point temperature increases by 113°C.



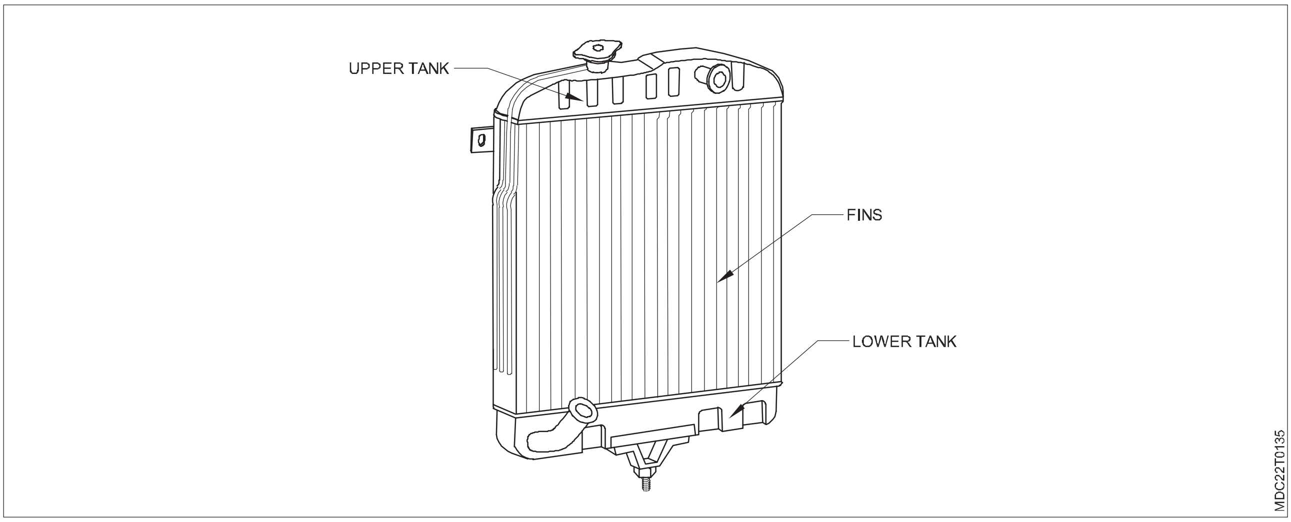
6 **Cooling fan:** The cooling fan or water fan is fitted on the water pump pulley. It has four or five blades. It sucks the air from the radiator core, due to which the tube gets cooled and the tube cools the water and this air keeps falling on the engine, due to which the engine keeps getting cooled.



Radiator, pressure cap, types of hoses.

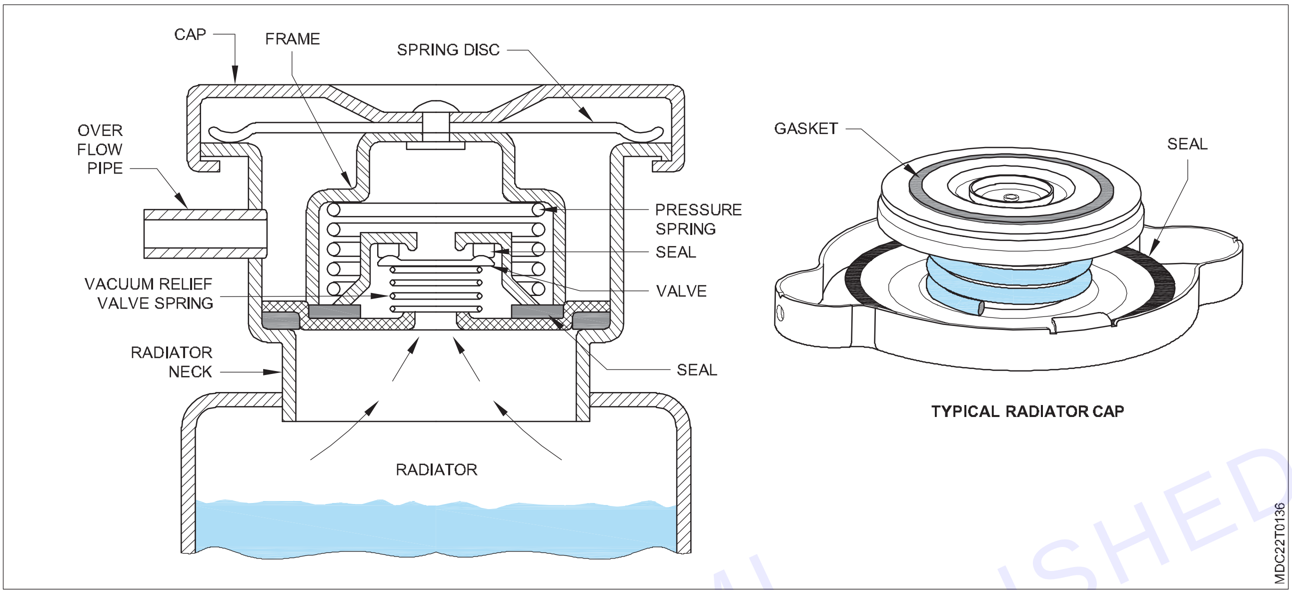
Radiator: The device that absorbs the heat of water and cools it is called “Radiator” or “Water Heat Condenser”. A radiator is a type of water tank to supply water to the engine. This process helps to prevent the engine from overheating.

It works by transferring heat from hot water or steam to the surrounding air, warming the space. The radiator is fitted in front of the engine.



Radiator Pressure Cap: Pressure on the mouth of the radiator to increase the efficiency of the cooling system

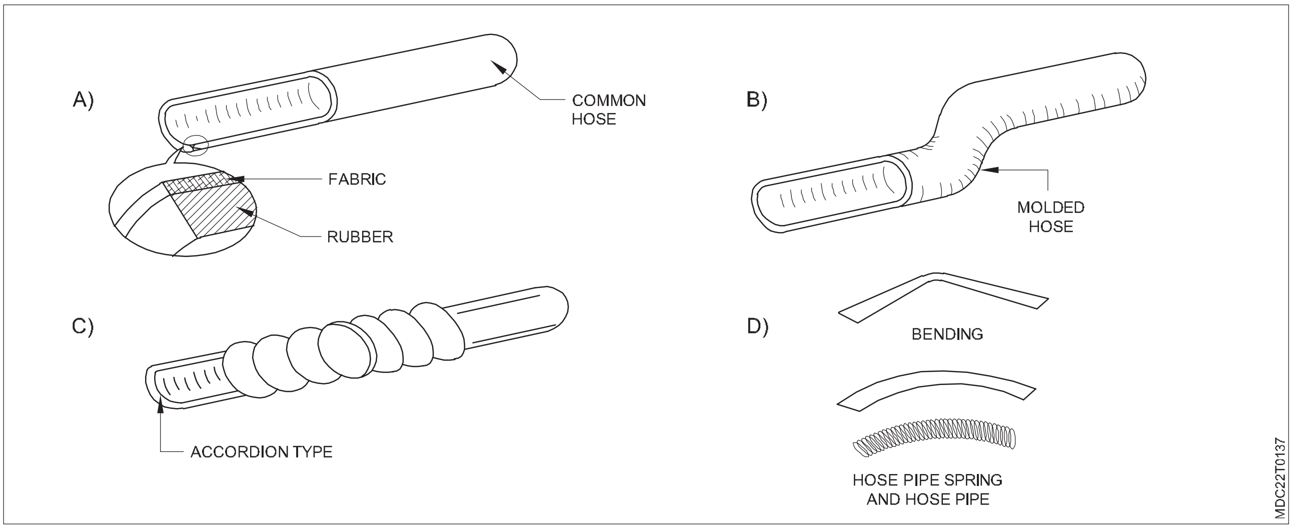
The camp is set up. Pressure is applied to the water in the radiator through the pressure cap. By artificially pressurizing the water in the radiator in this way, the water rises to 1000 cm. It also does not boil at gray (2120 F) temperature. For every 1 pound of pressure applied on water, the boiling point of water is 30 cm. Grows with gray. Water boils at a lower temperature in places where atmospheric pressure is lower. For this, the boiling point of water can be increased by installing a radiator pressure camp of suitable pressure.



In radiator pressure cap. A blow off valve type valve (pressure valve) is held firmly on the seat by a spring of specific pressure. This helps to create pressure on the water in the cooling system. If this pressure exceeds the spring pressure or 5 lb/sq. If it exceeds 1.5 inches, the pressure is lifted from the valve seat and the excess pressure is relieved through the overflow pipe. Pressure caps up to 15 pounds' pressure are available in the market, so the boiling point of water is 1450 cm. Gray. or is increased to 2930 F.

After turning off the engine, the water cools down and the pressure on the water decreases. At such a time, the vacuum valve under the pressure valve is opened and the outside air comes in and the atmospheric pressure on the water remains constant. This is how the pressure valve and vacuum valve in the radiator pressure cap work.

Hose Pipe: A hose pipe is used to connect the radiator lower tack outlet to the water pump, as well as the cylinder head water outlet path to the radiator upper inlet. straight or bent hose pipe is used depending on the level of the radiator and engine on the foundation. Different sizes of hose pipes are available as per requirement. The hose pipe is made of cotton threads and synthetic rubber to withstand the stress placed on the hose pipe due to the temperature of the water in the cooling system and the vibration of the engine. The hose pipe connection should not leak due to engine vibration and water pressure in the cooling system and the pipe connection of hose pipe to prevent loosening by tightening clamps or clips on the mouth Installed.



A Common Hose

A common hose typically refers to a Garden hose, which is used for watering plant, lawns, and gardens. These hoses are usually made of flexible rubber and come in various lengths and diameters to suit different needs. They often have standard fittings for connecting to outdoor equipment

B Molded Hose

Molded hoses are rubber hoses that are shaped to fit specific applications in vehicles or other systems. They are commonly used in automotive applications for coolant, air intake, and other fluid systems. These hoses are made by molding rubber into the desired shape, which allows for more precise fitting and often better performance compared to traditional straight hoses with multiple bends or fittings.

C Accordion Type

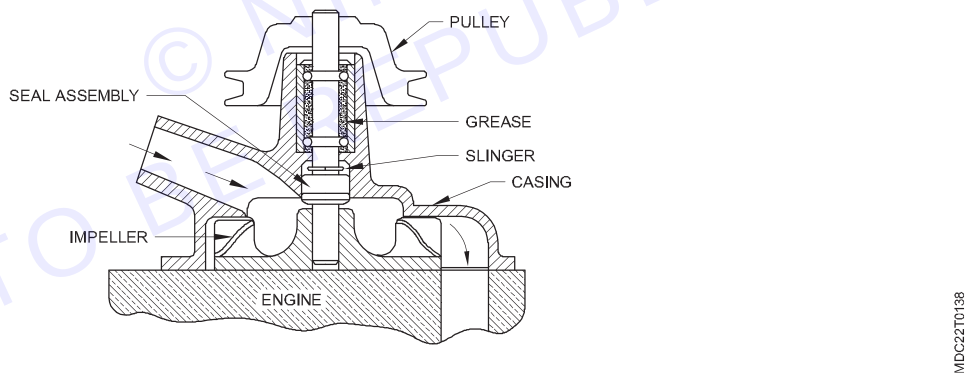
Accordion-type hoses are flexible hoses that expand and contract, similar to an accordion musical instrument, hence the name. These hoses are often used in gardening or for other outdoor tasks where a flexible, lightweight hose is beneficial.

Types of water pump

Water Pump

Centrifugal type water pump is used in engines. It is located towards the front of the cylinder block or head. The water pump fan is driven by a belt from the camshaft pulley. The impeller is fitted at one end of the water pump shaft.

The shaft is fitted with a bearing in the pump housing. A water seal is installed in the pump to prevent water from entering the bearings and to prevent water leakage. When the propeller rotates, it draws water from the lower tank of the radiator and delivers the water under pressure to the engine block through centrifugal force.



Types of water pump in automobile

There are primarily two types of water pumps used for cooling the engine

Electric Water Pump: Some modern vehicles use electric water pumps. These pumps are driven by an electric motor and can vary their speed based on engine needs, providing more precise control over the cooling system.

Both types of water pumps serve the same purpose of cooling the engine, but they differ in their design and method of operation.

In electrical water pump

Submersible Pumps: These pumps are designed to be submerged in the water they are pumping. They are often used in wells and deep water applications. Submersible pumps are efficient and require less maintenance than other types of pumps.

Diaphragm Pumps: These pumps use a diaphragm to move water. They are often used in applications where a continuous flow of water is not required, such as in spraying systems or for transferring water from one container to another.

Jet Pumps: Jet pumps use an impeller to create a vacuum which then draws water into the pump. They are often used in shallow wells or for applications where a centrifugal pump would not be suitable.

Booster Pumps: These pumps are used to increase the pressure of water in a system. They are often used in buildings or homes where the water pressure from the main supply is not sufficient.

Sump Pumps: Sump pumps are used to remove water that has accumulated in a sump pit, typically found in basements. They are designed to pump water away from the building to prevent flooding.

Mechanical Water Pump: This type of water pump is driven by a belt connected to the engine's crankshaft. It circulates coolant through the engine and radiator to maintain optimal operating temperature.

In a mechanical water pump

Centrifugal Pump: This is the most common type of water pump used in automobiles. It uses a rotating impeller to create a centrifugal force that pushes the coolant outward, increasing its pressure and flow rate.

Axial Flow Pump: This type of pump uses propeller-like blades to move coolant parallel to the pump shaft. It's often used in applications where a high flow rate is required.

Mixed Flow Pump: A mixed flow pump combo of the features of centrifugal and axial flow pumps. It uses a combination of radial and axial flow to move coolant, providing a balance between flow rate and pressure.

Diaphragm Pump: This type of pump uses a diaphragm to create suction and push coolant through the system. It's often used in applications where a smooth and pulse-free flow is required.

Study about electric fan, thermostat, fan belts, temperature gauge, temperature sensor

Electric fan

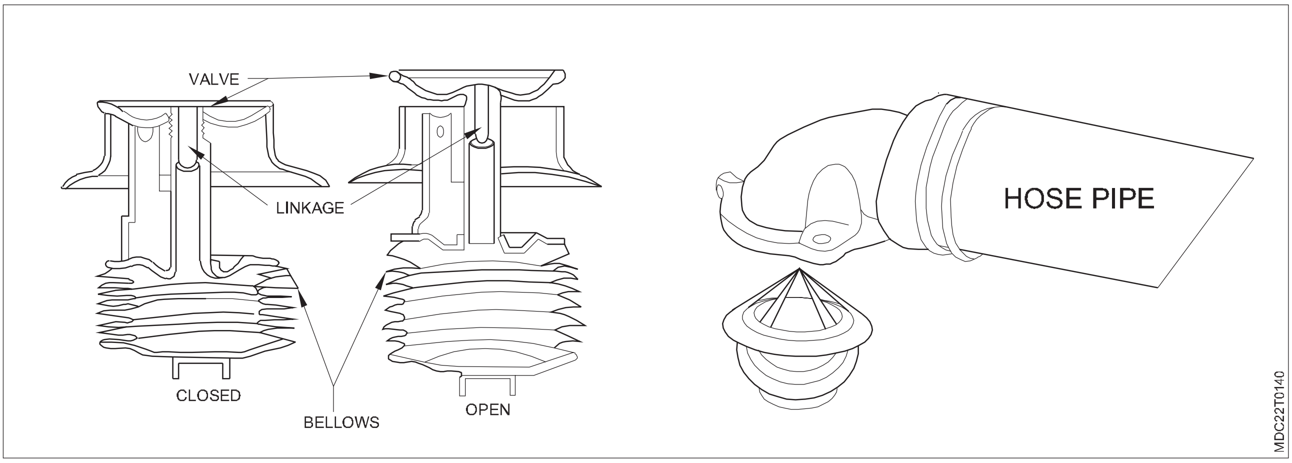
The demand for flat fan systems in engine cooling often requires compact EEC motors. These smaller motors need to be as efficient as larger ones but with reduced size and better heat dissipation. Achieving this is easier with high-quality materials, but cost is a concern. Balancing cost and performance is important.

Improving heat transfer inside EEC motors can help lower critical temperatures, increasing reliability without sacrificing power density. The study focuses on how motor temperature and airflow interact. It involves analyzing heat sources, airflow, and heat transfer. Both numerical analysis and experiments are used to develop a reliable method for analyzing EEC motors.

Thermostat

A thermostat valve is like a gatekeeper in a water cooling system for engines. It automatically regulates the flow of water and air to keep the engine at the right temperature in various situations. When you start a cold engine, the thermostat valve stays closed, stopping water from going to the radiator. Instead, it directs the water through a bypass pipe back into the engine.

The thermostat valve helps the engine warm up quickly. Once the engine reaches its normal operating temperature, the thermostat valve automatically opens, allowing water to flow from the engine to the radiator. This process doesn't involve the bypass pipe. Typically, the thermostat valve won't let water cooler than 77°C pass through it. There are two types of thermostat valves: bellow type and pellet type, which work on the same principle. The bellow type has a heat unit shaped like a closed bellows filled with a liquid that vaporizes when heated, causing the bellows to expand and open the valve. When it cools down, the liquid condenses, reducing pressure, and the valve closes again, stopping the flow of water.



Fan belt

Fan belts are essential in vehicles as they help cool the radiator and circulate coolant throughout the engine. They connect various components like the water pump, radiator fan, air conditioning unit, and cross the crank pulley.

Fan belts harness the engine's rotation to power crucial parts such as the water pump, fan, power steering pump, air conditioning compressor, and alternator. The alternator, which generates electrical power for the car, relies on fan belts to function. Without them, the alternator wouldn't charge the battery properly, leading to potential issues like power steering failure and engine overheating. Fan belts transfer mechanical energy to the alternator, allowing it to charge the battery and power other electrical systems in the vehicle. Newer cars often use Poly-V belts to drive multiple engine parts, eliminating the need for separate fan belts. However, older vehicles typically have separate fan belts, like raw edge cogged belts, specifically for the alternator.

Temperature gauge

The temperature gauge on your dashboard tells you how hot or cold your engine's coolant is. It's important because it shows if your engine is running at the right temperature, too cold, or overheating. Even though it might not get much attention, it's crucial to pay attention to it to avoid potential problems with your vehicle.

Temperature sensors

Valeo water temperature sensors help protect your engine and heat exchangers, especially in extreme temperatures. They measure coolant temperature and send this information to the Engine Control Unit (ECU). Valeo offers a wide range of these sensors, with 48 different part numbers available. They're backed by Valeo's expertise as a global leader in cooling systems. These sensors enable the control unit to detect engine

overheating or unusual temperature increases. They're usually placed near or inside the thermostat. Some vehicles even have two sensors—one sends information to the control unit, while the other relays data to the dashboard. These sensors work by detecting changes in temperature, which are then interpreted by the control unit. With Valeo water temperature sensors, you benefit from reliable performance and the assurance of a trusted brand in cooling systems.

Study about oil filtering systems

Objectives: At the end of this lesson you shall be able to

- explain about oil filtering systems.

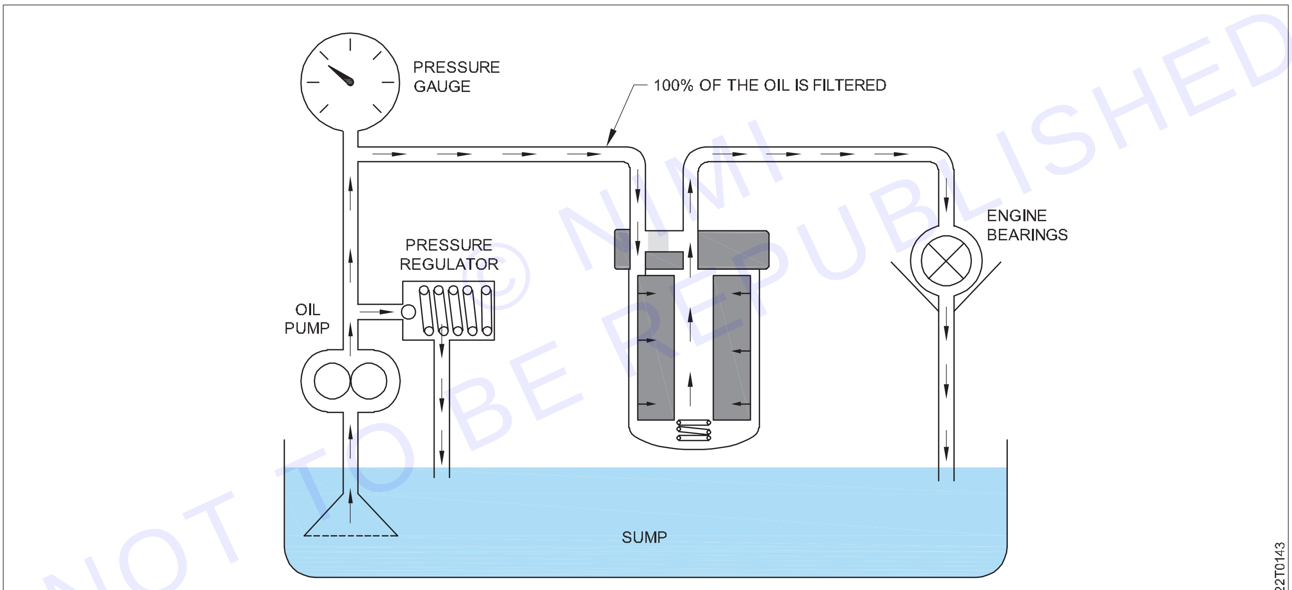
Oil Filter System

When the oil returns after lubricating all the parts of the engine, it brings with it the dirt and fine metal particles of the engine parts. If this dirt or metal particles go back between the engine parts with the oil, then the rubbing parts will start wearing out quickly and the oil passages may also get blocked due to the dirt, which will stop the lubrication of those parts. Therefore, it is necessary to clean this dirty and metal particle mixed oil. For this, an oil filter system is arranged between the oil pump and the main oil gallery.

Two types of systems are used to filter engine oil.

- Full flow Oil filter system
- Bypass Oil Filter System

Full flow Oil Filter system: In this system the oil passes through a filter before reaching the main oil gallery. The filter has a bypass valve which lets the oil pass directly to the main oil gallery in case the filter gets choked.



FULL FLOW OF OIL FILTERED SYSTEM

Bypass Oil filter system: In this system only a part of the engine oil enters the filter. After filtering, the oil reaches the oil sump. The remaining oil is directly transported to the main oil gallery.

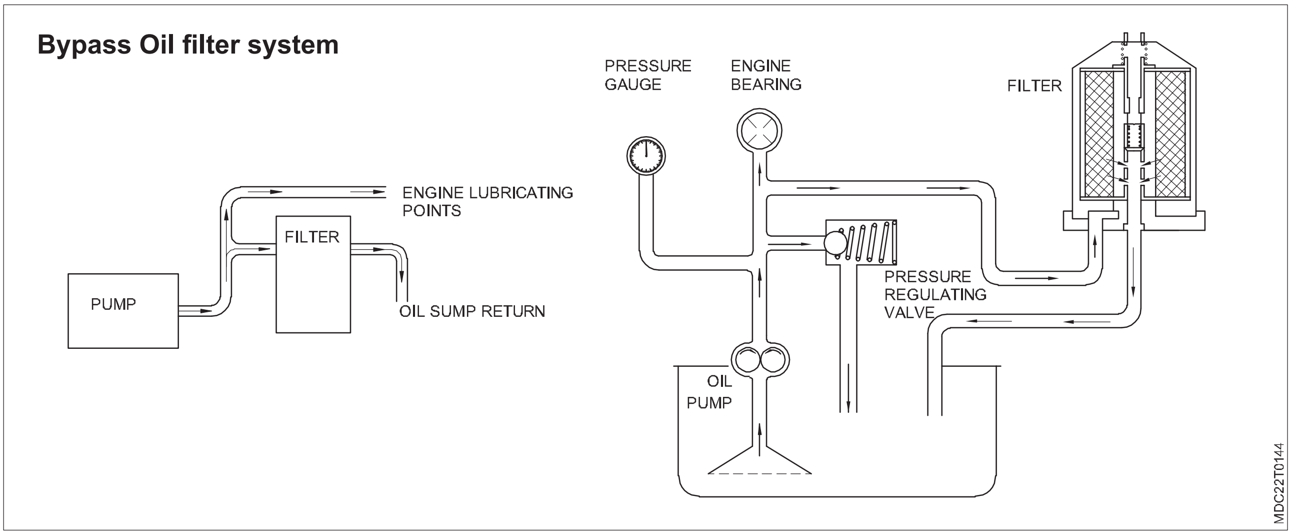
Filter Element: The filter is made of felt, cotton waste, cloth and paper. It is replaced after the engine has run a certain distance of kilometers, as specified by the manufacturer.

Types of Oil Filter

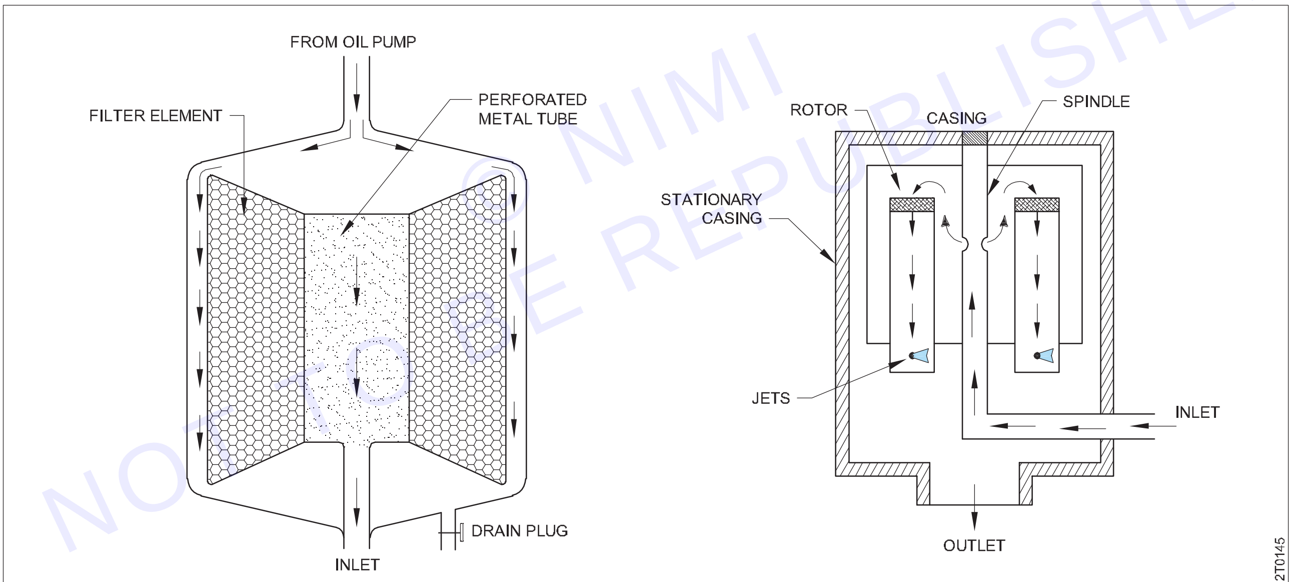
Oil filters are of the following types

- Cartridge type oil filter
- Centrifugal type oil filter

1 **Cartridge type oil filter:** The oil filtered through this oil filter goes back to the engine parts. In this filter also, like the fuel filter, a fine mesh of paper and wire is used as the filter element. This element is enclosed in a casing in which separate passages are made for the oil to come in and the filter to go out. A drain plug is fitted at its bottom, which is opened to take out the dirty oil.



2 **Centrifugal type oil filter:** This type of filter has four main parts; stationary casing, rotor casing, central spindle and jetted tube. In this, oil comes to the central spindle through the inlet route. From here it goes to the rotor casing and from the rotor casing the oil goes to the tube. Jets are fitted in these tubes, from which oil comes out with pressure, which gives speed to the rotor casing and it starts rotating. The oil coming out of the jet hits the wall of the stationary casing, on which dust particles remain and pure oil comes out from the outlet.



CARTRIDGE TYPE OIL FILTER

CENTRIFUGAL TYPE OIL FILTER

Importance of maintenance, diagnosis and Servicing cooling system and its components

Objectives: At the end of this lesson you shall be able to

- describe about importance of maintenance, of cooling system and its components
- diagnosis of cooling system and its components
- servicing of cooling system and its components

Combustion of fuel inside a cylinder develops a very high temperature (Appx. 2200°C). At this temperature the engine parts will expand and tend to seize. Similarly, the lubricating oil will lose its property. Therefore, it is necessary to keep the engine temperature to operating limits. This is done by the cooling system. Heat is removed from the engine by cooling media (water or air) and is dissipated to the atmosphere.

Types of cooling systems

There are two types of cooling systems used in engines.

- Direct cooling - air cooling.
- Indirect cooling - water cooling.

Importance of diagnosis of cooling system

Diagnosing cooling system issues is crucial for following reasons

- **Prevention of damage:** Identifying problems early can prevent more serious damage to the engine caused by overheating or coolant leaks.
- **Safety:** A properly functioning cooling system is essential for safe vehicle operation. Overheating can lead to engine failure, causing accidents.
- **Optimal performance:** A well-maintained cooling system ensures that your engine operates at the right temperature, which maximizes fuel efficiency and overall performance.
- **Cost savings:** Early finding cooling system issues promptly can prevent costly repairs down the line. Ignoring warning signs may lead to more extensive damage that requires expensive repairs or even engine replacement.
- **Longevity of components:** Regular diagnosis and maintenance help extend the life of cooling system components such as the radiator, water pump, hoses, and thermostat.

Overall, diagnosing cooling system problems is essential for maintaining the reliability, safety, and performance of your vehicle.

Importance of maintenance and servicing of cooling system and its components

Maintenance and servicing of cooling systems and their components are crucial for several important reasons:

- **Efficiency:** Regular maintenance make sure that cooling systems operate at peak efficiency, reducing energy consumption and costs.
- **Prevention of breakdowns:** Routine servicing helps identify and finding major issues before they escalate into costly breakdowns, minimizing downtime and disruptions to operations.
- **Prolonged lifespan:** Proper maintenance extends the lifespan of cooling components, protecting components and avoiding the need for premature replacements.
- **Safety:** Regular inspections and servicing ensure that cooling systems operate safely, reducing the risk of malfunctions or hazards such as leaks or electrical problems.
- **Optimal performance:** Servicing helps optimize the performance of cooling systems, ensuring consistent temperature control.
- **Compliance:** Regular maintenance helps businesses comply with regulatory requirements and industry standards related to environmental protection, safety, and equipment operation.
- **Cost savings:** Regular maintenance incurs some upfront costs, it ultimately saves money by preventing major repairs, improving energy efficiency, and avoiding costly downtime.

Overall, investing in the maintenance and servicing of cooling systems and their components is essential for ensuring reliable operation, safety, and cost-effectiveness over the long term.

Causes of failure of the cooling system and its components

Objectives: At the end of this lesson you shall be able to

- demonstrate Causes of failure of the cooling system and its components.

The failure of a cooling system and its components can be caused by various factors such as

- **leaks in hoses:** wear and tear, extreme temperature and high pressure poor connection or lines
- **leaks in radiator:** corrosion, physical damage like impact from road debris or accident can puncture the radiator, old radiator(age), due to blockage, due to high pressure, improper maintenance.
- **leak in water jacket:** corrosion, engine overheating, poor maintenance, physical damage, manufacturing defect.
- **A malfunctioning thermostat:** stuck closed, stuck open, mechanical failure, incorrect installation, electrical issue.
- **water pump failed:** bearing failure due to continuous rotation, seal failure, impeller damage due to corrosion cavitation or debris ingestion, overheating, contamination of dirt debris or rust particles.
- **blockage in system:** sediment buildup, corrosion, contaminate of dirt debris or sealant, air pocket creates, thermostat failure, improper coolant mixture.
- **Insufficient coolant level:** damaged radiator, hoses, water pump, or cracked engine block.
- **issue with the radiator fan:** faulty fan motor, a malfunctioning fan relay, a blown fuse or damage wiring.
- **issue with the fan belt:** wear and tear in over time, leading to cracks, fraying or stretching, improper tension.
- **issue with the fan clutch:** wear and tear in over time, stuck in engaged or disengaged position.
- **faulty thermostat:** corrosion, a buildup of debris, electrical or mechanical failure, stuck in open/closed position.
- **damage heat gasket:** overheating, coolant contamination, engine stress (rapid temperature changes or extreme pressure), poor installation, age and wear.
- **faulty radiator cap:** wear and tear, corrosion, damaged cap, improper installation, excessive pressure.
- **leak in reserve tank:** crack or damaged, loosen or damaged hoses connection, faulty cap seal, overfilling, coolant degradation.

Importance of testing of pressure cap

Objectives: At the end of this lesson you shall be able to

- demonstrate Importance of testing of pressure cap.

Pressure cap

In normal atmospheric conditions, water boils at 100°C. At the highest altitude, atmospheric pressure is less and water boils at temperatures below 100°C. To increase the boiling point of water, the pressure of the cooling system has to be increased. This is achieved by sealing the system with a pressure cap. Cooling losses due to evaporation can also be reduced by using a pressure cap. This allows the engine to run at higher temperatures resulting in higher engine efficiency. The pressure cap fits onto the filler neck portion above the radiator tank. If the pressure increases by 15 PSI, the boiling point temperature increases by 113°C. There are two valves in the pressure cap

1 Pressure valves

2 VACCUME valve

Importance of testing of pressure cap

It is imperative to test the pressure cap of a system, such as a vehicle's cooling system, for various reasons:

1 **Safety concerns -** The pressure cap plays a crucial role in maintaining the optimal pressure levels within the system. Testing is essential to verify that the cap can withstand this pressure without any leaks or failures, thus ensuring safety, preventing accidents, and safeguarding the system and the vehicle from potential damage.

2 **Enhanced system performance -** A properly functioning pressure cap is essential for ensuring that the system operates at the correct pressure levels. This is particularly important in a vehicle's cooling system to facilitate efficient cooling, prevent overheating, and uphold optimal performance.

3 **Damage prevention -** Failure or improper functioning of the pressure cap can result in damage to various components within the system, including hoses, radiators, and the engine. Regular testing aids in early detection of issues, thereby averting costly repairs or replacements.

4 **Ensuring durability -** Testing the durability of the pressure cap is crucial to ascertain its ability to withstand pressure fluctuations and temperature variations during normal operation. This aspect contributes to the longevity of the system and diminishes the likelihood of unexpected failures

5 **Regulatory compliance -** In numerous instances, particularly in automotive settings, testing the pressure cap is a mandatory requirement to comply with safety and performance standards established by regulatory bodies like the Department of Transportation (DOT) or industry standards organizations.

In conclusion, testing the pressure cap is indispensable for upholding safety, system performance, durability, and adherence to regulatory standards.

Importance of servicing radiator

Objectives: At the end of this lesson you shall be able to

- demonstrate importance of servicing radiator.

A device that absorbs the heat of water and cools it is called a "Radiator" or 'Water Heat Condenser'. A radiator is a type of water tank to supply water to the engine. The radiator is fitted in front of the engine.

Why it is Important to servicing the radiator is as follows.

1 To remove old coolant from the radiator and prevent blockages

2 If the radiator is choked or damaged, many problems can arise in the engine.

3 If the radiator is damaged, broken or the radiator fan is not properly sized If not running, the heat generated in the engine will go out properly therefore.

4 If the heat in the engine does not escape through the coolant, the engine will overheat

5 If the coolant is not supplied properly in the engine, the amount of overheating increases

6 To check radiator leakage

7 Having a water jacket choke up between cylinder block and cylinder head

8 Water in the cooling system may be damaged due to corrosion etc.

9 Having a radiator tube and fins choke up

Trouble shooting in cooling system and its components

Objectives: At the end of this lesson you shall be able to

- demonstrate Trouble shooting in cooling system and its components.

Reason.

i Not pouring water into the radiator for a long time.

ii Leakage from the radiator core.

iii Loose or damaged inlet or outlet hose pipe.

iv Head gasket broken.

v Leaking water drain plug.

vi Leaking of water from water pump.

i Lack of water in the radiator

ii Thermostat valve remaining closed.

iii Water pump being faulty.

iv Fan belt broken.

v Blockage of water passages in the radiator.

vi Rusting of water jackets.

vii Incorrect valve timing or ignition timing.

viii Pre-ignition defect.

ix Clogged (choked) exhaust manifold.

x silencer closure.

xi Brake and clutch being faulty.

xii Engine jamming.

Treatment.

i Fill the radiator with water.

ii Get the core soldering done.

iii Tighten or replace the hose pipe.

iv Replace the head gasket.

v Tighten or repair the drain plug.

Check and repair the water pump.

Remedies for cooling system.

i Replace the thermostat valve. If needed

iii Repair the water pump. If needed

iv Insert new fan belt. If needed

v Clean the radiator.

vi Clean the water jacket with water pressure.

vii set the right timing.

vii Remove the defects.

ix Clean the manifold.

x Clean the silencer.

xi Remove the defects.

xii Correct the engine.

LESSON 57 - 61: Battery/accumulator - types, construction, working. Battery capacity & rating, Booster starting. IBS, Disposal of waste battery

Objectives

At the end of this lesson you shall be able to

- explain about battery, types, construction and working procedure
- explain battery capacity, rating & booster starting
- demonstrate of disposal of battery.

Introduction and types of battery C

Introduction of Battery -A battery is a device that stores chemical energy and converts it into electrical energy as needed

Primary cells: Primary cells are those cells which are not rechargeable. Chemical reaction that occurs during discharge is not reversible. The following types of primary cells are used

- Voltaic cell
- Carbon zinc cell
- Alkaline cell
- Mercury cell
- Silver oxide cell
- Lithium cell

Secondary cell (Lead acid battery): These cells can be recharged by supplying electric current in the reverse direction to that of a discharged battery.

Lead acid battery: This battery is an electrochemical device for converting electrical energy into chemical energy and vice versa. The main purpose of the battery is to store electrical energy in the form of chemical energy. It provides supply of current for operating various electrical accessories, when the engine is not running. When the engine is running it gets electric supply from the dynamo/alternator. It is also known as accumulator and storage battery.

lithium-ion battery - Lithium-ion batteries are a type of rechargeable battery commonly used in consumer electronics. High energy density, light weight and long life. Better than lead acid batteries. For this reason, hybrid and electric vehicles are becoming increasingly common. These batteries are expensive in price. But gives good performance and functionality.

Construction and working of Battery

The following parts are used for Construction the battery.

1 **Case:** Its other name is cell container. It is made of a special type of hard rubber. It has separate compartments on the inside to keep the cells and there is a space (on the outside) to lift it. Acid does not affect it.

2 **Filler Cap:** Its other name is vent plug. It is fitted on top of each compartment or cell part. On removing it, the filler hole, the plate below and the electrolyte are visible. Electrolyte is poured into the cell compartment through this filler cap hole. The filler cap or vent plug also has a small hole through which gases come out during charging. This hole is called blind hole or half hole or vent hole. Some filler caps have a condensing chamber which works to convert gases into liquid form.

3 **Positive Plate:** Terminal or Post Strap The post or terminal with which the positive plates are internally connected is called the positive terminal or positive post. The + positive plate is soldered on it.

4 **Cell Compartment Cover:** Each compartment has cells. To cover them, a compartment cover is put on the cell. Under this cover, there is a place for the cell, and on the top, one negative terminal and one positive terminal per cell are seen coming out. In the middle of this, there are one or two filler or vent plug holes on which the vent plugs are tightened.

5 **Cell Connector or Link Connector:** Since the cells of the battery are installed in series, the positive terminal of one cell is connected with the negative terminal of the other cell. This work is done by the cell connector.

6 **Sealing Compound:** A special type of mixture (sealing compound) is applied to join the compartment cover of the cells with the battery body so that the battery electrolyte does not jump out due to shock.

7 **Negative Terminal or Negative Post:** All the negative plates inside the cell will be connected to the negative post.

8 **Negative Plate Strap:** Negative strap is used to keep the plates together like a shoulder.

9 **Sediment Space or Element Rest:** Sediment space is provided inside the battery case so that the debris or other dust particles etc. from the plates settle down. Element rest or ribs are made to keep the cell plate assembly on top and the space in between is left for the debris.

10 **Negative Plate:** It is connected to the negative strap at the top, its grid is filled with spongy metallic lead and its Colour is grey.

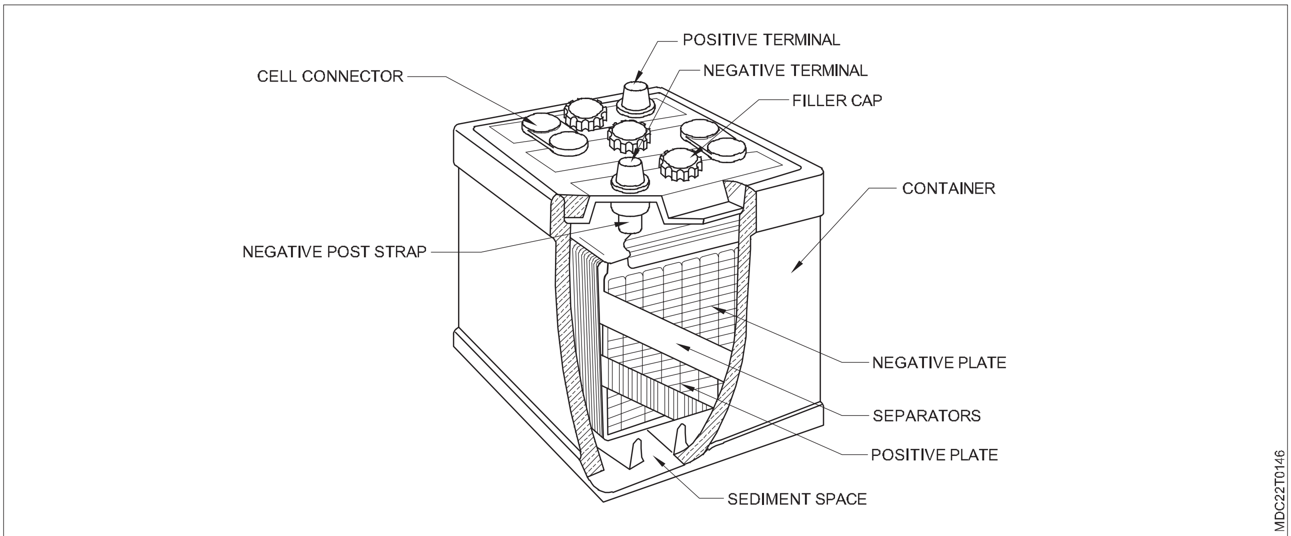
11 **Separator:** To prevent short circuit between the negative and positive plates of the battery cell, a separator made of special wood fiber, rubber and glass fiber mats etc. is used. It should be porous so that the solution can pass through it.

12 **Positive Plate:** Like above, it is connected to the positive terminal by its positive strap. Its grid is filled with red peroxide (PbO_2) of chocolate brown ring.

13 **Grid:** It is made by mixing antimony and lead and is cast in a rectangular/lattice shape. It does not get damaged in chemical reaction.

14 **Cell:** A cell is formed by having one positive plate, one separator on each side of it and then negative plates on both sides. Instead of using positive plate and big negative plates, the number of small plates has been increased in the cell to get more active area. Because the active paste acts on both the sides of the positive plate, hence there is one more negative plate.

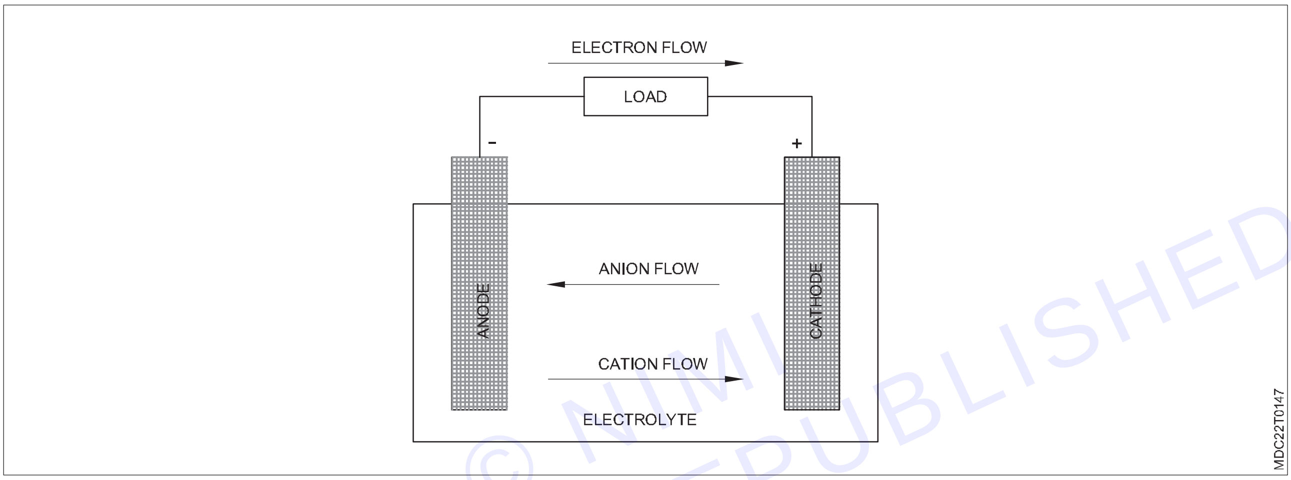
15 **Electrolyte:** The plates of the battery are immersed in a solution of sulphuric acid in their respective cell containers. The specific gravity of this solution is 1.250 to 1.280. The appropriate solution for the battery is also available readymade, otherwise it is prepared. Pure sulphuric acid and distilled water are used to make it. It should be made in a glass, porcelain or plastic container and it should be kept in mind that the acid should be poured into water, because if water is poured into the acid, its splashes will burn the body or clothes. This solution should be filled up to about 15 mm above the plates of the battery.



Working of battery: It has two groups of positive and negative plates. The number of positive plates is one less than the number of negative plates. The total number of plates is 11,13,17,23,25 etc. So that each positive plate can work from both sides, the number of negative plates is kept one more. Both types of plates are made of lead mesh and a pulp of red-lead (Pb_3O_2) is deposited in them.

Dilute sulphuric acid H2SO4 is used as electrolyte in the cell. Rests are made in the vessel to keep the plates at the bottom and separators are used to prevent them from short circuiting.

A vent plug is kept in every cell, through which the gases released in chemical reactions can come out. The connecting ends of both the plate groups are taken out and the vessel is sealed from the top. Initially both the electrodes of the lead acid cell are made of lead sulphade (PbSO4), but when the cell is charged by chemical reactions, the lead sulphade electrodes get converted into spongy lead (Pb) (negative plate) and lead peroxide (PbO_2) (positive plate). Along with this, the electrolyte solution gets concentrated and turns into sulphuric acid (H_2SO_4).



Chemical Reactions

In a lead-acid battery, chemical reactions are performed in the following stages

1 **Forming:** This process starts as soon as dilute sulphuric acid is filled in the cell. This work is usually done by the battery seller.

PbO4 + 2H2SO4 → PbO2 + 2PbSO4 + 2H2O

2 **Charging:** After 10-12 hours of filling dilute sulphuric acid in the cell, it is connected to a DC source, so that electrical energy can be collected in the form of chemical reactions. For this work, the positive connector of the cell is connected to the positive terminal of the source and the negative connector is connected to the negative terminal of the source and the following chemical reactions take place in the battery.

$H_2O \rightarrow 2H^+ + O^{2-}$

At Anode $PbSO_4 + 2H_2O + SO_4 \rightarrow PbO_2 + 2H_2SO_4$

At Cathode $PbSO_4 + 2H^+ \rightarrow Pb + H_2SO_4$

As a result of the charging process, the positive plates of the cell become of land peroxide (PbO_2) and the negative plates become of spongy lead (Pb).

Discharging: The discharging process starts when the charged cell is connected to the load.

$H_2O \rightarrow 2H^+ + O^{2-}$

At anode $PbO_2 + 2H^+ + H_2SO_4 \rightarrow PbSO_4 + 2H_2O$

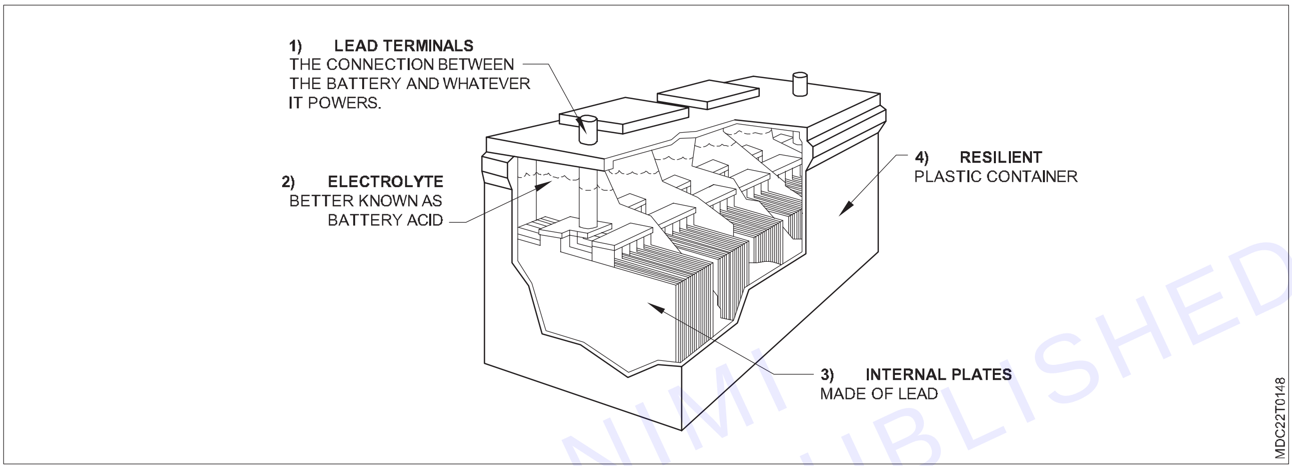
At Cathode $Pb + O^{2-} + H_2SO_4 \rightarrow PbSO_4 + H_2O$

As a result of the discharging process, both types of plates of the cell become of land sulphade ($PbSO_4$). Due to the formation of water in the chemical reaction, the acid becomes diluted the relative density of the acid decreases.

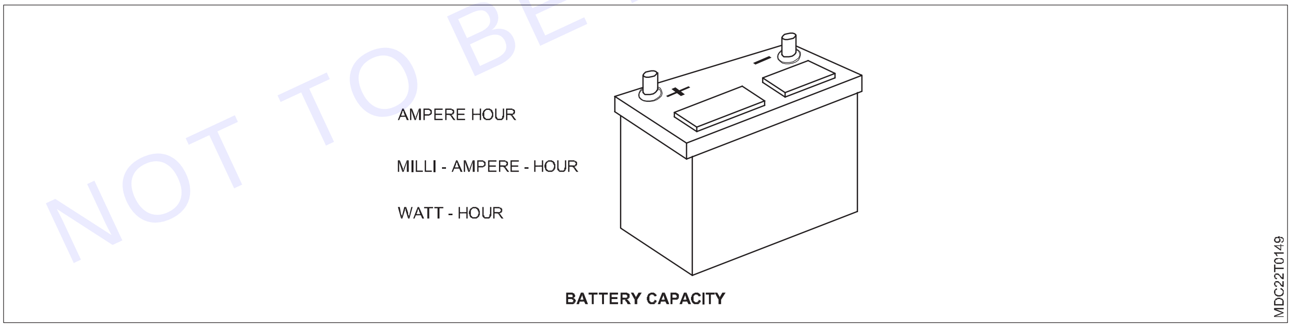
Recharging: After the cell is discharged, it is charged again by connecting it to a DC source. This process is similar to the charging process and the same chemical reactions take place in it, which take place in the charging process. In this process, due to the formation of sulphuric acid (H_2SO_4), the relative density of the electrolyte increases.

Battery (accumulator) capacity and rating, booster starting, IBS (Intelligent Battery System) system.

Introduction: Battery has an important part for vehicles. It provides electricity to self-starter for starting engine, it used to light headlights while travelling in the nights and vehicles other parts get electricity from it such as side indicators, radio-heater and wind screen wiper. Battery sends to controlled voltage to vehicles electrical parts. In petrol engine ignition system work by the current of the electricity sent by stores chemical energy. When a battery circuit is started or bulbs switches on, the stored chemical energy turns into electrical energy and starts going into that circuit through the wires.



Battery capacity and rating: Battery capacity refers to the amount of energy stored in a battery, typically measured in ampere-hours (Ah) or mill ampere-hours (mAh). Battery rating, on the other hand, often refers to the performance or quality of battery, which can include factors like longevity, efficiency and reliability.



The SOC (State of Charge) voltage chart give is you an indicative state of charge based on the battery voltage when the battery has been at rest for 30 minutes, this means no charging or loads in the past 30 minutes.

These should be compared to your SOC battery monitor and the battery monitor should read a given chart, if it does not then usually the battery, monitor needs adjustments, the SOC chart in most cases will be far from accurate.

But we should need always check these setting in your Battery monitor, we to some identify for battery rating here following these chart:

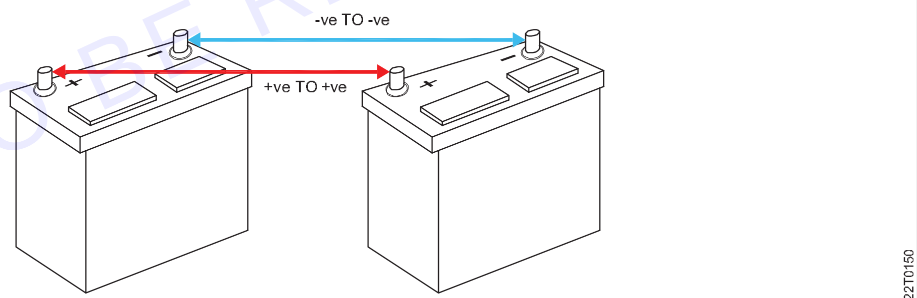
SOC for lead Acid battery, when at rest for 30 minutes.

Note: Voltage and state of charge (SOC) will vary with Temperature and Battery Type AGM batteries will read about 0.15 volts HIGHER than wet cell batteries.

Table

Voltage	Capacity (in %)	Condition
14.4 V	100%	Fully charged
13.6 V	100%	OK
13.4 V	99%	OK
13.3 V	90%	OK
13.2 V	70%	OK
13.1 V	40%	Average
13.0 V	30%	Average
12.9 V	20%	Chances of discharge
12.8 V	17%	Need for charge
12.5 V	14%	Need for charge
12.0 V	9%	Discharge
10.0 V	0%	Fully discharge

Booster starting: If a vehicles break-down, self-starter cannot operate the crankshaft properly due does not engine start. In this situations we start it by pushing or by attaching it with another vehicle by tow chain. This is too difficult task. It is not easy and handle for one person. Heavy vehicles such as heavy dumper, tractors or vehicles which are fitted with fluid flywheel do not starter by either pushing or using tow chain. In such situations we need also another battery otherwise set of batteries as per needed of vehicle voltage which is called booster starting method.



BATTERIES IN PARALLEL CONNECTION

Booster starting and it is precaution:

An above fig. shows how a weak battery is connected to a booster battery.

1 Before fixing jumpers on both batteries remove their vent plugs so that gases generating inside the battery can easily come out.

2 First, watch the ground terminal of jumper cable on both sides.

3 Then join jumper cables positive (+) terminal to weak battery (+) positive terminal and negative (-) terminal with the negative (-).

In parallel connection a batteries negative pole is connected to the negative pole of the battery and positive pole is connected to the positive pole of battery. No matter how many batteries are connected in this way, it will produce only 6 or 12 volts. The capacity of the battery also does not increase the volts only ampere will increase.

4 Before starting the engine put a piece of back or tarpaulin on the both the batteries so that in case of accidental explosion of battery nobody get injured. This is necessary precaution.

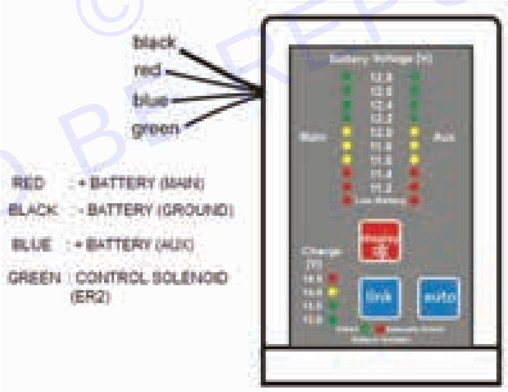
5 Start the engine when both the batteries are completely connected.

6 After the engine has started unfasten the jumper cable.

7 After starting the engine, give a sometime to charge the vehicle discharge battery. Let the engine run for at least 15 minutes to charge.

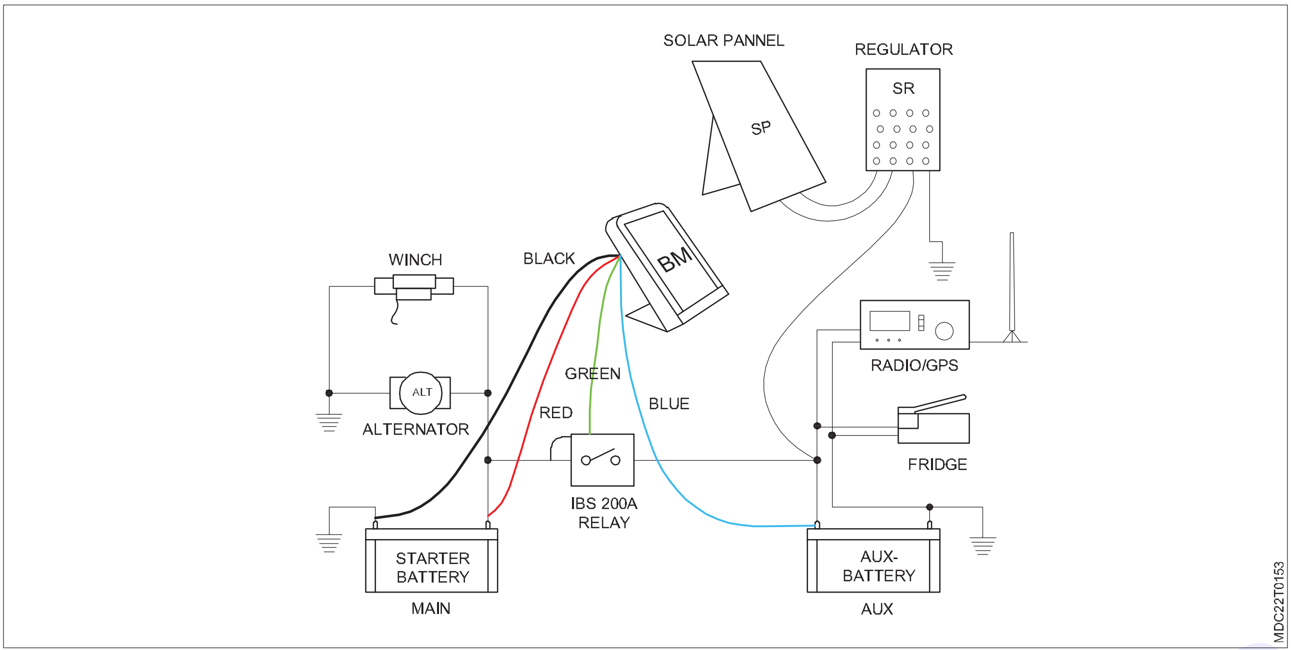
IBS (Intelligent Battery System) system

The intelligent battery system (IBS) informs you about the current energy status, allowing you to plan your energy supply. In order to carefully conserve the energy of the vehicle battery, it is necessary to know the state of charge, ageing and any changes to the battery, as weak batteries are the main cause of vehicle breakdown.



Application of IBS

The intelligent battery sensor (IBS) from HELLA is the key element of vehicle energy management. The IBS reliably and accurately measures the battery voltage, current and temperature parameters. Information on the state of charge (SOC), state of health (SOH) and state of function (SOF) of the battery is calculated algorithmically using these measurements. The IBS is designed to be used in starter, gel and AGM batteries to monitor in-vehicle starter or consumer batteries. The IBS can be directly integrated into the vehicle's electrical system with the standardize LIN protocol. The IBS is attached directly to the negative pole of the battery via the pole terminal. Alongside the terminal, the mechanical portion of the battery sensor consists of the shunt and grounding bolt. The shunt is attached to the vehicle's load path and is used as a measuring resistor to measure the current indirectly. The ground cable can be conveniently attached to the grounding bolt, e.g. with the optionally deliverable battery pole adapter. The electronics are located in a cast housing with a plug connector which functions as the interface to the energy management system. The LIN protocol is the communication interface to the higher-level control unit. The supply voltage, used simultaneously as the reference voltage for voltage measurement, is provided by the connection to the positive pole of the battery.



Disposal of waste battery

INTRODUCTION: Approximately 85% of the total global consumption of lead is for the production of lead-acid batteries. This represents a fast-growing market, especially in Asia. The main uses of these batteries are in motorized vehicles, for storage of energy generated by photovoltaic cells and wind turbines, and for back-up power supplies (for both the consumer market and for critical systems such as telecommunications and hospitals). In developing countries where power supplies are unreliable lead-acid batteries are used domestically for lighting and electrical appliances. The growth in of renewable energy sources and the concomitant need for storage batteries, as well as the in demand for motor vehicles as countries undergo economic development, mean that the demo lead-acid batteries will continue to increase. This is reflected in the increased global demand refined lead metal, which was estimated at 10.83 million tons in 2016. The demand is being in increases in both primary lead productions from mines and recycling. Indeed, currently over h global production of lead is from lead recycling. The manufacturing and recycling of lead-acid batteries is practiced worldwide in both regulated industries and unregulated, informal establishments. Lead recycling is an important source of environmental contamination and h exposure in many countries. This is because it is frequently carried out without the necessary processes and technologies to control lead emissions and, in many developing countries, is a regulated industry. The unregulated, informal recycling of used lead-acid batteries presents problems as it is mainly carried out by small family businesses, often in domestic backyards, sometimes in secret. Even established, industrial-scale recycling facilities can, however, cause significant environmental contamination and human exposure to lead in countries without ad

standards or when regulatory controls are inadequately enforced. Recycling used lead-acid batteries is of public health concern because this industry is associated with a high level of occupational exposure and environmental emissions. Further there is no known safe level of exposure to lead, and the health impacts of lead exposure are significant. Based on 2016 data, it is estimated that lead exposure accounted for 495 550 dean 9.3 million disability-adjusted life years lost due to long term impacts on health, with the high burden in low- and middle-income countries. Young children and women of childbearing age a particularly vulnerable to exposure to, and the toxic effects of, lead.

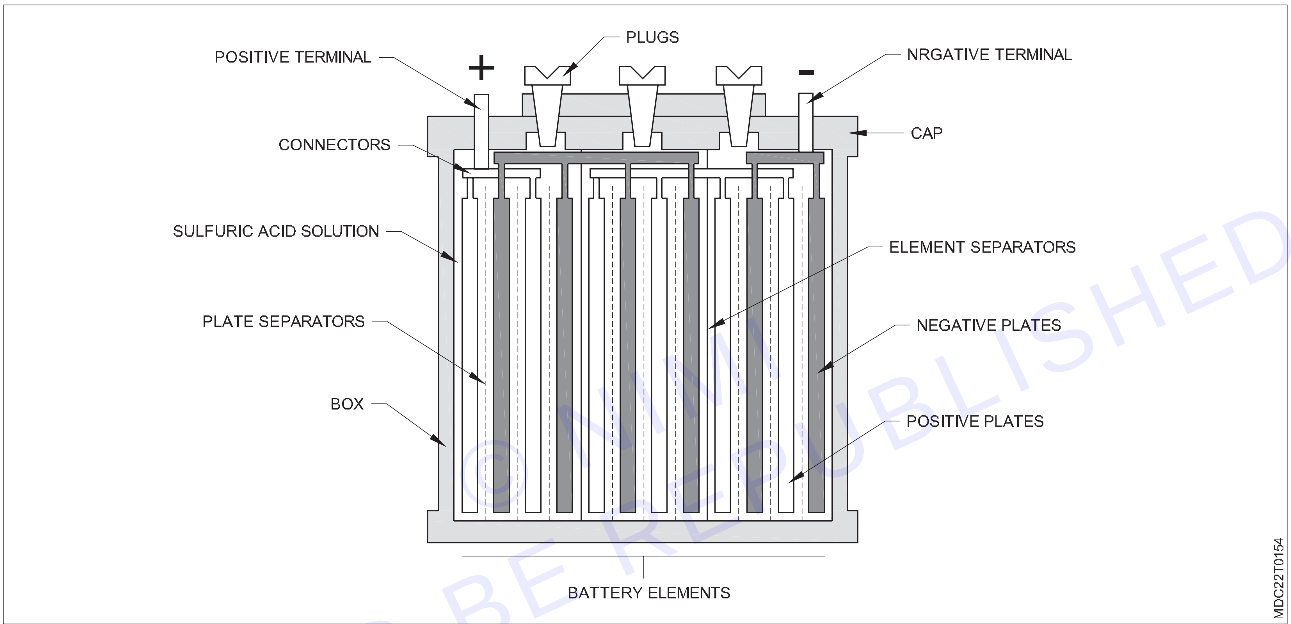
How lead exposure occurs during recycling and disposal

The main pathways of exposure to lead from recycling used lead-acid batteries arise from environmental emissions. These occur at various stages in the recycling process, as described below. Lead particles and fumes emitted into the air can be inhaled and are also deposited onto soil, water bodies and other surfaces, including in gardens and homes. Waste materials from lead processing can, if not treated and correctly disposed of, contaminate land and water bodies. Used acid with high concentrations of lead is often dumped on land or released into waterways. Lead can enter the food chain through crops growing on contaminated land, from direct deposition onto crops, through food animals foraging in contaminated areas and consuming lead particles, and from fish and shellfish living in lead-contaminated water

Components of a lead-acid battery

A lead-acid battery is made up of the following components, enclosed within a plastic or ebonite box or casing. There are positive and negative terminals made of lead, which provide the connection points to external devices. There are sets of positive and negative plates kept apart by plate separators - porous sheets of PVC or polyethylene plastic, glass microfiber, or phenolic resins that allow the free movement of the ions in the electrolyte solution. The positive plates are grids made of lead or lead alloy coated with porous metallic lead paste, and the negative plates are lead grids coated with lead dioxide paste. A series of negative and positive plates plus separators makes up a battery element, and the battery elements are separated by plates of the same material as the battery box. The elements are bathed in a sulfuric acid electrolyte solution, which can be topped up via the plugs. In sealed batteries the electrolyte is either a gel or is soaked onto glass microfiber separators.

The average amount of lead in automotive batteries can range from 2 to 13 kg, depending on the size of the vehicle



Steps in the recycling process

Almost all parts of a lead-acid battery can be recycled. The main steps in the recycling process are as follows:

- Collection and transportation of the batteries to a recycling facility
- Separation of the component parts of the batteries smelting and refining of the lead components
- Washing then shredding or melting of the plastic components
- Purification and treatment of the sulfuric acid electrolyte
- Treatment and disposal of waste

The batteries are mechanically or manually broken up to separate out the acid and component parts. The lead components are conveyed to the furnace for smelting. After smelting the slag is removed and the molten unrefined lead may be poured into moulds and cooled or it may immediately be directed to a holding kettle (cast-iron pot) to keep it molten prior to refining. The aim of the refining process is to produce lead of high purity or to produce alloys (requiring the addition of specific trace elements to the refining kettle) that can be used to make a new lead battery. The molten lead is then cast into moulds and allowed to cool

Recyclable plastic components are washed then shredded or ground and melted. The molten plastic is extruded into pellets, which can then be used in the manufacture of other plastic goods, including new battery casings. In many smaller recycling facilities in low- and middle-income countries, the plastic battery cases are often not recycled and may be dumped or burned The electrolyte may be recovered for re-use or neutralized with alkali and treated to remove lead and other contaminants before being released into the sewage system. Alternatively, the solution may be purified and sodium sulfate extracted for use in making detergents and other products

At each of these stages, lead fumes and dust are released into the air, contaminating both the workplace and the wider environment. The use of automated, enclosed processes with pollution control devices can reduce these emissions.

In a typical automated enclosed process, the lead batteries are broken up in a hammer mill or shredder and the pieces are fed into tanks filled with water. Here gravity is used to separate the components: the lead and heavy materials sink to the bottom and the plastics rise to the top. The plastic materials are skimmed away and the liquid, including the sulfuric acid electrolyte is drawn off. The metallic components are channeled to closed furnaces for smelting and refining and then piped into casting moulds. Waste from recycling is collected, treated and disposed of at a designated waste disposal site

In a manual process the batteries are drained then broken up with electric saws, machetes or axes. The components are separated by hand into piles. The lead components are carried to the furnace or taken on an open conveyer belt. The furnace may, in the worst case, be no more than an open pot on a fire. The molten lead is then poured into casting moulds.

Lead release and exposure during recycling

At the collection and transportation stage, the sulfuric acid electrolyte solution is sometimes drained out to reduce the weight of the batteries or because a higher price is offered for drained batteries. If not done at this stage then the electrolyte may be drained out at the recycling site (in some enclosed processes the batteries are not drained prior to crushing). In addition, electrolyte may leak out of damaged batteries during storage and transportation. If adequate precautions are not taken to avoid skin contact, the acid will cause corrosive injury. The electrolyte contains dissolved lead and, if the electrolyte leaks out or is poured onto the ground rather than into collection tanks, the lead becomes incorporated into soil particles, which subsequently become a source of lead dust. Pouring the electrolyte into ponds or streams will contaminate water that may be used for drinking, fishing and cooking.

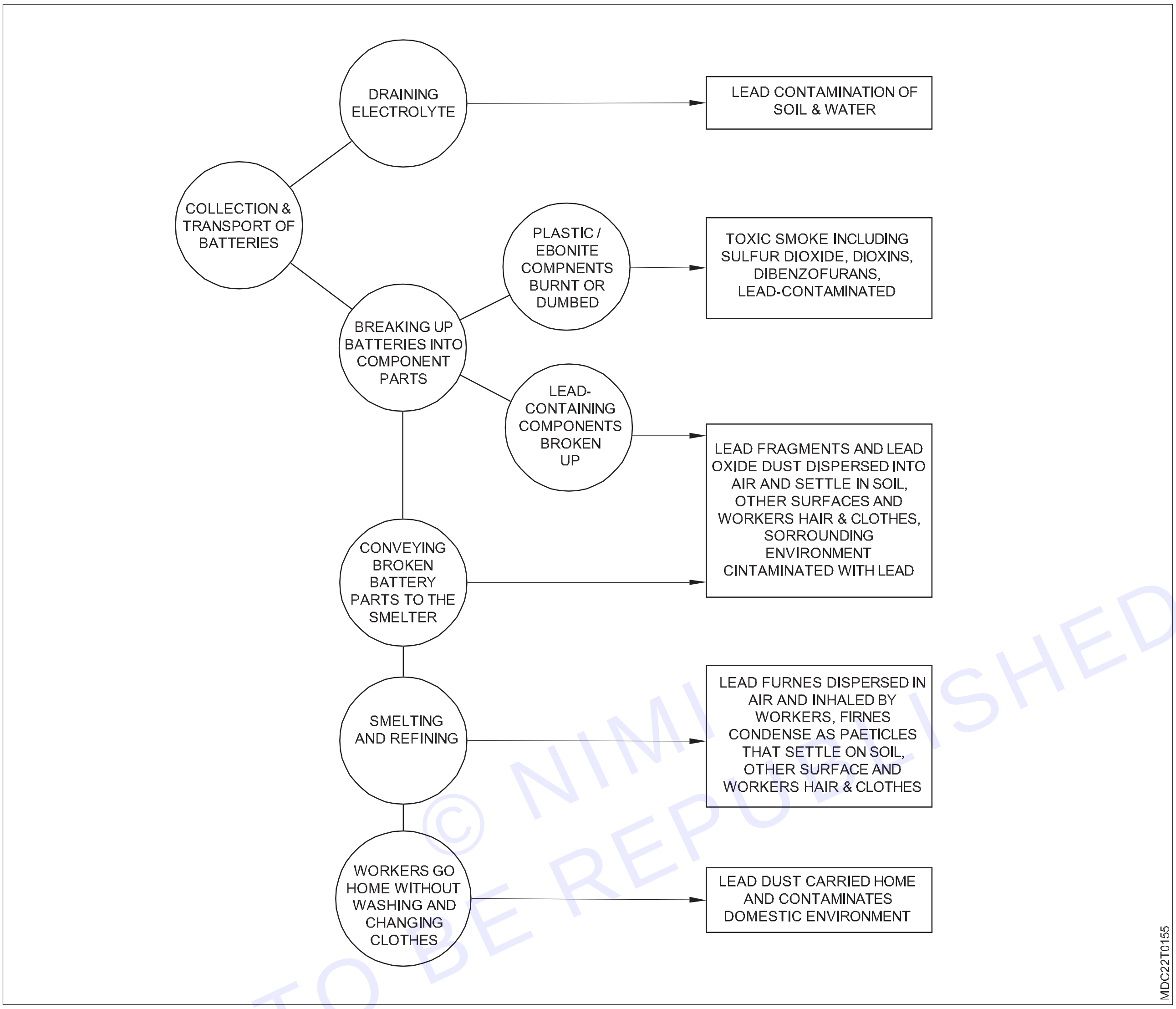
Manually breaking up the batteries releases lead particles and lead oxide dust, which are a source of lead exposure to the worker. The dust and particles also settle in the surrounding soil and may be blown to more distant areas, contaminating the wider environment and becoming a source of exposure to the community. Hammer mills and shredders may release lead mist, which can dry and release lead dust if disturbed. Dust settled on vibrating equipment can become re-suspended in air and inhaled.

During the separation process, water used in automated systems for separating lead from other components becomes heavily contaminated with lead compounds. If this leaks or is not treated before disposal it will contaminate the ground or soil. As this water evaporates it leaves a residue of fine lead dust that may then be dispersed by wind

When lead components are moved around the recycling site, e.g. on open conveyor belts or in wheelbarrows, and when they are shoveled into the furnace, lead fragments and dust are released. The temperatures used for refining lead can be up to 1000 °C, which generates large amounts of lead fume. If the furnace is not under negative pressure or if the plant has inadequate ventilation and/or emission controls, the fumes will be inhaled by workers. Lead fumes are particularly

hazardous as the small particle size enables the lead to be inhaled into the lower respiratory tract and absorbed. The fumes will eventually settle as lead particles on surrounding surfaces and the soil, creating lead dust, which can also be inhaled. Fugitive lead emissions from these sources can be substantial and are more difficult to control. Sometimes ash from the smelting process is manually sifted to retrieve metal particles, dispersing lead-contaminated dust into the air

Fume, lead particles and dust released at various stages in the recycling process will also settle on the skin, hair and clothes of workers. If workers do not wash and change clothes before returning home this lead becomes a source of take-home exposure to household members and even, potentially, to the wider community. Lead poisoning in the spouses and children of lead workers, caused by transfer of lead from the workplace to home, has repeatedly been documented



Informal lead recycling

Non-regulated, informal ("backyard" or "cottage") recycling practices occur in many countries and have resulted in lead exposure and poisoning, with young children being particularly at risk. This practice is sometimes carried out in urban areas with high population densities, meaning that a recycling operation has the potential to affect a large number of people. There are few (if any) pollution controls. Lead-containing waste products, such as electrolyte solution and slag from the smelting process are often simply dumped, although slag may also be sold on for further smelting. The work may be carried out by small family groups around the home. Children often assist with dismantling the batteries and washing components. Because the recycling process is done with little knowledge of the toxicity of lead, and is conducted under poor conditions of safety, health and environmental controls, informal recycling is particularly likely to result in environmental contamination and human exposure

Soil contaminated with lead compounds can spread throughout the community and be tracked into homes. If recycling activities take place around the home, then airborne lead can enter the home and accumulate on the floor, on beds and on other furniture. Settled dust can be re-suspended in the air and inhaled as people walk through or brush up the dust. Young children, who spend large amounts of time on the ground and who frequently put their hands and other objects in their mouths, are at particularly high risk of lead exposure in these settings

If the plastic components are inadequately washed before re-use for other products, then these products will be contaminated with lead. Battery casings may be used around the home as a construction material or as containers, again introducing the possibility of lead contamination There have been reports in Cameroon and other countries of lead scrap from informal recycling being mixed with scrap aluminum to make cooking pots. Lead can leach out into food being prepared or stored in these pots

Other chemicals released during recycling

While the focus of this document is on the release of lead, there are a number of other hazardous chemicals that can be released during recycling. In addition to the lead terminals and plates, batteries contain various plastics or hard rubber (ebonite) and the sulfuric acid electrolyte solution. The lead components may contain other elements such as arsenic, antimony, barium and cadmium. These substances may form part of the waste and emissions generated at various stages of the recycling process. The rubber and plastic components may be burned rather than recycled, producing toxic gases, including Sulphur dioxide, chlorine, dioxins and dibenzofurans.

Advantages of slow charging. Advantages of solidification of electrolyte by adding salicylic acid or introducing absorbed glass mat (AGM) - VRLA batteries Electrolyte-definition, percentage of sulphuric acid and water effects of improper ratio of acid and water on battery life

Objectives: At the end of this lesson you shall be able to

- describe Advantages of slow charging Advantages of solidification of electrolyte by adding salicylic acid
- explain introducing absorbed glass mat (AGM) - VRLA batteries Electrolytedefinition
- explain percentage of sulphuric acid and water effects of improper ratio of acid and water on battery life.

Advantage of Slow Charging

1 **Improved Battery Lifespan:** Slow charging helps maintain the health of your battery by reducing stress and wear on the cells.

2 **Minimized Heat Generation:** Slow charging generates less heat, which can reduce the risk of overheating and damage.

3 **Enhanced Safety:** With slow charging, there is less chance of overcharging or short-circuit,

4 **Consistent Performance:** Slow charging is a more stable charging process, which can help maintain your device's performance over time.

5 **Low Energy Consumption:** Slow charging results in less energy consumption, which contributes to energy efficiency and reduces your carbon.

6 **Compatibility:** Slow charging is compatible with a wide range of devices and chargers, does not require high-power charging technology.

7 **Cost-Effectiveness:** Slow charging doesn't require a special charger, so it can be a good choice to charge your devices.

8 **Less Strain on Electrical Infrastructure:** Slow charging puts less pressure on the electrical grid and infrastructure than fast charging.

9 **Prevention of Battery Degradation:** By charging slowly, you minimize the degradation of your battery's capacity and overall performance.

10 **Optimal Charging:** Slow charging is a more controlled and accurate charging process, allowing your battery to reach its optimal charge level without overloading it.

11 **Reduced Risk of Battery Swelling:** Slow charging reduces the risk of battery swelling, a common problem with lithium-ion batteries.

12 **Improved Charging Efficiency:** Slower charging can be more efficient in terms of transferring energy to the battery,

13 **Flexibility:** With slow charging, you are not tied to time constraints, allowing greater flexibility.

14 **Extended Usage Time:** Slower charging may take longer, but may result in a more durable and longer lasting charge,

15 **Peace of Mind:** Knowing that your device is charging slowly especially when left charging overnight or unattended.

These advantages collectively make slow charging an attractive option for users concerned about battery health, safety, and long-term device performance.

Advantages of solidification of electrolyte by adding salicylic acid

Electrolyte: Electrolyte is prepared by mixing pure water in concentrated H_2SO_4 in a lead acid cell and with its help current flows in the cell.

Advantages

1 **Improved safety:** Solid electrolytes are often more stable and less prone to leakage or combustion compared to liquid electrolytes, reducing the risk of accidents, especially in high-energy applications like batteries.

2 **Enhanced performance:** Solid electrolytes can enable higher energy densities, longer cycle life, and improved efficiency in electrochemical devices such as batteries and fuel cells.

3 **Wider temperature range:** Solid electrolytes can operate over a broader temperature range compared to liquid electrolytes, making them suitable for applications in extreme environments.

4 **Reduced self-discharge:** Solid electrolytes typically have lower rates of self-discharge compared to liquid electrolytes, leading to improved shelf life and standby performance in batteries.

5 **Miniaturization:** Solid-state electrolytes allow for more compact and lightweight designs in electronic devices and energy storage systems, enabling miniaturization and increased portability.

Overall, solidification of electrolytes offers a promising avenue for advancing the performance, safety, and versatility of various electrochemical technologies.

Introduction of absorbed glass mat (AGM)- vral batteries

AGM: AGM stands for Absorbent Glass Mat, and AGM batteries are a type of lead-acid battery. They use a fiberglass mat to absorb and hold the electrolyte solution, which makes them spill-proof and maintenance-free. AGM batteries are known for their high-power density, fast recharge rates, and good resistance to vibration and shock. They are commonly used in applications such as backup power systems, renewable energy storage, and in vehicles like motorcycles and boats.

VRAL: A VRLA (valve-regulated lead-acid) battery is a type of rechargeable battery. It is sealed and maintenance-free, meaning it does not require regular addition of water to the cells. VRLA batteries are commonly used in applications such as backup power systems, emergency lighting, and renewable energy storage. They are designed to be non-spill able and operate in any position, making them suitable for a wide range of uses.

AGM battery vs Lead-acid battery

VRLA (Valve-Regulated Lead-Acid) and AGM (Absorbent Glass Mat) batteries are both types of lead-acid batteries commonly used in various applications, including automotive, marine, and renewable energy systems.

The main difference between VRLA and AGM batteries lies in their construction and design. VRLA batteries are a broader category that includes both AGM and gel batteries. AGM batteries, on the other hand, use a fiberglass mat to absorb and hold the electrolyte solution, which allows for a higher efficiency in both discharging and recharging.

In summary, while VRLA is a broader category that includes AGM and gel batteries, AGM batteries specifically use a fiberglass mat to hold the electrolyte, providing certain advantages in terms of efficiency and performance.

Uses of AGM Batteries

As widely used SLA batteries, AGM batteries are a sought-after choice for fuel-efficient, high-end vehicles with large power demands. It is not, therefore, surprising to see AGM as the preferred motorcycle battery for upscale motorcycles.

Moreover, the higher CCA (cold cranking amp) rating of AGM batteries is responsible for their reliable performance in cold temperatures and enhances usability for marine (marine battery), motor home, and robotic applications.

Battery manufacturers worldwide continue to tap into the AGM technology potential to manufacture high-performance AGM batteries.

For example, Yuasa AGM batteries are recognized globally in the power sports battery market. In 1983, Yuasa launched the first motorcycle maintenance-free AGM batteries with the YT series.

The Crown Battery line includes a broad range of industrial deep cycle batteries and SLI (starting, lighting, and ignition) batteries for varied applications, such as automobiles and light trucks, electric forklifts, pallet trucks, farm equipment, floor care equipment, marine and recreational vehicles, etc.

Uses of VRAL Batteries

VRLA batteries (valve-regulated lead-acid batteries) are commonly used as backup power sources for uninterruptible power supply (UPS) systems, emergency lighting, and alarm systems. They are also used in large portable electrical devices and off-grid power systems. VRLA batteries are maintenance-free and sealed, so they don't require regular electrolyte (water) level topping up. However, they still need to be cleaned and regularly tested.

Here are some other uses for VRLA batteries:

- **Telecommunications:** VRLA batteries are well-known for their maintenance-free operation and wide use in telecommunications.
- **Mounting:** GEL and AGM types of VRLA batteries can be mounted in any orientation.
- **Transportation:** VRLA batteries can be safely transported by air or ground without special handling.
- **Ventilation:** VRLA batteries are safe for use in areas with limited ventilation.

Limitations of AGM Batteries

- **Cost:** AGM batteries are more expensive than flooded lead-acid batteries.
- **Weight:** AGM batteries are heavier than flooded lead-acid batteries of the same size.
- **Energy:** AGM batteries have a high-power output but low specific energy.
- **Capacity:** AGM batteries gradually lose their charging capacity over time.
- **Sensitivity:** AGM batteries are sensitive to overcharging, high voltages, and high temperatures.
- **Discharge rate:** AGM batteries have a relatively low discharge rate, so they can't provide as much power at once as other batteries.
- **Lifespan:** AGM batteries typically last 3–5 years, which is shorter than some other types of batteries.
- **Deep discharge:** AGM batteries have a limited deep discharge capability, so they aren't well-suited for applications that require a high depth of discharge.
- **Charging:** AGM batteries require full charging between uses and need a charger that monitors volts, amps, and ambient temperatures.

Limitations of VRAL Batteries

- **Capacity:** In comparison to newer battery technologies, lead-acid batteries have a restricted capacity, resulting in a lower energy storage capability. Consequently, a greater quantity of batteries will be necessary to store an equivalent amount of energy, leading to potential cost implications.
- **Efficiency:** Lead-acid batteries are not as efficient as some of the new battery technologies. They make use of only about 80% of their stored energy, meaning that you will need to store more energy to make up for this loss.
- **Weight:** Lead-acid batteries are relatively heavy, which can make them difficult to transport, especially in rural or remote areas. This additional battery requirement can contribute to increased costs associated with solar power systems.

Maintenance: While lead-acid batteries are relatively easy to maintain, they do require regular maintenance to ensure that they are working correctly. When lead-acid batteries reach the end of their lifespan, appropriate disposal methods must be followed.

Electrolyte-definition, percentage of sulphuric acid and water effects of improper ratio of acid and water on battery life

Electrolyte

A liquid substance that dissolves when an electric current flows through it is called an electrolyte. E.g. Sulfuric acid, sodium chloride etc. Dilute sulfuric acid (H_2SO_4) is used as the electrolyte for lead acid batteries. Specific gravity of pure sulfuric acid is 1.84. Dilution of this pure sulfuric acid is usually done by mixing one-part sulfuric acid with seven parts distilled water to bring its specific gravity from 1.300 to 1.230. As per the battery manufacturer's recommendation if the battery cell contains P.V.C. 1.200 Vs if separators are used. Th. 1.230 Vs. Th. Use electrolyte containing The electrolyte level in the battery cell should be 1/2" to 3/4" above the plates.

Percentage of sulphuric acid and water effects of improper ratio of acid and water on battery life -

The % sulfuric acid in a lead-acid battery electrolyte is around 37 - 38%. this concentration can do effect on the battery's performance.

High Acid Concentration: Too much sulfuric acid cause corrosion of the lead plates, battery life and potential damage to the battery casing.

Low Acid Concentration: Insufficient sulfuric acid can reduce battery capacity and reduced ability of charge.

It is difficult to maintain acid-to-water ratio when adding electrolyte to a battery.

Batteries store electrical energy in chemical form. When the battery is fully charged, the positive plate, PbO, is dark brown in color, while the negative plate, Pb, is gray in color and a spa of sulfuric acid, H,SO, (electrolyte). Gravity ranges from 1.20 to 1.30. Each cell of a battery has a voltage of 2.2 volts. Thus is the whole battery situation. Now when the current is taken from the battery, the sulfuric acid decomposes and H and SO ions are separated from it. Of these, hydrogen (H_2) is liberated to lead peroxide (PbO,) and is first converted into lead oxide (PbO), which, on mixing with sulfuric acid, is converted into lead sulphate (PbSO,). Water (H_2O) is produced in this process. The sulfate group (SO_2) released during the decomposition of sulfuric acid is released from spongy lead (Pb) and is also converted into lead sulfate (PbSO,). Thus both the plates are converted into lead sulphate (PbSO,) and appear white in color and as the water content increases in acid, the specific gravity of the acid decreases.

Now when a current is sent through the cell to charge the battery, on the positive plate PbSO, SO, H_2O PbO,+ 2H,SO, and On the negative plate, PbSO, + H_2 = Pb + H_2SO_4 chemically reacts so that one plate becomes PbO, and the other Pb. The specific gravity of sulfuric acid increases due to the loss of water in the chemical process.

Specific gravity of water, acid and electrolyte. Temperature effect on specific gravity. Battery troubles and their remedies

Objectives: At the end of this lesson you shall be able to

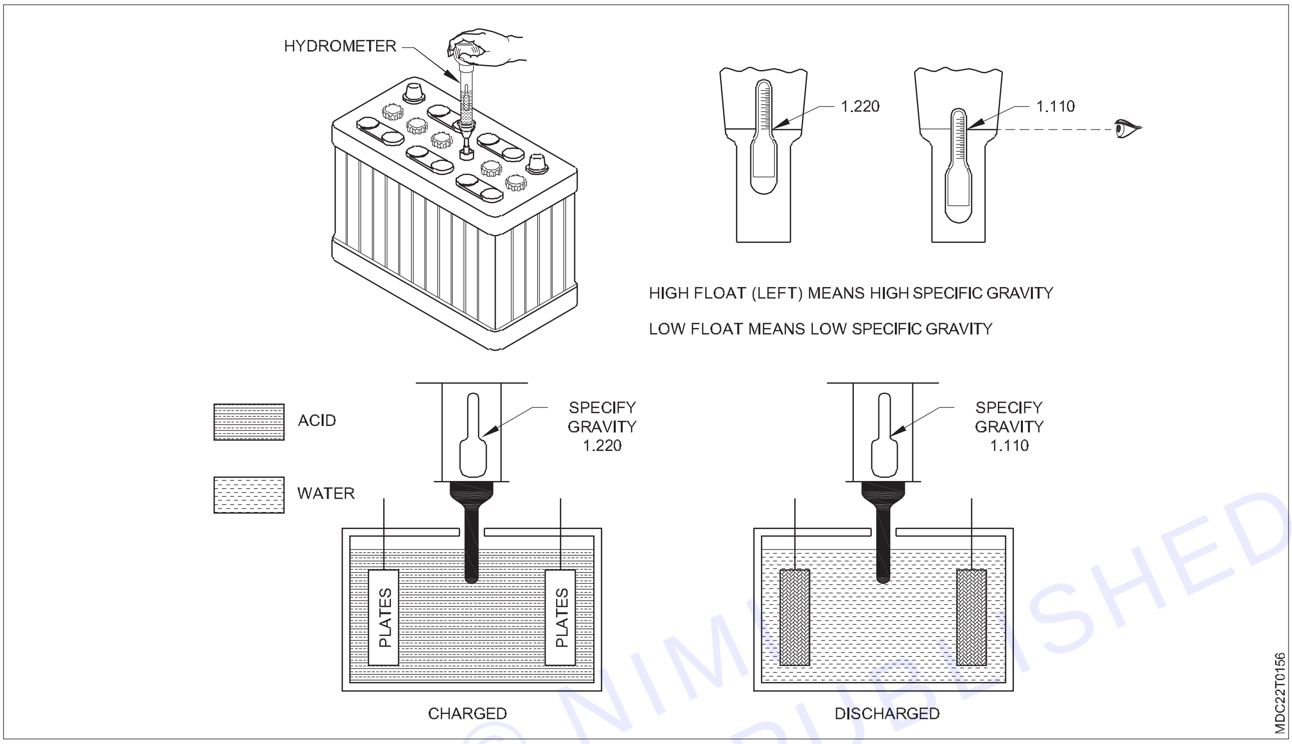
- explain about specific gravity of water, acid and electrolyte
- demonstrate temperature effect on specific gravity
- demonstrate battery troubles and their remedies

Specific gravity of water, acid and electrolyte. Temperature effect on specific gravity

Specific gravity of water: The density of water is always considered to be 1. This makes it a standard for comparing the density of other substances.

Specific gravity of acid: An acid is a substance in chemistry that either gives away a proton or accepts an electron pair during reactions. Acids usually taste sour and can change the color of litmus paper to red. They're often grouped into strong or weak categories depending on how easily they break apart in water, releasing hydrogen ions (H+). Examples include hydrochloric acid (HCl) and citric acid.

Electrolyte Specific Gravity: The charged or discharged state of the battery can be determined by measuring the specific gravity of the electrolyte in the battery cell. Spa. Hydrometer is used to measure gravity. Figure no in hydrometer. there is a glass tube and a rubber ball (ball) is placed at the top to create suction in the tube and draw the electrolyte. A fine hose is attached to the underside of the tube.



A glass tube contains a floating float on the top of which a paper strip with specific gravity numbers is attached. To check the gravity of the electrolyte in the cell, when the electrolyte in the cell is suctioned in the hydrometer, the float in the hydrometer starts floating and becomes more or less submerged in the electrolyte depending on the specific gravity of the electrolyte. The number at which the float on the level of the electrolyte in the tube is stable is the specific gravity of that electrolyte. 1.300 to 1.230 spe to indicate the state of full charge at the lowest point on the paper strip on the hydrometer float. Gr. There is a yellow bar with a limit of up to 1.230 to 1.160 spec to indicate the half charged state of the battery. Gr. Mayadi has a white stripe up to 1.140 to 1.100 spec to indicate the discharge state of the battery.

Temperature effect on specific gravity

Temperature has an impact on the specific gravity of substances, such as liquids like water. Usually, when temperature rises, the density of most substances decreases, leading to a decrease in their specific gravity. However, this change might not be consistent for all substances. In the case of water, it reaches its highest density at approximately 4 degrees Celsius (39.2 degrees Fahrenheit). When the temperature moves away from this point, the density of water alters, influencing its specific gravity. Hence, when determining specific gravity, it's crucial to account for the temperature during the measurement and make adjustments if needed.

Battery troubles and their remedies

Battery troubles

1 Self-Discharging.

2 Sulphation

3 Internal Short Circuiting.

4 Deterioration of Plates.

5 Cracking of Container.

6 Corrosion of Battery Terminals and Clamps.

7 Loss of Water.

8 Variation in Specific Gravity of Electrolyte.

Self-discharging

When a battery sits unused for a while, it loses its charge gradually. This is known as self-discharging. A new battery typically loses about 1% of its charge each day when left unused. If a battery loses 3% or more of its charge daily, it's considered defective. Keeping the battery clean from dust particles and using pure sulfuric acid and distilled water can help reduce self-discharging. If a battery remains idle for a long time, the electrolyte can deteriorate, leading to a phenomenon called stratification, where it becomes heavier at the bottom. This can cause localized current flow, accelerating self-discharging. To address self-discharge, the electrolyte should be removed and the battery washed with plain water followed by distilled water. Then, it should be recharged with fresh electrolyte.

Sulfation

Occurs when lead sulfate accumulates on the battery plates during discharge, and if a discharged battery remains idle for an extended period, large crystals of lead sulfate form, which don't convert back into lead peroxide during recharge. This condition, called sulfation, increases the internal resistance of the cell and causes the plates to become distorted. Sulfation is often caused by a low quantity of electrolyte and very high specific gravity. Preventive measures should be taken to avoid sulfation, but if it occurs, sulfated batteries can be recharged using slow charging rates.

Internal short circuit

An Internal Short Circuit Occurs When the Separator in The Battery Is Damaged, Or When the Active Substance Falls from The Plates. This Leads to Rapid Self-Discharge and Sulfation. To Prevent This, It's Important to Replace the Damaged Separator and Ensure the Battery's Interior Remains Clean.

The battery plates can sustain damage due to several factors:

1 Excessive charging rate

2 Elevated specific gravity of electrolyte

3 Incorrect electrolyte level

4 Normal wear and tear from maintenance activities.

If the container cracks due to a shock or fall, it must be replaced.

Rusting of battery terminals and clamps occurs due to oxidation, which disrupts the circuit. Regular cleaning is necessary to prevent this

The Electrolyte in A Battery Consists of a Mixture of Sulfuric Acid and Water. Over Time, Water Evaporates from The Electrolyte, Reducing Its Quantity. It's Important to Periodically Check the Electrolyte Level and Add Distilled Water as Needed to Maintain the Correct Quantity and Specific Gravity. Keeping The Specific Gravity Within the Correct Range Ensures Optimal Battery Performance.

To Maintain Optimal Performance, The Specific Gravity of Each Cell in A Battery Should Remain Consistent. However, Fluctuations in The Amount of Water or Acid Can Cause Changes in The Specific Gravity of the Cell. Regular Monitoring and Adjustments Are Necessary to Ensure That the Specific Gravity Remains Within the Desired Range for Each Cell.

Their remedies

- Maintain electrolyte levels by adding distilled water periodically.
- Ensure vent plugs are clean.
- Keep battery connectors and cells free from soil or debris by washing with hot water.
- Clean sulphade battery terminals with hot water and apply petroleum jelly; use trickle charge if the vehicle is unused for some time.
- Secure the battery firmly inside its box to prevent cracking.

- Clip battery cables securely to the chassis to avoid short circuits.
- Check vehicle's specific gravity regularly and correct it by adding electrolyte if necessary.
- Use a puller, not a screwdriver, to remove the battery from the post.
- Tighten loose terminal posts with lead sheet or wire, not iron nails.
- Place a rubber sheet under the battery box to prevent direct contact with iron.
- Avoid bringing an open flame near the battery.
- Handle the battery carefully to prevent spillage of electrolyte.
- Use grommets for passing battery cables inside the body.
- Use battery cables of correct size and grade.
- Maintain the correct charging rate for the battery.

MODULE 9 : Starting System

LESSON 62 - 66: Study about starting system and its components. Importance of checking starter circuit for proper functioning

Objectives

At the end of this lesson you shall be able to

- explain About starting system and its components
- demonstrate importance of checking starter circuit for proper functioning.

Study of starting system and its components starting system

Internal combustion engines are not capable of starting automatically. Hence various systems to start these engines; Like starter motor, self-start etc. are used. Some large engines used in trucks, tractors, and industrial plants are operated by compressed air or a small starting engine, but automotive engines (spark ignition and diesel) are operated by a small but powerful electric motor, which can prevent cracking or Starting motor (cranking or starting motor) An ideal starting system includes the battery, starting motor, drive mechanism, ignition switch, starter relay and all the wiring that helps in starting the engine. Facts like components of starting system, starting circuit, various starting systems, starter driving mechanism, other methods of starting the engine etc. are described.

The Starting System: In an automobile, starting system cranks the engine initially. It has replaced manual effort to crank the engine with the help of cranking rod that was used in ancient days. Initially, the engine requires cranking but once the cycle is completed it starts and runs on its own. In two wheelers, it is common to 'kick start' the engine but in recent times a number of manufacturers have introduced 'button start'. For initial cranking an electric motor is provided that gets electric current as input from battery.

The mechanical energy, in the form of rotation of shaft, is transmitted to engine. This provides initial movement of crankshaft, connecting rod and piston. As soon as spark occurs the fuel is ignited and output becomes available from engine. No more cranking is needed and starting system stops working and engine runs on its own. The starting system makes starting of vehicle convenient.

Requirements of the starting system

An internal combustion engine requires

- A combustible mixture,
- Compression stroke,
- A form of ignition, and
- The minimum initial starting speed (about 100 rpm) in order to start and continue running.

To meet the first three of these requirements the minimum starting speed must be attained. This is where the electric starter comes in. The attainment of this minimum speed is again dependent on a number of factors, such as;

1 The rated voltage of the starting system.

2 The lowest possible temperature at which the engine can still be started. This is known as the starting limit temperature.

3 The torque required to crank the engine at its starting limit temperature (including the initial stalled torque).

4 The battery characteristics.

5 The voltage drop between the battery and the starter.

6 The starter to ring gear ratio.

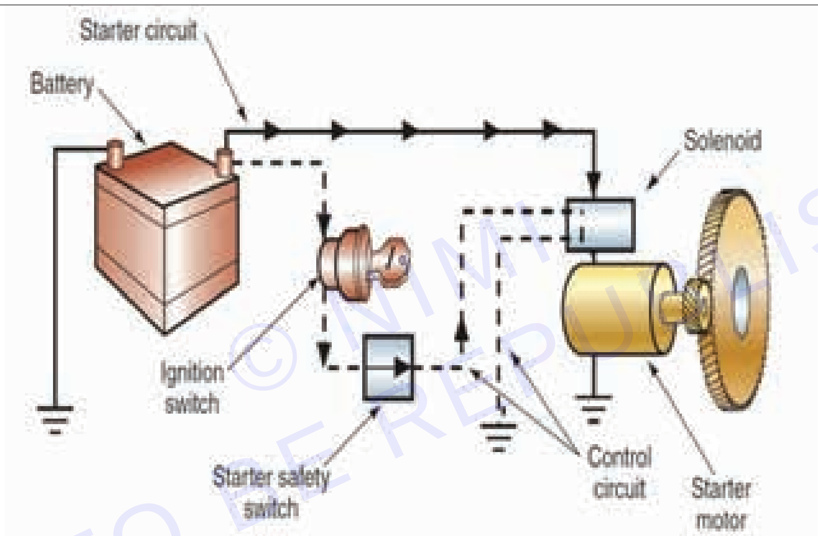
7 The characteristics of the starter.

8 The minimum cranking speed of the engine at the starting limit temperature.

Objective of Starting System: To make the engine functional, it needs to be started. Various mechanisms of the engine become active only after starting, due to which it is possible to use these engines as per requirement. Starting system is used to fulfill this purpose. There are different types of engines, hence different methods are used to start them. It is important for people who use engines in any form to know all the methods of starting the engine. Among these methods, self-starter method is most popular

Construction and Working: The starting system is a combination of mechanical and electrical parts that work together to start the engine. The starting system is designed to change the electrical energy, which is being supplied by the battery, into mechanical energy. For this conversion to be accomplished, a starter or cranking motor is used. A starting system consists of starting motor, magnetic switch, safety switch, battery, cables and ignition switch. These components are connected with each other through two circuits. One is starting circuit, in which high current flows which is used to start the engine. Second is control circuit, in which low current flows.

The ignition switch acts as switch for starting circuits also. In starting circuit, the current flows from battery to starter motor through solenoid or magnetic switch. The control circuit connects magnetic switch with, battery through ignition switch (Figure 6).



Major components of Starting system

Component of Starting System: Those components of the starting system, which enable the system to function properly, are called components of the starting system. Knowledge of these components is essential to fully understand the starting system. The arrangement of components of the starting system is shown in the figure

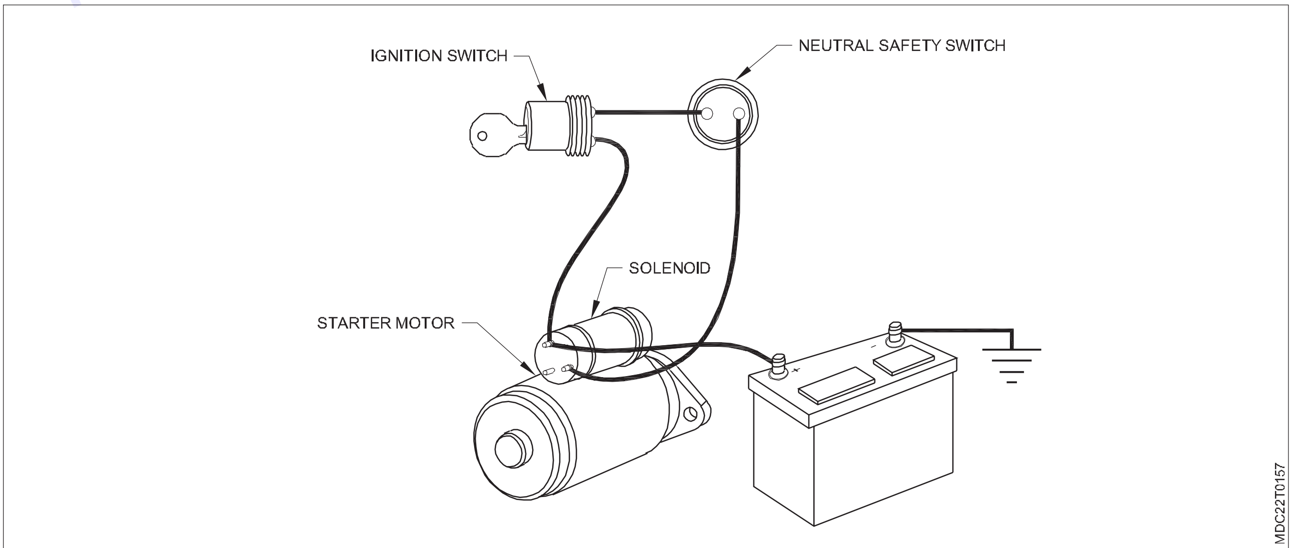


Diagram of components of starting system arrangement

These components are as follows-

Battery: A group of cells is called a battery. It is an important auxiliary component used in the automobile sector. Various devices requiring electricity are used in vehicles through it; Such as self-starter, meter, indicator and gauge etc. are operated. Additionally, various activities while operating a motor vehicle; For example, batteries are also used in lighting the lights of vehicles, blowing horns and operating wind screen wipers. The main parts of a battery are box, plates, separator and terminals.

Battery Cable: A sheathed wire with one or more twisted wires is called cable. Battery cables are available in different gauges and are used according to the nature of the work. At present, 02 and 04-gauge battery cables are generally being used in vehicles. The lower the gauge of a wire, the greater the thickness of that wire; For example, a 02-gauge cable will be thicker than a 04-gauge cable.

Neutral safety and ignition switch neutral safety and ignition switch

The device used to control the flow of electric current, i.e. to 'start' or 'end' it in an electrical circuit built for a vehicle, is called a switch.

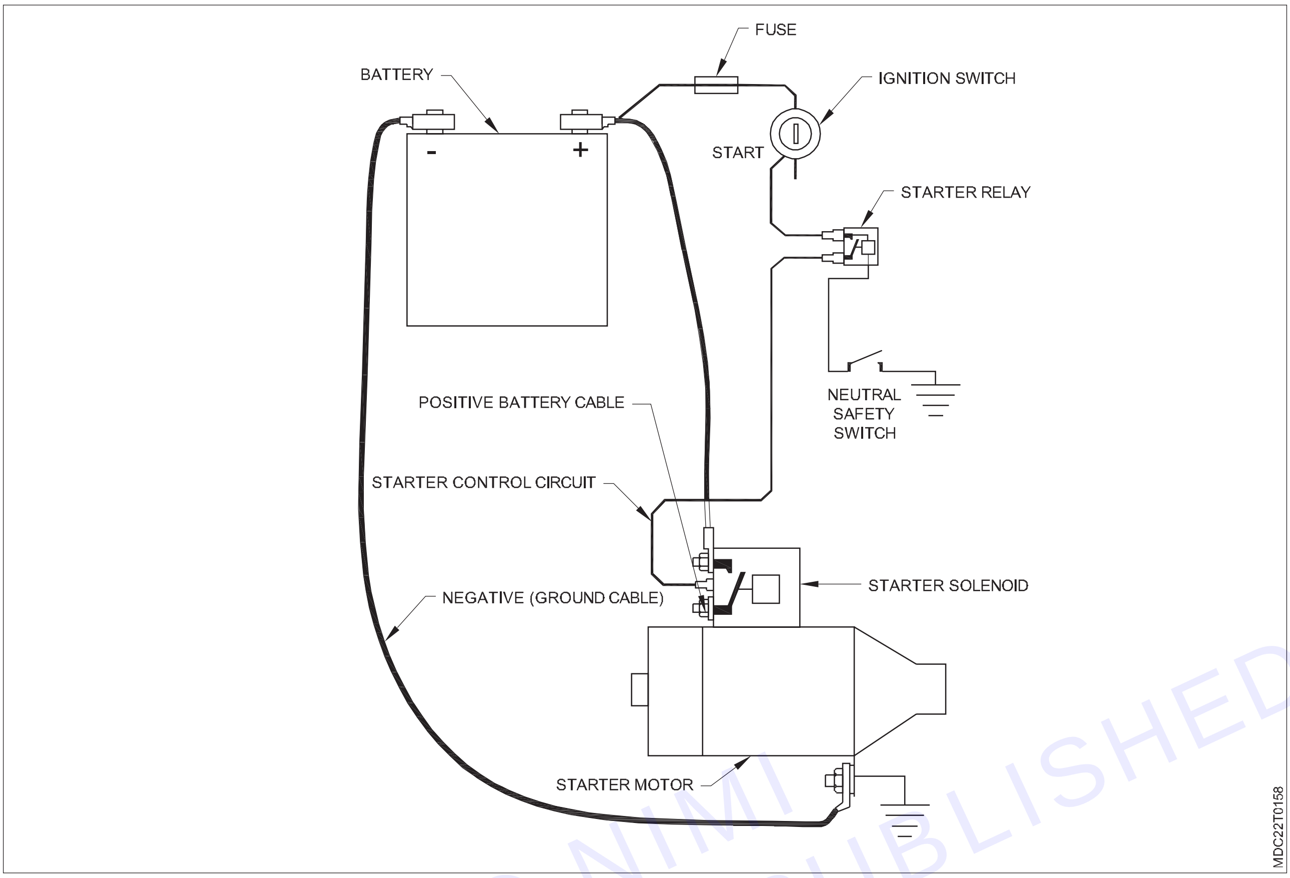
In the starting system, when the transmission is in any gear, neutral The safety switch opens the starter circuit. This switch is generally connected to transmission leakage or directly to the transmission. In most cars this switch is used to supply current to the backup lights. Additionally, the ignition switch is used to distribute electrical current to the vehicle operator at desired conditions.

Starter Solenoid: Electro-magnetic device, starter solenoid or starter relay is used in the starting circuit to serve two purposes, one is to complete the circuit between the battery and the starter and the other is to drive the starter gimbal in conjunction with the engine ring, gear in the vehicle. Due to high current flow in vehicles, corrosion occurs automatically in the starter, due to which the parts of the starter; Like brushes and winding need to be changed.

Starter Motor: The starter motor is a powerful electric motor, which has a small gear at one end. When the motor is operated, the smaller gear meshes with the larger gear or the one mounted on the engine. When the starter motor is fixed at the rear side of the engine, the pinion of the starter motor and the flywheel ring engage with the gear and the flywheel ring rotates the gear.

Description of Starting Circuit: The diagram of the starting circuit is shown in the figure. In this, the negative end of the battery is connected to earth and the positive end is connected to the solenoid switch installed on the battery terminal. By connecting a wire to the input terminal of the starter switch, it is connected to the input terminal of the solenoid winding. The other terminal of the solenoid winding is earthed. A connection from the starter terminal of the solenoid switch is connected to the input terminal of the starter motor.

The internal connection of the starter motor is done with the field winding as well as the armature through bushes and its other terminals are earthed. When the switch is turned on, some amount of current flows between the battery and the starter solenoid. This current provides power to the solenoid winding, due to which the plunger, battery and starter motor ends are connected to the solenoid switch. Conversely, when the switch is turned off, the return spring pulls the plunger back, stopping the flow of current in the circuit. Thus the battery is separated from the starter motor.



Starting System Circuits: The starter circuit is very simple in comparison with most other circuits on the modern vehicle. The voltage drop in the main supply wires is the problem with the system which is to be overcome. This problem is because of the high current required by the starter particularly under adverse starting conditions such as very low temperature. The starter is usually operated by a spring-loaded key switch, which also controls the ignition and accessories. The supply from the key switch, through a relay in many cases, causes the starter solenoid to operate and this in turn, controls the heavy current through a set of contacts. In some cases, an extra terminal on the starter solenoid provides an output while cranking, usually used to bypass a dropping resistor on the ignition or fuel pump circuits. Figure 8 illustrates basic circuit for the starting system.

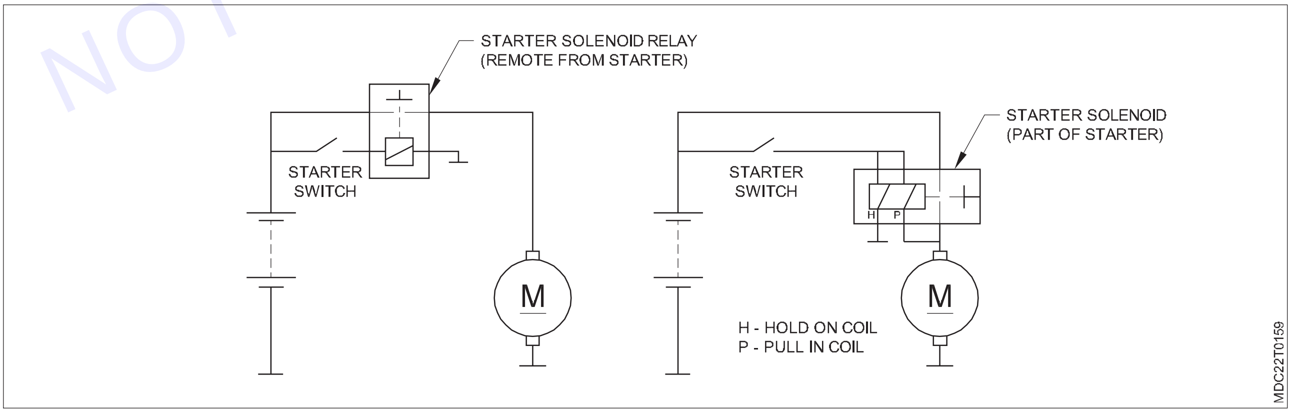


Figure. 8 Basic starting circuit. A. Inertia starter circuit. B. Pre-engaged starter circuit. For a light vehicle engine, a typical cranking current is around 150 A, which may increase to the order of 500 A to provide the initial stalled torque. A maximum voltage drop of only 0.5 V is generally allowed between the battery and starter when the latter is operating. Using Ohm's law a maximum allowed circuit resistance can be calculated as 2.5 mfi for a 12 V supply. This is a worst situation and generally lower resistance values are used. The selection of suitable conductors in the starter circuit is highly important.

The basic starting system includes the following components:

1 Battery.

2 Cable and wires.

3 Ignition switch.

4 Starter solenoid or relay.

5 Starter motor.

6 Starter drive and flywheel ring gear.

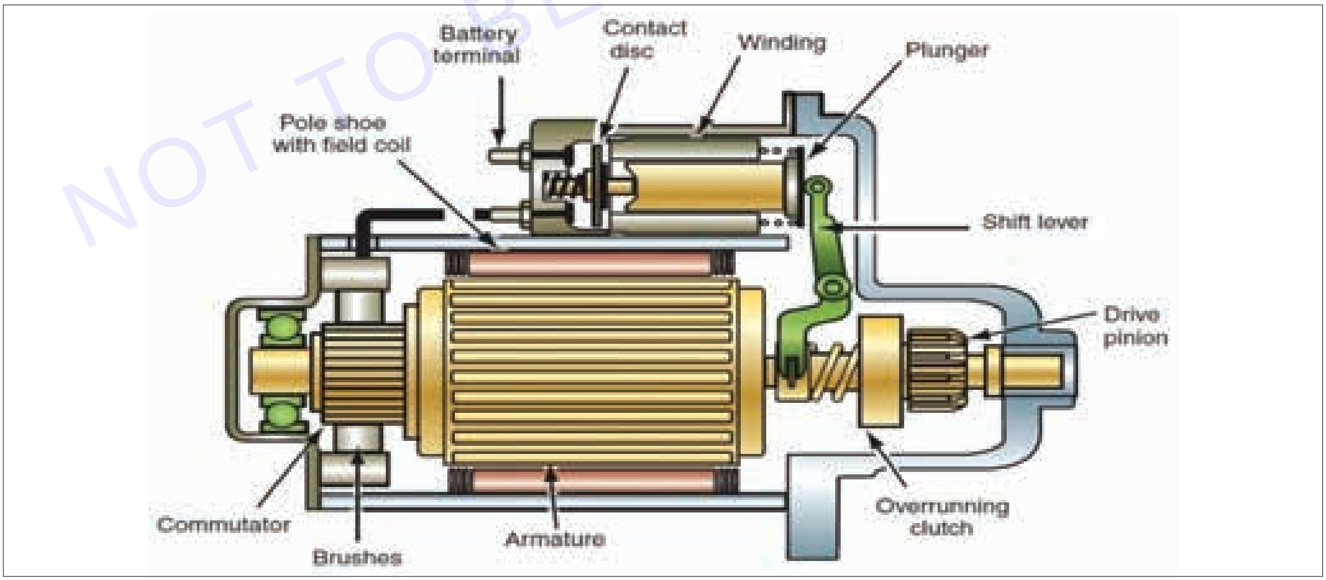
7 Starting safety switch.

Starter Motor: The starter motor is like any other electrical motor but it is designed to work under high electrical overloads and produces very high power. Due to this, the motor can operate for short durations. High current is needed to operate it that generates heat. Time is also required to dissipate this heat. Therefore, it is advisable that the motor be given enough gaps between more than one starting attempts.

The motor has got field coils with pole shoes, armature and a housing that encloses them. Apart from these it has brushes, bushings that make its operation efficient. The field coils and pole shoes produce strong stationary electromagnetic fields as current is passed through them. Magnetic polarity (N or S) depends upon the direction in which the current flows. The magnetic fields produced are opposite in nature.

The armature is located between drive and end frames. It has windings and the commutator mounted on the armature shaft. The windings are made of a number of coils of a single loop each. These are insulated from each other and fit into slots in the armature shaft. The commutator has heavy copper segments surrounding the shaft but are insulated from each other and the shaft. The armature is surrounded by field coils. Current is supplied to armature and it produces magnetic field in each conductor. The magnetic fields are also produced by field coils. The reaction between these magnetic fields causes the rotation of armature. The rotation is transferred to crankshaft of the engine through armature shaft. This causes cranking of engine.

The current from field coils to the armature is transferred through brushes. These brushes are held with the help of springs against the commutator. The brushes can be from two to six in number for smooth motion and constant torque delivery. Figure 7 represents starter motor



Types of starting system

Starting system is used to start the engine. When the starter switch is pressed or turned, the current flowing through the battery causes the starter shaft to rotate. The drive pinion is coupled to the starter motor shaft. The drive pinion rotates the engine's flywheel until the engine starts. Various systems are used to start the engine, which are as follows-

1 Starter motor system

2 Solenoid Switch System

3 Self-starter system

Starter Motor System: To start the engine, the minimum rotational speed of the engine's crankshaft should be 100 rpm. This action is called engine cranking. Because it is very difficult to turn the engine at that speed by hand or with a lever, a starter motor is used to start the engine. The starter motor is fixed to the rear side of the engine. When the starter switch is turned on, the pinion of the starter motor engages with the flywheel ring gear to rotate the flywheel.

Working Principle of Starter Motor

When current flows through an armature coil placed between two stationary magnets, an emf is induced in the coil. Is induced and the armature coil starts rotating.

Self-Starter System

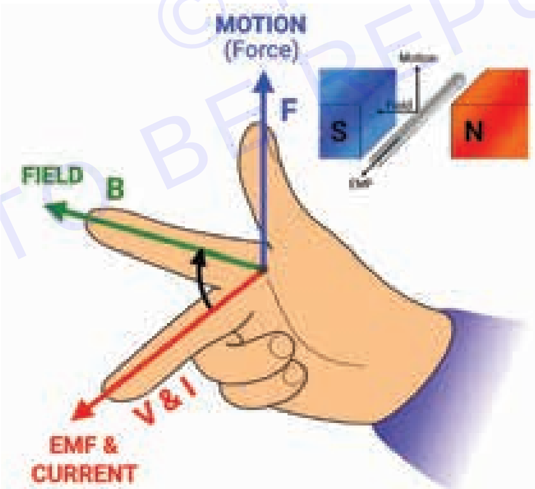
Self-starter is also based on the same principle Lills 146 Azole Baje & health folk

Then a mechanical force is generated on that conductor, which rotates it. The direction of this force is determined by Fleming's right hand rule. plain to kho bluble pie the poliok link 1946 17sne Huey be yoj L t will start working. to the to witya be the als 1214 215 lak llilow the resolve like to lththis in 'ille faire pagliok =

According to this rule, one has to open one's right hand in such a way that the fore-finger, middle finger Taltk lalse 196

Starting system

Now place your hand along the conductor in which the direction of current is to be found as per the position shown in the figure. Thus, the direction of the magnetic field is indicated by the index finger, the direction of motion of the conductor is indicated by the thumb and the EMF induced in the conductor is indicated by the middle finger. And the direction of current flow can be known.



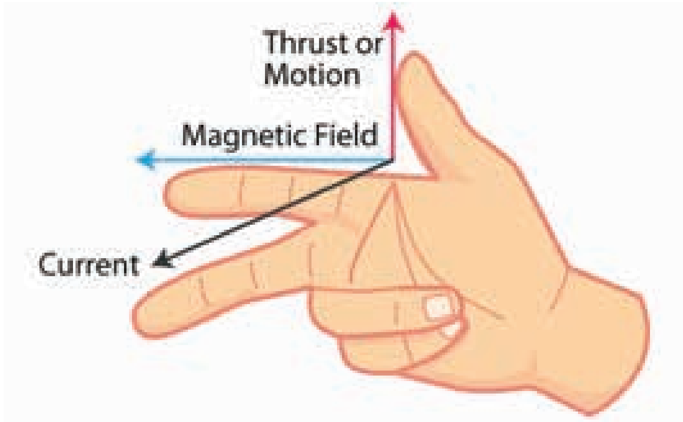
Fleming's right hand rule

Working principle of self starter

In the given figure, current is flowing in a conductor. In this, the direction of current flow is shown by wires. Due to the current flowing in the conductor, a magnetic field is generated around it, whose direction is anti-clockwise. This conductor is installed in the magnetic field. The lines of force in this region are straight from the North Pole to the South Pole.

As shown in the Fig. The circular magnetic field on the left side of the conductor is in the same direction as the perpendicular field of the magnet, but the field on the right side of the conductor is in the opposite direction. Thus, the field on the left side of the conductor is strong and the field on the right side is weak, due to which the field on the left side of the conductor gets distorted, because the properties of the magnetic lines of force in this region become like rubber. Due to this distortion in the magnetic field, the more current flows in the conductor, the more the magnetic force lines will be distorted and the more force will rotate the conductor at a faster speed.

Working principle of self-starter motor



Fleming's right hand rule

Construction of self starter

The structure of Self Starter is almost similar to that of a dynamo and like a dynamo, it also has pole shoe, field coil, armature, commutator and bush etc. The windings of a self-starter are usually series wound. Their field coil and armature winding are made of thick insulated copper wire or thin copper strips. Because more power is required to rotate the crank shaft, it is made by this type of winding.

In this, the resistance remains very low and a higher current of about 400 to 500 amps can be obtained, due to which it is capable of rotating the crankshaft with sufficient power. Due to excessive current flowing in the self-starter, it gets heated quickly, hence it should not be run for more than 30 seconds at a time, otherwise there is a danger of its winding getting burnt.

Apart from this, only two carbon brushes are used in dynamo, but four carbon brushes are used in self-starter, which are made of a mixture of graphite and copper, due to which they can handle more current. Can also bear it. All its remaining parts are similar to those of a dynamo, only the armature. The shaft is kept relatively longer, because a pinion is fitted on it, which connects to the fly wheel and rotates it.

Starter drive mechanisms

All types of self-starters are almost the same, but Starter Drive Mechanism or the difference between them lies only in the drive mechanism connecting the flywheel and the self-starter. Many types of driving mechanisms are used. These have a gear ratio of 15:1 between the self-armature and the flywheel i.e. when the self-pinion

When 15 revolutions are completed then the flywheel is able to rotate one revolution. This gear ratio of the driving mechanism provides powerful torque to the engine, but it is necessary to break the connection between the self-armature and the flywheel as soon as the engine starts running, otherwise the self-armature etc. start rotating with the speed of the engine, due to which there is a danger of breaking the commutator segment and connections etc. lives. For this purpose, special types of mechanisms are used to provide drive, which are as follows-

1 Lever or over running clutch type driving mechanism

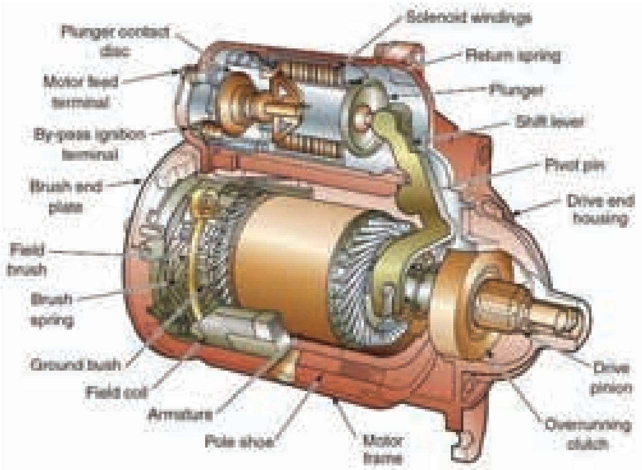
2 Bendex type drive mechanism

3 Axial type driving mechanism

1 Lever or Over Running Clutch Type Mechanism

Hand operated lever assist with self-starter in some older vehicles The connection between the drive pinion and the flywheel is established. In this system, there is a lever installed near the driving seat, which is related to the shift lever. When the self has to be rotated, this lever is pressed. Due to this, the shift lever simultaneously depresses the starting switch and also connects the drive mechanism to the flywheel. As soon as the pressure is removed from the lever, the starting switch closes (OFF).

The connection between the drive mechanism and the flywheel also breaks. over running in picture The structure of clutch drive mechanism is shown-

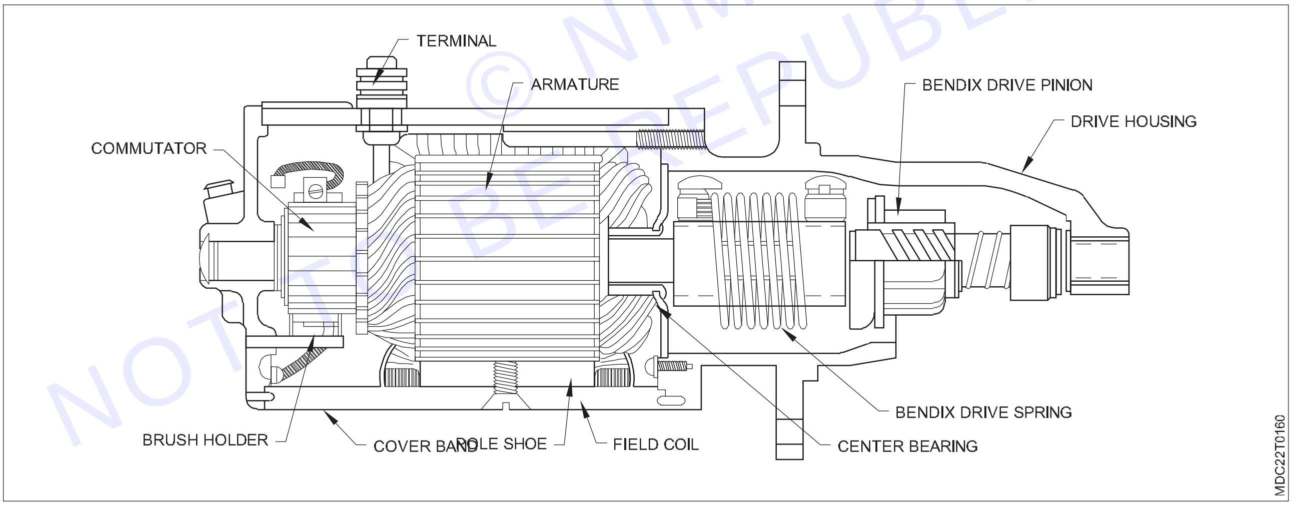


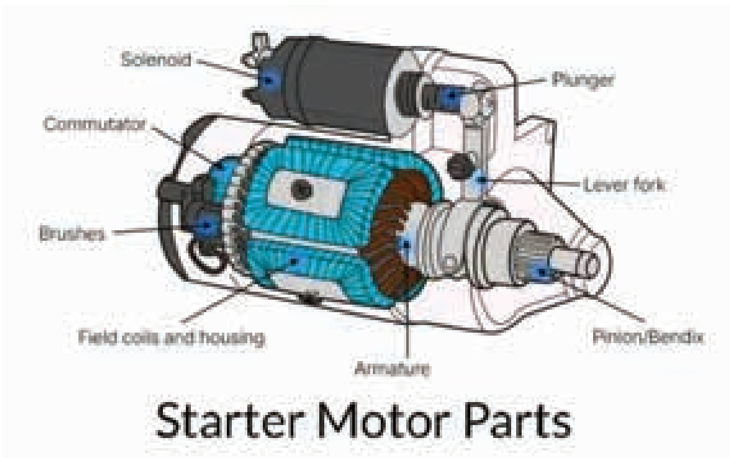
2 Bendex type drive mechanism

Armature shaft with the help of a key. This unit has three bangles cut and one sleeve. A Bendex pinion is fitted on top of the sleeve, on which teeth are made according to the flywheel ring gear and on the inside the bangle is cut according to the sleeve.

Antidrift spring is used to prevent the pinion from colliding with the flywheel. When the starting switch is turned on, the armature starts rotating. As the armature rotates, the pinion fitted on its shaft slips on the sleeve due to centrifugal force and moves forward and does not establish connection with the armature shaft and the flywheel.

In this way the self also starts rotating the flywheel. As soon as the starting switch is closed or the engine is started, due to reverse pressure, the pinion comes back into place, like a nut-bolt. In this way the connection between the flywheel and the self-starter is broken. The structure of the Bendex drive mechanism is shown in the figure.





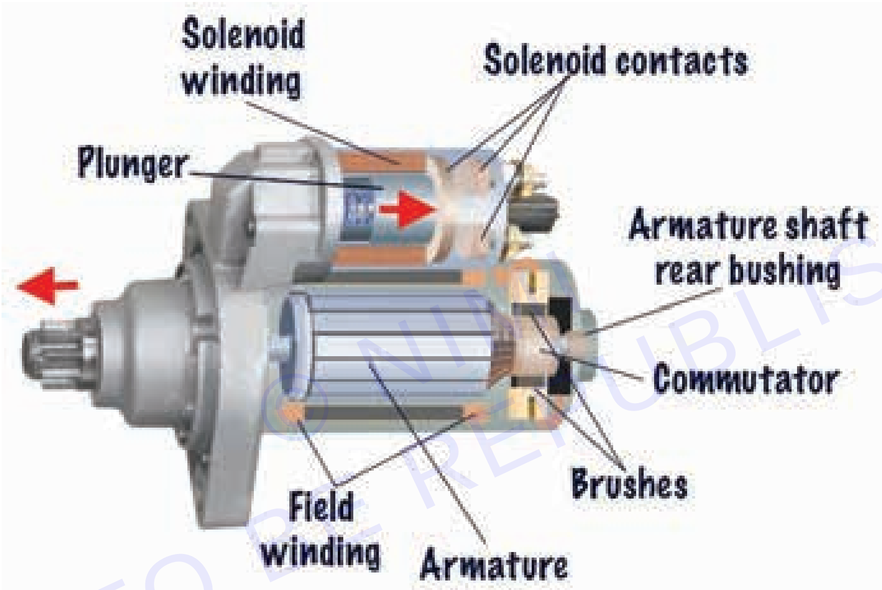
3 Axial Type Drive Mechanism

Axial self-starter is used in some heavy motor vehicles and stationary engines. In this system, the drive pinion is fitted with the armature shaft and the armature shaft itself moves forward in its initial movement and connects the pinion to the flywheel.

When the starting switch is turned ON, the self-armature starts rotating at a slow speed initially. For this, auxiliary shunt and series winding are combined as a special arrangement. In this type of self-starter, a two-step solenoid switch is also used.

And the biggest advantage of this system is that the grip of the pinion and flywheel ring gear is very good and the teeth of the pinion do not get spoiled for a long time. The structure of the axial drive mechanism is shown in the figure. Section with some self-starters in addition to the above drive mechanism

Reversible switches are also used. Using these, electric current by changing the direction of flow, the pinion is disconnected from the flywheel. Arrangements are made. Over running clutch is also used for this purpose in some self. It is done for.



Other Methods of Starting Engines

Various types of starting methods and systems are used to start any engine. The simplest starting method is by pulling the rope or cracking by hand. But these methods can be used only for small engines. The most popular method of starting the engine is to use an electric start powered by a lead acid battery.

To maintain battery capacity, an alternator or dynamo is used, driven by a belt from the engine. The following various methods are used to start the engine:

1 Starting by Self Starter (Electric Starting)

For this, 12 volt D.C. Motor is used. This motor rotates with the electric current received from the battery. As soon as the switch is turned on, its pinion moves forward by rotating and the teeth of the pinion start the engine by rotating the ring gear of the flywheel. A solenoid switch is used to supply current to this motor.

Precautions: The following precautions should be taken to start the engine by self-starter:

- The battery should be fully charged.
- Hands should be completely grease free.
- The wiring of the engine should be completely arranged.

2 Starting by Manual Starting Switch Starting by Manual Starting Switch

Under this, a paddle is installed near the engine, by pressing which the electrical circuit is completed. This causes the electric motor to rotate and start the engine. On releasing the pedal, the circuit is broken and the motor stops. Precautions: To start the engine through manual starting switch, the following precautions should be taken:

- There should not be any kind of greasy substance on the hand
- The battery should be fully charged.
- The wiring of the vehicle/engine should not be broken anywhere.
- Spark plugs should be carbon free.

3 Starting by Push

Motor vehicles can also be started with the help of push. For this, after engaging the rider, we press the clutch pedal and as soon as the clutch pedal is released while pushing, the engine starts.

Precautions to jump start the engine:

Precautions should be taken-

- Balance should be maintained while pushing the vehicle.
- One should not put unnecessary effort into pushing.
- One should not try to push minors.
- There should be necessary air in the wheels of the vehicle while pushing.

4 Starting by Handle

In many engines of motor vehicles, the handle is stuck in the groove cut in the driving pulley. The engine starts even by turning it.

Precautions: The following precautions should be taken to start the engine using the handle:

- Hands should be kept completely grease free.
- The handle should be properly seated in the groove.
- Balance should be maintained while applying the handle to the vehicle.
- The handle should not be deformed.

5 Starting by Flywheel

To start a single cylinder stationary engine, the flywheel is rotated by placing the starting handle in its flywheel and at the same time the compression lever of the engine is pressed. As soon as the flywheel starts rotating, the compression lever is lifted, thus starting the engine.

Precautions: To start the engine by flywheel, the following precautions should be taken care of-

- Keep hands completely grease free.
- Do not remove the de-compression lever when the flywheel is running at low speed.
- Never try to touch the rotating flywheel.

6 Starting by Rope

Usually, a rope is wrapped around the pulley of a tractor and the engine is pulled by pulling it. This method is also used for Shree-Wheeler or Auto etc.

Precautions: The following precautions should be taken to start the engine by rope-

- The rope should be wound on the pulley in a suitable manner.
- Hands should be completely grease free.
- Maintain balance while pulling the rope.
- Do not use weak rope in this process under any circumstances.
- Fix the knot of the rope properly in the groove of the pulley, so that any kind of accident can be avoided.

7 Starting with compressed air

In this method an air tank is attached to the engine. Air is filled in this tank by an air compressor. After this, using compressed air from the tank, the engine is rotated and started.

Precautions for starting the engine with compressed air

The following precautions should be kept in mind-

- Keep hands completely grease free.
- Do not try to fill more than the prescribed amount of air.
- There should not be any space for air leakage in the air tank.

Safety and Maintenance of Engine Starter

To keep the self-starter working for a long time without any inconvenience, it is important to keep the following things in mind-

1 Self-starter should never be used for more than 30 seconds at a time.

2 Immediately turn off the starting switch as soon as the engine starts.

3 After 1500 km, open the self-starter inspection band and check the carbon bushes to see if they are burnt, short or run smoothly in the holder. If there is any defect in it, it should be removed.

4 Check the self-armature commutator for grease or copper filings between its segments. If there is any of these defects, it should be removed. 5. Oiling should be done in bush bearings.

Precautions for starting the engine

The self-starter should be run on the no-load test for as long as necessary. If it is operated for a longer time, its coils will generate more force, due to which the armature will be pulled towards that pole and the bearing will quickly get damaged. To start the engine, it is necessary to take care of some precautions, which are as follows-

1 If both current and speed are low, then it shows that the starter Internal resistance is more inside. This fault usually occurs on the commutator It is caused due to looseness of fitted carbon brushes.

2 If the current and speed are high, then it is known that there is some kind of load or drag on the armature. This defect occurs due to worn bearing, crooked armature shaft or excessive tension of carbon bush.

3 If while testing, the speed is high and the current is normal or slightly higher, then it shows that the cracking motor is fine.

Importance of checking starter circuit for proper functioning.

1 Reliable Engine Start: A properly functioning starter circuit ensures that the engine starts correctly every time you turn the ignition key. This is critical to the utility and safety of the vehicle.

2 Breakdown Prevention: Regular checking of the starter circuit can help identify and resolve problems before a breakdown occurs. Due to which the problem can be solved by getting it repaired in time.

3 Safety: A faulty starter circuit can pose a risk, especially if the vehicle fails to start in critical conditions.

4 Battery Health: Checking the battery in the starter circuit that provides power to start the engine helps to monitor the health of the battery and ensure adequate charging.

5 Vehicle Performance: A faulty starter circuit can affect vehicle performance, causing slow starts or intermittent issues. Therefore, checking and maintaining the circuit is necessary

6 Electrical system integrity: The starter circuit is part of the vehicle's broader electrical system. Ensuring its proper functioning can prevent potential problems with other components.

7 Preventive Maintenance: Performing a starter circuit check helps prevent unexpected failures and increases the lifespan of starter system components.

8 Troubleshooting: Checking the starter circuit is often one of the first steps. Identifying any problems in this circuit can help the mechanic identify the root cause of starting problems.

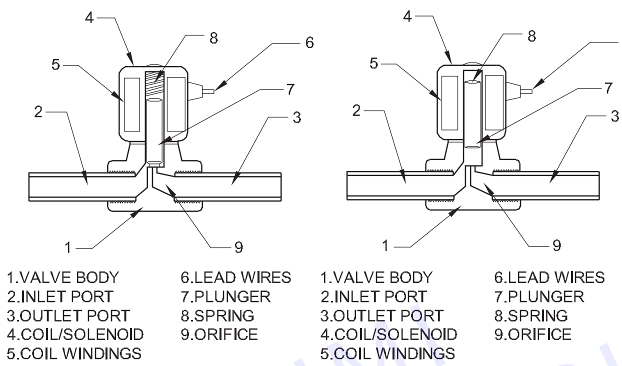
9 Overall Vehicle Reliability: By regularly checking this circuit, drivers can be confident that their vehicle will start reliably.

Role of solenoid switch and relay, Importance of checking of Soleniod switch and Relay

Objectives: At the end of this lesson you shall be able to

- explain Role of solenoid switch and relay
- demonstrate importance of its checking solenoid and relay.

Solenoid switch: A solenoid is an electrochemical switch/ valve that is controlled by an electric current. The electric current runs through a solenoid, which is a wire coil wrapped around a metallic core. A solenoid creates a controlled magnetic field when an electrical current is passed through it. This magnetic field affects the state of the solenoid valve, causing the valve to open or close.



Roll of solenoid switch: In automobiles, a solenoid switch plays a crucial role in starting the engine. It's typically part of the starter system, responsible for engaging the starter motor with the engine's flywheel when the ignition key is turned. Essentially, it acts as a relay, allowing high current to flow to the starter motor from the battery to start the engine.

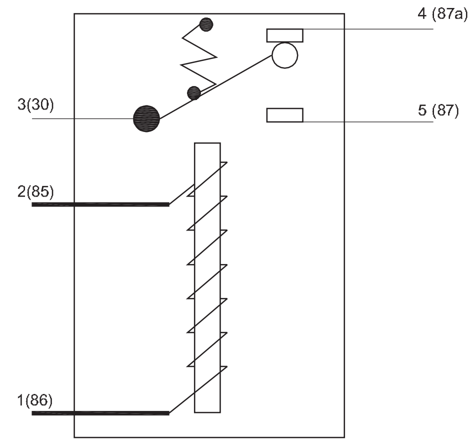
Importance of checking solenoid switch:

- **Reliability:** Make sure that solenoid switch is functioning properly helps maintain the reliability of the vehicle's starting system. A faulty solenoid switch can lead to starting problems.
- **Safety:** A malfunctioning solenoid switch can potentially cause electrical issues or even lead to a vehicle fire in extreme cases. Regular checks help ensure safety on the road.
- **Preventative maintenance:** By checking the solenoid switch regularly, you can find out any issues early on, preventing more significant and costly problems down the line.
- **Extended lifespan:** Proper maintenance and inspection can extend the life of a solenoid switch, reducing the need for premature replacement.
- **Performance:** A well-functioning solenoid switch ensures smooth engine starting, which can contribute to the vehicle's overall efficiency and performance.

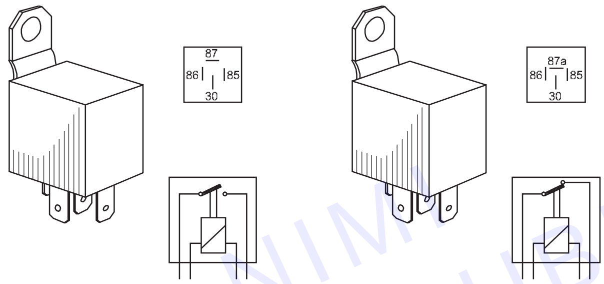
Relay: A relay is an electrically operated switch. many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Relays are used where it is necessary to control a circuit by a low-power signal (with compete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal.

Types of relay:

- **Normally open relay [NO]:** Power circuit is in open position. Circuit closes when control circuit is activated.
- **Normally close relay [NC]:** Power circuit is in close position. Circuit opens when control circuit is activated.



RELAY



NORMALLY OPEN RELAY NORMALLY CLOSE RELAY

Role of relay:

In automobiles, relays play an important role in controlling the flow of electricity to various components and systems. Here are some important roles of relays in automobiles:

- **Switching high currents:** Relays allow low-power signals, such as those from switches or sensors, to control high-power circuits. For example, a relay can enable a small electrical signal from the ignition switch to activate the starter motor, which requires a much higher current.
- **Protecting control circuits:** Relays act as a buffer between sensitive control circuits and high-current devices, protecting the control circuitry from damage due to excessive current flow.
- **Enhancing safety:** Relays are often used in safety-critical systems, such as lighting, horn, and wiper systems. They ensure these systems operate reliably and consistently, contributing to overall vehicle safety.
- **Improving efficiency:** By using relays to control power-hungry devices, automobiles can minimize the amount of wiring and switches needed in the vehicle's interior. This simplifies the electrical system and reduces overall vehicle weight and complexity.
- **Enabling remote operations:** Relays are commonly used in remote keyless entry systems, allowing signals from key fobs to activate door locks, trunk releases, and other functions wirelessly.

  Overall, relays are essential components in modern automobiles, facilitating the efficient and safe operation of various electrical systems and components.

Importance of checking of relay:

Checking relays in an automobile is important for various reasons:

- **Electrical system integrity:** Relays play an important role in the electrical system, controlling the flow of electricity to various components such as lights, fans, and motors. Checking relays ensures the integrity of the electrical system, preventing issues like short circuits or electrical failures.

- **Component operation:** Many essential components in a vehicle rely on relays for proper operation. Checking relays ensures that these components, such as fuel pumps, ignition systems, and cooling fans, function correctly, contributing to the vehicle's overall performance and safety.
- **Preventative maintenance:** Regular relay checks can help identify potential problems early on, preventing more significant issues in the future. Addressing relay issues promptly can save time and money by avoiding unexpected breakdowns and repairs.
- **Safety:** Malfunctioning relays can compromise safety systems in a vehicle, such as airbags or anti-lock braking systems (ABS). Checking relays helps ensure these safety features operate as intended, keeping drivers and passengers safe on the road.
- **Optimal performance:** Relays that are in good condition contribute to the optimal performance of various vehicle systems. Checking relays and replacing any faulty ones can help maintain the vehicle's performance and fuel efficiency.

  Overall, regular checks of relays are essential for maintaining the reliability, safety, and performance of an automobile.

Importance of testing starter components. Troubles and remedies in starting system

Objectives: At the end of this lesson you shall be able to

- explain Importance of testing starter components
- demonstrate Troubles and remedies in starting system.

Importance of testing starter components for several reasons

- **Functionality Assurance:** Testing ensure they perform as intended, preventing potential issues down the line.
- **Compatibility:** starter components are come in contact with various frameworks, libraries, or devices. Testing helps to make sure they work seamlessly across different environments.
- **User Experience:** starter components are the first interaction users have with an application. Testing helps to make sure a smooth and intuitive user experience, which is necessary for user satisfaction and retention.
- **Bug Detection:** find and fixed bugs early in the development process save time and resources. Testing starter components help catch issue before they rise.
- **Security:** flows in starter components can create vulnerabilities in the application. Testing helps to find security risks and ensure proper safeguard are in place.
- **Scalability:** According to the grow of application starter components need to adjust increased traffic or data loads. Testing helps to make sure their scalability and performance under different conditions.
- **Maintainability:** well-tested starter components can easier to maintain and extend. They provide a stable foundation for future development efforts.

In summary, testing starter components is necessary for make sure their functionality, compatibility, user experience, security, scalability, and maintainability of the application.

Troubles and remedies in starting system

Fault	Trouble	Remedies
1 Motor not working	Discharged battery Reduction in battery voltage due to deterioration in the battery. Improper connection of battery terminals. Loose connection of ground cable. Fuse failure Incorrect connection of ignition switch and magnetic switch. Loosening of load wire coupler Failure of starter motor control relay.	Recharge the battery Replace the battery Check the combination Do the combination Replace the fuse Change the magnetic and ignition switch position Tight the load wire coupler Repair the relay
2 Motor not running (sound of magnetic switch being activated	Commutator burning out Weakening of bush spring Interruption of rotation of the crankshaft Short circuit of armature layers.	Replace the commutator Replace the bush assembly Make repairs Replace the armature
3 Starting motor operating too slowly	Incorrect key connections of magnetic switch Short circuit of armature layers Weakening of bush spring.	Convert the magnetic switch Repair or replace it Replace it
4 Starting motor operating but not cranking	Wear of pinion tip Sliding of over-running clutch is not correct Grinding of ring gear teeth Slipping of over-running clutch	Make repairs Repair the over running clutch Replace the flywheel Replace the over running clutch
5 Noise generation	Wear of bushes Teeth of ring gear or pinion wear	Change the bushes Convert the over running clutch or flywheel

LESSON 67 - 70:Study about Charging system and its components

Objectives

At the end of this lesson you shall be able to

- explain about charging System
- locate different components of charging system.

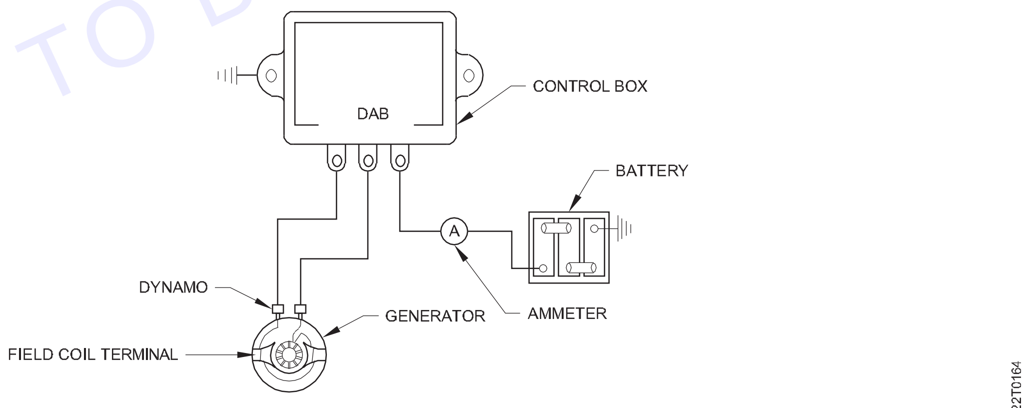
Introduction: A charging circuit provides electrical energy to operate electrical devices in an automobile. When the engine is in motion, the charging circuit converts mechanical energy into electrical energy. This energy is required to operate the loads in the vehicle's electrical system, such as horns, lights, indicators etc.

This is achieved by the charging circuit used in GA energy vehicles. The charging circuit includes battery, dynamo and alternator. In addition to the charging circuit, a starter circuit is also used in automobiles to start an engine that is unable to start itself (internal combustion engine).

Self-starter, starter motor or solenoid switch is used in the starter circuit for this purpose. This chapter deals with the functionality of battery, dynamo and alternator along with starting circuit, self-starter, solenoid switch keeping in mind the utility of charging and starter motor circuits.

Components of charging system:

Electricity is required for the useful operation of automotive vehicles. In the charging circuit, the battery is connected to the ammeter, the ammeter to the control box terminal (B), the control box terminal (A) and D, the generator output terminal and the control box terminal to the field coil terminal of the dynamo. Dynamo, control box and battery are earthed. To regulate the power supply, the main devices required to maintain the level of charging in the charging circuit are as follows:

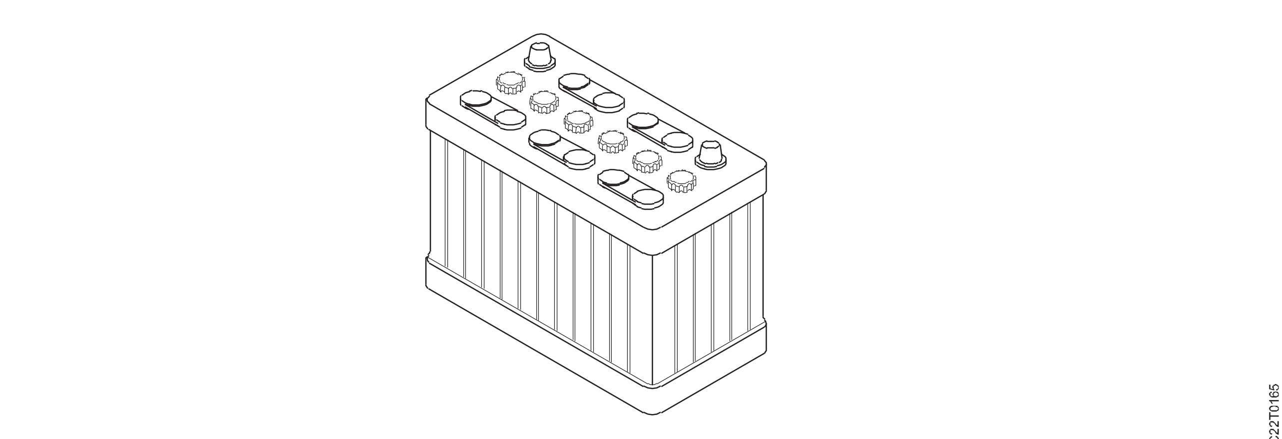


CHARGING CIRCUIT

Battery

Batteries are a group of cells, which are an important accessory in the automobile sector. Various devices requiring electricity used in vehicles thereby; Like- self-starter, meters, indicators and gauges etc. are operated.

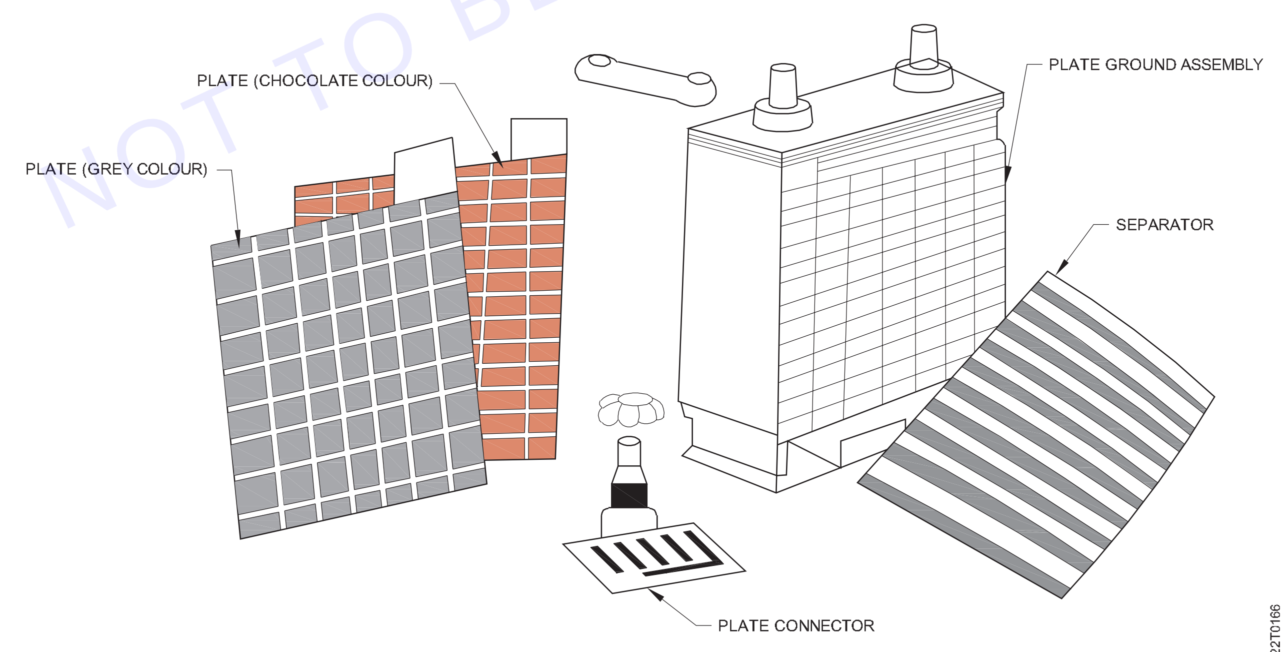
Additionally, various activities while driving a motor vehicle; For example, the battery is also used in lighting the lights of motorcycles, playing the horn and running the wind screen wiper.



BATTERY

Main part of battery

- **Battery box:** It is also known as battery container. It is made of hard rubber. The top cover that closes it from above is also made of this hard rubber. The top cover has grooved holes into which the vent plugs are screwed. The battery box has three, six or twelve parts in the form of separate compartments according to its voltage. There is an empty space in each compartment at the bottom, so that the metal of the plates etc. can fall and get deposited in it, otherwise this metal filing can also short the plates.
- **Negative and positive plates:** At present, 6, 12 or 24 V batteries are used in motor vehicles, which have 3, 6 or 12 cells. These cells have negative and positive plates. These plates are made of lead, which are like square mesh. These positive plates are filled with land peroxide (PbO_2), which is brown in color. The negative plates are filled with antimony and its color is grey. The power of a cell depends on the number and size of plates used in it. In each cell, a group of separate negative and positive plates are made and they are stuck together in the form of a bunch. Separators are placed between each plate, so that they do not short together.
- **Separator:** A separator is used to prevent the negative and positive plates of the battery from colliding with each other and causing a short. These are made of glass fiber, glass wood and plastic etc.



BATTERY COMPONENTS RELATED TO PICTURE PLATES AND SEPARATOR

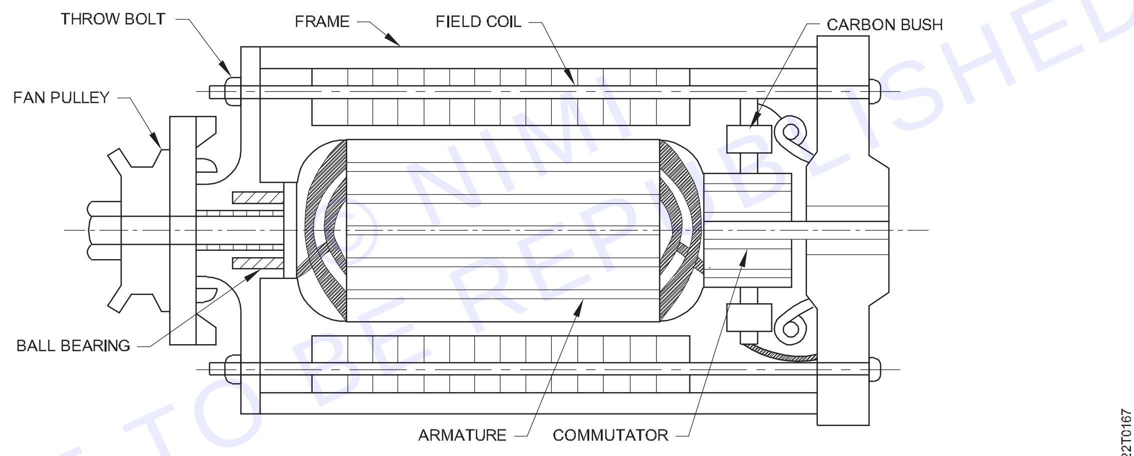
- **Main terminal post:** There are two pegs protruding on the first and last cell of each battery, one of which acts as negative and the other as positive terminal. By connecting battery wires to these main terminal posts, electric current is supplied to other places. These pegs are also made of lead. It has been observed that the chemical reaction of the battery causes the terminals of the battery wire to stick to its pegs. One should never try to remove them by banging, but by pouring boiling water on them, they come out easily.
- **Electrolyte:** The battery plates are immersed in a solution of sulfuric acid in their respective cell containers. The specific gravity of this solution ranges from 1.250 to 1.280. Suitable solution for battery is also available ready otherwise it is made.

To make it, pure sulfuric acid and distilled water are used. It should be made in a glass, ceramic or plastic vessel and keep in mind that the acid should be added to water, because if you add water to the acid, it will burn its small body or clothes. This solution should be filled approximately 15 mm above the battery plates.

Dynamo: Dynamo is also known as generator. It converts mechanical energy into electrical energy. The dynamo is mounted on the front of the engine, which is driven by a belt from the engine's crankshaft. Therefore, dynamo is used to fully charge the battery.

Main part of daynamo

1 frame	2 field coil	3 Armature	4 Throw bolt	5 ball bearings
6 commutator	7 carbon brush	8 fan pulley	9 poll shoe	10 side plate



VARIOUS PARTS OF CHINNA DYNAMO

A dynamo is a cylindrical body made of mild iron, which is constructed by closing both the ends of the frame after inserting the armature between the poles along with the field coil. The front end cover is called driving end bracket. Both ends are fixed with bolts.

The armature is supported at both ends of the ball bearing. A longitudinal slot is cut in its core, which provides housing for the armature winding. To keep the dynamo cool, the front end of the armature is connected to a fan pulley Is combined. This fan pulley is driven by a fan belt. The amateur is operated by this fan pulley between the magnetic poles. The ends of the amateur leads are soldered to each segment of the commutator. The carbon bushes are above the commutator segments. This segment receives energy and supplies it to the dynamo output terminal. Thus the current flows to the battery through the control box.

Working principle of dynamo

In order for the dynamo to supply sufficient electricity for a long time without any fault, the following things should be kept in mind.

- While servicing the dynamo, high grade Mobil oil should be poured into the bushes.
- The tension of the fan belt should be correct, so that it can rotate the dynamo without slipping.
- The bolts of dynamo foundation should be tightened properly.
- The terminal nut on the dynamo should be tightened properly.

Regular

The regulator is used to control the power supply going to the battery. The regulator is fitted between the battery and dynamo. When the speed of the engine increases, the speed of the dynamo also increases and the dynamo generates high voltage and electric current. This may cause damage to batteries and other electrical equipment. The regulator does the following.

- It controls voltage and current.
- It consists of a voltage regulator, a current regulator and a cut-out. Terminals are provided for dynamo and battery. These are denoted by terminals A or D, F and B.

The following methods are adopted to control the dynamo.

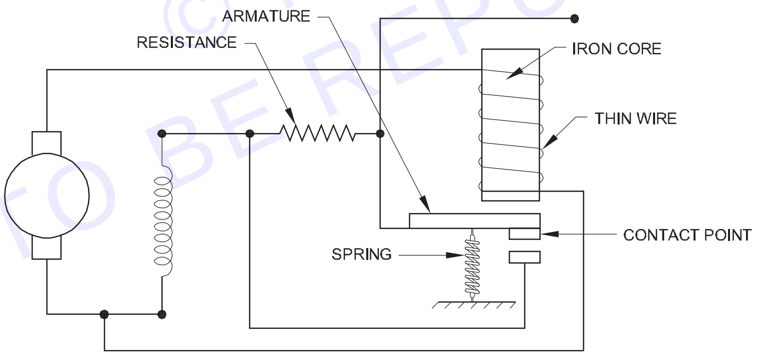
- Voltage regulator system
- Current regulator system

Voltage regulator system: A voltage regulator consists of a coil of thin wire with several turns. This wire is connected to the dynamo in parallel. It consists of an iron core, contact point, armature spring etc. The spring holds the contact in the closed position. The voltage regulator controls the magnetic field circuit of the dynamo to maintain the fixed voltage (12 V) output condition at 14.5 to 15 V.

When the output of the dynamo is greater than the battery voltage, the voltage flows to the solenoid winding. The solenoid is emitted to attract the armature against the spring and

The connoisseur is isolated. Now poltage flows through the resistance in the dynamo field. Due to which there is some voltage drop.

When there is a voltage drop in the dynamo, the solenoid becomes demagnetised. The contact spring completes the pitch of the armature. Through the contact the voltage flows into the field winding of the dynamo. Thus, the output voltage of the dynamo plays.



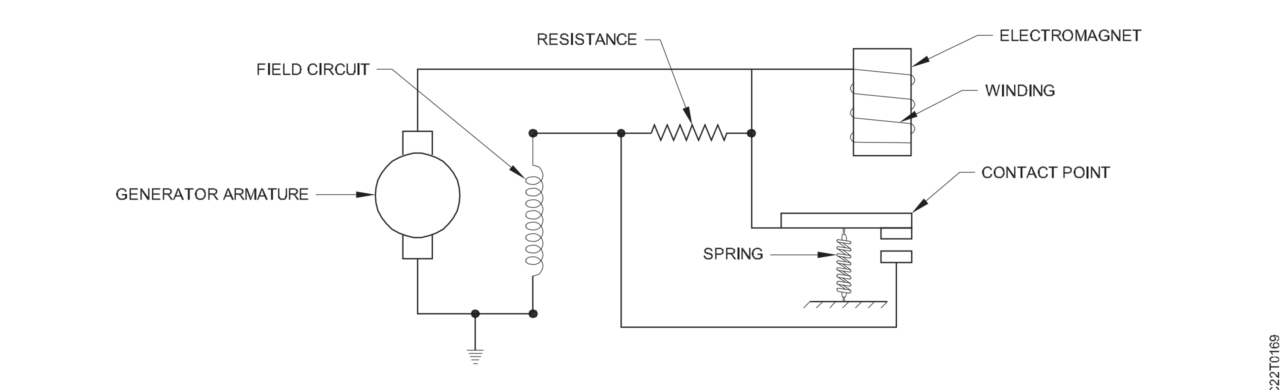
SIGNAL VOLTAGE REGULATOR SYSTEM

Current regulator system: Bara regulator system is installed on the basis of voltage regulator and cut-out only. The current regulator consists of a few turns of high efficiency wire winding, connected in series with the generator ammeter. This system is similar to the voltage control system. The electromagnet controls the contacts.

When the contact is closed and the speed of the dynamo is high, current flows through the coil of the electromagnet. When the current is too high, the iron core becomes an electromagnet.

The armatures are attracted to separate the contacts. When the contacts open, current passes through the resistance. This resistance creates obstruction in the flow of current.

When the value of current is relatively low, the magnetism of the electromagnet decreases, as a result of which the contact closes again. Thus, the resistance of the field circuit gets separated from the circuit and the value of output current in the circuit increases.



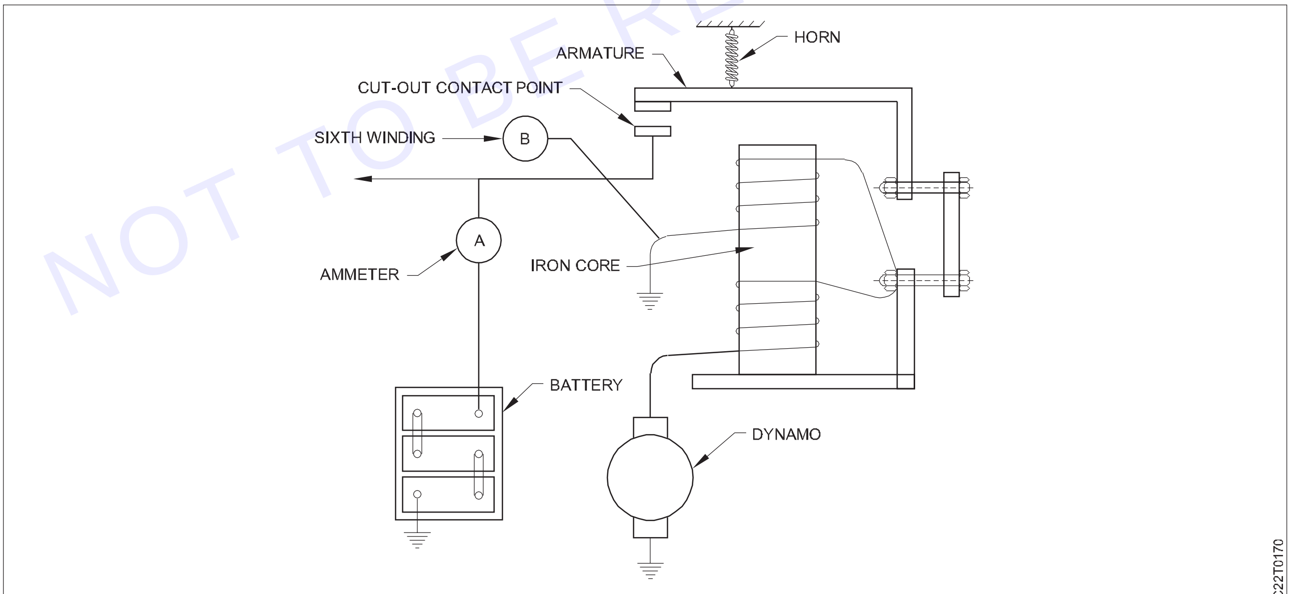
PICTURE CURRENT REGULATOR SYSTEM

CUT- OUT

The cut-out is an automatic device located between the dynamo and the battery. When the battery is discharged, the cut-out connects the dynamo to the battery, but when the battery is fully charged, the cut-out isolates the dynamo from the battery. In a cut-out, the primary (series) winding on a soft iron core is thick and has fewer turns, while the secondary winding (shunt) is thin and has more turns.

One end of the primary winding is connected to the dynamo and the other end is connected to one end of the secondary winding through a hinge. Secondary winding means the other end. The hinge has an armature attached at the top, which is adjusted by a spring. CB with this armature. (contact breaker) points are installed. C.B. One part of the point is connected to the armature and the other to the ammeter. The cut-out functions similarly to an automatic magnetic switch. When the dynamo does not run, the C.B. The points are open, due to which the connection between the battery and the dynamo is broken. When the dynamo runs, the current of the dynamo goes to the primary and secondary windings and creates a magnetic field.

Now the current from the dynamo starts going to the battery through the ammeter, but this is possible only when the dynamo is creating current according to the voltage of the battery.



PICTURE CUT-OUT ARRANGEMENT

Indicating device

The indicating device is fitted on the panel board of the vehicle. This device can be lamp type (warning lamp) or gauge type, which is called ammeter. Ammeter displays the flow of current in two directions.

Alternator

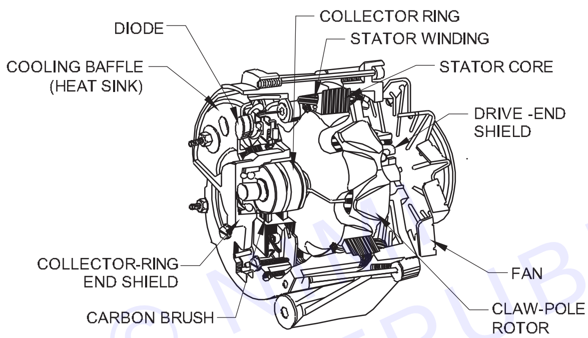
Mechanical energy is converted into AC. Alternator or AC is a machine that converts electrical energy. Is called alternator or AC generator. At present, alternator has started being used in place of dynamo in some engines, because due to heavy traffic in big cities, the vehicle cannot be driven at high speed. The dynamo is unable to charge the battery properly at low speeds of the vehicle.

Alternator, which is AC. There is a generator, so it is D.C. AC instead of current. Produces current, which is again converted into DC. The battery is charged by converting. The weight of alternator is less than that of dynamo. It does not have commutator, carbon bush and armature winding etc.

Hence copper is saved. It produces relatively high current even at low engine speed. It requires less care. A small regulator is used with it, because the diodes used in it only allow the current to flow in one direction and do not allow it to come back, due to which there is no need to install a cut-out coil.

As shown in the picture, it consists of an armature magnet with insulated copper wire wound on it. In this, the north pole of the magnet is at the top and the south pole is at the bottom.

When the armature magnet is rotated, an electric force is generated in the wires in half of its revolution, the direction of which is one way. After this the position of the magnetic poles changes to opposite. In the forward half of the movement of the amateur magnet, the current flows in the other direction. Thus, current flows on both sides in one turn of the armature magnet, hence it is called alternating current (AC).



SECTIONAL VIEW OF BOSCH CLAW-POLE ALTERNATOR

Importance of checking charging circuit for proper functioning

Objectives: At the end of this lesson you shall be able to

- explain Importance of checking charging circuit for proper functioning.

Charging System

Introduction

Electronic devices used in automotive vehicles; For example, horn, light, indicator etc. require a direct current energy source and the best source for obtaining pure direct current is the battery. Battery is basically a group of chemical cells, in which electrical energy is obtained through the electromotive force (emf) generated as a result of chemical reaction. This can be termed as a reliable device. All batteries, once charged, get discharged after some time when used.

Therefore, the process done to recharge them is called charging system. of charging system

It has two essential functions - one is to produce electrical power to operate the vehicle's electrical system and the other is to produce current to recharge the battery installed in the vehicle. In these, electrical power means the power which is provided to the vehicle as per its requirement at low engine speeds. At high engine speeds the charging system meets all the vehicle's electrical needs. The charging components mainly include alternators. In the present chapter, a detailed description of the charging system and its components has been given.

Purpose of Charging System

Various assistive devices requiring electricity in fuel engine based vehicles

Charging system is very necessary for operation, because with its help it becomes possible to supply electricity to these devices. Almost all of these devices are battery operated. We know very well that the battery needs constant charging, because it keeps getting discharged during its continuous use. Electrically based devices run smoothly for many years with the help of batteries. Alternator is used to charge the battery. The current from the battery is used to start the engine, blow the horn, turn on the lights and run all other devices. Therefore, providing continuous charge to the battery is the priority of the charging system.

Components of Charging System The components which are required to maintain the level of charge in the charging system for regulation of power supply are called components of the charging system. The main components of charging system are as follows

1 Alternator 2 Battery 3 Rectifier assembly 4 Indicator 5 regulator

Importance of voltage Regulation

Objectives: At the end of this lesson you shall be able to

- explain the importance of voltage regulation.

The voltage regulation of an alternator: The voltage regulation of an alternator is defined as the rise in voltage when the load is reduced from the full rated value to zero, with the speed and field current remaining constant. It is normally expressed as a percentage of the full load voltage.

$$\% \text{ of voltage regulation} = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100$$

where V_{NL} - no load voltage of the alternator

V_{FL} - full load voltage of the alternator

The percentage regulation varies considerably, depending on the power factor of the load, and as we have seen for leading P.F. the terminal voltage increases with load, and for lagging P.F. the terminal voltage falls with the load.

Example: When the load is removed from an AC generator, its terminal voltage rises from 480V at full load to 660V at no load. Calculate the voltage regulation.

$$\% \text{ regulation} = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100$$

$$\frac{660 - 480}{480} \times 100 = 37.5\%$$

Importance of testing charging system components

Objectives: At the end of this lesson you shall be able to

- explain Importance of testing charging system components.

Testing of charging system components is important for following reasons:

- **Proper functionality:** Testing allows us to verify that each component of the charging system, such as the alternator, voltage regulator and battery, is or is not functioning correctly. This ensures that the vehicle's electrical system operates efficiently and reliably.
- **To prevent breakdowns:** Identifying problems early through testing can prevent unexpected breakdowns or failures while driving. This is especially important for components such as the alternator, which is needed to keep the battery charged and provide power to electrical systems while the engine is running.
- **Maximizing battery life:** A properly functioning charging system ensures that the battery receives the correct voltage and current, thereby increasing its lifespan. Regular testing can help detect problems that can lead to overcharging or undercharging, both of which can degrade battery performance over time.
- To start the engine quickly
- For proper lighting and indication: Headlights and indicator lights of the vehicle
- **Safety:** Malfunctions in charging system components can cause safety risks, such as electrical fires or power outages while driving. Testing helps identify and eliminate potential hazards before they cause damage.
- **Saving Money:** Proactively testing and maintaining charging system components can save money in the long run, as it prevents costly repairs or replacements resulting from overlooked or unexpected failures.

Overall, testing charging system components is essential to ensure vehicle reliability, safety, and longevity.

Here are some important components of battery charging system in automobile.

- Alternator
- Voltage Regulator
- Wiring
- Belt
- Fuse boxes
- Charge indicator light …. etc…

Troubles and remedies in charging system

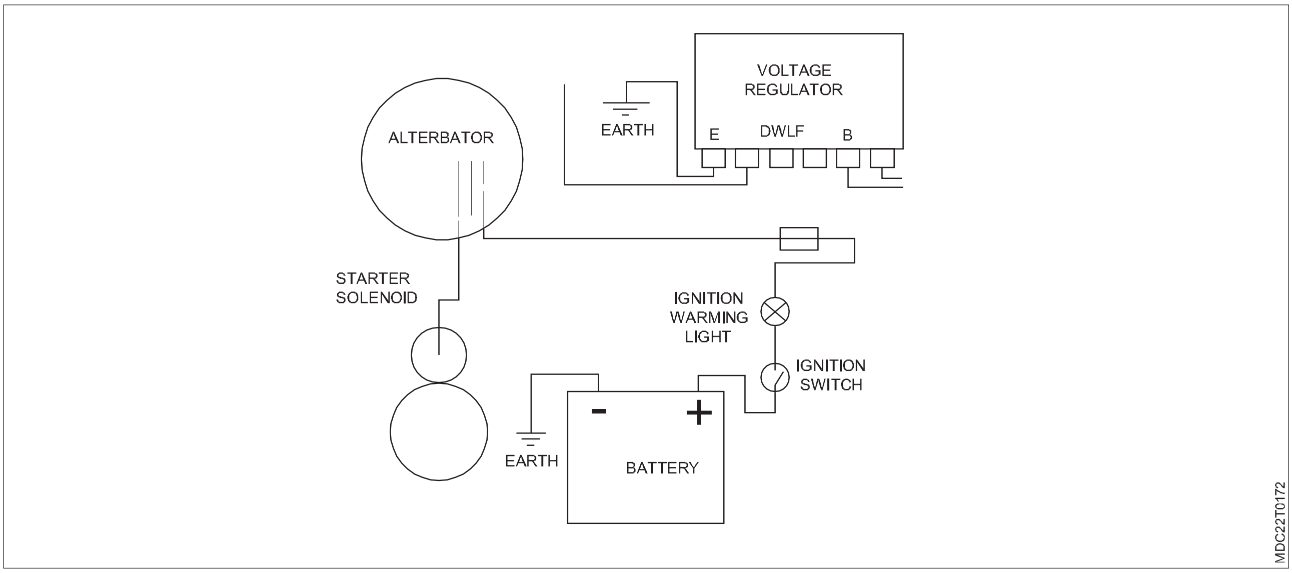
Objectives: At the end of this lesson you shall be able to

- trace the troubles in charging system
- understand faults and remedies of charging system.

Introduction

The vehicle charging system is responsible for supplying electrical power to the battery and the electrical components of the vehicle. It consists of several key components battery, alternator, fan belt, fuse relay etc.

To identify and address any issues that may arises, ensuring that the vehicles battery stays charged and the electrical system functions properly. This help maintains the vehicles reliability, prevents breakdowns, and extend the life of charging system components.



Troubles and remedies of charging system

Alternator not producing current

Sl. No.	Possible causes	Remedies
1	Loose V- belt, drive	Adjust the belt or replace
2	Defective voltage regulator	Adjust it is points or replace
3	Stick brushes of slip ring or worn out brushes	Clean the brush holder checkup brushes, if worn out replace it
4	Short circuit in charging system	Rectify the short circuit and tape it
5	Stator winding short	If short is outside the coil, tape it inside, rewind the stator
6	Short or defective diodes	Replace it
7	Short circuit in rotor wiring	Repair if possible or change the rotor
8	Blow out charging circuit fuse	Replace the fuse but check the defect is due to not proper earth in regulator or adjustment not proper
9	Poor charge/alternator magnet moisture	Vacuum motor oil seal check

Alternator producing less current

Sl. No.	Possible causes	Remedies
1	Diodes not working effectively	Replace it
2	Slipping of alternator drive belt	Replace or adjust it
3	Short diodes	Replace it
4	Short circuit in stator winding	Rewind or replace the stator
5	Dirty or loose wiring connection	Clean and fix this correctly
6	Faulty setting of voltage regulator	Adjust voltage regulator correctly

Sound in alternator

Sl. No.	Possible causes	Remedies
1	Worn out bearing	Replace it
2	Loose pulley and fan	Tight the same
3	Loose pulley foundation bolt	Tight the same
4	Loose drive belt	Tight the same
5	Short diodes	Replace with new diodes
6	Short in stator	Rectify the fault

Less or poor life of regulator

Sl. No.	Possible causes	Remedies
1	Short in rotor	Repair the short or replace the motor
2	Loose earth connection of regulator	Make the earth connection correctly
3	Regulator points air gap too much	Set it correctly

Some common fault found in charging system

Sl. No.	Faults	Remedies
1	Battery low	Charge it, if it's need sulphuric acid then top up
2	Battery terminal loose	Tighten it, if it need soldering then arrange to new soldering terminal
3	Battery not charge properly	Alternator wiring socket loose tight it
4	Battery continuous low	Remove and disconnected extra accessories of your vehicle like extra lightening
5	Vehicle dashboard light blinking or vehicle engine off while running	Fuse connection getting to contact with moisture try to cover it properly and to put a dry

LESSON 71 - 75: Study about types of conventional ignition system and its components

Objectives

At the end of this lesson you shall be able to

- explain about conventional ignition system.
- differentiate types of Ignition system
- locate and explain different components of Ignition system.

Components of ignition system

Two types of ignition systems are used for fuel combustion in automobiles – magneto ignition system and battery ignition system.

1 Battery ignition system

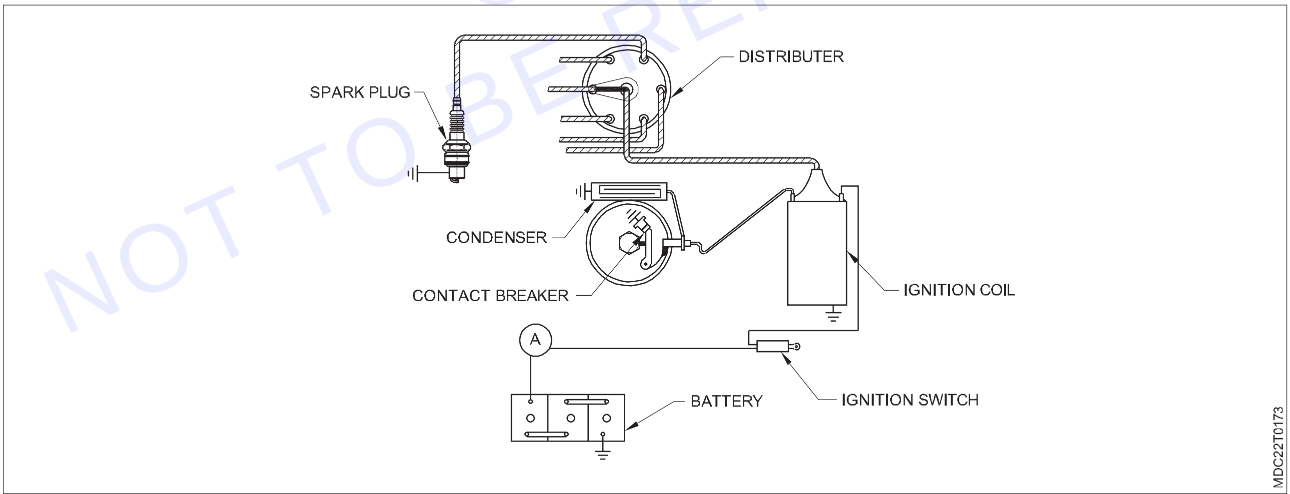
2 Magneto ignition system

3 Electroni ignition system

4 Distributor less ignition system

1 Battery ignition system

Battery ignition systems are used in passenger cars, light trucks and some two-wheelers. This system includes the following parts

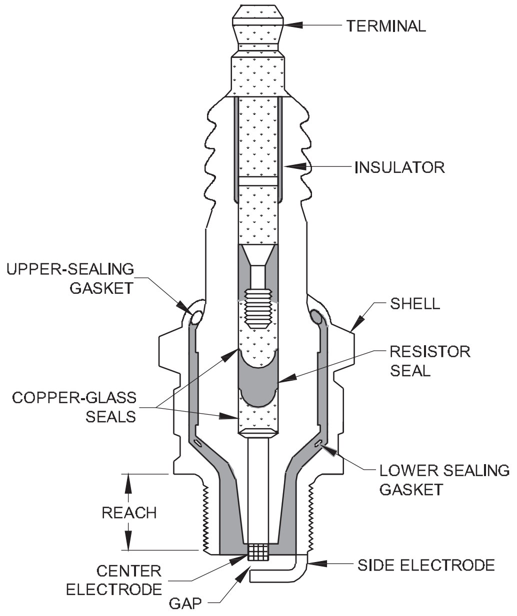


1 Spark Plug 2 Battery 3 Ignition Coil 4 Distributor 5 Ignition Switch 6 Condenser
7 Contact breaker

1 Spark plug

Spark plug plays an important role in generating spark in the ignition process. Through this, the mixture of compressed air and petrol is burnt in the combustion chamber. It is fitted in such a way that its central and side electrodes remain in the combustion chamber. Hence when HT reaches the central electrode. (H.T.) current comes, due to excessive voltage of about 24,000 volts, it jumps over it and goes to the side electrode and after completing the electrical circuit, a spark is generated between those two electrodes, due to which the mixture burns.

Some air gap is kept between the central and side electrodes, which is also called spark plug gap. This gap varies for different engines (from 0.5 to 0.7 mm for trains).



CUTAWAY OF RESISTOR-TYPE SPARK PLUG

Main part of spark plug

Following are the main parts of spark plug

Terminal

The topmost part of the spark plug is called the terminal. A bangle cut cap is fitted on it, through which HT is connected to the spark plug. Lead is added.

Central electrode

The central electrode is in the form of a wire attached below the terminal, through which the IHT reaches the terminal. The current jumps to the side electrode and produces a spark.

Insulator

A ceramic insulator fits in the center of the spark plug. It separates the central electrode from other parts and HT. Prevents the ghara from being unnecessarily earthed, due to which it usually ‘cracks’ due to carelessness.

In such a situation the spark plug should be changed otherwise HT. The current will be wasted in the engine parts itself, due to which the ignition will not be able to function.

Side electrode

To tighten the spark plug, a thick wire is attached to the part where the bangle is cut, which is bent till below the central electrode. HT reaching the central electrode. With its help the stream becomes earth and jumps.

Insulator nut

This nut is used to tighten the insulator with the plug. On this, the bangle is cut in the lower part on the outside. This part is screwed to the engine. It is made of strong enough mild steel. The bangles cut on it are of 14 mm and 18 mm.

Copper gasket

There is a copper washer at the bottom of the spark plug, which acts as a gasket. By using this the gas from the cylinder does not leak.

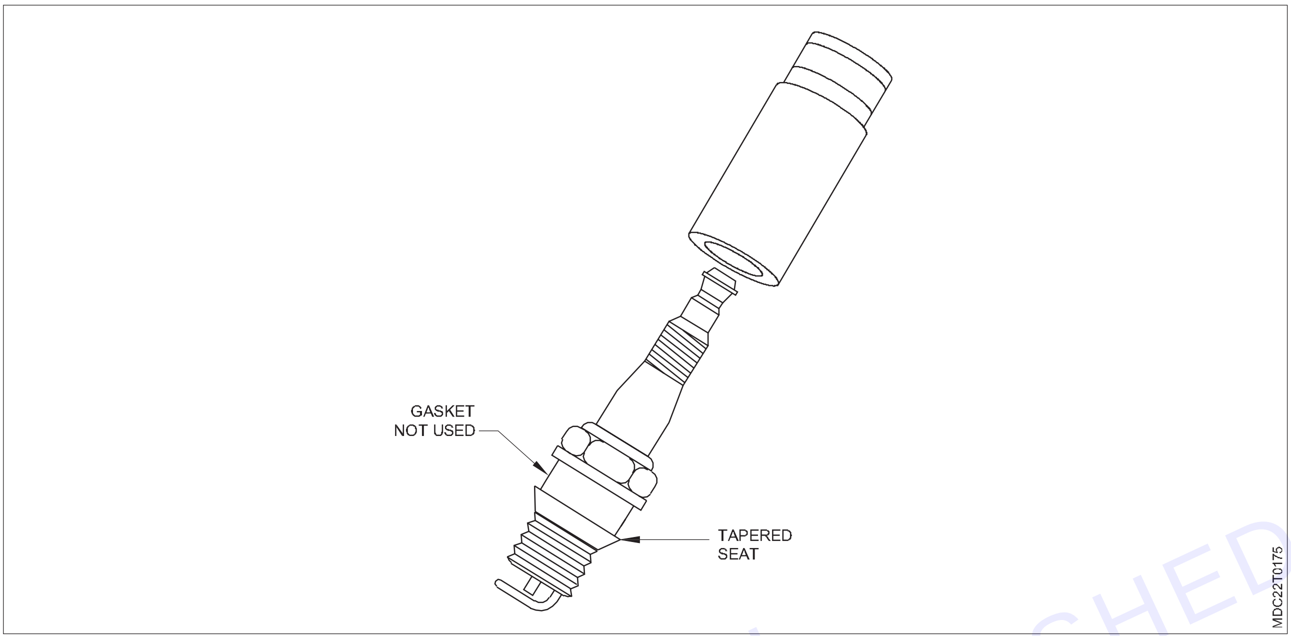
Working of spark plug

The first function of the ignition system is to generate a high voltage to produce a spark in the spark plug gap.

The spark plug has an end cap, which has some gap. When the mixture of air and fuel is compressed, some of it enters the compressed mixture gap, due to which spark is generated and ignition starts in the gap.

After this the combusted mixture comes out of the orifice and ignites the remaining compressed mixture.

A gasket is used during installation of some spark plugs for the purpose of providing a leaf proof seat. Additionally, some engines use a plug with a tapered seat, which acts as a perfect seal.



Types of spark plug

Two important properties of a spark plug are its heat range and accessibility. The heat range of a spark plug refers to the temperature the spark plug will tolerate in the engine, which determines how hot the spark plug will get. The heat range of a spark plug is controlled by its size and the distance it takes for the heat to reach the center electrode of the plug and the cooler of the cylinder head. If this distance traveled by heat is large, the plug becomes hot and if this distance is small, the plug is cold. Apart from the above description, on the basis of spark plug cleaning etc., spark plugs are mainly of the following types:

Detachable spark plugs

The biggest advantage of this type of plug is that by opening it, the carbon deposited inside it can be cleaned thoroughly. Similarly, among the other differences in the plugs, the difference in electrodes is important. Usually, spark plugs have side electrodes installed below the central electrode, but in some plugs, two or more side electrodes are also installed. Similarly, in some plugs, the side electrode is not placed below the central electrode but is placed at 90°.

Cold Spark Plug

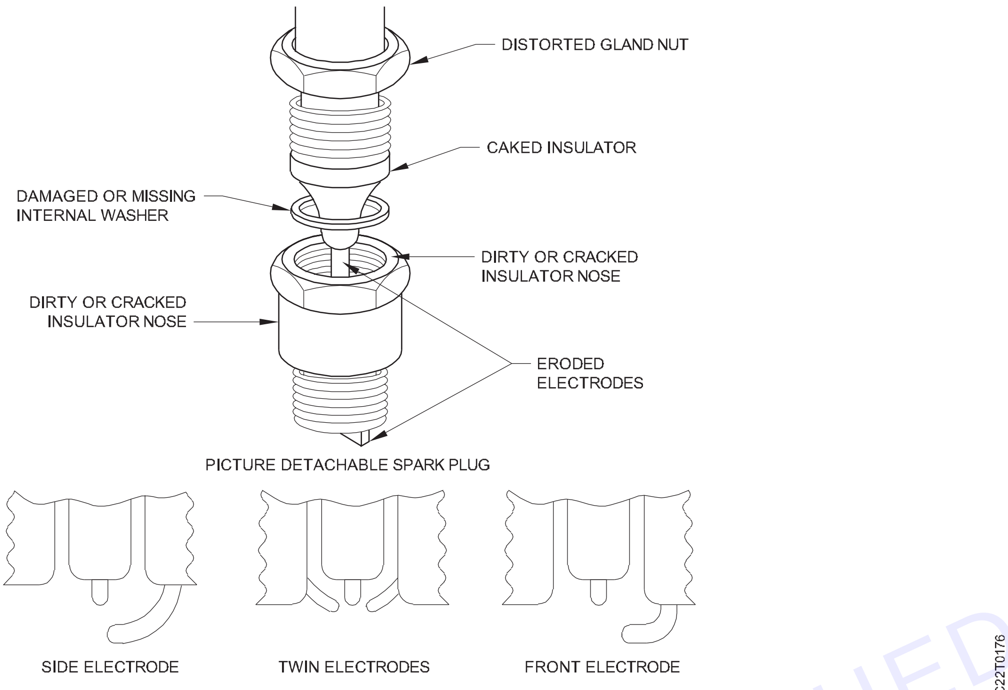
These types of spark plugs are relatively cold. In these, the length of the insulator is somewhat less, due to which they are not able to retain much heat inside themselves. The path of heat is less in these, hence carbon etc. gets deposited quickly.

This type of spark plugs is often used in engines in which the cylinder heads are made of aluminum alloy. Apart from this, similar type of cold plugs is also used in engines which are fitted in the engine valve block.

These plugs should be cleaned from time to time, otherwise there is a possibility of pre-ignition fault in the engine due to carbon accumulation. The structure of the spark plug is shown with the hot spark plug inserted.

If for some reason the spark plug becomes too cold, it is not able to burn the residue accumulated on the insulator present around the center electrode and ignition fault occurs due to lack of spark.

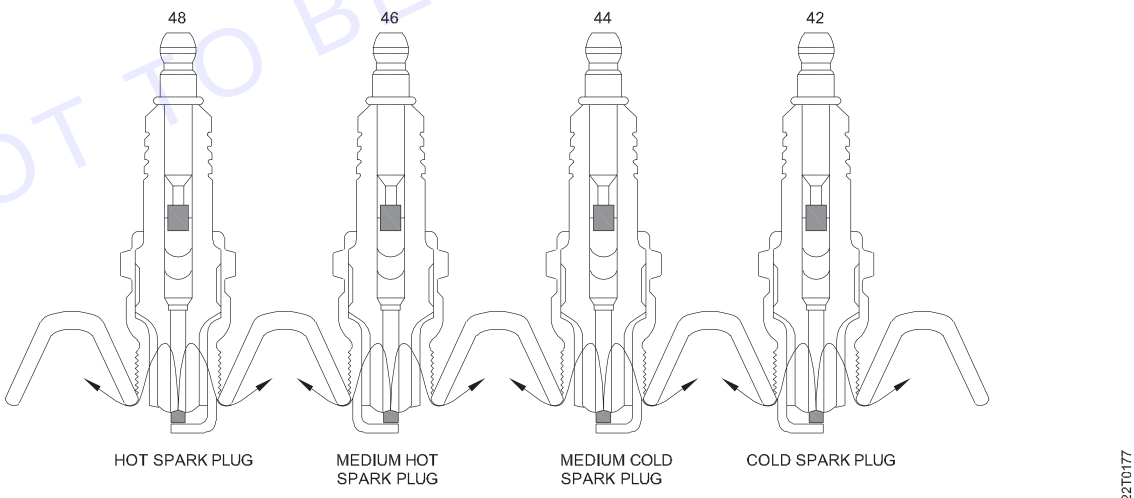
The main reason for this is that the high voltage leaks around the residue collected on the insulator of the center electrode and cannot reach the spark gap.



TYPES OF CENTRAL ELECTRODES IN DETACHABLE SPARK PLUGS

Hot Spark Plug

In this type of spark plug, the length of the insulator is longer, due to which the central electrode remains hot enough for a longer period, due to which carbon does not accumulate quickly around the electrode. If for some reason the spark plug becomes hotter than necessary, it starts wearing out or its electrodes start burning quickly. Apart from this, there is a possibility of spark not being generated because due to the gap being too wide, spark jump is not possible.

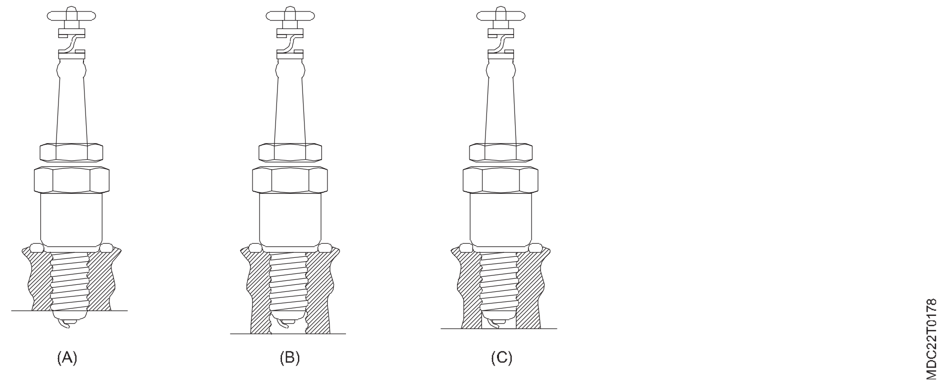


PICTURE HOT SPARK PLUG

Spark Plug Range

Spark plugs have three types of access to the cylinder or cylinder head, which are shown in the figure (a), (b) and (c) below:

Using long range spark plugs causes the plugs to overheat. There is a possibility of damage to the piston due to these. The outer part of this type of plug acts as a hot spot. There may also be difficulty in opening them, because more carbon gets accumulated on them. Short reach of the spark plug can quickly lead to misfire in the engine, resulting in a weak spark. More carbon accumulates in the area left below the spark plug tip, which absorbs the heat of the spark



2 Battery

The battery is the main source of electric current in the ignition process. It generates low tension current for this system. In petrol engine, electric current is used to burn the compressed mixture of air and petrol through spark plug. Generally, 6 or 12 volt batteries are used in the ignition system.

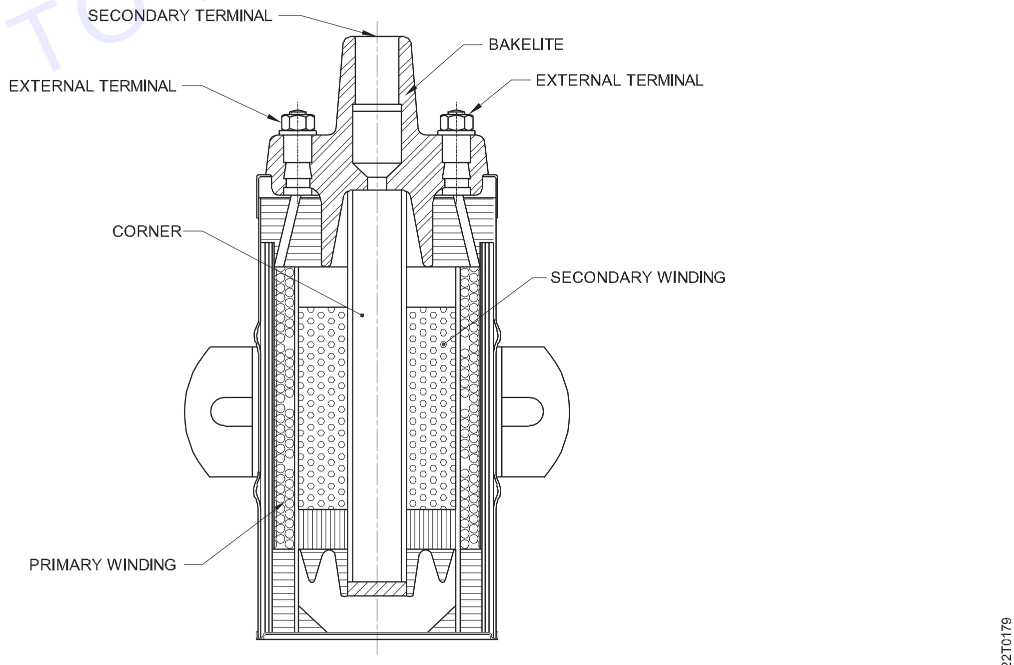
3 Ignition Coil

This coil plays a main role in converting the low tension current of the battery into high tension current. It works like a 'step-up' transformer. With its help, the current of 6 volt or 12-volt battery can be increased to 20,000 volts.

This ignition coil has primary and secondary windings of insulated copper wires on an iron core. The circuits of primary and secondary winding are shown in the figure below.

The primary winding is down to the thick copper wires on the same shaft iron core and has fewer turns, about 200-300. On the contrary, above this winding there is a secondary winding, which has more turns of thin wire, which are about 21000.

Primary winding, which is the CB of the battery and distributor. (contact breaker) point, there are two low tension terminals on the ignition coil.



IGNITION COIL

One end of the secondary winding is connected to the primary winding and the other end is connected to the HT of the ignition coil. (High Tension) terminal. Both these windings are immersed in oil in a sealed container, due to which they are kept cool. Ignition coil is used to convert low voltage into high voltage to produce spark. Its both. The ends of the winding are connected to the external terminal. The Bakelite cap insulates the secondary terminal and the primary terminal.

4 Distributor

In multi-cylinder engines, it distributes the high tension current received from the ignition coil to the spark plugs of all the cylinders according to the firing order. CB installed in it Points also help in creating high tension current by making and breaking the primary circuit. Apart from this, the ignition timing is also adjusted according to the engine speed by the advanced retard mechanism associated with it.

Some distributors also have an advanced retard mechanism and a small gear mounted on the shaft to drive the distributor. The distributor mainly consists of the following parts

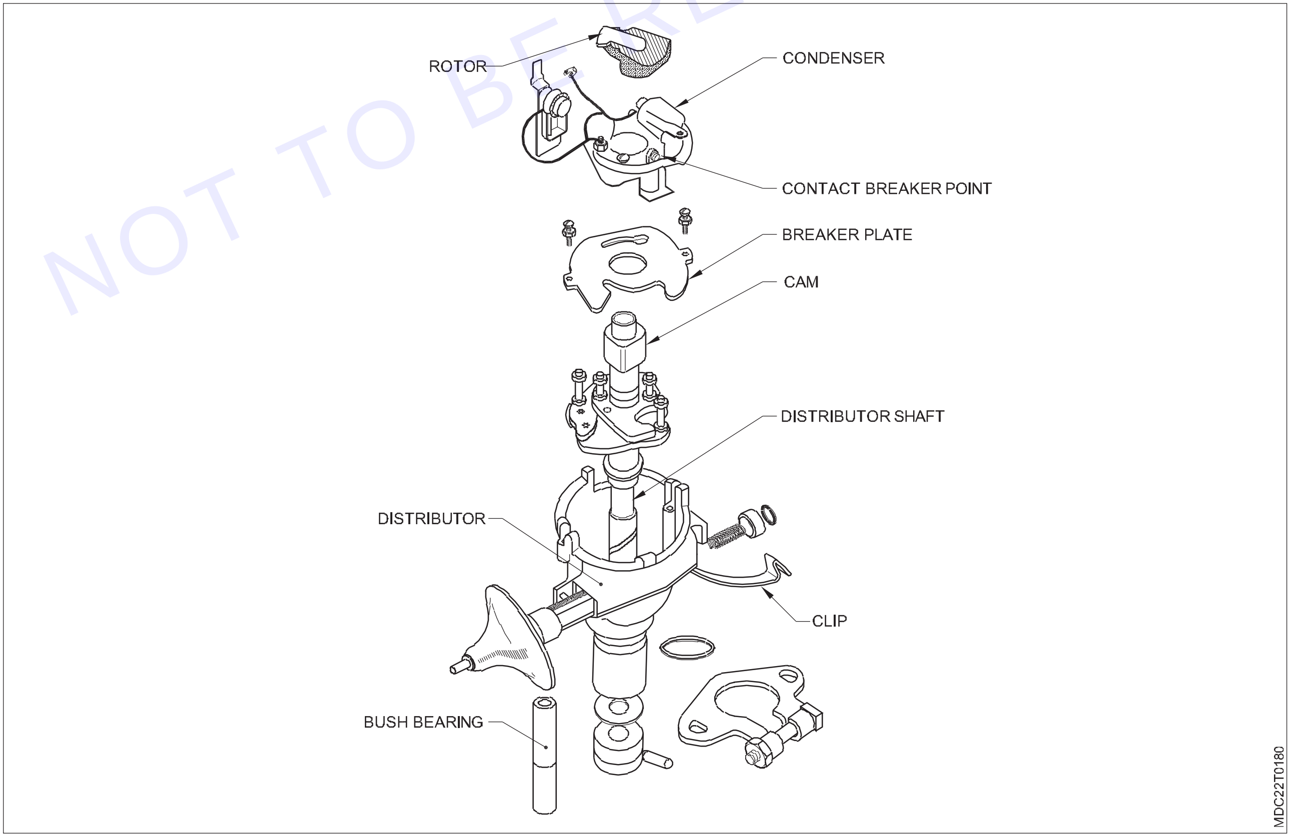
Distributor Body

The distributor consists of advanced mechanism, distributor, shaft, bush breaker plate, contact breaker, cam, condenser, rotor and distributor cap. The bowl shaped distributor housing is closed from the top by a distributor cap. The cap has segment terminals corresponding to the cylinder number. This terminal high tension as per firing order

The leads are connected to the spark plug. The center tower of the cap is connected to the HT terminal of the ignition coil. A spring loaded actuation electrode operates the mercury rotor’s ignition surge. HC current/surge flows from the rotor arm to the side segments of the distributor cap. The body of the distributor is closed from above by a cap, due to which the spark plug and HT. (high tension) lead pair.

A shaft is fitted in the middle of the body, it has a cam lobe at the top according to the number of cylinders and a small gear is fitted at the bottom.

This gear drives the camshaft and drives the distributor. There is a groove cut on the end of the distributor shaft, in which the oil pump is threaded through the shaft and also drives the pump.



On the contrary, sometimes a small gear is located on the shaft of the oil pump and the end of the shaft of the distributor, which is in the shape of a screwdriver, fits into the groove made in the shaft of the oil pump and gives drive to the distributor shaft through the pump.

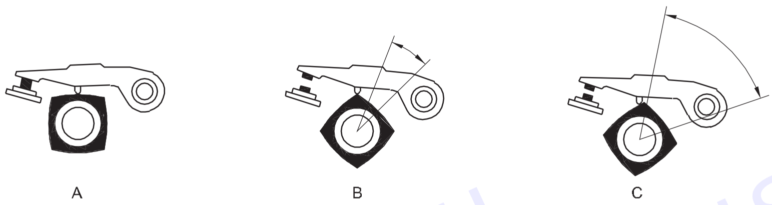
2 Contact breaker point

The important part of the distributor assembly which is made up of two pieces is called the contact breaker circuit. One piece of it remains fixed with the base plate and the other piece, to which the spring leaf is attached, is movable.

A piece of fiber or Bakelite is attached to it. The distance between the two points is kept minimal but sufficient in open condition. When the distributor shaft rotates and rotates the cam, pressure of the cam lobe is applied on the moving part, due to which this point is pressed against the tension of the spring and the primary circuit is broken.

On the contrary, when the pressure is removed due to rotation of the cam lobe, the points come back together due to the spring.

As long as the engine runs, this process continues and the primary circuit keeps creating high tension current by making and breaking.



A = Closed contact

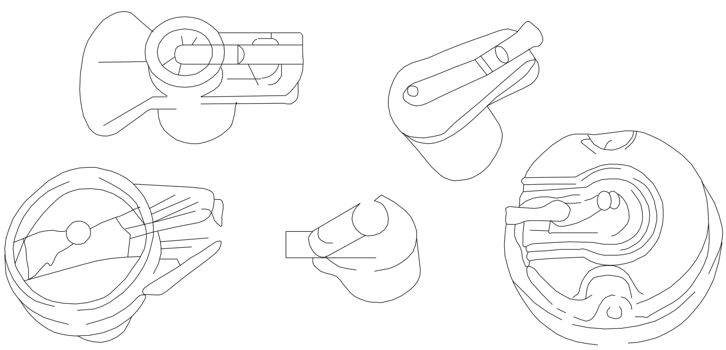
B = Large Point Gap-Small Well Angle

C = Small Point Gap-Large Well Angle

C.B. Point gap is usually kept as per the vehicle manufacturing instructions. This gap should be from 0.35 to 0.51 mm, which should be measured by filler gauge. If this gap is less, then C.B. The points will burn out and get damaged quickly and the engine will miss. On the contrary, if the gap is large, then high tension current will be formed for a very short time and proper spark will not be obtained and it may happen that high tension current is not formed at all.

3 Rotor

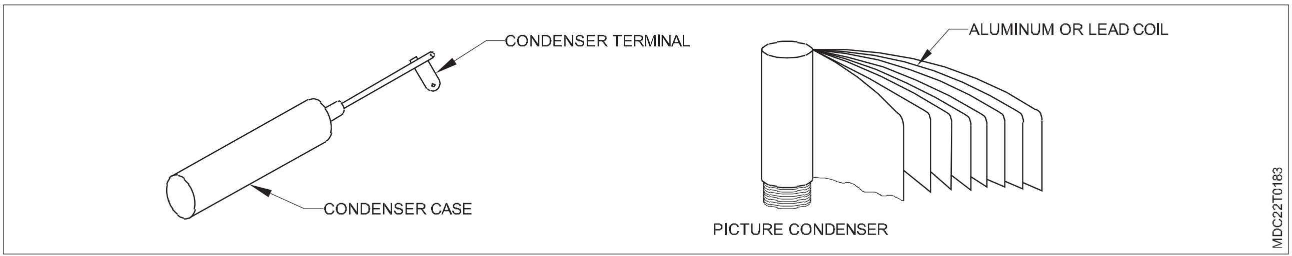
This rotor, made of Bakelite or ebonite, is fitted in the grooves made in the distributor cap. The brass leaf on the edge of the rotor is connected to the carbon rod in the distributor. The rotor rotates with the rotation of the distributor shaft and transmits the high tension current coming to the distributor cap to the spark plug with the help of segments and leads respectively.



4 Condenser

CB on the base plate of the condenser and distributor. The points are fitted parallel. CB in the ignition circuit of petrol engine. Two condensers are connected with the points, which are C.B. Protects the points from getting damaged. In the condenser, two leaves made of tin or aluminum are wrapped in layers, between which wax paper is applied as insulation. These leaves are kept closed in a case.

When C.B. Points rotation opens to break the circuit, in that case C.B. Spark is generated in the points, due to which C.B. The points start burning and the formation of high tension current is hindered. In case of high tension current flowing in a low tension circuit, condensers store maximum current inside them. The condenser and its structure are shown in the figure. It consists of lead or aluminum coils, which are separated from each other. One end of the coil is connected to the condenser terminal and the other end is connected to the condenser case.



5 Ignition Switch Ignition Switch

The ignition switch is fitted on the panel board between the battery and the ignition coil. It connects and separates the primary circuit from the battery.

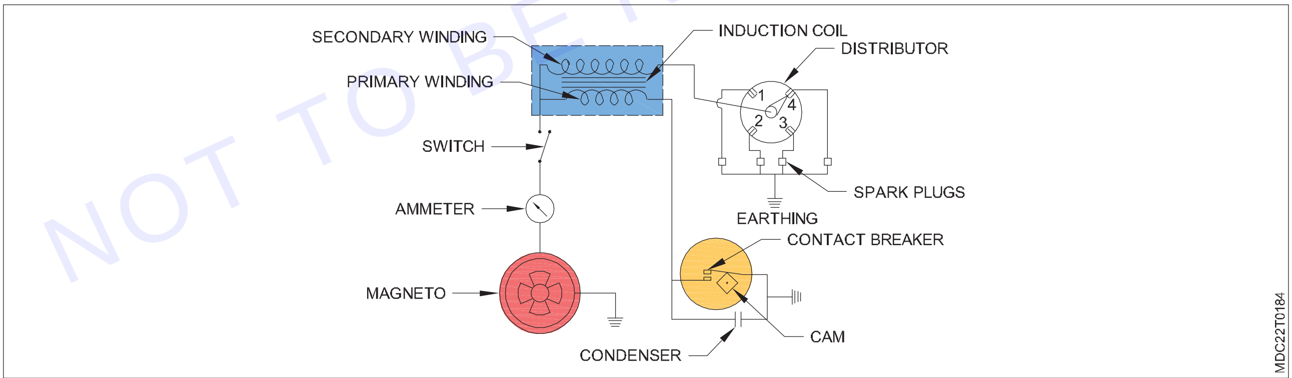
6 Contact Breaker

To generate high voltage in the secondary winding of the coil, the contact breaker connects and disconnects the primary circuit at certain time intervals. There are two number of contact breaker points, one of which is directly fitted on the base plate and the other is insulated and operated by a rotating arm.

2 Magneto ignition system

Magneto ignition system has its own current generating device, therefore battery is not required.

The arrangement of the magneto ignition system for four cylinder S.I. Engine is shown in figure.



Essential components of the system

1 Electrical generator

An electrical generator with permanent field magnets and rotating armature which produces an alternating current.

2 Induction coil

An induction coil with primary and secondary windings being wound on the armature.

3 Contact breaker

A contact breaker to interrupt the generator primary circuit and the condenser.

4 Distributor

A distributor to distribute high tension current to spark plugs.

Working

As the magneto rotates, the voltage and current are generated in the primary circuit, and circuit is completed passing the current through the contact breaking point and through the ground.

As the current passes through the primary coil through the contact breaker, the circuit is completed through ground.

As the camshaft rotate, the camp opens the contact breaker and interrupt the flow of current in the primary.

This causes the decay in the magnetic field lines and cuts the line of magnetic field in the secondary, and a high voltage is generated in the secondary.

The process of generating the high voltage in the secondary is known as an induction phenomenon.

The voltage generated in the secondary depends upon the ratio of number of turns in the secondary and primary winding

Magneto ignition system is similar to the battery ignition system.

Main difference is that it has own current generating device instead of battery.

It is mostly used in moped, motorcycle, scooter and racing car.

As most of the parts of both types are same except battery, working of magnetic ignition system is similar to the battery ignition system.

Application of magneto ignition system

It is used in racing car and aero plane engines since the magneto system provides a strong spark at high speeds.

It is preferred in two wheelers because of its low weight and low maintenance.

Advantages of Magneto System

1 Less maintenance
2 Light in weight and occupies less space
3 Provides high intensity spark at high speeds.
4 System is reliable.

Disadvantages of Magneto System

1 Since wirings carry high voltage current, there is a strong possibility of leakage which may cause misfiring of engine.
2 The system requires extensive shielding to prevent leakage of high voltage current.
3 At low speeds it develops poor quality of spark at the time of starting.

3 Electronic ignition system

Principle of electronic ignition system

A timer is used in the distributor of electronic ignition system. It sends electrical pulses to an electronic control unit (ECU) which switches off the flow of cur- rent to the primary winding as a result, a high volt- age is induced in the secondary winding which is then distributed to the spark plugs as in the case of the breaker point ignition system.

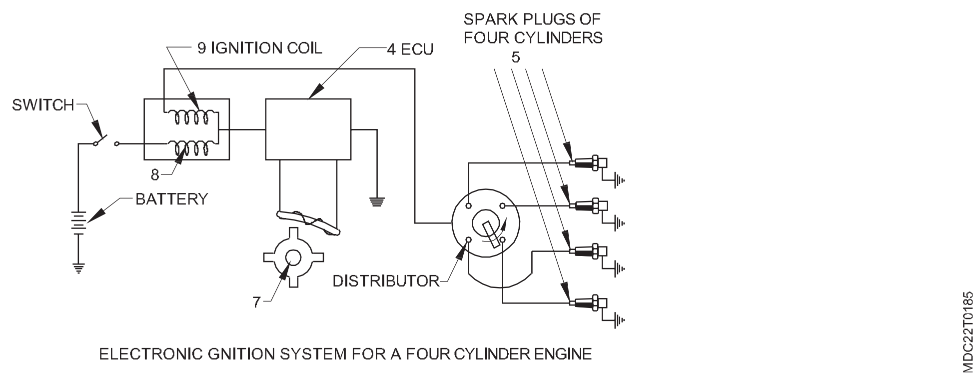
The electronic control unit later switches on the flow of current to the primary circuit so that the primary circuit current can be built up for the next cycle.

The timer may be a pulse generator or a hall effect sensor.

A pulse generator consists of a permanent magnet a timer coil and reluctor . The permanent magnet and the time coil remain stationary. The reluctor is fitted to the distributor shaft and is in the shape of a wheel with teeth.

When the distributor shaft revolves, the reluctor wheel rotates, its teeth moving very near to the pole plates of the permanent magnet.

The reluctance of the air gap between the other inductor tooth and the timer coil is reduced. At the same time, the reluctance of the air gap between the reluctor tooth and the magnet is also reduced. This results in a strong magnetic field around the timer coil.



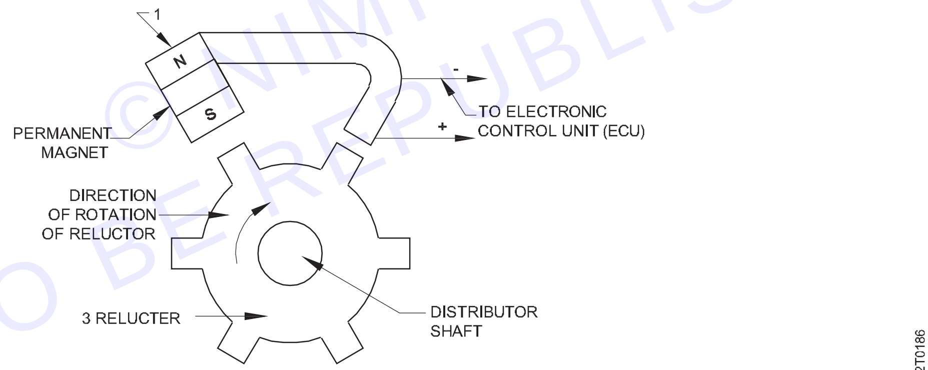
ELECTRONIC GNITION SYSTEM FOR A FOUR CYLINDER ENGINE

Current is permitted to flow through the timer coil to the electronic control unit, where the primary current flows. As a result, the ignition coil builds up a strong magnetic field.

As the reluctor wheel rotates slightly further, the reluctor tooth moves away from the timer coil. The air gap becomes wider offering a high reluctance. This results in a weaker magnetic field for the timer coil and the induced voltage reverses. The flow of current to the primary circuit is stopped.

The magnetic field in the ignition coil collapses and enough high voltage is produced for producing spark at the spark plug.

The reluctor wheel in the figure has six teeth. This wheel is used for a six-cylinder engine. The reluctor wheel has the same number of teeth as there are cylinders in the engine.



PULSE GENERATOR

Hall effect sensor

The hall effect was named after the scientist who dis- covered the effect. Magnetic sensors used in electronic distribution utilize the principle of Hall effect.

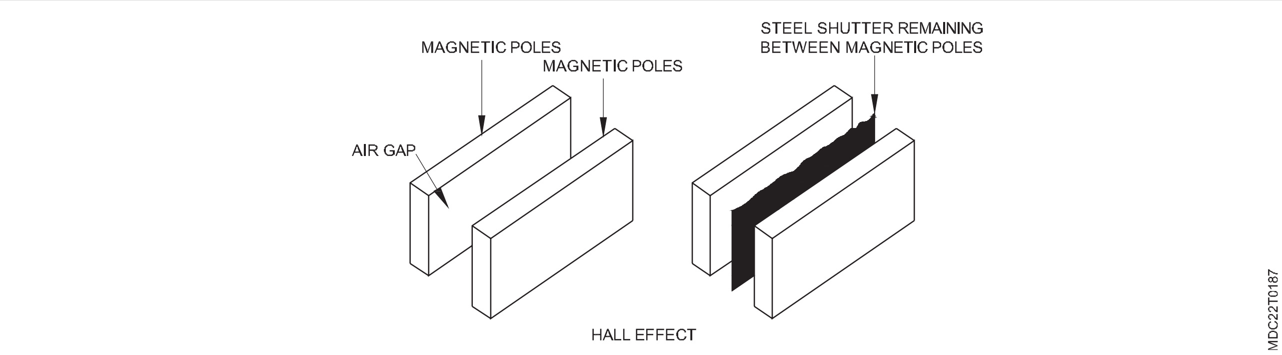
As shown there is magnetism in the air gap between the two poles of a magnet. When a steel shutter is placed or moved between these poles, the magnetism in the air gap is cut off. This principle is called Hall effect.

A rotor with curved plates is used in the Hall effect distributor of an electronic ignition system. These curved plates are called shutters. The shutters are curved in such a way that they can move between the two poles of the magnetic sensor with the movement of the rotor.

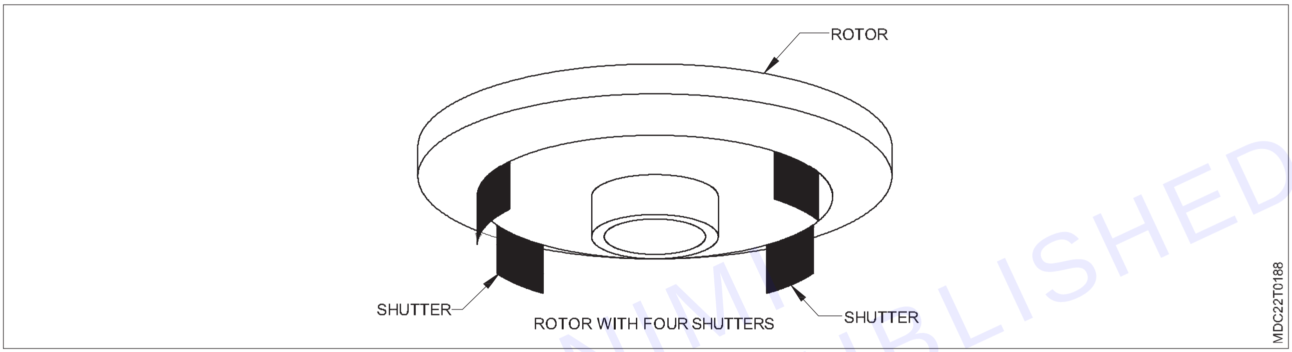
The number of shutters is the same as the number of cylinder in the engine.

Whenever a shutter passes between the two poles of the magnetic sensor, it outs off the magnetism in the air gap between the poles. This send a signal to the electronic control unit.

When a shutter moves away from the air gap, the magnetic sensor develops a voltage. ECU then receives a single from the magnetic sensor, to permit the current to pass through the primary winding of the ignition coil. However, when a shutter passes between the poles, the magnetic field is cut off and the signal voltage comes to zero.



When the ECU suddenly cuts off the flow of current to the ignition coil primary winding, the magnetic field collapses. This results in the production of high voltage in the secondary winding which gives rise to a spark in the spark plugs.



4 Distributor less ignition system

This engine has no distributor. In this system, two spark plugs are ignited at the same time. Out of these two spark plugs, one provides ignition in one cylinder during its exhaust stroke. However, the ignition has no effect, as only burnt gases are present inside the cylinder during the exhaust stroke.

The other spark plug ignites the mixture in another cylinder when the piston is at the end of the compression stroke. Here normal combustion takes place.

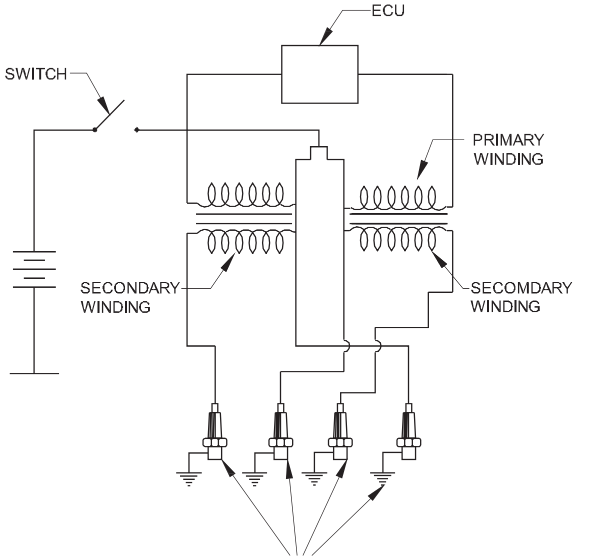
In the ignition coil, there are two primary and two secondary windings. The rotary hall effect sensor on the crankshaft controls the flow of current through the primary winding and consequently, the production of high voltage in the secondary winding.

The trigger has two triggering points, one for each primary winding. Each triggering point sends a signal to the electronic control unit (ECU) so that the flow of current through one of the two primary windings is stopped. When the flow of current is stopped, the magnetic field in the primary winding collapses suddenly and a high voltage is produced in the secondary winding.

A four-cylinder engine with the firing order 1,3,4,2 has a special arrangement in which cylinders 1 and 4 and cylinders 3 and 2 are paired.

In a six-cylinder engine, which has no distributor, there are three pairs cylinders 1 and 4, cylinders 5 and 2, and cylinders 6 and 3.

Each ignition coil is a true transformer.



DISTRIBUTORLESS IGNITION SYSTEM FROM A FOUR CYLINDER ENGINE

Importance of checking ignition circuit

Objectives: At the end of this lesson you shall be able to

- explain Importance of checking ignition circuit.

Checking the ignition circuit is important because it ensures that the engine's spark plugs receive the necessary voltage to ignite the fuel-air mixture. Without proper ignition, the engine will not start or may run poorly, leading possible damage. Regular checks help maintain optimal engine performance, reliability and fuel efficiency.

1 **Reliable Engine Starting:** Engine starting reliably, especially in various weather conditions such as cold or rain.

2 **Optimum Engine Performance:** It contributes to maintaining engine performance and output power.

3 **Fuel Efficiency:** Proper ignition timing improves fuel efficiency, which saves fuel costs.

4 **Emission Control:** Helps reduce harmful emissions by providing efficient combustion.

5 **Preventing Engine Damage:** Early detection and resolution of ignition problems helps prevent damage to engine components.

6 **Safety:** A properly functioning ignition system ensures safe vehicle operation.

7 **Smooth Engine Idle:** Helps keep engine running steady and smooth while reducing vibration and noise.

8 **Acceleration Response:** Ensures responsive acceleration by providing consistent spark timing.

9 **Diagnostic Aid:** Checking the ignition circuit can help diagnose other engine performance problems.

10 **Long Term Reliability:** Regular checks contribute to engine reliability and longevity.

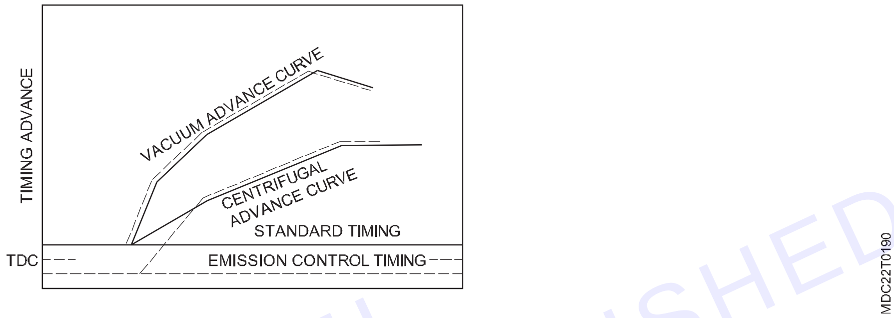
Importance of checking and setting correct ignition timing

Objectives: At the end of this lesson you shall be able to

- explain Importance of checking and setting correct ignition timing.

Ignition: The ignition system is a crucial component in internal combustion engines that generates and delivers high-voltage electrical sparks to ignite the air-fuel mixture in the engine's cylinders. It typically consists of a battery, ignition coil, distributor (or ignition module), spark plugs, and related wiring. When the ignition system fires, it initiates the combustion process, allowing the engine to generate power and operate.

Ignition timing: Idling, deceleration and running rich with closed throttle are some engine operating conditions which produce excessive unburnt hydrocarbons and carbon monoxide in exhaust. The emission quality is greatly affected by the ignition timing as shown in Fig.



Typical distributor advance curve for lower HC and CO exhaust emission.

Retarding ignition timing at idle tends to reduce exhaust emission in two ways. With retarded timing, exhaust gas temperatures are higher (fuel economy is adversely affected), thereby promoting additional burning of the hydrocarbons in the exhaust manifold. Since engine efficiency is reduced, retarded timing requires a slightly larger throttle opening to maintain the same idle speed. The larger throttle opening means the possibility of better mixing and combustion during idling. This reduces exhaust emissions appreciably especially during deceleration.

1 **Engine Performance:** Proper ignition timing ensures that the air-fuel mixture ignites at the optimal moment in the engine's cycle, maximizing power output and efficiency.

2 **Fuel Efficiency:** Correct timing results in more efficient combustion, leading to better fuel economy and reduced fuel consumption.

3 **Engine Longevity:** Incorrect timing can cause engine knocking, which can lead to damage over time. By setting the timing correctly, you prevent premature wear and tear on engine components.

4 **Emissions Control:** Proper timing helps minimize harmful emissions by ensuring that fuel is burned efficiently, reducing the release of pollutants into the atmosphere.

5 **Smooth Operation:** When ignition timing is accurate, the engine runs smoothly with minimal vibration and noise, enhancing overall vehicle performance and driving experience.

6 **Locate Timing Marks:** Find the timing marks on the engine's crankshaft pulley or flywheel and the timing scale on the engine block or timing cover. These marks indicate the top dead center (TDC) position of the piston.

7 **Consult Specifications:** Refer to the manufacturer's specifications for the correct ignition timing for your vehicle. This information can usually be found in the owner's manual or a repair manual.

8 **Prepare Engine:** Ensure the engine is at operating temperature and that all accessories are turned off. Disable any advance mechanisms, such as vacuum advance or electronic advance, if applicable.

9 **Connect Timing Light:** Connect a timing light to the battery and the number one spark plug wire. Secure the light so you can see the timing marks while the engine is running.

10 **Adjust Timing:** With the engine running, point the timing light at the timing marks. Adjust the distributor or timing mechanism until the timing mark on the crankshaft pulley aligns with the specified timing mark on the engine block.

11 **Tighten Distributor:** Once the correct timing is achieved, securely tighten the distributor or locking mechanism to hold the timing in place.

12 **Verify Timing:** Recheck the timing to ensure it remains accurate after tightening the distributor. Make any necessary adjustments to fine-tune the timing if needed.

13 **Test Drive:** Take the vehicle for a test drive to ensure that it operates smoothly and performs optimally with the new ignition timing settings.

By following these steps and ensuring the timing is set correctly, you can help maintain your engine's performance, efficiency, and longevity.

LESSON 76 - 79: Study about distributor and its components

Objectives

At the end of this lesson you shall be able to

- explain about Distributor
- demonstrate different components of Distributor.

Distributor

The primary circuit for generating high voltage current in the ignition coil is c. B. The function of breaking and connecting through the points, as well as supplying the high voltage current from the secondary winding of the ignition coil to the spark plug is done by the distributor. come on in addition, according to the increasing speed of the engine C. B. As much as the exposure of the point

Pre-processing is done by the distributor. In the early days 'Delco' company distributors were used on the engine. Hence the distributor is also called as 'Delco'. Currently T. V. S. Distributors of T. V. S. Lucas, Presto light and Globe Auto are in use.

Distributor unit includes following components

1 Distributor cap

2 C.B. point

3 Rotor

4 Distributor shaft

5 Centrifugal advance mechanism

6 Distributor body or housing

7 C.B. Point mounting plate or breaker plate

The distributor shaft is fitted between bronze bushings in the distributor body or housing. The distributor shaft is driven by the cam shaft. The drive gear of the cam shaft meshes with the drive gear on the oil pump shaft or the drive gear on the distributor shaft. Some distributor shafts have a dog pin on the lower end. The distributor shaft with dog pin fits into the oil pump gear nut. Hence the cam shaft drives both the oil pump gear and the distributor shaft at the same time can get The advance cam in the centrifugal advance mechanism and the advance weights are mounted on the distributor shaft from the inside of the distributor housing with the help of two springs. The ignition cam sits on the advance weights pin (peg) and on the upper end of the distribution shaft. The ignition cam has lobes machined on it equal to the number of cylinders.

In the distributor housing, the breaker plate on the top side of the centrifugal advance mechanism is fitted to the housing by means of screws. C on the breaker plate. B. The fixed point carrier in the point is fitted with a screw. C. B. in point

An adjusting screw is provided on the breaker plate in the neck of the point carrier to be set. C. B. The movable point in the point is fitted to the pole of the breaker plate provided in ucett. The Baker arm creel fiber raving block of the mountable point sits on the emission cam on the riscouter shaft. Rubbing due to spring pressure on breaker arm Inonk keeps sitting on the cam. The work of breaking and connecting the primary circuit c. B. done by point. Therefore, this point is called the contact breaker point (Contact Breaker Point) or c. B. It is called Poit. C. B. It is called a point. C. B. Points are inlaid with platinum or tungsten metal.

The rotor sits on top of the distributor shaft after the ignition cam. A locating knob on the inside of the rotor fits into a groove on the shaft end to keep the rotor fixed on the shaft. A brass strip is mounted on the upper surfaces of the rotor at a distance from its center to just short of the segment. Through this strip, the high voltage from the ignition coil is transferred to the cap segment by taking a Karanj jump. The rotor is made of hard fiber or bank light and is of different shapes for different car makes.

The distributor camp is mounted on top of the distributor housing with the help of a cap holder. The cap remains fixed on the housing as the locating knob on the underside of the cap sits in the groove of the housing. The top surface of the distributor cap has sockets or lumps, one in the middle and one on each side for the number of spark plugs on the engine. H fitted in the center socket of the ignition coil. T. The other end of the wire fits into the center socket of the distributor cap. While the H installed in the side socket of the cap. T. The wires are attached to the spark plug terminals with clips. The socket on the distributor cap is fitted with a fiber or rubber cap to prevent dust, water or other dirt from entering. On the inner surface of the distributor cap, a round carbon brush is mounted with the help of a spring in the central groove below the center socket. Also brass or aluminum nails are fitted below the side socket of the cap. These nails are called segments. A brass strip on the top surface of the rotor connects the carbon brush to the segment.

To start the engine when the engine is cranked by the starter motor, the drive gear on the distributor shaft is rotated from the gear on the cam shaft. C in the distributor. B. Primary when the point is in the erased state

Components of Distributor

1 Distributor cap

A distributor cap is a component in the ignition system of an engine. Its main function is to distribute the high-voltage electricity from the ignition coil to the spark plugs in the correct firing order. The distributor cap contains a rotor that spins inside it, passing by the contacts for each spark plug wire. As the rotor passes each contact, it sends a high-voltage pulse to the corresponding spark plug, igniting the fuel-air mixture in the engine's cylinders.

2 C.B. point

C.B. points refer to the concept of a limited amount of carbon dioxide (CO2) emissions that can be released into the atmosphere to limit global warming to a certain level, typically 1.5 or 2 degrees Celsius above pre-industrial levels.

This concept is based on the idea that there is a finite amount of CO^2 that can be emitted before surpassing the threshold where the Earth's climate would experience dangerous and irreversible changes. Once this budget is exhausted, further emissions would lead to exceeding the desired temperature targets.

3 Rotor

It is a part of a mechanical device, such as an electric motor, that is responsible for producing or transmitting motion. In an electric motor.

4 Distributor shaft

It is a rotating shaft driven by the engine's camshaft or, in older designs, by a gear on the engine's crankshaft. The distributor shaft's main function is to distribute high-voltage electricity from the ignition coil to the spark plugs in the correct firing order and at the right time.

The distributor shaft has a rotor, which rotates with the shaft. The rotor is connected to the high-voltage terminal of the ignition coil through a central carbon brush or metal contact. As the rotor spins, it passes close to a series of contacts inside the distributor cap, each of which is connected to a spark plug wire leading to a specific cylinder. When the rotor aligns with a contact, high voltage is transferred from the ignition coil through the rotor and into the spark plug wire, reaching the spark plug and igniting the air-fuel mixture in the corresponding cylinder.

5 Centrifugal advance mechanism

It is a component found in some internal combustion engines, particularly in older vehicles with mechanical ignition systems. Its purpose is to advance the ignition timing as engine speed increases, improving engine performance.

6 Distributor body or housing

In summary, the distributor body or housing is a crucial part of the ignition system in old vehicle with traditional distributor-based ignition systems. It houses the distributor shaft, distributor cap, and rotor, which work together to ensure that the engine's spark plugs fire at the right time.

7 C.B. Point mounting plate or breaker plate

A breaker plate, is a component used in electrical panels or distribution boards to mount circuit breakers. It serves as a mounting platform for the circuit breakers, providing a stable and secure location for installation. The mounting plate typically has slots to utilize different types of circuit breakers, allowing for flexibility in the configuration of the electrical panel. The breaker plate is essential for ensuring that circuit breakers are properly installed and secured, maintaining the functionality of the electrical system.

Importance of checking distributor for proper functioning

Objectives: At the end of this lesson you shall be able to

- explain the Importance of checking distributor for proper functioning.

Distributor: In multi-cylinder engines, it distributes the high tension current received from the ignition coil to the spark plugs of all the cylinders according to the firing order. CB installed in it Points also help in creating high tension current by making and breaking the primary circuit. Apart from this, the ignition timing is also adjusted according to the engine speed by its associated advanced retard mechanism.

Some distributors also have an advanced retard mechanism and a small gear mounted on the shaft to drive the distributor. The distributor mainly consists of the following parts

Importance of checking of Distributor

It ensures that products are reaching accurate customers. It maintains product quality, timely deliveries, and customer satisfaction. and monitoring distributors ensures compliance with agreements and helps identify any trouble in the distribution chain that could affect sales and brand reputation.

1 **Quality Control:** Regular checks on distributors help ensure that products are handled and stored properly, optimize their quality until they reach the customer.

2 **Timely Deliveries:** Monitoring distributors ensures that dispatch of shifting on time, ensure minimizing delays in delivery to customers and preventing stock outs.

3 **Customer Satisfaction:** By verifying distributors, businesses can ensure that customers receive their orders accurately leading to higher levels of satisfaction.

4 **Brand Reputation:** Distributors are often the face of a brand in the marketplace. Regular checks help maintain brand integrity by ensuring that distributors adhere to brand guidelines and represent the brand positively.

5 **Compliance:** Checking distributors helps ensure compliance with distribution agreements, pricing policies, and regulatory requirements, mitigating risks associated with non-compliance.

6 **Market Insights:** Monitoring distributors can provide valuable insights into market trends, customer preferences, and competitor activities, helping businesses make informed decisions about their distribution strategies.

7 **Performance Evaluation:** Regular assessments of distributor performance allow businesses to identify strengths and weaknesses in distribution network and improve implementation.

8 **Risk Management:** Through monitoring distributors, businesses can proactively identify and address potentials.

9 **Relationship Management:** Regular communication and feedback in both exchanges with distributors foster stronger relationships, promoting collaboration and bonding of business objectives.

10 **Cost Efficiency:** Effective distributor management can lead to cost savings through optimized inventory management, reduce costs of transportation, and streamlined operations.

Importance of testing ignition coil, spark plug, condenser for proper functioning. Common troubles in Ignition system

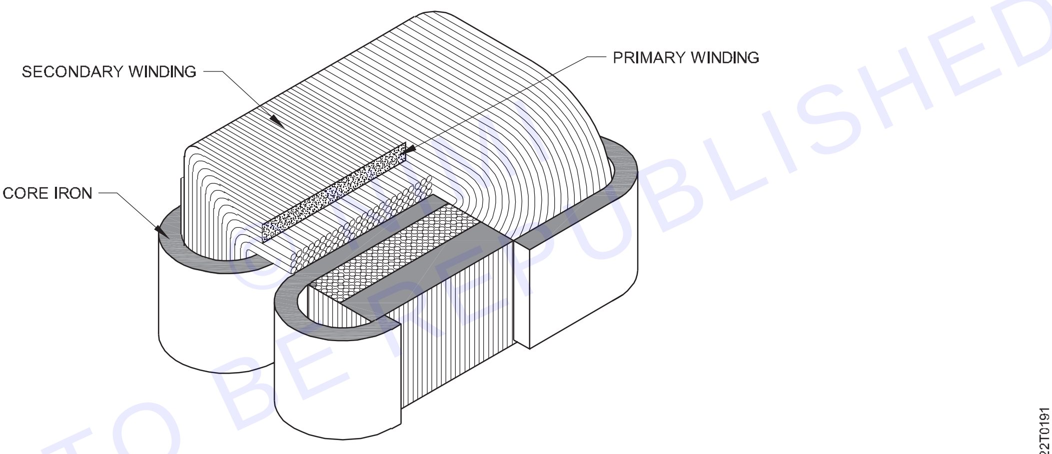
Objectives: At the end of this lesson you shall be able to

- explain Importance of testing ignition coil, spark plug, condenser for proper functioning
- trace Common troubles in Ignition system.

Importance of testing ignition coil, spark plug, condenser for proper functioning

The ignition coil is a type of transformer that sets the voltage in the ignition system. It has a soft iron core, primary winding and secondary winding. The primary winding has 200-300 turns of thick wire (20 SWG) and the secondary winding has 15000-20000 turns of thin.

Importance of testing ignition coil because it helps ensure the proper functioning of your vehicle's ignition system. A faulty ignition coil can lead to misfires at the time of ignition, rough idle, weak fuel economy, and even prevent your vehicle from starting. allowing for timely repairs and preventing potential damage to other components in the ignition system.



CORE TYPE IGNITION COIL

Spark Plug

The spark plug produces an electric spark which ignites the air-petrol mixture inside the cylinder. The spark plug is screwed onto the top of the cylinder.

Construction – The spark plug has three main parts:

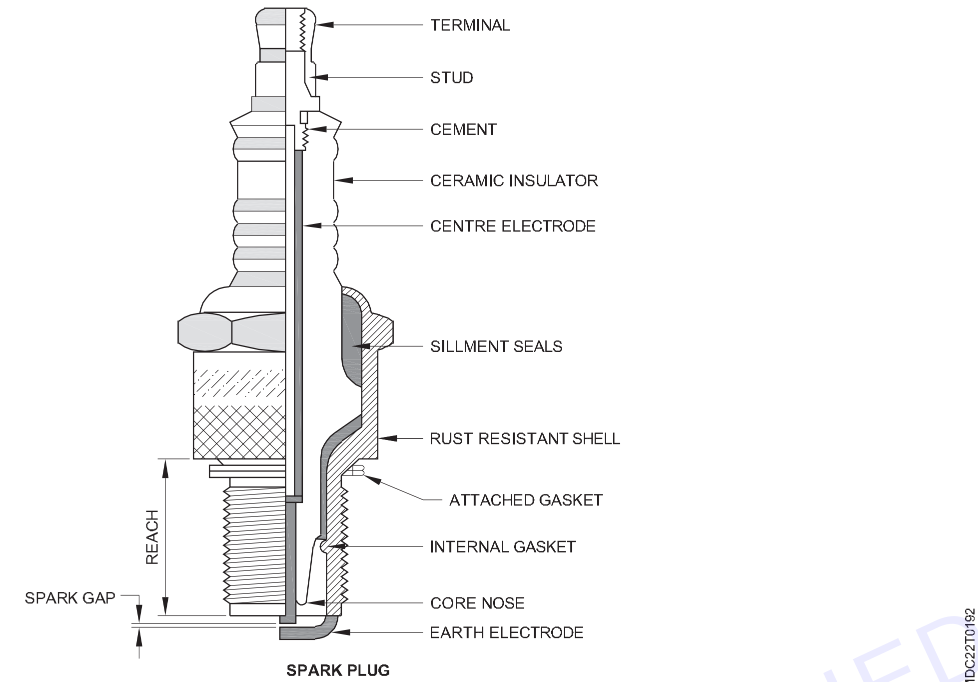
1 Center electrode or insulated electrode.

2 Ground electrode or outer electrode.

3 Insulator which keeps the two electrodes apart.

The upper end of the center electrode is connected to the spark plug terminal. To this the high tension cable of the ignition coil is connected. There is a porcelain insulator around it. The lower half of the insulator is covered with a metal shell. At the bottom of the shell, there is a ground electrode on one side, which is bent towards the center electrode.

There is a gap between the two electrodes. Thus both the electrodes remain separated by the insulator. There is a gasket between the insulator and the shell which prevents leakage of gas under different conditions of temperature and pressure. There are bangles on the lower part of the shell and the upper part is hexagonal so that it can be screwed into the cylinder head.



SPARK PLUG

Spark Plug Gap

There is a center. But the gap between the electrodes is called spark plug gap. This gap is adjusted by bending the ground electrode. This gap ranges from 0.4 mm to 1.0 mm. It is measured with a feeler gauge. The electrical resistance of the spark plug also depends on this gap. If the gap is more or less, the efficiency of the ignition system decreases. Due to this the power of the engine also decreases. Therefore, it is very important to have proper gap. There should not be carbon deposits on the electrodes. This reduces the gap and may even close it. There should be no rust on the electrodes. This increases the gap. Due to carbon deposits on the outer insulator between the plug terminal and the shell, the full voltage cannot reach the gap. Due to this the spark becomes weak and ignition does not occur. No spark is produced due to leakage of current. This happens when the insulator cracks.

Function of Condenser

To condense the exhaust steam from the turbine and reuse it.

Enables removal of air and other non-condensable gases from steam.

Function of condenser system is to transfer heat from the refrigerant to another medium, such as water. By rejecting heat, the gaseous refrigerant condenses to liquid in the condenser. The major types of condensers used are:

- Water-cooled condenser
- Air-cooled condenser
- Evaporative condenser

Common trouble in ignition system

Common issues with ignition systems

Various components within the ignition system can develop issues, each impacting the vehicle's functionality in different ways:

Faulty Spark Plugs and Wires: Worn or damaged spark plugs and wires can result in engine misfires, reduced power, and increased fuel consumption.

Ignition Switch Failures: Issues with the ignition switch can prevent the car from starting, cause electrical problems, or even lead to sudden stalling during operation.

Distributor and Coil Problems: Failures in the distributor cap or ignition coil can disrupt the electrical flow, leading to misfires or a complete failure to ignite the engine

Identifying and addressing these common problems is crucial for maintaining your vehicle's health and performance.

Reasons Behind Ignition System Problems

Ignition system issues can arise due to a variety of factors

Wear and Tear: Over time, components like spark plugs, wires, and distributors can degrade, impacting their functionality.

Electrical Faults: Loose connections, corroded terminals, or faulty wiring can lead to inconsistent power delivery and ignition failures.

External Factors: Exposure to extreme conditions, such as moisture, heat, or oil and dirt build-up, can also compromise component integrity and function.

Symptoms of a faulty ignition system

Recognizing the signs of ignition system trouble can help prevent more significant issues

1 **Difficulty in Starting the Vehicle:** This is often the first indicator of an ignition system problem, where the car struggles or fails to start.

2 **Engine Misfires and Stalling:** These symptoms can point to issues with spark plug firing or electrical connections within the ignition system.

3 **Inconsistent Engine Performance:** Experiencing fluctuations in power or unusual noises during operation can be linked to ignition system faults.

4 **Decreased Fuel Efficiency:** An inefficient ignition system can lead to poor fuel combustion, resulting in reduced mileage.

Ignition switch problems how to fix them

Normally, a car engine should start in a single key turn.

1 Key won't turn

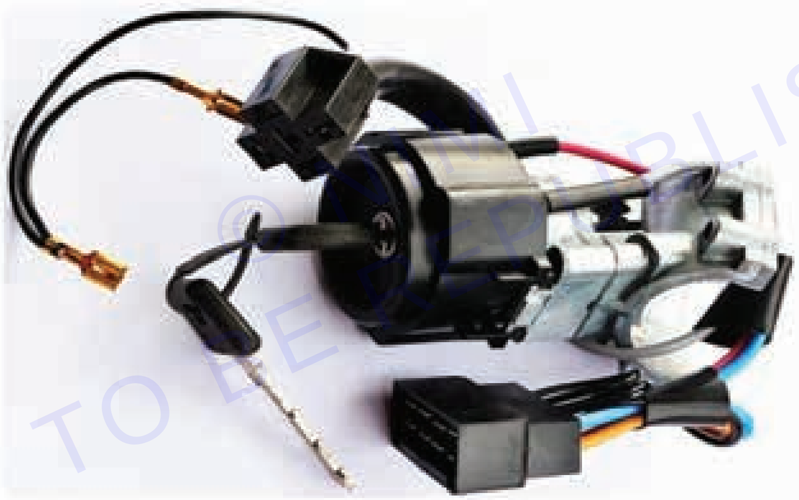
This issue can be encountered in older or modern cars. Sometimes the key won't move in the ignition switch. Old and worn-out keys are generally responsible for this problem.

2 Key breaks inside ignition

A broken key inside the ignition switch is a common issue. Generally, old and worn-out keys can't resist the pressure exerted and break inside the switch. It left the ignition unusable and hence requires an immediate solution.

3 Worn-out wafers

Wafers are the design or pattern inside the ignition switch that complies with the key patterns to start an engine. They come in three different sizes to match three different depths or cuts of the key. In an old or bad ignition switch, wafers may get jammed or worn out, which causes trouble in key movement and engine start.



4 Push start switch not working

New vehicles have a push ignition switch which comes with its own issues. The electrical ignition system can encounter defective transponder problems. In this, the transponder fails to recognize the key or fob and the engine will not start. It is usually due to a physical hit or when a potential attempt is made to hack the transponder.

PUSH START IGNITION

5 Key stuck in ignition

The key can get stuck due to the worn-out ignition cylinder or steering lock. Both of these causes will prevent the key from rotating inside the switch.

Inspecting and elimating of common faults of engine ignition system

Under normal circumstances, the engine suddenly turns off during operation, and the reason for the failure to start is mostly the failure of the ignition system. Ignition system failures are manifested as no fire, misfire, weak spark, and incorrect ignition.

1 The engine cannot be started

Turn on the ignition switch and the engine cannot start. It may be caused by abnormal power supply, incorrect ignition timing or poor spark plug.

- The spark is strong, indicating that the low-voltage circuit and the ignition coil are in good condition, and the fault lies in the distributor and the high-voltage circuit of the spark plug.
- Weak or no sparks indicate that the low-voltage circuit and short circuit, open circuit, failure of ignition electronic components or failure of ignition coil and central high-voltage line.

2 Energy requirements for ignition

The total enthalpy required to cause the flame to be self-sustaining and promote ignition, is given by the product of the surface area of the spherical flame and the enthalpy per unit area. It is reasonable to assume that the basic requirement of the ignition system is that it should supply this energy within a small volume. Further, ignition should occur in a time interval sufficiently short to ensure that only a negligible amount of energy is lost other than to establish the flame. In view of this last mentioned condition, it is apparent that the rate of supply of energy is as important a factor as the total energy supplied. A small electric spark of short duration would appear to meet most of the requirements for ignition. A spark can be caused by applying a sufficiently high voltage between two electrodes separated by a gap, and there is a critical voltage below which no sparking occurs.

Magneto ignition system

The main disadvantage of the high tension magneto ignition system lies in the fact that the wirings carry a very high voltage and thus there is a strong possibility of causing engine misfire due to leakage.

Battery ignition system

1 Battery is necessary. Difficult to start the engine when battery is discharged.

2 Maintenance problems are more due to battery.

3 Current for primary circuit is obtained from the battery. A good spark is available at the spark plug even at low speed. Efficiency of the system decreases with the reduction in spark intensity as engine speed rises.

4 Occupies more space.

In today's low emission and high-efficiency engines, the key to effective combustion is a consistent, high-energy ignition output.

The high voltage required for ignition is provided by the Ignition Coil – a type of transformer that features primary and secondary coils of wire wrapped in layers around an iron core.

The role of the Ignition Coil is to transform the low voltage in a car's battery into the thousands of volts which are used by the Spark Plug to generate sparking. These sparks ignite the air-fuel mixture inside the combustion chamber.

Ignition Coils can sometimes fail before their usual service life due to wear and defects. These could include overheating caused by internal short circuits, vibration, low battery power, defective ignition cables and mechanical damage, to name a few.

There are many signs that there is a fault with the Ignition Coil, including:

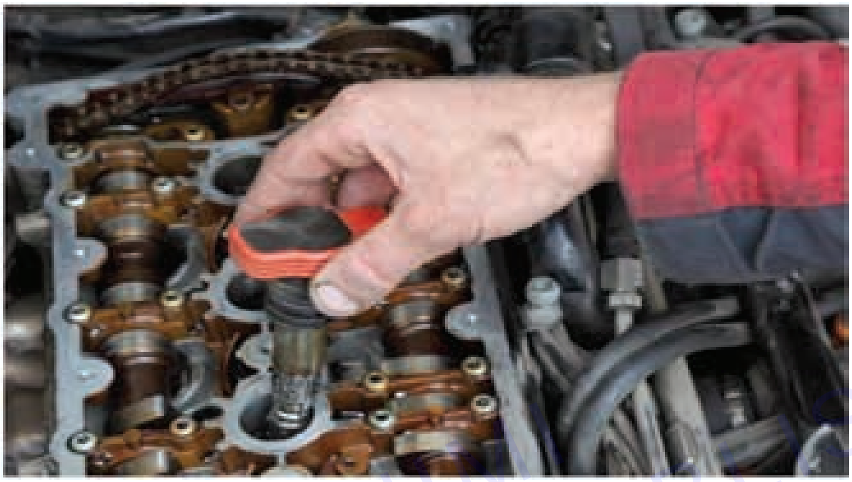
- **No combustion:** No combustion occurs because no spark is emitted.
- **Stalling:** The engine stalls but can be restarted.
- **Poor drivability:** Hesitation during acceleration or the engine misfires.

However, there are many ways to effectively manage Ignition Coils and prolong their lifetime, some as simple as paying extra attention when connecting the Ignition Coil to the Spark Plug, as misalignment can cause severe Spark Plug damage.

For the Electronic Ignition Control, the Diagnostic Trouble Code (DTC) engine warning light will probably be turned on, indicating an ignition error – however, this might be caused by another system problem.

Common indicators of a failed ignition system

While newer cars fitted with a 'distributor' engine ignition coil do see fewer issues. No car is immune to electrical problems. These generally emanate from the coil packs and the plugs or are signs that related sensors have seen better days. Typical indicators of a failed system include:



Loss of engine power: Any problems with the ignition system mean a loss of engine power, due to voltage that's not delivered to plugs to ignite the air and fuel mixture. This can be from worn or fouled spark plugs, fraying in spark plug wires, or damage to coils and coil packs requiring you to buy a new engine ignition coil.

Stalling and hard starts: The role of the ignition is to provide the right voltage at the right time so combustion occurs. Malfunctioning coils or faulty plugs mean this doesn't happen, and results in difficulty turning the engine over, or repeated stalling. Related issues are unburnt fuel that clogs the exhaust and catalytic converter.

Changes in engine noise: clicking sounds and the engine not starting point to a failed starter motor (or depleted battery). In addition, misfires or failed combustion in any cylinder lead to the engine coughing or sputtering and are accompanied by pronounced vibrations due to bad ignition timing. Backfiring or the fuel combustion outside the cylinders (most often in the exhaust), is a loud and unnerving sound that also points to faults in either the plugs or the coil.

Rough idling: this is a related issue of missed ignition timing that doesn't correspond to engine speeds and fueling. You'll notice vibrations as RPMs repeatedly rise and fall. And when sudden jolts when pressing the gas pedal.

Poor fuel economy: if all parts are working as they should, then sparks happen at the right time and ignite the designated amount of fuel for the engine load. With faulty ignition components, drivers may notice a substantial increase in fuel use, this is down to low voltage in the coils, soiled or damaged plugs, and the ECU overcompensating by spurting more fuel from the injectors.

During any of the problems above, drivers will also see the 'check engine' light in the dash. When running a diagnostics test with the car connected to an OBDII scanner or computer, most cases point to damaged coil packs or plugs.

Issues can also arise due to bad sensors, most notably the oxygen sensor, and the camshaft and crankshaft position sensors. Though rare, newer vehicles can experience problems with the ignition module, or the electronics controlling the ignition, and separate from the ECU.

Coil Pack Issues

Most manufacturers today don't consider an engine ignition coil as a regular replacement part. There are vehicles with 200 thousand plus miles on the odometer, and no signs of ignition failure, or any of the symptoms stated above. Not all coils are created equal though, and not all drivers are that lucky.

Newer ignition coil types do tend to be more durable even while providing almost double the voltage than older conventional distributor types to feed power-hungry spark plugs. Coil blocks, pencil coils, and rail systems fall into this category. They're typically more efficient too, with no voltage lost in plug wires.

The downside to this is that once the coil goes bad, you'll be replacing the whole part, or in the case of rail systems, the whole rail. While the job is relatively straightforward and completed within minutes, car owners do have to dig deep to get replacements. Prices vary for different engines and from different makers but are generally higher the bigger (higher cylinder count) and more powerful the engine is.

The good news for older cars with distributor coils is that parts are significantly cheaper, and only the faulty parts, either the distributors, the distributor cap, housing, or rotor, and (one or all) plug leads need to be changed. The downside is that you'll be doing this more often, as older ignition systems lose puff around the 30-thousand-mile mark.

Spark Plug Issues

Plugs, unlike coil packs, need to be replaced at recommended intervals. After all, they provide the spark needed for combustion. Here lifespans differ according to the plug type. The cheapest, basic copper and nickel plugs should give you 30 thousand miles of worry-free motoring. Platinum variants last around 50, and the priciest Iridium spark plugs are good for roughly 75 thousand miles.

Common problems are worn electrodes due to overheating, improper electrode gaps (meaning uneven sparks or misfires), and cracked or damaged insulation housings. Contamination from oil (often from blown gaskets or worn piston rings) or the electrodes collecting unburnt fuel and soot (carbonization) are other frequent reasons why they fail prematurely. Plugs will also malfunction due to faulty coil packs supplying too high voltage.

Issues with Sensors

Ignition timing in newer engines is made easier with sensors. The crank position sensor for instance determines the speed and position of the crankshaft so that coils and plugs can fire at the correct time. A faulty sensor often leads to stalling and hard starts. Damaged or disconnected wiring is often the cause, but there can also be problems with the internal sensor circuitry, damage to the plastic housing because of excessive engine heat, and misaligned parts (wheel and pins) by which the sensor gauges the crank position.

The camshaft position sensor also has a say in the engine running smoothly, particularly the ignition system. This part determines the position of the inlet and outlet valves in relation to the crankshaft and pistons, so helps the ECU with correct timing and the firing sequence in the cylinders. Cam position sensors fail because of cracks in the outer housing, exposure to moisture or dirt, more severe mechanical damage, or faulty wiring and connectors. This leads to misfires, and stalling, and eventually, the car won't start.

Troubleshooting Defective Ignition System Parts

While replacement parts are the easiest way out, most issues can be revealed with a simple diagnostics test. Scanners with current software will generally point to the cylinder where misfires (or non-starts) occur, meaning either bad plugs, defective coils, or wiring problems. Remove the spark plugs from wires or the coil-on-plug connectors, remove the plugs with a socket, and do a thorough inspection. Plugs with cracked or damaged insulation casings need to be replaced.

Those that have oil or carbon buildup can be cleaned using medium grit sandpaper or a wire brush. Once cleaned, check the gap between electrodes with a gap tool. Plugs should also be tested with a spark plug testing tool. This connects to the ignition wire on one end and the plug on the other, with the engine on and observing whether there's a visible spark. Lastly, check the wiring for plugs that connect them to coils as these are often the first to cause ignition issues if damaged, frayed, or affected by environmental factors, such as moisture.

Coils and coil packs are generally tested with a multimeter and the resistance results are compared to manufacturers' recommendations (usually between 0.3 and 1 ohm). Distributors, distributor caps, and rotors are first checked for visible damage, and then a multimeter is used to verify that resistance is up to scratch. The same tool can be used to diagnose ignition modules.

Lastly, sensors are checked for rust, debris, loose wiring, or burned and broken connectors. Sensors will display code readouts during diagnostic scans and a multimeter can verify if they are in working order.

MODULE 12 : Emission Control System

LESSON 80 - 83: Emission control system Definition, Sources of emission & Its Methods

Objectives

At the end of this lesson you shall be able to

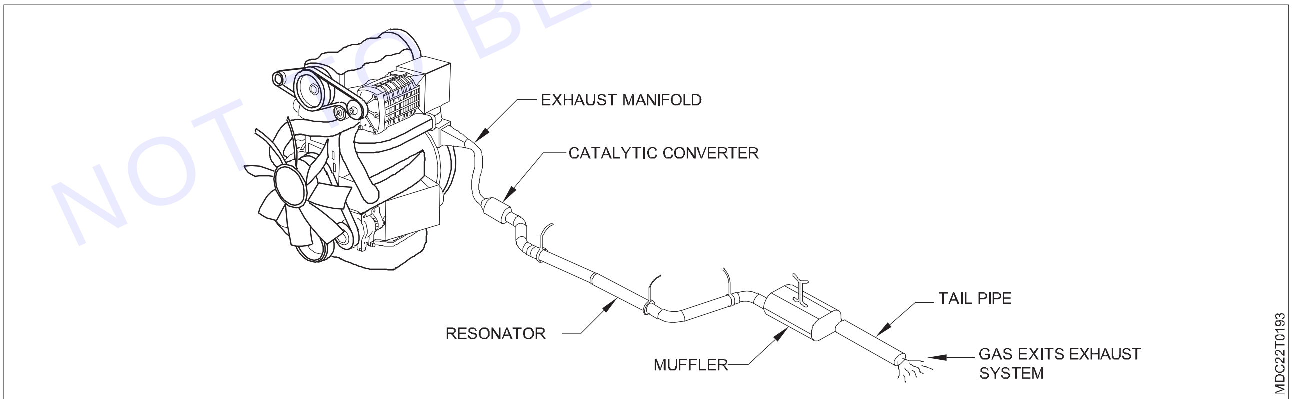
- define emission control system
- find sources of emission and its methods.

Emission Control System: definition, source of emission (such as exhaust system, crank case, fuel tank and carburettor)

Emission Control System: In the automobile sector, pollutants are emitted into the atmosphere through the fuel tank, carburetor, crankcase and exhaust system. Fuel vapor is emitted from the fuel tank and carburetor, while half-burnt air-fuel mixture is emitted from the crankcase through the piston and rings, and half-burnt hydrocarbons, carbon monoxide, nitrogen oxides and Sulphur oxides are emitted through the exhaust system. Apart from this, particulate matter also forms a major part of the exhaust emissions in diesel engines.

Particulate matter, apart from water, also includes those substances which are obtained by filtering the exhaust gas. Some unburnt hydrocarbons are absorbed on the smoke and carbon-containing particulate matter.

Exhaust system: The internal combustion engine of a car is the source of its power. It burns fuel along with air in order to create hot gases at high pressure that drives a piston with their force. During this process, the toxic gases that are some of the products of this combustion would be emitted into the atmosphere were it not for the car's exhaust system. The exhaust system of a vehicle has several important functions, which include the purification of the toxic gases and the reduction of engine noise. Without an exhaust system, cars would create both noise and air pollution that would be as dangerous as it is unpleasant



Fuel tank: To fill the fuel, diesel vehicles have a diesel tank installed above the engine assembly. It is made of strong metal sheet in round or square or other convenient designs. There is enough space to fill diesel in it, which has a lid on it. There is a union fitted at the bottom of the tank, through which the diesel, with the help of pipes, goes to the filter or fuel transfer pump. Diesel tanks are constructed from sheet metal with oil seams and a special coating of glass or fiber glass reinforced plastic metal is applied to protect against corrosion. Other contaminants found in diesel also keep accumulating in this sediment chamber. Another electrical device is installed on top of this tank, through which the amount of fuel in the tank is detected through the gauge installed on the dashboard. There is also a provision of installing a pipeline on the tank to bring the excess fuel coming from the injectors back to the tank, which is called an overflow pipeline.

Crankcase Emission: Crankcase emission occurs between the piston and the crankcase in the engine cylinder.

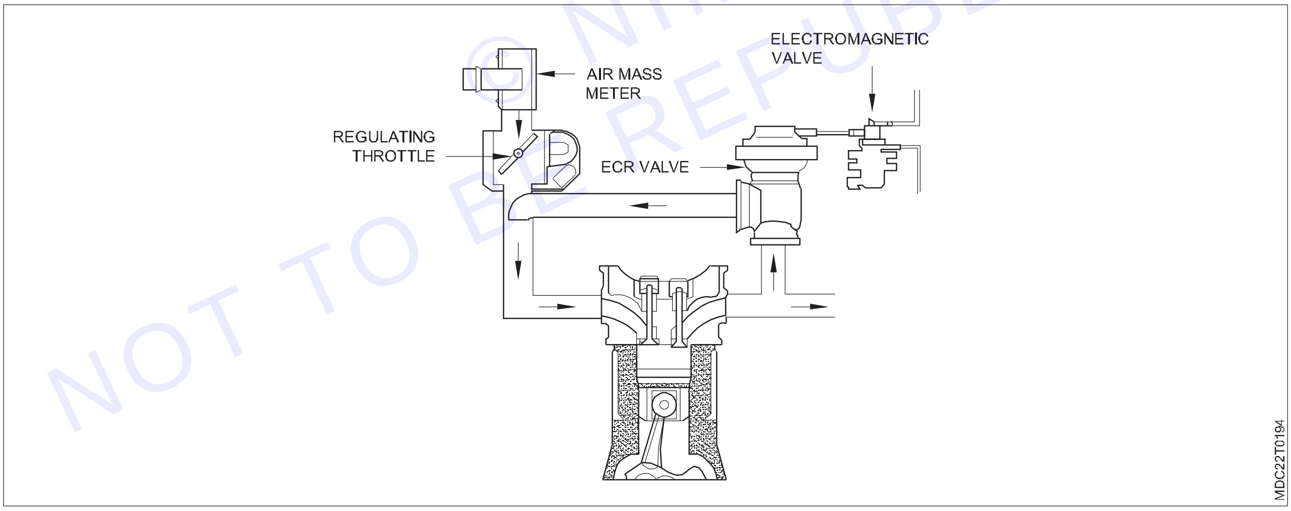
This is due to the difference in pressure generated. In this, fuel emissions constitute about 5-10% of the total fuel emissions. In this type of emissions, various components (lubricants) present inside the engine along with the gases released after fuel combustion start evaporating and being emitted due to the pressure present in the engine's cylinder.

The gases emitted are mainly hydrocarbons (HC) and carbon monoxide (CO). To avoid this emission, EGR (Exhaust Gas Recirculation) valve is used.

Carburettor: Carburetor is a device which takes petrol in liquid form from the fuel pump, vaporizes it with air, mixes it in appropriate quantity and sends it to the cylinder through intake stroke of the engine.

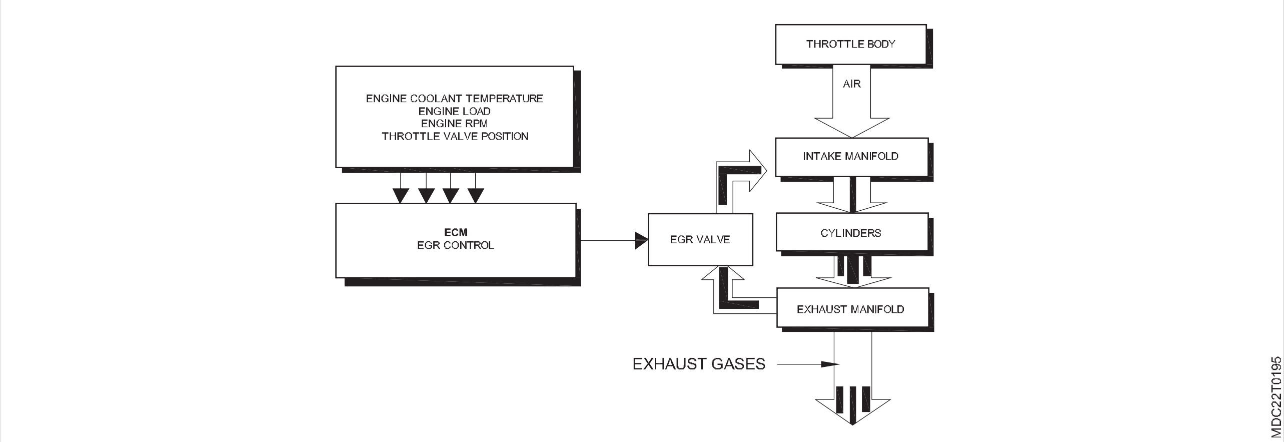
Exhaust system with egr or air injection system in to exhaust manifold with catalytic converter

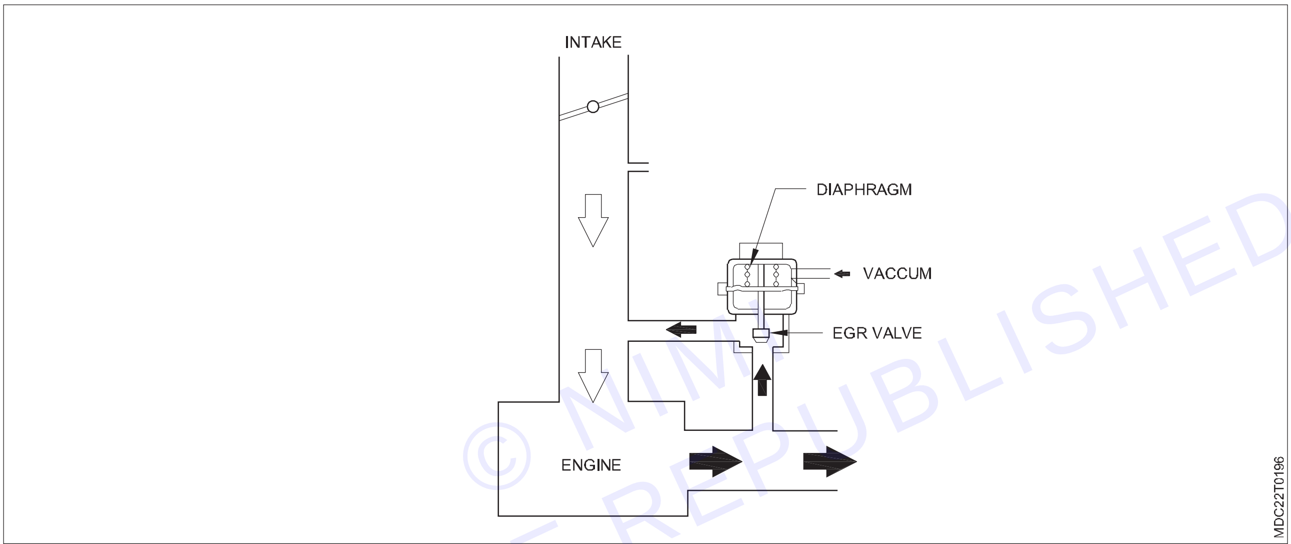
- **Exhaust system:** The exhaust manifold is used to collect the exhaust gases from the different cylinders and send them to the silencer. The exhaust manifold is generally made of cast iron. The exhaust manifold may include a heat control valve or a heat riser which has a thermostatically operated butterfly valve fitted in exhaust manifold. When the engine is cold, the valve is closed and hot gases are directed around the inlet manifold. When the engine attains operating temperature the valve opens and the exhaust gases are directly sent to the muffler. Now exhaust system comes with EGR (Exhaust Gas Recirculation).
- **EGR Valve**
- **Purpose of exhaust gas recirculation (egr) system:** Purpose of exhaust gas recirculation (EGR) system's purpose is to reduce NOx emissions that contribute to air pollution.
- **Working principle of egr valve:** Exhaust gas recirculation reduces the formation of NOX and engine knock control. By re-circulating an allowing a small amount of exhaust gas into the intake air-fuel mixture on intake manifold as shown in Fig.



EGR, valve, connected between the exhaust port, or manifold, and the intake system. If engine conditions are likely to produce oxides of nitrogen, the EGR valve opens, letting some gases is (only about 6 to 10% of the total) pass from the exhaust, into the intake system. During combustion, these exhaust gases absorb heat from the burning air and fuel. This lowers peak combustion temperatures (below 1500 degrees c) to reduce the reaction between the reaction between nitrogen and oxygen that forms NOx. Older EGR systems use a vacuum regulated EGR valve while newer vehicles tend to have an electronic EGR valve to control exhaust gas recirculation. When the engine is idling, the EGR valve is closed and there is no EGR flow into the manifold. The EGR valve remains closed until the engine is warm and is operating under load. As the load increase and combustion temperatures start to rise, the EGR valve opens and starts to leak exhaust back into intake manifold this has a quenching effect that lowers combustion temperatures and reduces the formation of NOx.

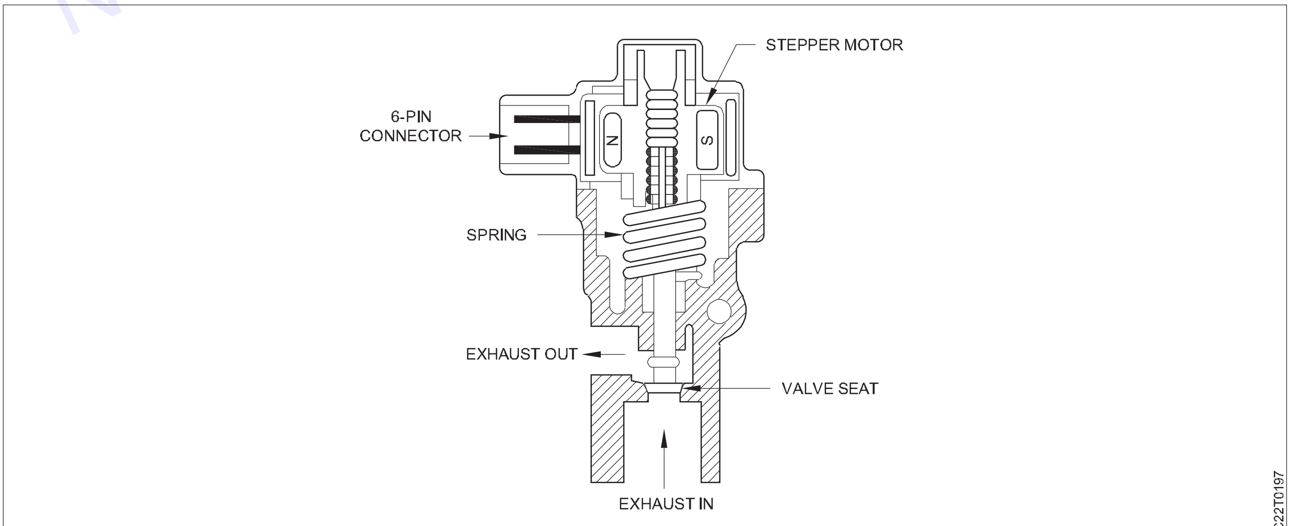
The EGR valve opens and closed the passage between the exhaust manifold and intake manifold. Vacuum is remove EGR valves. Inside the vacuum actuated EGR (Fig 3) valve is a valve, diaphragm and spring. When vacuum is applied to diaphragm lifts the valve off its seat allowing exhaust gases into the intake air stream. When vacuum is removed the spring forces the diaphragm and valve downward closing the exhaust passage.



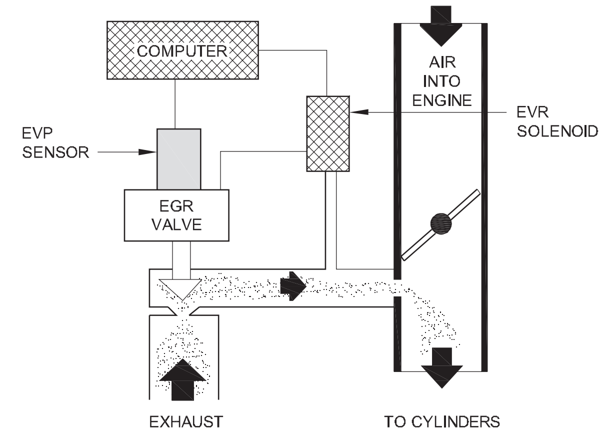


Current technology of egr valve:

- **Linear electronic egr valves:** Electronic EGR valve is the LINEAR EGR valve. This type uses a small computer – controlled stepper motor to open and close the EGR valve instead of vacuum. The advantage of this approach is that the EGR valve operates totally independent of engine vacuum. It is electrically operated and can be opened in various increments depending on what the engine control module determines the engine needs at any given moment in time.



LINEAR EGR VALVE



LINEAR EGR SYSTEM CIRCUIT

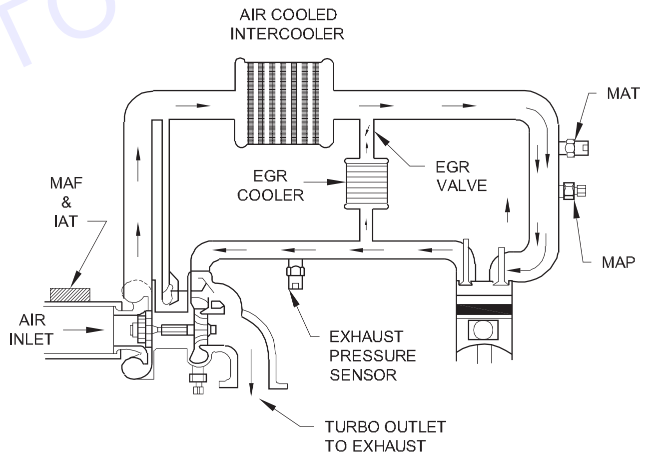
Liner EGR valves may also be equipped with an EGR valve position sensor (EVP) to keep the computer informed about

- **What the egr valve is doing**

The EVP sensor also helps with self – diagnostics because the computer looks for an indication of movement from the sensor when the it commands the EGR valve to open or close. The sensor works like a throttle position Sensor and charges resistance. The voltage signal typically Varies from 0.3 (closed) to 5 volts (open).

- **EGR system in diesel engines:** The EGR systems are quite the same as those used in gasoline engines, which means a sample of Exhaust introduced into combustion chambers to reduce combustion temperatures. One of the main different is that most manufactures cool the incoming EGR gases before introducing them into the cylinders. This reduces the temperature of combustion and therefore reduces the amount of NOx emitted by the exhaust as shown in Fig.

  Most systems with EGR coolers use engine coolant that passes through a separate circuit to cool the recirculated exhaust Gases. The ECU/PCM operates and monitors the EGR system, EGR flow is controlled by the ECU/PCM through a digital EGR valve. EGR flow will occur only when the engine is at a predetermined level and conditions.

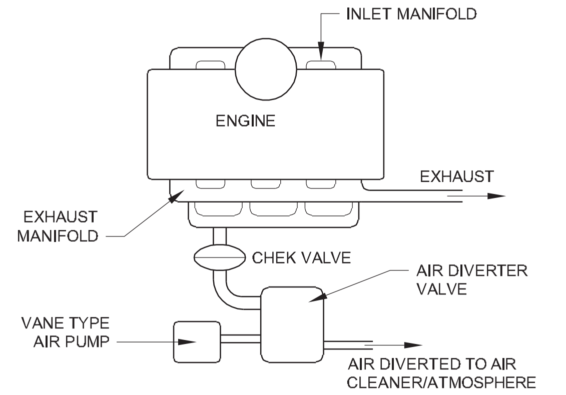


INTAKE EGR SYSTEM IN DIESEL ENGINE

- **Air injection system in to exhaust manifold**

An air injection system which is also called SECONDARY AIR INJECTION in this system in exhaust manifold injects fresh air into the exhaust stream to help burn any remaining fuel vapor, reducing harmful emissions like carbon monoxide and hydrocarbons. It's a component of the vehicle's emissions control system.

In this system the vane type AIR pump drown air from filter and injection in exhaust manifold which helps to burn unburn gases.



AIR INJECTION SYSTEM WITH

- **Air injection with catalytic converter:** A catalytic converter with air injection is a type of emission control system used in vehicles. It injects air into the exhaust system before the catalytic converter to help burn off harmful pollutants more efficiently, reducing emissions. This system aids in meeting stricter emissions standards and improving air quality.

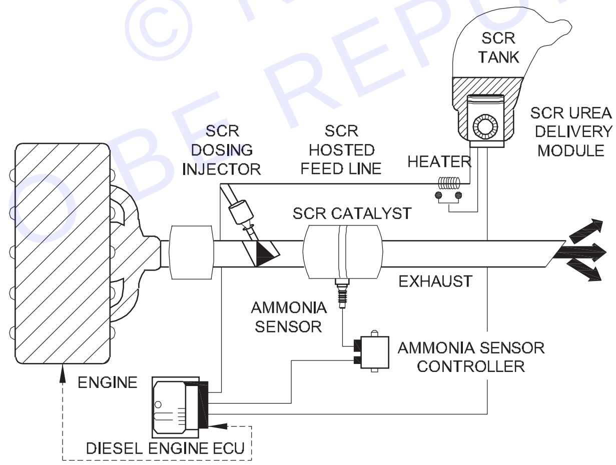
  1 **Selective catalytic reduction (SCR):** Selective catalytic reduction (SCR) is the process by which oxides of nitrogen (NOx) contained in diesel exhaust are reduced to nitrogen (N_2) and water (H_2O)

  2 **Selective catalytic reduction**

  SELECTIVE: targets NOx in diesel exhaust

  CATALYTIC: requires a catalyst

  REDUCTION: NOx is reduced to nitrogen (N_2)



SELECTIVE CATALYTIC REDUCTION (SCR)

SCR requires diesel exhaust fluid (DEF) - a urea based solution

SCR reduces NOX emissions up to 93%.

Selective catalytic reduction (scr) system components

- Diesel exhaust Fluid (DEF)
- DEF injector
- Mixing tube
- SCR catalyst

1 **Working principle of SCR system:** SCR works by injecting diesel exhaust fluid (DEF), into the hot exhaust stack. DEF works in conjunction with the hot exhaust gases and catalyst to break NOx into two components of our normal atmosphere wair vapor and nitrogen.

2 **Engine:** The NOx reduction process starts with an efficient CRD engine design CRD engine design that burns clean ultra low sulfur diesel (ULSD) and produces inherently lower exhaust emissions- exhaust that is already much cleaner due to leaner and more complete combustion.

3 **Diesel exhaust fluid (def) tank and pump:** Under the direction of the vehicle's onboard computer, Def is delivered in precisely metered spray patterns into the exhaust stream just ahead of the SCR converter. DEF is a urea based solution, Composition – 67.5% de-ionized water – 32.5% urea. Urea- Under heat, decomposes to ammonia (NH3) and Carbon dioxide (CO2) Ammonia (NH3) reacts with NOx in the presence of a Catalyst DEF is required for the selective catalytic reduction (SCR) system to function.

4 **SCR Catalytic converter:** This is where the conversion happens. Exhaust gases and an atomized mist of DEF enter the converter simultaneously. Together with the catalyst inside the converter, the mixture undergoes a chemical that produces nitrogen gas and water vapor.

5 **Control device:** Exhaust gases are monitored via a sensor as they leave the SCR catalyst. Feedback is supplied to the main computer to alter the DEF flow if NOx levels fluctuate beyond acceptable parameters.

Positive Crankcase Ventilation

Purpose of crankcase ventilation: The first controlled emission was crankcase vapors. While the engine is running during combustion some unburned fuel and other products of combustion leak between the piston rings and the cylinder walls, down into the crankcase. This leakage is called blow-by. Blow by gases are largely HC gases

Unburned fuel, and water from condensation, also find their way into the crankcase, and sump. When the engine reaches its full operating temperature, the water and fuel evaporate. To prevent pressure build - up, the crankcase must be ventilated.

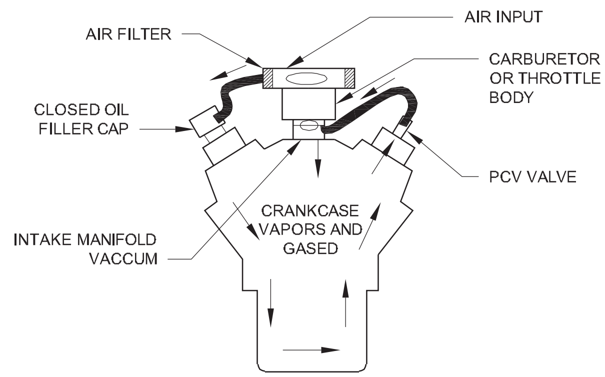
In earlier vehicles, crankcase vapors were vented directly to the atmosphere through a breather tube, or road draught tube. It was shaped to help draw the vapors from the vapors from the crankcase, as the vehicle was being driven.

Modern vehicles are required to direct crankcase breather gases and vapors back into the inlet system to be burned.

A general method of doing this is called positive crankcase ventilation, or PCV.

PCV working principle: The PxCV vacuum circuit works as follows (Fig 1). Air for the system enters the air cleaner area. The air then goes through the air filter, through a tube, and through the closed oil filler cap.

The intake manifold vacuum the draws the crankcase vapors and gases back to the PCV valve. From the PCV valve, the vapors and gases are drawn into the intake of the engine to be burned by combustion.

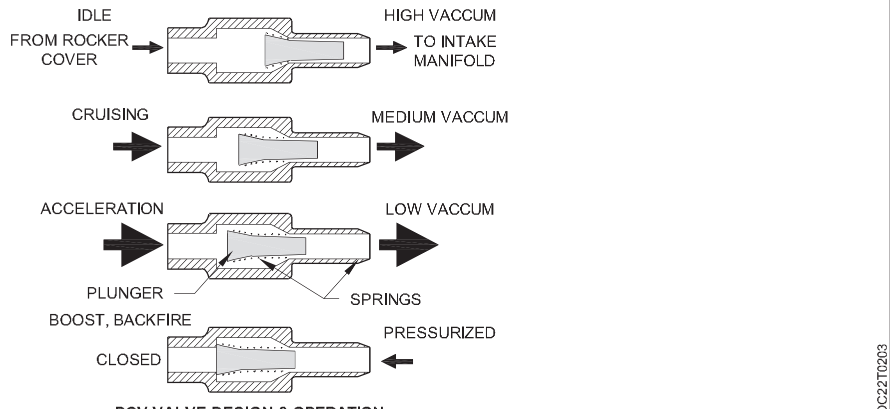


TYPICAL PCV SYSTEM

If too many vapors and gases get into the intake manifold, it may upset the air-fuel ratio. The PVC valve helps to control the amount of vapors and gases going back into the intake manifold.

As shown in the diagram (Fig 2), the PCV valve consists of a tapered plunger and two springs, and limits the air flow based on intake manifold vacuum.

During idle and deceleration when blow-by gases are minimal, the low pressure (or "high" vacuum) in the intake manifold pulls the plunger against the springs and restricts the airflow through the valve.



PCV VALVE DESIGN & OPERATION

During acceleration and heavy-load operations when blow-by gases are at their maximum, low vacuum in the intake manifold allows the springs to keep the plunger "back" for maximum airflow through the PCV valve.

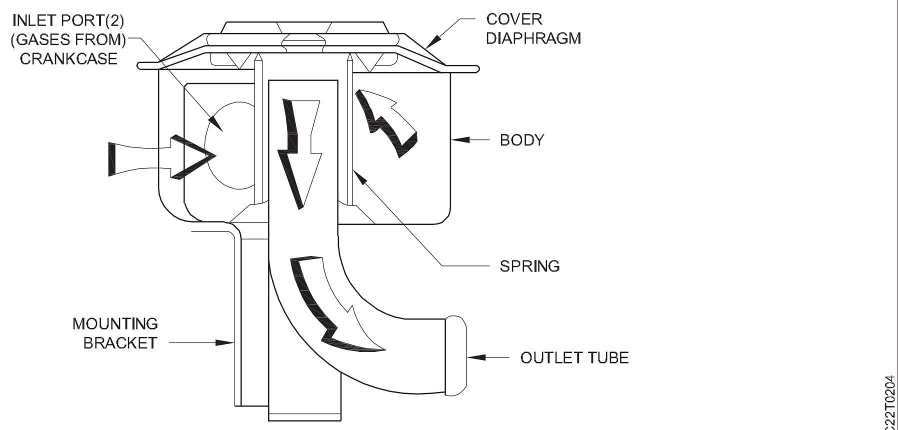
In the case when the intake manifold becomes pressurized, such as during boost on turbocharged engines or during backfire, the plunger's seat is forced against the valve case preventing air from entering the crankcase.

Crankcase depression regulator valve (CDRV) for diesel engine

A crankcase depression regulator valve (CDRV) is used to regulate the flow of crankcase gases back into the engine. This valve is designed to limit vacuum in the crankcase. The gases are drawn from the valve cover through the CDRV and into the intake manifold.

Fresh air enters (Fig 3) the engine through the combination filter, check valve, and oil fill cap. This air mixes with blow-by gases and enters the opposite valve cover. These gases pass through a filter on the valve cover and are drawn into the connected tubing.

Intake manifold vacuum acts against a spring loaded diaphragm to control the flow of crankcase gases. Higher vacuum levels pull the diaphragm close to the top of the outlet tube. This reduces the amount of gases being drawn from the crankcase and decreases vacuum in the crankcase. As intake vacuum decreases, the spring pushes the diaphragm away from the top of the outlet tube allowing more gases into the manifold. The diesel crankcase ventilation system should be cleaned and inspected every 15,000 miles (24,000 km) or at 12 month intervals.



THE CRANKCASE DEPRESSION REGULATOR VALVE

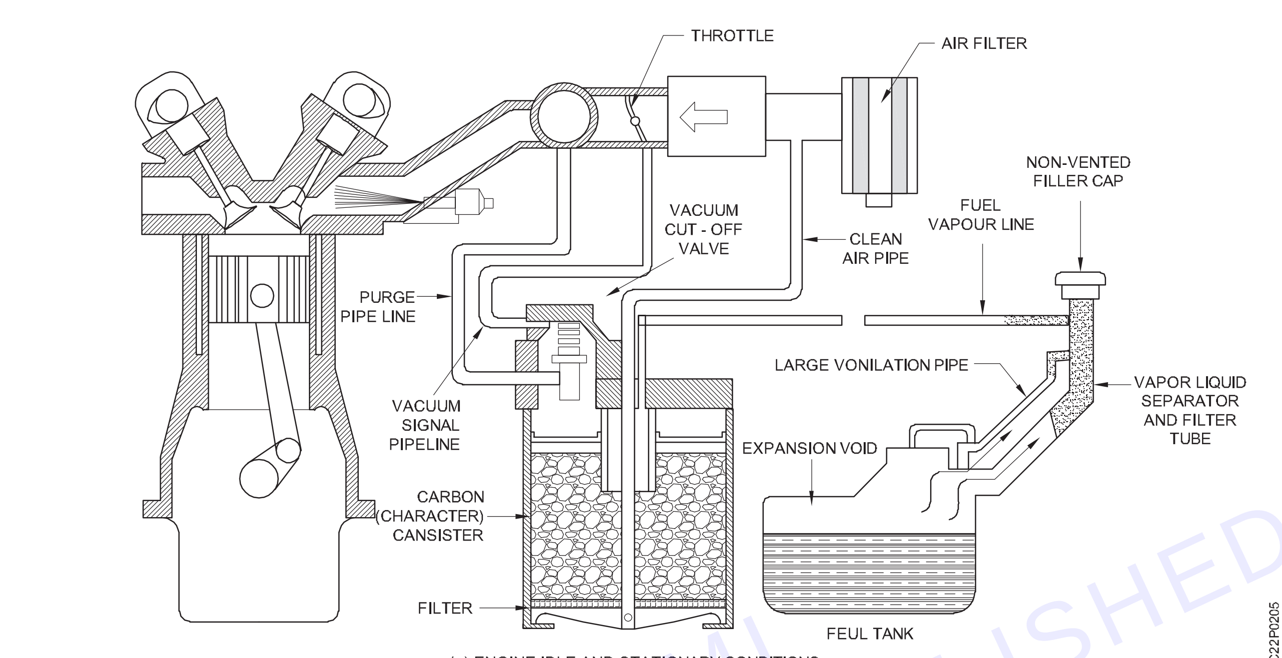
Evaporative control system i.e. charcoal canister

Evaporator emission control system

This system accounts for about 20% of the total fuel emissions from the engine. In this, the fuel gets emitted without being used, hence it is necessary to control evaporative emissions to prevent the fuel from being emitted and to put it to use.

In this, the fuel emitted from the fuel tank is not emitted into the environment but is collected in the system itself.

In this, the charcoal container is fitted with the fuel tank. The charcoal container is connected to the combustion chamber of the engine through a thermos vacuum valve and vacuum purge port, where the fuel is used.



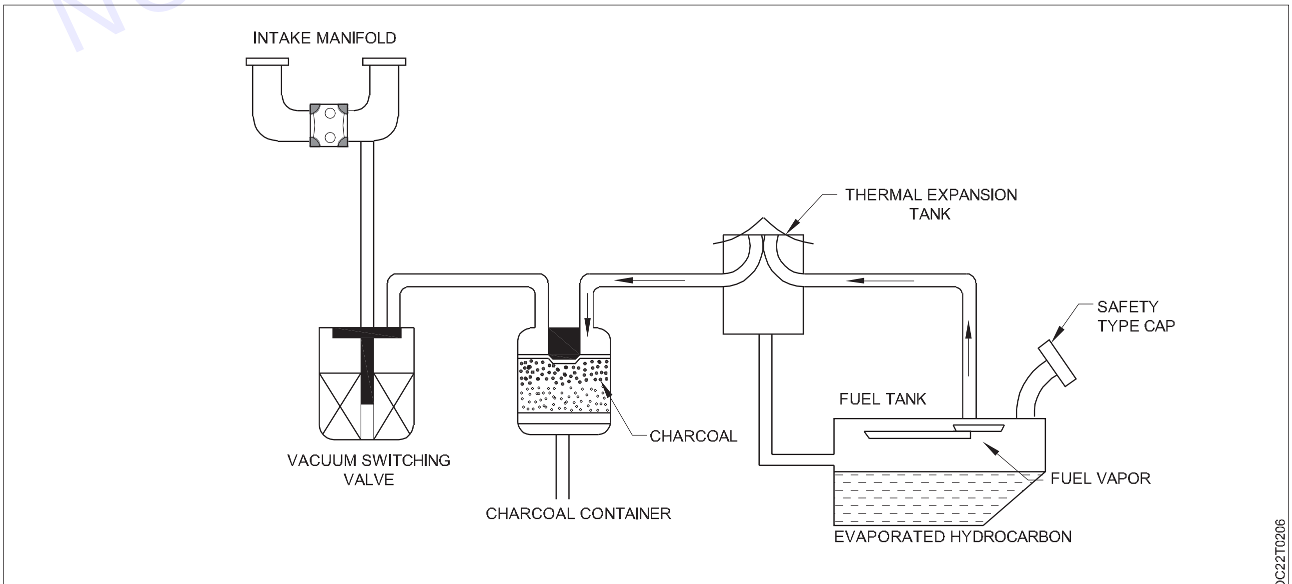
(a) ENGINE IDLE AND STATIONARY CONDITIONS

Working

In the evaporative emission control system, the fuel goes into the fuel tank with the help of a check valve and air is flowed with high pressure in the charcoal container, due to which the emitted fuel opens the valve on the purge port and the fuel enters the combustion chamber (It reaches the combustion chamber), where the fuel is combusted

Charcoal storage device

A container of activated charcoal is a storage device. Activated charcoal means porous charcoal with greater surface area. It is used to store fuel vapor. This charcoal container or charcoal storage device is connected to the fuel tank and filter line, which collects the vapor to the intake manifold. In some engines this device is also attached to the carburetor.



PICTURE CHARCOAL STORAGE DEVICE

When the engine runs, a low pressure area is created in the intake manifold during the intake stroke of the piston. It is used to open the filter valve, allowing fresh air to enter the bottom of the container. This air absorbs the fuel vapor from here and comes to the inlet manifold and enters the combustion chamber of the engine and takes part in combustion.

This filter valve is designed in such a way that it can operate at a speed higher than the idle speed of the engine. If this valve operates at a low engine speed, excess fuel vapor will disturb the fuel air ratio, causing engine failure. Evaporation of vehicle fuel is the main source of hydrocarbon emissions. The rate of evaporation of gasoline fuel is higher than that of diesel because gasoline dissolves quickly.

Vehicle emission standard euro and bahrat standard, emission control

Introduction: In the automobile sector, pollutants are emitted into the atmosphere through the fuel tank, carburetor, crack face and exhaust system. Fuel vapor is emitted from the fuel tank and carburetor, while the half-burned air-fuel mixture is emitted from the crankcase between the piston and rings and the exhaust system emits half-burned hydrocarbons, carbon monoxide, nitrogen oxides, and oxides of sulfur. are emitted. Apart from this, particulate matter also plays a major role in exhaust emissions in diesel engines.

Apart from water, particulate fluid also includes those substances which are obtained by filtering the exhaust gas. Some unburned hydrocarbons are absorbed above the smoke and carbon-containing particulate liquids.

Vehicle emissions standard: Every country sets standards for vehicle emissions. Standards related to vehicle emissions have also been made by the Government of India. The Government of India has set some emission standards, which are called ‘Bharat Stage Emission Standards’, to control the air pollution factors emitted from the internal combustion of engines. The Central Pollution Control Board, under the leadership of the Ministry of Environment and Forests, sets emission standards and sets deadlines. Every vehicle and machine should be made as per the emission standards.

At present, the number of vehicles and machines is increasing day by day, as a result of which pollution in the environment is also increasing. In order to control the pollution factors generated by vehicles, i.e. to avoid pollution, the Central Pollution Board has set the values of various components in the fuel used in vehicles as emission standards. Gas vacuum standards were first implemented in India in the year 1989, then instructions were issued for petrol vehicles in the year 1991 and diesel vehicles in the year 1992. Bharat Stage III legislation was passed in India since April, 2010, while Bharat Stage IV legislation was implemented in India since April, 2017.The Organization of European Countries unanimously passed the law of emission related standards for all European countries in the year 2000, which is called Euro Stage Emission Standard. The details of emission standards passed in India are as follows

Table Emission standards related to four-wheelers

Standard	Reference	Year	Area
India 2000	Euro I	2000 2001	entire India NCR, Mumbai, Kolkata, Chennai
India stage II	Euro. II	2003-04 2004-05	NCR*, 13 cities +entire India
India stage III	Euro. III	2004-05 2004-10	NCR*, 13 cities + entire India
India stage IV	Euro. IV	2004-10	NCR*, 13 cities +
India stage V	Euro. V	2020 proposed	entire India

National Capital Region [NCR (Delhi and its surrounding areas).

- Mumbai, Kolkata, Chennai, Bangalore, Hyderabad, Ahmedabad, Pune, Surat, Kanpur, Lucknow, Solapur, Jamshedpur and Agra.

Table Emission standards related to two-wheeler and three-wheeler vehicles

Standard	References	Date
Bharat Stage II	Euro II	April 1, 2005
Bharat Stage III	Euro III	April 1, 2010
Bharat Stage IV	Euro IV	Proposed April 1, 2016
Bharat Stage V	Euro V	Proposed April 1, 2020

Table Emission standards related to trucks and buses (grams/km)

Year	Reference	tests	Co	HC	NOx	PM
1992	_	ECER49	17.3-32.6	2.7-3.7	_	_
1996	_	ECER49	11.20	2.40	14.4	_
2000	Euro I	ECE R49	4.5	1.1	8.0	0.36*
2005+	Euro II	ECE R49	4.0	1.1	7.0	0.15
2010+	Euro. III	ESC ETC ESC	2.1 5.45 1.45	0.66 0.78 0.46	5.0 5.0 3.5	0.10 0.16 0.02
2010+	Euro IV	ETC	4.0	0.55	3.5	0.03
*.612(for engines below 85 kw)						

Table Emission Standards for Light Diesel Vehicles (LDVs) (g/km)

Year	Reference	CO	HC	HC+NOx	NOx	PM
1992		17.3-32.6	2.7-3.7			
1996		5.0-9.0		2.0-4.0		
2000	Euro I	2.72-6.90		0.97-1.70		
2005+	Euro II Euro III	1.0-1.5 0.64 0.80		0.7-1.2 0.56 0.72	0.14-0.25 0.08-0.17 0.50	0.36 0.15 0.05
2010	Euro IV	0.95 0.50 0.63 0.74		0.86 0.30 0.39 0.46	0.65 0.78 0.25 0.33	0.07 0.10 0.025 0.04
2010+					0.39	0.06

Table Emission standards for three-wheeler gasoline light vehicles (LGVs) (g/km)

Year	CO	HC	HC+NOx
1991	12-30	8-12	
1996	6.75		5.40
2000	4.00		2.00

2005(BSII)	2.25		2.00
2004-10(BSIII)	1.25		2.00 1.25

Table Emission standards related to diesel engines used for light purposes (g/km)

Year	Reference	CO	HC	NOx	PM
1992		14.0	3.5	18.0	
1996		11.20	2.40	14.4	
2000	EuroI	4.5	1.1	8.0	0.36*
2005+	EuroII	4.0	1.1	7.0	0.15

For engines of capacity below 85 KW + Mumbai, Kolkata, Chennai, Bangalore, Hyderabad, Ahmedabad Pune, Surat, Kanpur Lucknow, Sholapur

Year	Reference	CO	HC	HC+NOx	NOx
1991	-	14.3-27.1	2.0-2.9		-
1996	-	8.68.12.4	-	3.00-4.36	-
1998*	-	4.34-6.20	-	1.50-2.18	-
2000	Euro I	2.72-6.90	-	0.97-1.70	-
2005+	Euro II	2.2-5.0 2.3	-		-
2010+	Euro III	4.17 5.22 1.0	0.20	0.5-0.7	0.15
2010+	Euro IV	1.81. 2.27	0.25 0.29. 0.10 0.13 0.16	- -	0.18 0.21 0.08 0.10 0.11

For vehicles fitted with catalytic converter + Mumbai, Kolkata, Chennai, Bangalore, Hyderabad, Ahmedabad, Pune, Surat, Kanpur Lucknow, Sholapur Jamshedpur and Agra.

Table Emission standards for two-wheel gasoline light vehicles (LGVs) (g/km)

Year	CO	HC	CH+NO
1991	12-30	8.12	-
1996	5.50	-	3.60
2000	2.00	-	2.00
2005(BSII)	1.50	-	1.50
2010(BSIII)	1.00	-	1.00

Table Emission standards related to two and three wheeler diesel vehicles (grams/km)

Year	CO	HC+NOx	PM
2004-05	1.00	0.85	0.10
2004-10	0.50	0.50	0.05

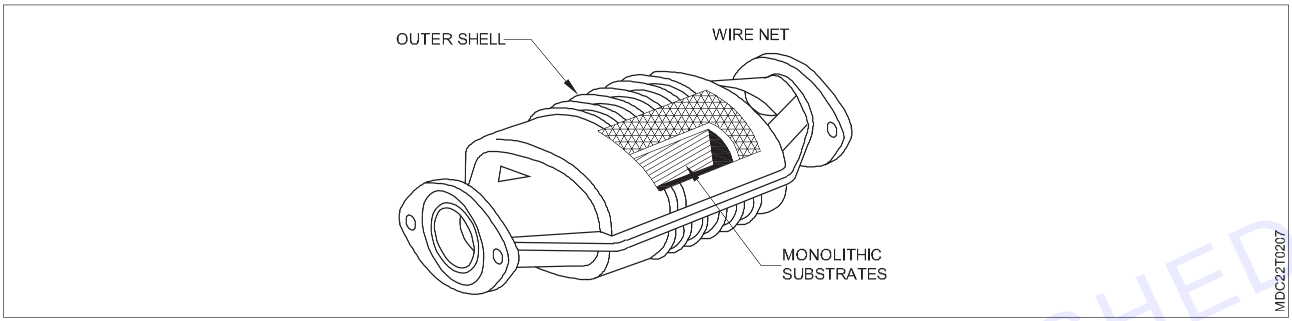
Devices for emissions control

In the beginning, when emission standards did not exist, there were no efforts towards emission control, but since the emission standards came into existence, efforts have been made towards controlling the factors that pollute the environment as a result of emissions. Efforts were also started and research was done keeping in mind the emission control methods. The result of these researches came out in the form of emission control devices. Following are some of those useful and popular emission control tips.

1 Catalytic conversation

A catalytic converter is an emissions control device that converts toxic pollutants into less toxic pollutants through a redox catalytic reaction. Catalytic converter is mainly used in internal combustion engines.

It is made of ceramic and expensive metals in the shape of a bee hive, hence it is known as honeycomb, as shown in the following picture.



In this, polluted i.e. toxic gases coming out of the engine are flowed, which are converted into less toxic gases by reacting with the elements present in it; For example, it converts hydrocarbons, carbon monoxide and nitrogen oxides into less harmful elements carbon dioxide, water vapor and nitrogen. Three-way catalytic converter is called closed loop catalytic converter.

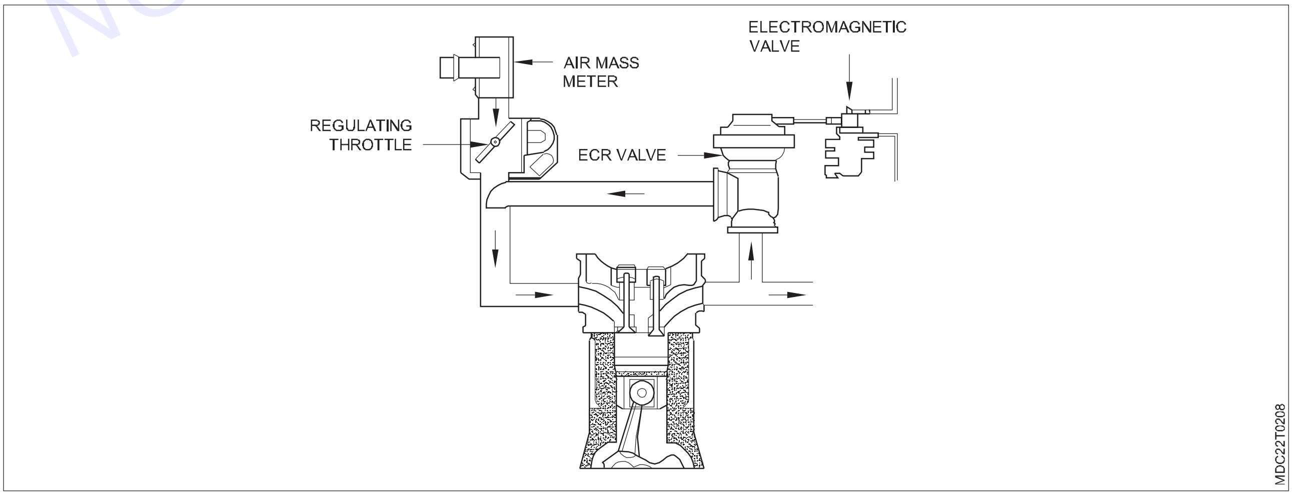
Note: The first catalytic converter was built in the year 1976, which oxidizes HC and CO and the second catalytic converter was built in the year 1977-78, which controls the emission of NO.

2 Exhaust gas recirculation (EGR) valve

The main objective of using exhaust gas recirculation (EGR) valve is to reduce the emissions of oxides of nitrogen in vehicles which increase air pollution.

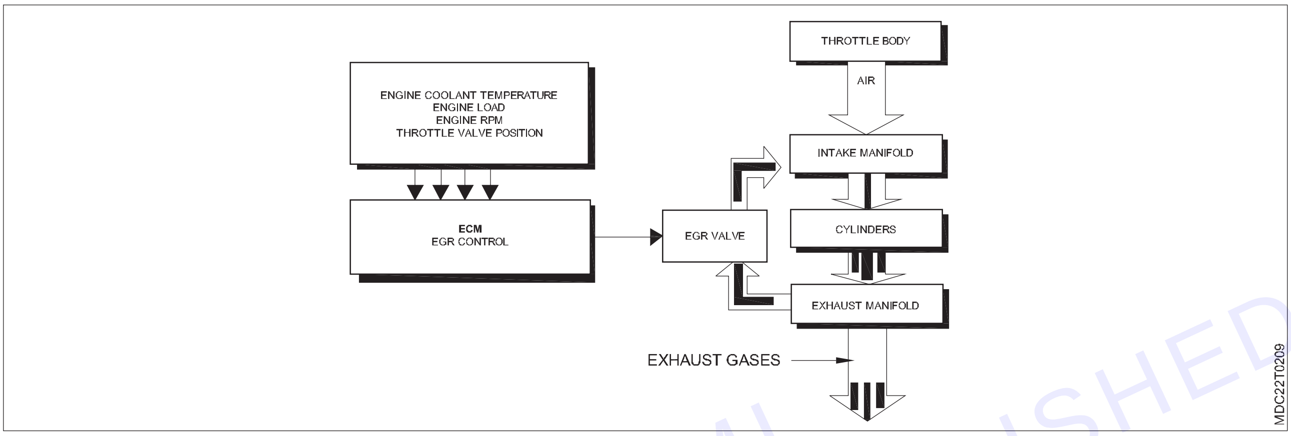
Working Method

The EGE system reduces nitrogen oxide formation and also controls engine knocking.



The Ganche diagram shows the entry of a small amount of exhaust gas into the intake air-fuel mixture at the intake manifold by recirculation. The EGR valve is installed between the exhaust port or manifold and the intake system. If the engine produces oxides of nitrogen, the EGR valve is opened, allowing some of the gases (6 to 10%) to pass through the exhaust and into the intake system. During combustion, these exhaust gases absorb heat from the burning air and fuel. Due to this the combustion temperature decreases and nitrogen oxide is formed by the reaction of nitrogen and oxygen. Older EGR systems use a vacuum regulated EGR valve while newer vehicles use an electronic EGR valve to control the recirculation of exhaust gases.

When the engine operates at ideal conditions the EGR valve is kept closed. In this condition no EGR gas flows from the manifold. The EGR valve is kept closed until the engine warms up and starts operating under load. As load and combustion temperatures increase, the EGR valve is opened and exhaust gases begin to leak into the manifold. This process produces a quenching effect which reduces the temperature of combustion thereby reducing the formation of oxides of nitrogen.



The EGR valve opens and closes the passage between the exhaust and intake manifold, allowing vacuum to be removed through the EGR valve.

MODULE 13 : Trouble Shooting of HMV

LESSON 84 : Digital panel board gauges and their circuit. Details about MIL indicator, cooling system indicator, oil level indicator, battery charging indicator, glow plug indicator etc

Objectives

At the end of this lesson you shall be able to

- locate and trace digital panel board gauges and their circuit
- explain the details of different Indicators of panel board.

Introduction of dashboard: A digital panel board gauge is an electronic display used to monitor and display various parameters such as temperature, pressure, voltage, or current within an electrical system. It provides real-time data in a digital format, offering accuracy and convenience for monitoring and control purposes.... dashboard (also called dash, instrument panel or IP, or fascia) is a control panel set within the central console of a vehicle or small aircraft. Usually located directly ahead of the driver (or pilot), it displays instrumentation and controls for the vehicle's operation. An electronic equivalent may be called an electronic instrument cluster, digital instrument panel, digital dash, digital speedometer or digital instrument cluster.

The dashboard in a vehicle is the panel facing the driver's seat where most of the instruments and switches are. An automobile dashboard monitors vehicle speed, engine speed, and engine temperature. Contemporary dashboards may include the speedometer, tachometer, odometer, engine coolant temperature gauge, and fuel gauge, turn indicators, gearshift position indicator, seat belt warning light, parking-brake warning light, and engine-malfunction lights.

Car dashboard function & parts:

- **Car indicator light:** Car indicator lights are one of the components in a dashboard. The indicator light will usually get special attention from drivers because it is positioned right in front of the rider....

  Indicator lights can show engine temperature, door, airbag indicator, brake, check engine, RPM, speedometer ignition key is usually at the bottom right of the car steering wheel. You insert your car key there to start the carter, seat belt and odometer. All the indicators listed have different functions....

- **Car drawer:** The car drawer is usually right at the front of the passenger and serves to store various goods. Some items must be stored in a car drawer, but many car owners ignore them.

  Items that must be stored in a car drawer are usually cell phone chargers, flashlights, first aid kits, manuals and car insurance document books. The availability of these items is important, so you fill them up if you haven't already.

- **Ignition key:** The ignition key is usually at the bottom right of the car steering wheel. You insert your car key there to start the car.

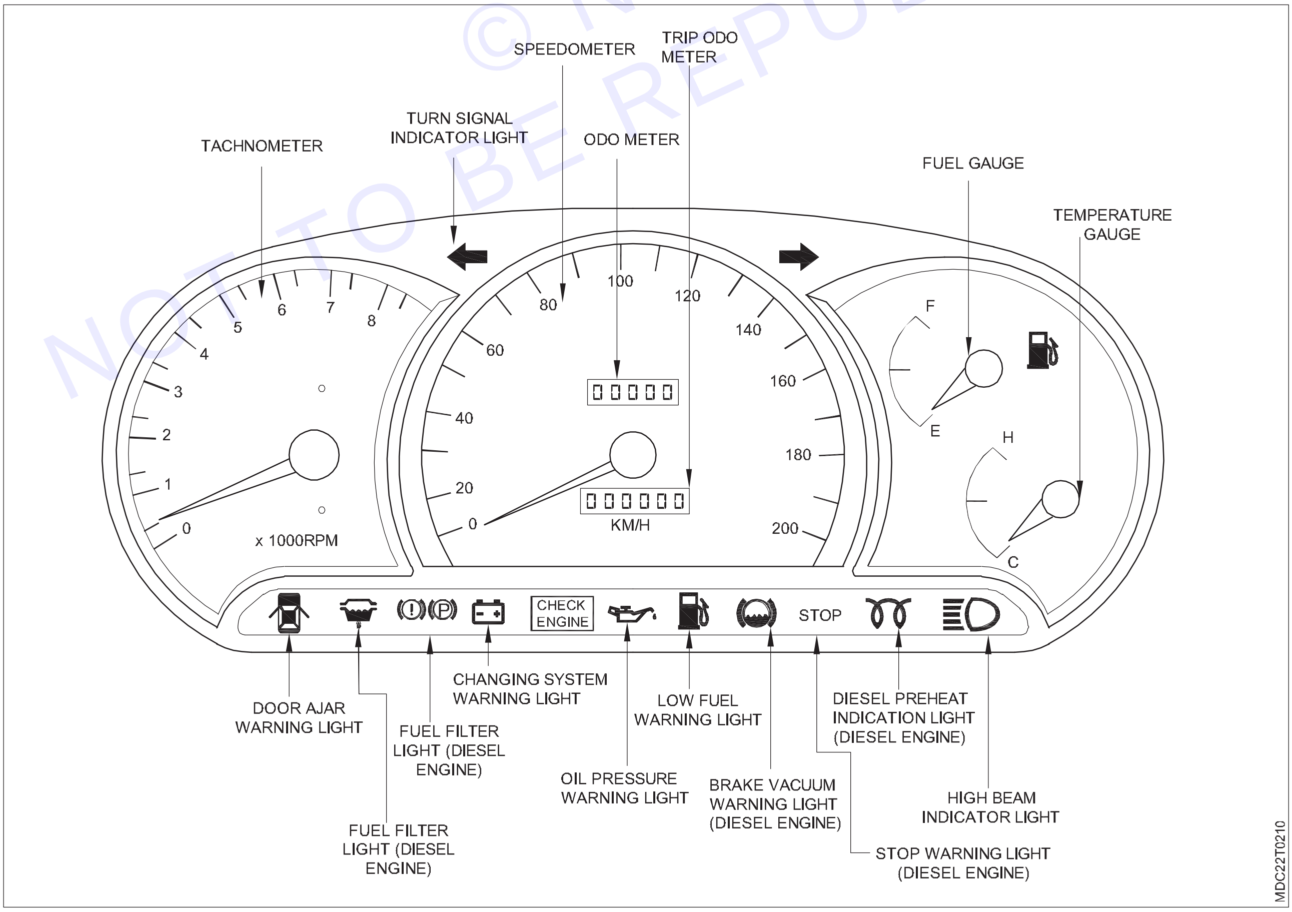
- **Lever:** Car levers are usually located on the left and right of the car's steering wheel. When turning on the turn signal & the lever functions to turn on the headlights at night and turn on the fog lights when the weather conditions are foggy....

The transmission lever used in a car is a lever that functions to shift gears in the car's transmission system. With the transmission lever, you can increase or decrease the car's speed by shifting gears....

- **Head unit:** In general, the head unit becomes the entertainment center of a car. With the head unit, you can play music or connect to a cellphone to make a call. If the car is not equipped with a head unit, the nuances in the car will be boring.

The head unit on the market has 2 sizes, namely 1 DIN or single DIN and 2 DIN or double DIN sizes. In that sense, DIN stands for Deutsche Institute Fur Norming which is the standard measure in manufacturing head unit products.

Gauges of dashboard: In simple words, gauges are those dials and sensors that help a driver to monitor various systems of a car. For every driver, it is essential to learn about these details before taking off on the road. Monitoring dash gauges while driving is crucial because it displays issues and malfunctions in a car.



Where the dashboard originally included an array of simple controls (e.g., the steering wheel) and instrumentation to show speed, fuel level and oil pressure, the modern dashboard may accommodate a broad array of gauges, and controls as well as information, climate control and entertainment systems.

Contemporary dashboards may include the speedometer, tachometer, odometer, engine coolant temperature gauge, and fuel gauge, turn indicators, gearshift position indicator, seat belt warning light, parking-brake warning light, [4] and engine-malfunction lights. Heavy vehicles that feature air brakes, such as trucks and buses will also have gauges to indicate the available air pressure in the braking system. Other features may include a gauge for alternator voltage, indicators for low fuel, low oil pressure, low tire pressure and faults in the airbag (SRS) systems, glove compartment, ashtray and a cigarette lighter or power outlet – as well as heating and ventilation systems, lighting controls, safety systems, entertainment equipment and information systems.

Types of gauges: These are six common types of dashboard gauges. Let's understand their functions and how one can read them....

- **Speedo meter:** If someone has to rank the most important gauge in a car, it would be the speedometer. However, a speedometer's function is highly dependent on car tyres. Therefore, even minor inaccuracies can affect your car's speed. Previously a car's speed was measured through a complicated system, but it got simplified with the electronic sensors.

How to read a Speedometer?

Speedometers contain two semicircles with markings. The smaller or inner semicircle indicates your car's speed in kilometres per hour (km/h). However, the outer semicircle indicates your speed in miles per hour (mph).

- **Fuel gauge**

Another crucial dash instrument is the fuel gauge. Car manufacturers deliberately made it for inaccurate reading. After filling the tank, you will notice that this gauge stays on the full (F) sign for a long time and gradually drops. When this needle points at the empty sign (E), it still contains some fuel (1-2 gallons) in reserve.

How to read a Fuel Gauge?

Reading a fuel gauge is the simplest. 'F' in this gauge denotes 'Full', and 'E' stands for 'Empty'. Unfortunately, when one is too focused on the road, they can miss where that needle is located in this gauge. To avoid such situations, car manufacturers have installed warning lights. If you notice it is blinking, immediately fill your car tank.

- **Temprature gauge**

From the name itself, you can figure out its function. This particular dashboard meter measures the engine coolant. When you start a car, the gauge will first display it is cold and then rise. If your car signals a rising temperature, it is better to pull over and let the engine cool down. Continuing to drive with an overheated engine can cause permanent damage to the car.

How to read a Temprature Gauge?

In older car models, this was simply denoted with hot or cold signs. It is now changed to a thermometer symbol, but not all cars come with a temperature gauge. Instead, they now have a temperature warning light that glows when the engine overheats. You must let your engine cool down in situations like this by making a pit stop.

- **Tacho meter**

Unlike other dashboard gauges, a tachometer is the least used. However, tachometer readings are essential in cars that need a manual transmission. This helps the driver know the right time to change gears. Monitoring a tachometer also helps maintain fuel efficiency along with the best acceleration. Another purpose of a tachometer is to warn if the engine is pushed roughly.

How to read a Tachometer?

The function of this gauge is to measure how fast the engine turns RPM (revolutions per minute). So, on the dashboard, you will find single-digits displayed along with “x 1000”. Thus, indicating you need to multiply the number displayed by 1000. With a higher RPM reading, more fuel is consumed. So, the best reading is when the RPM is lower and consistent to help the engine operate at an optimal level.

- **VOLT METER**

Voltmeter provides information on the battery health of a car. Unlike the other digital dashes, not all passenger cars have this gauge but contain a low-battery warning light. If the voltmeter lights up in any condition, it indicates something is wrong with your vehicle’s electrical system.

How to read a Voltmeter?

Most vehicles nowadays contain a 12-volt electrical system. Therefore, when a car battery is fully charged and functional, it must read 12.5 volts when the engine is not running. On the other hand, if the engine is running, its alternator will recharge the battery. Therefore, if you notice a drop in the voltmeter, the car will not start....

- **Oil pressure gauge**

As the name states, the oil pressure gauge measures fuel consumption. Oil is responsible for running all its other parts. It is never a wise decision to drive a car with a lower fuel level as it can damage your car’s engine. Lower oil pressure can occur in instances if there is any serious leakage. Another possibility is that the fuel is full of dirt, making it difficult to flow....

How to read an Oil Pressure Gauge?

Previous automobile models used to have a dial displaying oil pressure. However, newer models now have a warning light on the dashboard that marks the oil pressure levels. You can measure this in pounds per square inch or psi. Whether in an older car or new, if you find the low oil pressure signal is on, you must opt for car servicing.

Indicator

Indicators are a universal language by which all the drivers communicate. The job of the indicators is not only the left and right turn, but it has the much wider possibility and can be combined with the hand gestures that everyone can understand and follow to avoid any mishap on the road....

- Warning symbol indicator
- Safety symbol indicator
- Light symbol indicator
- Advanced features symbol indicator

Warning symbol indicator

1 **Break warning lights**

This warning light signals that the brake fluid pressure is too low. This could be a hazardous situation as you might find yourself without any brakes and must be checked immediately. As soon as it’s safe to do so, pull over and come to a complete stop. Maintain a modest pace and prevent abrupt braking. Even if it flickers on and off, you should still check your brake fluid level.

2 Air bag warning lights

This warning light indicates that something is wrong with the seatbelts or the airbags. It is not safe to drive when this light is on. The front occupant classification system determines the front passenger's weight as well as position to securely deploy the airbag. If the airbag device is malfunctioning, one or more airbags may not deploy in a collision or, in certain situations, it may even deploy unexpectedly and result in a collision.

3 Power steering warning lights

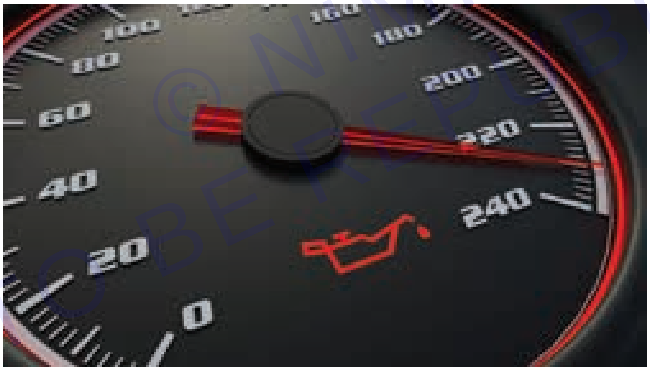
This warning light indicates that the power steering is malfunctioning and prompts you to investigate for a cause. When you see this warning light, it is best to stop in a secure location and restart the car after 30 seconds. You should get your automobile examined as quickly as possible if the light remains on.

4 Engine temperature warning lights

When the engine is overheated, this light will illuminate. When the light becomes red, you should immediately come to a stop and wait till the engine has completely cooled. An overheated engine can cause irreparable damage to your engine; you should have it checked as soon as possible.

5 Oil warning lights

This warning light indicates that the engine oil pressure is too low. This drop in oil pressure could be caused by dirty oil, low oil level, or leaking oil. It is unsafe to drive when this warning light comes on. Stop the vehicle at a safe spot and turn off the engine. Check your oil level or signs of leaking oil. If the warning light persists, it is best to call for a tow.



Safety symbol

1 Seat belt reminder light

The seatbelt warning sign indicates that your seatbelt is not fastened. This sign will light up when the person in the passenger seat hasn't fastened his/her seatbelt. Putting on the seatbelt is the easiest way to fix this. If this light comes on even after the seatbelts are fastened properly, you should have it checked.

2 Door open warning symbol

If one or more doors are open, this cautionary sign will light up. This warning sign will also appear if one or more doors are not properly closed. Open the doors and then close them properly to stop the warning light.

3 Bonnet open symbol

The icon signifies that the car's bonnet is opened or not properly closed. If there is a problem with the bonnet's locking system, the light can come on.

4 Steering wheel lock symbol

This indicator should come on when the ignition is in the off position and the steering lock is engaged. If you see it come on under any other circumstances, you should have it checked.

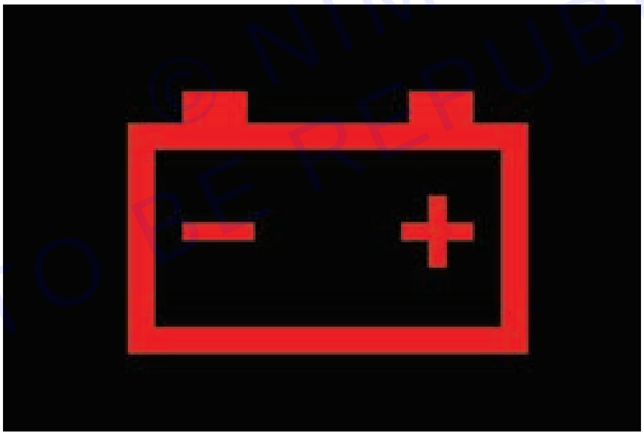
5 **Automatic gear box warning symbol**

If there is an issue with automatic transmission, the warning indicator will activate. Driving should be avoided when this symbol appears.

Lighting symbol

1 **Battery charge warning light**

If your dashboard displays a battery symbol, there is an issue with battery charging. This indicator may also illuminate when the battery is overloaded. When you notice this warning light, have your battery examined right away.



2 **Low fuel warning light**

This indicator has one purpose—to tell the driver that the fuel tank is running low. Refuel at the nearest gas station as soon as you notice a limited fuel warning signal.

3 Low beam indicator

Whenever the low beam lights are activated, a low beam illumination sign appears. The symbol has rays indicating how the light is falling on the road ahead rather than pointing forward.

4 High beam indicator

You see this sign when the high beam lights are active. The symbol has rays indicating how the light is pointed forward rather than on the road.

5 Exterior Light Fault

A warning light for exterior lights signals a problem with one or even more external lights, typically with damaged light.

Advandced features symbols

- **Cruise control Light**

  This sign will illuminate whenever the cruise control is activated. Your vehicle may use two different colours to let you know which state the cruise control is in. The colour of the light will tell you if the cruise control has been engaged or not. If the light is on even when cruise control is not engaged, it could be due to many reasons such as a blown fuse or a malfunctioning speed sensor.

- **Collision warning light**

  When a car is driving dangerously close to another vehicle, an object, or a group of pedestrians, a warning message will show. Some cars feature sensors that detect front, side, and rear collisions. If you get this warning, be prepared to brake / steer to safety.

- **Speed limiter light**

  It is a sign that turns on when the speed limit feature is engaged. To avoid going faster than a certain speed, the driver might establish a speed restriction.....

- **Hill descent light**

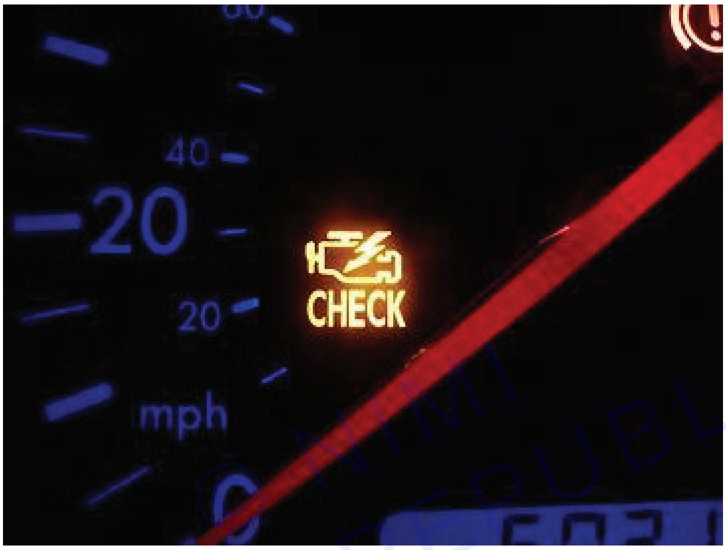
Whenever the hill slope control system is engaged, this sign illuminates. You can keep a certain pace while descending the hill with the aid of the system.

- **Lane assis light**

The lane assist function is engaged while this light is on. It can recognize lane markings or road markings to help the driver stay in the same lane.

Malfunction indicator lamp (mil) indicator

The MIL (Malfunction Indicator Lamp) indicator on a digital panel board gauge signals the presence of a malfunction or fault in the vehicle's engine or emissions system. When illuminated, it alerts the driver that the onboard diagnostic system has detected a problem that needs attention. Common issues that trigger the MIL indicator include engine misfires, emissions system faults, or sensor malfunctions. It's essential to address the underlying problem promptly to prevent potential damage to the vehicle and ensure it meets emissions standards. check engine light or malfunction indicator lamp (MIL), is a tell-tale that a computerized engine-management system used to indicate a malfunction or problem with the vehicle ranging from minor (such as a loose gas cap) to serious (worn spark plugs, engine problems or a faulty oil valve, etc.). Found on the instrument panel of most automobiles, it usually bears the legend engine,[1] check engine, service engine soon, maintenance required, emiss maint,[2] or a pictogram of an engine—and when illuminated, it is typically an amber or red color.



Cooling system indicator

A cooling system indicator on a digital panel board gauge typically displays vital information about the cooling system of a device or equipment. It might show parameters such as coolant temperature, coolant level, fan speed, any alarms related to overheating or malfunctioning components within the cooling system.This information is crucial for maintaining the optimal operating conditions of the equipment and preventing potential damage from overheating.If the coolant warning light becomes illuminated on your dashboard as you're driving along, it's a certain sign that your engine is overheating. In order for your car to work,series of explosions are created in the combustion chamber.

Glow plug indicator

A glow plug indicator on a digital panel board gauge is designed to show the status of glow plugs in a diesel engine. When starting a diesel engine, especially in cold weather, glow plugs preheat the combustion chamber to aid ignition. The indicator will typically illuminate when the glow plugs are active, helping the operator know when it's safe to start the engine. Once the engine is running, the indicator should turn off, indicating that the glow plugs are no longer needed.The glow plug light, also known as the preheat light, is an indicator on a diesel engine that tells the driver that the engine's glow plugs are heating up. These plugs are used to heat the air in the combustion chamber before the engine is started.

LESSON 85 & 86 : Tune up the engine with the help of multi scan tool, adjusting of valve tappet clearance checking and setting at injection timing & valve timing

Objectives

At the end of this lesson you shall be able to

- tune up the engine with multi scan tool.
- adjust Tappet clearance
- setting Vale timing and Injection timing.

Tune up the engine with the help of multi scan tool

Below are the steps to tune the engine with the help of Multi Scan Tool

- **Connect the multi-scan tool:** to the vehicle's OBD-II port, which is usually located under the dashboard on the driver's side. Carefully plug in the multi-scan tool.
- **(DTC) Read Diagnostic Trouble Codes:** Read stored diagnostic trouble codes using the multi-scan tool. These codes indicate potential problems with various engines.
- **Live Data Check:** Access multi-scan tool live data to monitor real-time engine parameters such as fuel trim level, engine speed, coolant temperature, oxygen sensor readings.
- **Analyze Data:** Analyze live data to identify any anomalies or areas where engine adjustments may be needed. Pay attention to fuel trim parameters, which may indicate the engine is running too low or too fast.
- **Adjust parameters:** Depending on the data analysis, various engine components may need to be adjusted.

  Spark Plugs: Replace damaged spark plugs with new ones to ensure proper ignition

  Ignition Timing: Use the Multi-Scan tool to adjust ignition timing as necessary for optimal performance.

  Fuel Injectors: Clean or replace fuel injectors if you want to improve fuel delivery and efficiency.

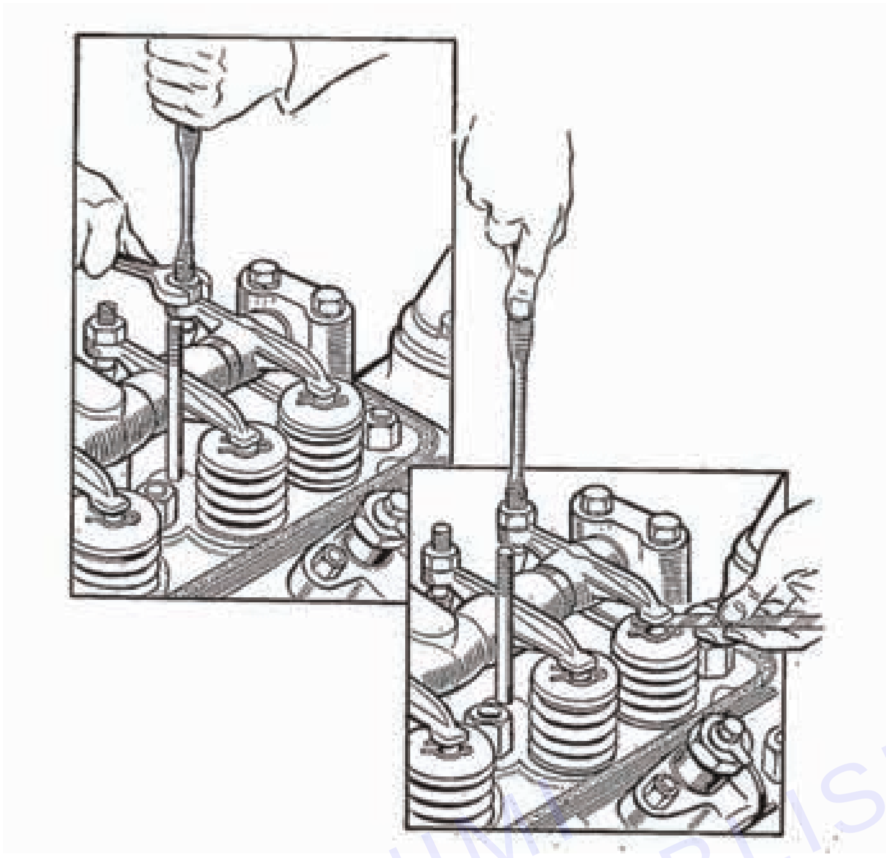
  Air/Fuel Mixture: Adjust the air/ fuel mixture based on oxygen sensor readings to achieve the ideal ratio for combustion.
- **Monitor changes:** After adjustments have been made, monitor the live data again to ensure that engine efficiency has improved as a result of the changes. Performance also improved.
- **Clear DTC:** After the tuning procedure is complete and the problem has been resolved, clear any stored diagnostic trouble codes. Use the multi-scan tool to clean.
- **Test Drive:** Engine running smoothly. Take the vehicle for a test drive to verify that the previous issues have been resolved.
- **Final Check:** Reconnect the multi-scan tool to recheck the engine parameters if any residual problems or abnormalities occur.

Adjusting of valve tappet clearance checking and setting at injection timing & valve timing

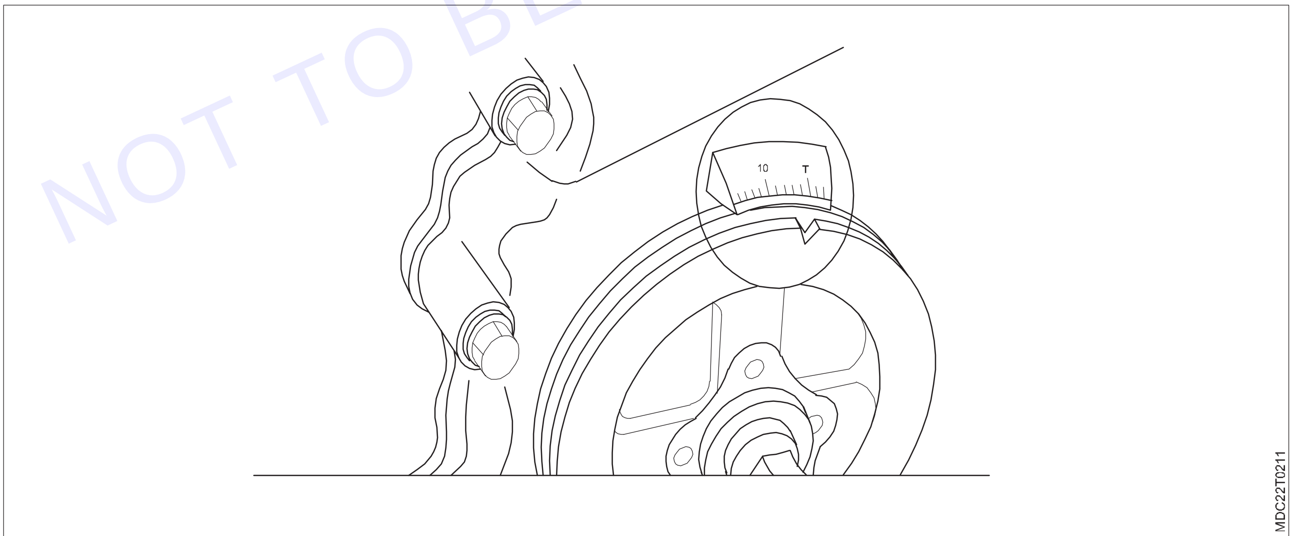
Adjusting the valve tappet clearance: It is important to check the clearance and calibration of valve to avoid noise, loss of power as well as less fuel consumption with excessive emission of pollutants.

Through these problem, the engine manufacturers suggest to identify the valve timing problem.

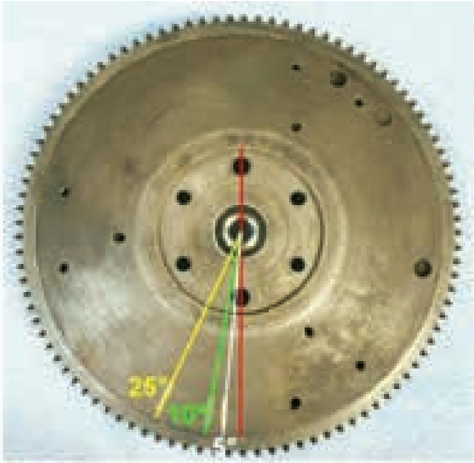
It is also called tappet clearance. The clearance is given between the top face of valve stem and rocker arm tip when valve is closed. As shown in given fig.



Adjustment of tappet process: For tappet adjustment both valves should be in closed position when piston of that cylinder is at TDC on compression stroke. At this time, the valve timing mark punches either on flywheel or on Dumper pulley, should coincide with pointer. Remember piston inn one cycle reaches on TDC twice during compression and exhaust stroke. We have to adjust the during compression stroke only. To confirm this, rotate both to push rods by hand. If they are loose enough, piston TDC compression stroke.



You can also check this by another method by bringing the timing mark under the pointer and then rotating the flywheel 20 degree clockwise and then anticlockwise. If rocker arm starts dancing i.e. inlet valve opens and exhaust valve closes or vise-versa. It shows that piston is at exhaust stroke TDC position. So to get piston in compression stroke, rotates the crankshaft by one revolution and adjust tappets.

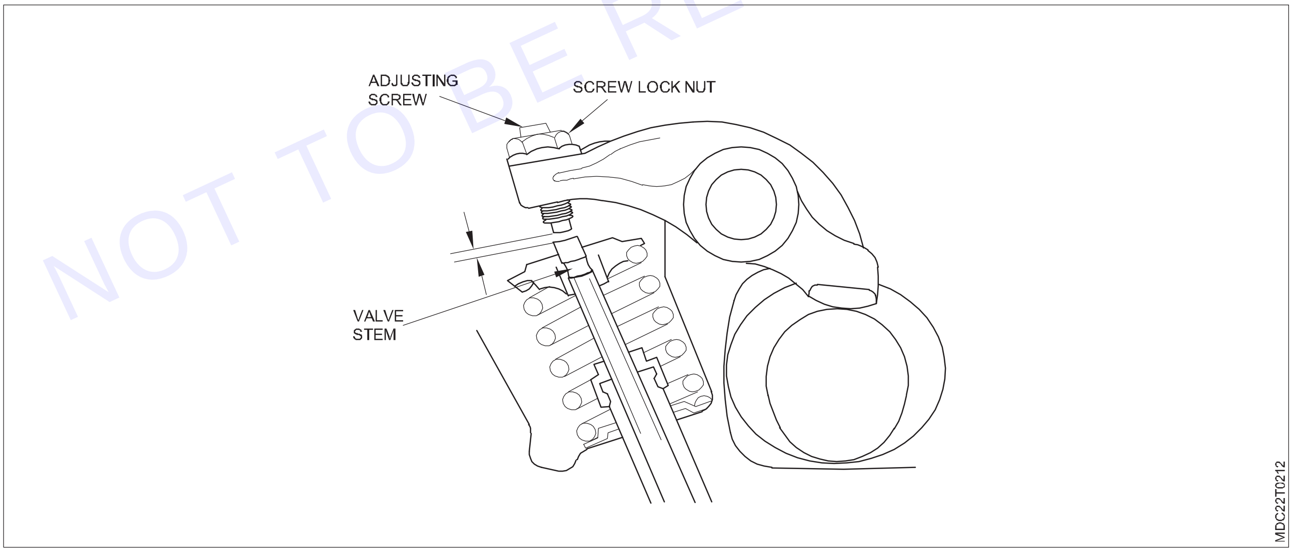


Tappet adjusting in multi-cylinder engine

If tappet adjustment four cylinders' engine is to be adjusted having firing order 1, 3, 4 and 2, then adjust the tappet clearance of 1 cylinder, as explain above method, then rotate the crankshaft by half revolution, adjust tapped 3 cylinder again rotate by half revolution and adjust 4th tapped cylinder and finally rotate it by half revolution and adjust tappet of 2 cylinder. For six cylinders' engine having firing order 1, 5, 3, 6, 2, 4. Adjust tappet of 1 cylinder by bringing the pistons on TDC in compression stroke, rotate the crankshaft one third (1/3) revolution every time and go on adjusting tappet according fining order.

Adjusting tappets Engine

Engine has a camshaft fitted on its head which operates directly rocker arm, the other of rocker operates the valve through adjusting screw. The system for valves operating mechanism is shown in given figure. In this valve clearance is adjusted by means of adjusting screw up and down with the help of screw driver and placing the feeler gauge between valve.



here are some important points While adjusting of valve tappet clearance checking and setting at injection timing & valve timing

Preparation: Before starting, ensure the engine is cool and in the correct position, usually at top dead center (TDC) for the cylinder being adjusted.

Locate Specifications: Refer to the manufacturer's specifications for the correct valve tappet clearance, injection timing, and valve timing for your engine model.

Access the Valves: Remove any necessary components to access the valves, such as the valve cover.

Adjust Tappet Clearance: Using feeler gauges, measure the clearance between the valve stem and the tappet. If adjustments are needed, loosen the locknut and turn the adjusting screw until the correct clearance is achieved. Then, tighten the locknut.

Injection Timing: Follow the manufacturer's instructions to set the injection timing. This often involves aligning timing marks on the crankshaft and camshaft gears.

Valve Timing: Ensure the valve timing is correctly synchronized with the crankshaft position. This typically involves aligning timing marks on the camshaft(s) and crankshaft.

Verify and Reassemble: Double-check all adjustments and timing marks. Once satisfied, reassemble any components removed for access.

Test & Run: Start the engine and listen for any unusual noises or performance issues. Recheck the adjustments if necessary.

Final Checks: After running the engine for a brief period, recheck the valve tappet clearance, injection timing, and valve timing to ensure they remain within specifications

LESSON 87 : Engine performance tests

Objectives

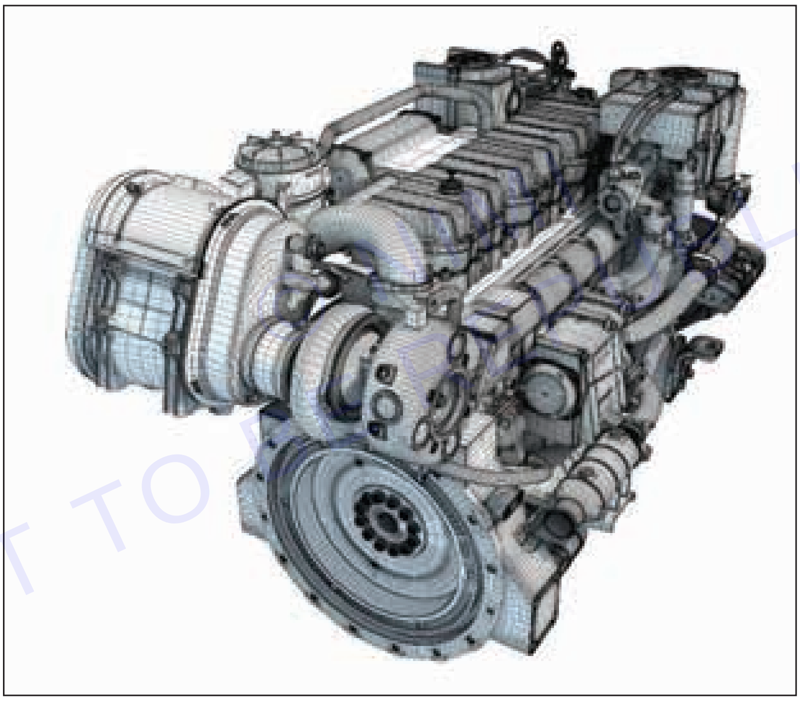
At the end of this lesson you shall be able to

- perform different tests in engine.

Purpose of testing an IC engine. Classification of test, fault finding tests, routine test

Introduction

We know about of engine, Engine is one of the most and crucial machine, it also powerhouse which develop and provides motive power to propelled the vehicle for performing the various function of vehicle. I.C engine is work is very quick or strong therefore, it's effective is also strong. For strong and effective performance, we should follow some different types of testing, this testing is best to identify and analysis for make a strong engine performance as well as also surety of increase engine life too. Therefore, we should need to understand about different kind of testing.



To find out performance before mass production and fitting it into a vehicle. Historically, the test basically was to find out the power and fuel consumption, also test effectiveness of cooling, vibration and noise, lubrication, controllability such like all things.

Engine test are classified in different way

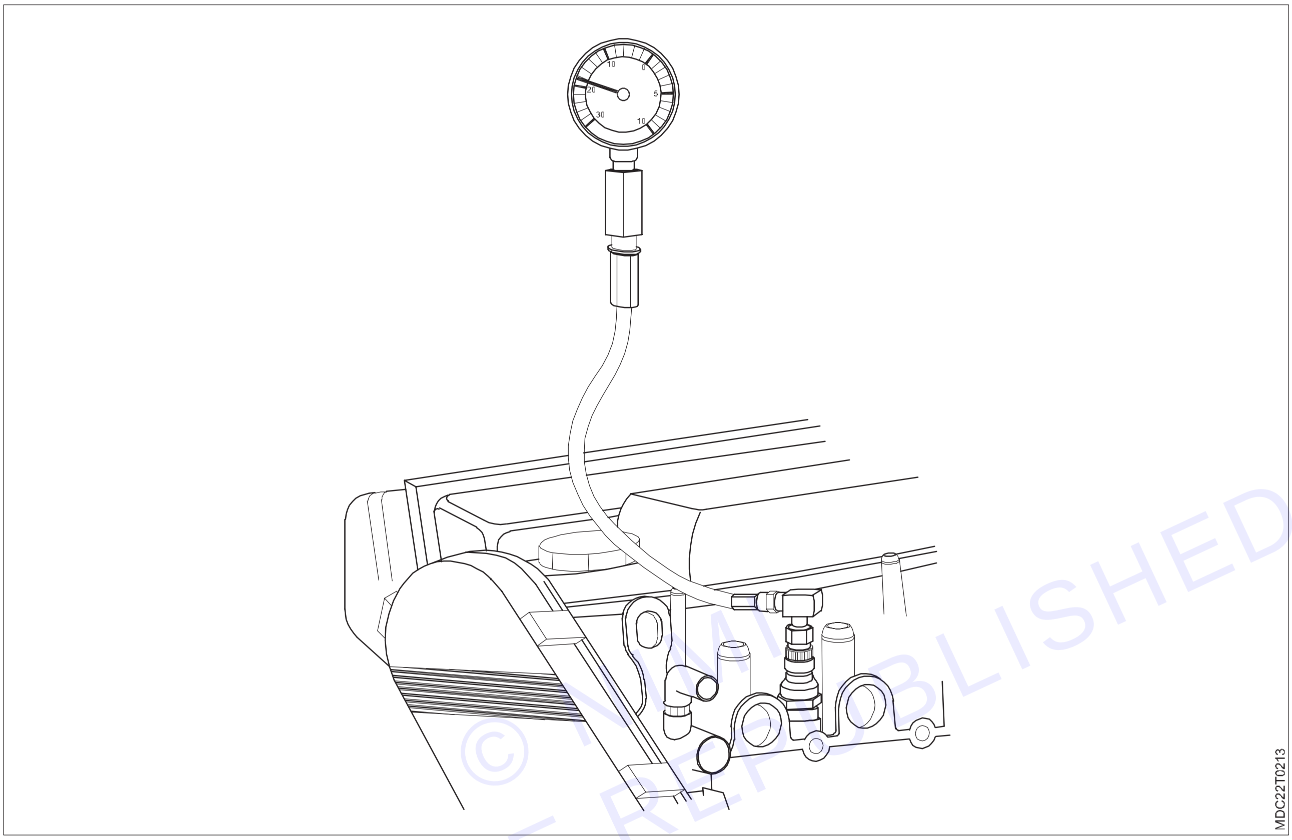
First of all, ensure that about your engine like parameters, type engine if you sometimes you have doubt about your engine please give proper suggestion before testing.

Precaution: The engine operates effectively, delivering expected power, output, and fuel efficiency while meeting emission standard.

Here, discus about some common method used to test I.C engines. However, some specific testing procedures may vary depending on the type and application of the engine.

Compression test

A compression test measure's a cylinder ability to hold pressure as the piston move's up and down. The pressure at the end of the operation is about 35 bar in petrol engine and about above 95 bar and above (HCV) in diesel engine.



A good rule of thumb says that each cylinder in mechanically compression should have approximately 130 psi (8.96 bar) and higher.

Visually inspection

The engine should be inspected visually for any signs of damages or wear. This includes looking for cracks, leaks, excessive corrosion and any other things.

Visual inspection is non-destructive testing method for quality control. In its original form, visual inspection is used to observed the surface of an engine any other physical activates

Performance testing

Performance testing basically its including some technical specification about engine like friction power, indicative power, brake power, specific fuel consumption, air fuel ratio, thermal efficiency, mechanical efficiency, volumetric efficiency etc.

Here for measuring power and torque use dynamometer.

Dynamometer are types is

1 Prony brake dynamometer

2 Rope dynamometer

3 Hydraulic dynamometer

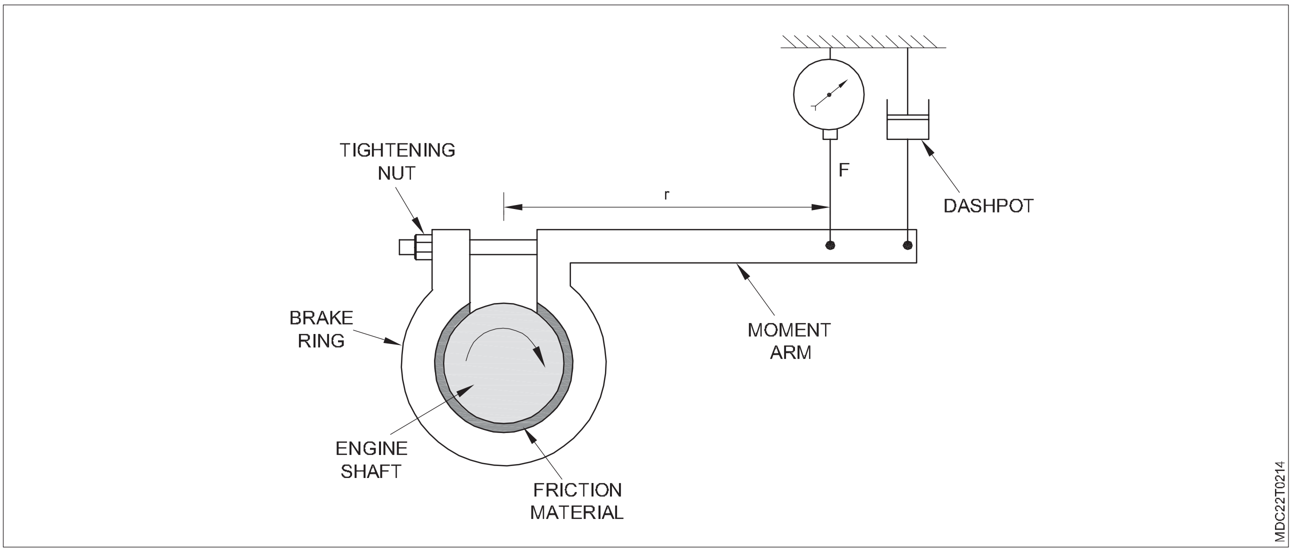
4 Belt transmission dynamometer

5 Epicyclic dynamometer

6 Torsion dynamometer

Engine torque: The fundamental output of the engine.

Torque is measured by a dynamometer or an in-line devices.



Torque measurement= restraining force × radius of movement arm

Power = torque × angular speed

Angular speed = 2π × engine speed

As are some different types dynamometer work about depend upon it's characteristics

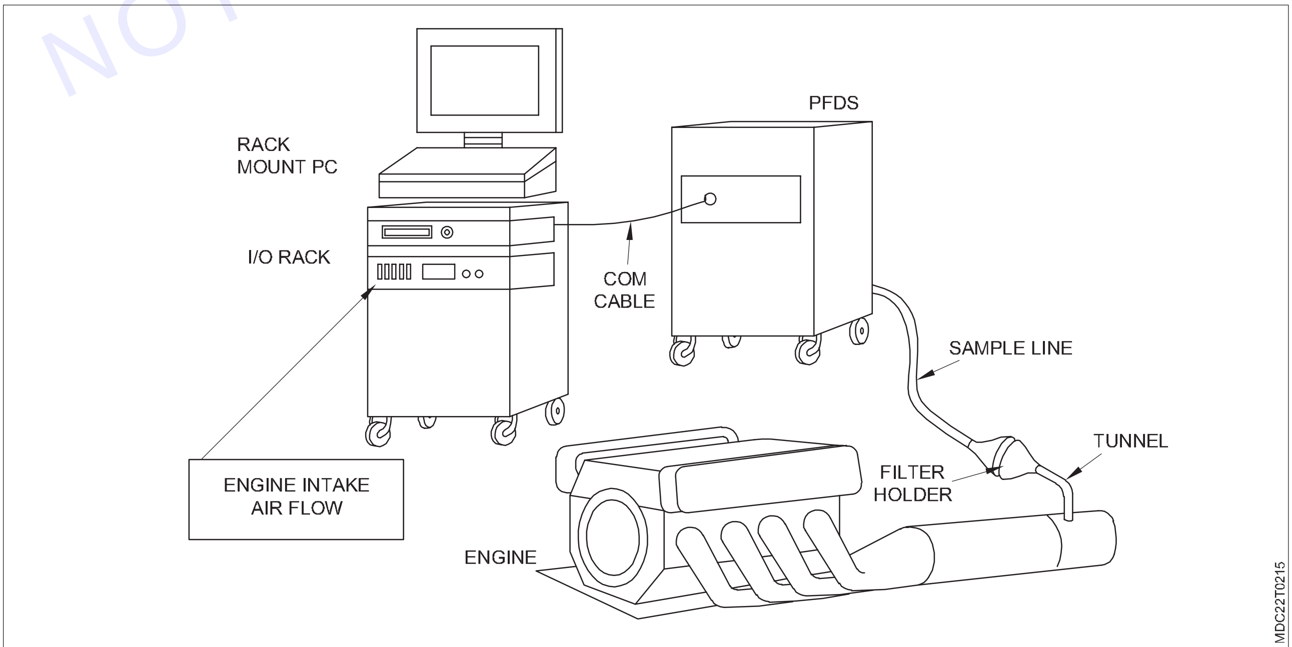
Emission testing

Emission Sampling: Collect samples of exhaust gases using specialized equipment placed at the tailpipe of the engine.

Analyzing Emissions: Analyze the collected samples for various pollutants, including carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx), particulate matter (PM), and others.

Measurement Methods: Utilize specific measurement techniques such as gas analyzers, smoke meters, and particulate analyzers to quantify emissions.

Testing Conditions: Conduct tests under standardized conditions defined by regulatory bodies, including engine speed, load, and ambient temperature.



Fuel supply testing

fuel system for use in an internal combustion engine includes a plurality of fuel injectors, each injector including at least one capillary flow passage, the at least one capillary flow passage having an inlet end and an outlet end, a heat source arranged along the at least one capillary flow passage, the heat source

A fuel supply system for a spark-ignition internal combustion engine

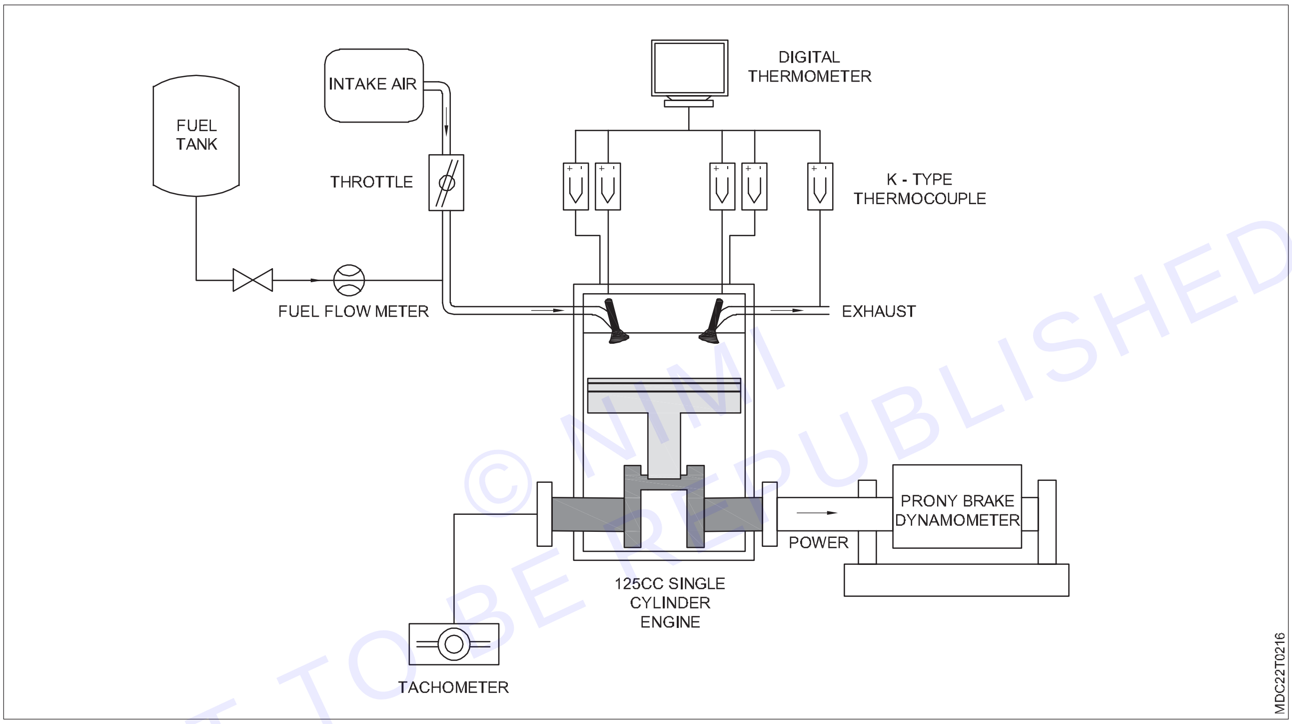
1 Having at least one cylinder

2 Defining a combustion chamber

3 With a blow-in nozzle

4 For blowing a mixture of a liquid fuel and a pressurized

5 Each including a blow-in valve combustion gas into the combustion chamber.



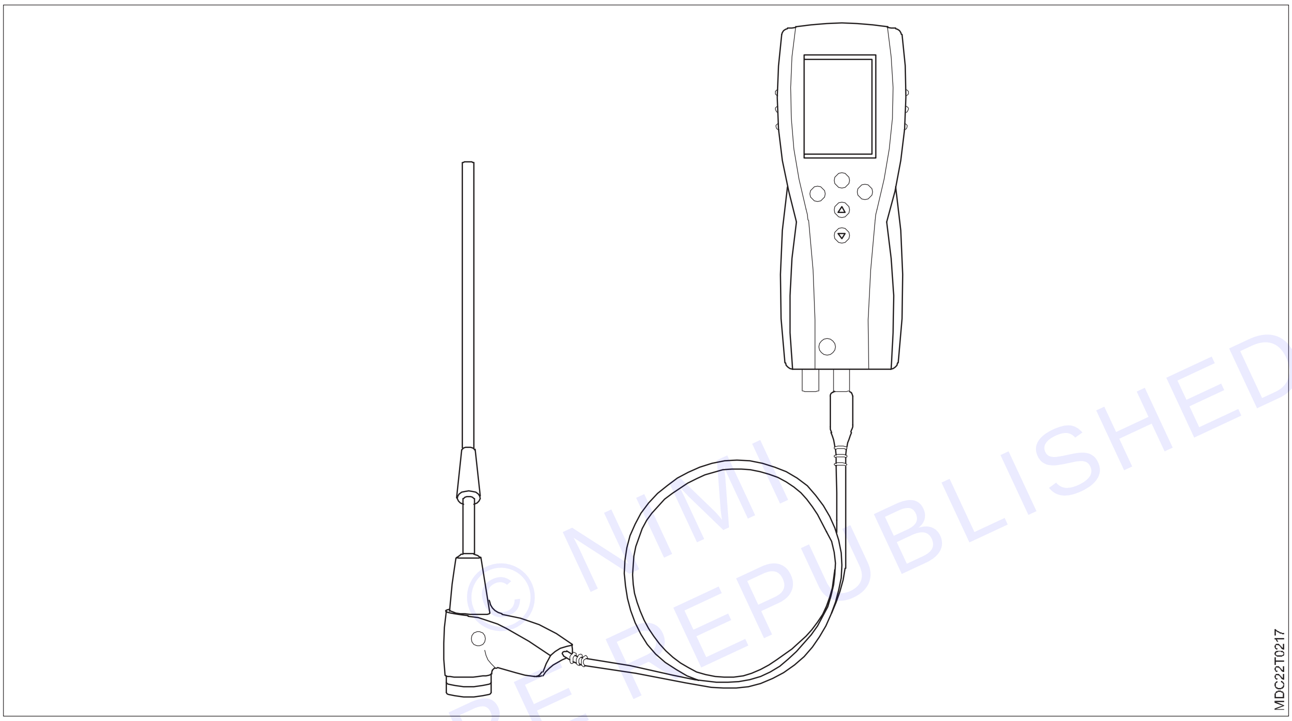
Back-leak testing

It is part of fuel supply testing. In these test are identify, which injector are supply un proper fuel in cylinder. In these system injector are test by Picoscope.

Injector back-leakage is seen as a pulsation when viewed using a PicoScope. The pulsation is formed as a result of each injection event as follows: High-pressure diesel generated by the high-pressure diesel pump is fed directly to the common rail and into the injector assemblies.

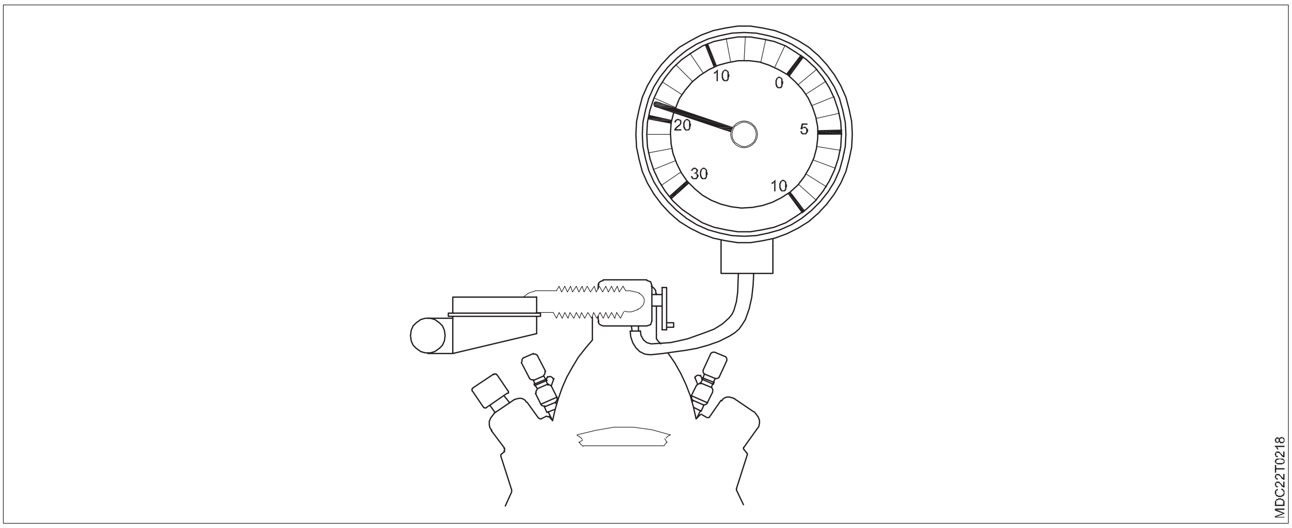
Exhaust analysis

Exhaust analysis is conducted to check the engine emission's level, which are regulated by many countries. This test analyzing the gases emitted by the engine, such as carbon monoxide, nitrogen oxides, hydrocarbons etc.



Vacuum test

- Cranking vacuum test
- Idle vacuum test
- Low and steady vacuum
- Fluctuating vacuum



Procedure for performing engine vacuum tests

Perform a vacuum gauge test to determine engine condition and performance.

Note

Accurately diagnosing problem with a vacuum gauge can be difficult. Steady and compare reading to diagnostic charts.

Connect the vacuum gauge to an intake manifold vacuum source. Connect a vacuum hose to an accessible intake manifold vacuum connector and extent it up to the vacuum gauge.

Connect the exhaust ventilation equipment.

Caution

Be use to sure approved exhaust ventilation equipment when operating a vehicle in an enclosed area.

Start the engine and allow it to reach normal operating temperature.

Measurement of ihp, indicative mean effective pressure, bhp, mechanical efficiency, fuel consumption

Indicated horse power (IHP) - The power developed in an engine cylinder, is called the indicated horsepower. The formula is as follows

$$IHP = \frac{PmLAN}{4500} \times K$$

Here,

pm = mean effective pressure (in kg/cm)

L = stroke length (in meters)

A = Area of the piston (in cm)

N = Number of strokes in one minute

K = number of cylinders.

Brake horse power (BHP) - The output power of the engine present on the engine flywheel is called Brake Horsepower (BHP).

This is represented by the following formula

$$BHP = \frac{2\pi NT}{4500}$$

Here,

N = rotating speed of the crankshaft (in rpm) and

T = generated torque.

Frictional horsepower (FHP) - The power lost due to friction in an engine is called frictional horsepower. The formula is as follows

$$FHP = IHP - BHP$$

Mechanical efficiency - The ratio of brake horse power (BHP) and INDICATED horse power (IHP) in the engine is called mechanical efficiency. It is expressed as a percentage. Its formula is as follows

$$\text{Mechanical efficiency} = \frac{BHP}{IHP} x100$$

Indicated mean effective pressure: When we consider an imaginary Pressure which when remaining constant will give the same work done for some change in volume like that of actual cycle. than the imaginary constant pressure is known as indicated mean effective pressure of cycle.

Work done by IMEP is:

$$Pm = W/Vs$$

Vs = swept volume.

Fuel consumption: Fuel consumption measures the amount of fuel a car consumes to go a specific distance. It is expressed in liters per hundred kilometers.

Specific fuel consumption - How much fuel required to generate 1 KW OR 1 BHP power for 1 hour

Unit of SFC-- g/kWh or g/BHP h

Type of SFC

1 ISFC - Indicated specific fuel consumption

2 BSFC - Brake specific fuel consumption

Measurement of Thermal efficiency, Volumetric efficiency, Relative efficiency, Air consumption, Lubricating oil consumption

Measurement of Thermal Efficiency: Thermal efficiency is a measure of how well an appliance converts input heat energy into useful work or output energy. It is calculated as a percentage using the formula. It applies to engines, power plants, and other systems that involve converting heat into work.

For example: In the context of engines, it refers to the ratio of the mechanical work produced by the engine to the heat energy contained in the fuel consumed.

Measurement of Volumetric Efficiency: Volumetric efficiency is a measure of how effectively an engine can draw and utilize the air-fuel mixture into its combustion chamber compared to its theoretical maximum. The theoretical maximum volume is determined by engine displacement, atmospheric pressure and temperature. Actual conditions during engine operation, however, affect how much air-fuel mixture can actually be drawn into the combustion chamber.

Measurement of Relative Efficiency: “Relative efficiency” which can be used in different contexts, but refers to comparing the efficiency of a process to another. Relative efficiency may refer to comparing the efficiency of two different equipment or systems. Let the comparing two refrigerators: one with an Energy Star rating and one without. Relative efficiency will be calculated by comparing the energy consumption of two refrigerators for the same cooling capacity metric.

This measurement helps to understand which system is more effective or productive than the other.

Measurement of Air Consumption: It refers to the amount of air used by an appliance or system. Can be measured in various units such as litres per minute cubic feet per minute or cubic meters per hour. Air consumption is often an important parameter for pneumatic devices such as air compressors.

For Example: In the case of pneumatic tools such as air drills or impact wrenches, air consumption is measured in terms of the amount of air required to maintain their operating pressure and flow rate during use. It helps to avoid wastage of compressed air as well as select the right size of air compressor and other equipment to meet the demand.

Measurement of Lubrication Oil Consumption: This measurement is particularly relevant in the context of machinery, engines and equipment that require lubrication to reduce friction and wear between moving parts. Lubricating oil consumption can be measured in different units such as litres, gallons or barrels depending on the volume and duration of use. By accurately measuring lubricating oil consumption, operators can ensure efficient operation and longevity of machinery and equipment, and reduce maintenance costs.

Dynamometers and its types

Objectives: At the end of this lesson you shall be able to

- differentiate types of dynamometers.

Dynamometer: Dynamometers are devices used to measure force, torque, or power. They come in various types, including hydraulic, electric, and eddy current dynamometers, each suited to different applications like engine testing or material strength analysis.

Types of dynamometer

1 **Engine Dynamometers:** These measure the torque and power output of an engine.

2 **Chassis Dynamometers:** Used for measuring the power and torque of a vehicle's wheels, simulating real-world conditions.

3 **Hydraulic Dynamometers:** These use hydraulic fluid to apply resistance, measuring force or torque.

4 **Eddy Current Dynamometers:** These use electromagnetic induction to provide resistance, often used in automotive testing.

5 **Towing Dynamometers:** Used for measuring the pulling force of vehicles or other machinery.

6 **Absorption Dynamometers:** Absorb and measure power by dissipating it as heat, water, or air resistance.

7 **Torsion Dynamometers:** Measure torque by twisting a calibrated shaft.

8 **Electric Dynamometers:** Employ an electric motor to apply resistance, often used in automotive testing.

9 **Prony Brake Dynamometers:** Apply friction to a rotating shaft to measure torque and power.

Preparation of heat balance sheet

Objectives: At the end of this lesson you shall be able to

- prepare of heat balance sheet.

Heat Balance Sheet

The heat generated inside the cylinder is not entirely used for external work. Some part of it goes into the cooling system, some into the exhaust gas and some goes out through radiation. This reduces the thermal efficiency of the engine. How much heat was generated in the cylinder, how much heat was spent in doing external work, how much heat was lost, all these

The quantities are recorded in a table called heat balance sheet. To prepare the heat balance sheet of an engine, it is run at a certain load and speed and from this the performance of the engine is known. To prepare heat balance sheet the following items have to be known:

1 Heat supplied - Heat generated by burning of fuel = W x Q kJ/min Where, W = fuel supplied, kg/min Q = Lower calorific value of fuel, kJ/kg

2 Heat converted to IP – = IP x 60 kJ

3 Heat Carried away by Cooling Water - = W (1-2) kJ W = Weight of cooling water, kg/min

Where,

11 = Temperature of cooling water at outlet, °C

12 = Temperature of cooling water at inlet, °C

4 Heat Carried away by Exhaust Gases -= W (T2-T1)= T8-Tambient [W (Tw2-T)] KJ Tg1-T82

This is determined from the exhaust gas calorimeter (Figure 6.7), in which

W = weight of water that flowed from the calorimeter, kg

12 = Water temperature at outlet, °C

T1 = water temperature at inlet, °C

T1 = temperature of exhaust gas at inlet, °C

T2 = temperature of exhaust gas at outlet, °C

Tambient = ambient temperature, °C

5 Heat Converted to BP = BP x 60 kJ

Heat to FP heat to IP-heat to BP

6 Unaccounted Heat – Add the values of formulas (1), (3) and (4). By subtracting these sums from the value of (1), Agya heat is obtained.

The format of heat balance sheet is as follows.

S.No	Item	Heat Unit (KJ)	
1	Heat supplied		
2	Heat to IHP		
3	Heat to cooling water		
4	Heat to exhaust gases		
5	Heat unaccounted (by difference)		
	Total		

Example 1: Find the IP of a four-cylinder two-stroke petrol engine from the following data.

diameter of piston = 10 cm

stroke = 15 cm

rpm = 1600

Area of positive loop of indicator diagram = 5.76 cm^2

Area of negative loop of indicator diagram1600 = 0.26 cm^2

Length of indicator diagram = 55 mm

spring constant = 3.5 bar /cm

Solution: The net area of the indicator diagram =5.76-0.265.50 cm^2

$$\text{Area of height} = \frac{\text{Area of the diagram}}{\text{Length of the diagram}}$$

Mean effective pressure = Mean height Number of cylinder) 11 x 4 = 44 kW. = 11 kW

Abduction 2. The diameter of the cylinder of an auto cycle gas engine is 25 cm and stroke is 45 cm.

MODULE 14 : Alternative Fuel system

LESSON 88 - 93 : Alternative fuels, types, PROPERTIES, Advantages & disadvantages of each type of fuel. CNG engine and its advantages. CNG conversion kit, function, constructional details. (conventional type) CNG conversion kit, function, constructional details. (Gas injection type) L P G engine and its advantages. LPG Conversion kit, function, constructional details. Comparison between petrol, diesel, LPG and CNG

Objectives

At the end of this lesson you shall be able to

- explain in detail types of alternative fuels
- demonstrate CNG conversion kit
- demonstrate LPG conversion kit.

Alternative fuels, types, properties, advantages and disadvantages of each type of fuel

Alternative Fuels: These are options other than traditional gasoline or diesel that can power vehicles and machinery.

Types

1 **Electricity:** Powers vehicles through batteries or fuel cells.

Properties: Clean, renewable, and can be generated from various sources like solar, wind, or hydro.

Advantages: Zero tailpipe emissions, lower operating costs, quieter operation.

Disadvantages: Limited driving range, long charging times, reliance on electricity grid infrastructure.

2 **Biofuels:** Derived from organic matter such as plants or algae.

Properties: Renewable, carbon-neutral, and can be blended with traditional fuels.

Advantages: Reduces greenhouse gas emissions, supports agricultural economies.

Disadvantages: Land use competition with food crops, potential for deforestation, may require large amounts of water and energy for production.

3 **Hydrogen:** Used in fuel cells to produce electricity.

Properties: Clean burning, abundant, and produces only water vapor as a byproduct.

Advantages: High energy density, quick refueling, versatile applications.

Disadvantages: Costly production, limited infrastructure, energy-intensive to produce.

4 **Natural Gas:** Compressed or liquefied natural gas (CNG/LNG).

Properties: Abundant, cleaner burning than gasoline or diesel.

Advantages: Lower emissions, domestic availability, established infrastructure.

Disadvantages: Still a fossil fuel, methane leakage concerns, limited refueling stations.

5 **Hybrid:** Combines internal combustion engines with electric propulsion.

Properties: Utilizes both traditional fuels and electricity's

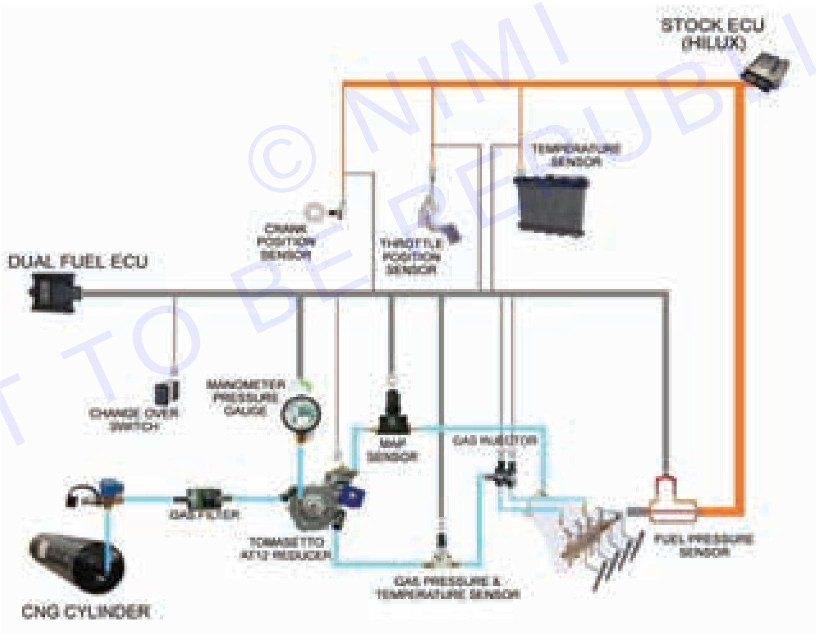
Advantages: Improved fuel efficiency, lower emissions, longer driving range.

Disadvantages: Initial cost premium, complexity of dual systems, limited pure electric range.

Each type of alternative fuel has its unique set of properties, advantages, and disadvantages, making them suitable for different applications and contexts.

CNG engine and its advantages. CNG conversion kit, Function, constructional details of Gas injection type

Petroleum Liquid Fuels Like Petrol and Diesel Used in Motor Vehicles Contain Harmful Elements Such as Lead, Sulphur, And Benzene, Which Contribute to Pollution. When These Fuels Burn, They Release Nitrogen Oxide (No2) And Volatile Organic Compounds (VOCS), Which, When Exposed to Sunlight, Form Ozone, A Pollutant. To Address Increasing Pollution and Fuel Prices, in 1987, There Was a Move Towards Using LPG and CNG as Alternative Fuels for Vehicles. In 2001, The Delhi Government Decided to Officially Adopt CNG Due to Concerns About the Risks Associated with LPG. CNG Has Been Used as A Vehicle Fuel Since 1958 In Over 100 Countries.



CNG (Compressed Natural Gas) Is Composed of Carbon, Sulfur, And Nitrogen. It Has a High Self-Ignition Temperature of 730°C, Making It Safe to Handle. With A Molecular Weight of 16, It's Lighter Than Air, Reducing The Risk of Pollution If Leaked. CNG Only Ignites in The Air When Its Concentration Is Between 5.3% And 15%, So It's Not Highly Flammable. Compared to Vehicles Running On Petrol and Diesel, Those Powered by CNG Are Safer, Emitting Lower Levels of Carbon Monoxide, Sulfur, And Lead. This Leads to an 85% Reduction in Nitrogen Oxides and A 70% Reduction in Reactive Hydrocarbons. CNG Combustion Produces Less Particulate Matter, Increasing Engine Lifespan and Reducing Maintenance Costs. Its Purification Process Is Simpler, with an Octane Number of 120 To 130, Offering High Knock Resistance. Engines Running On CNG Have Higher Thermal Efficiency and Longer Distances Per Unit of Fuel Compared to Petrol Engines. For Example, A CNG-Powered Taxi Can Cover 18 Km Per Liter, While A Petrol Taxi Covers Only 10 Km. A Maruti 800 Zen Can Cover 350 Km On a Full CNG Cylinder, And A Cielo Can Cover 200 Km.

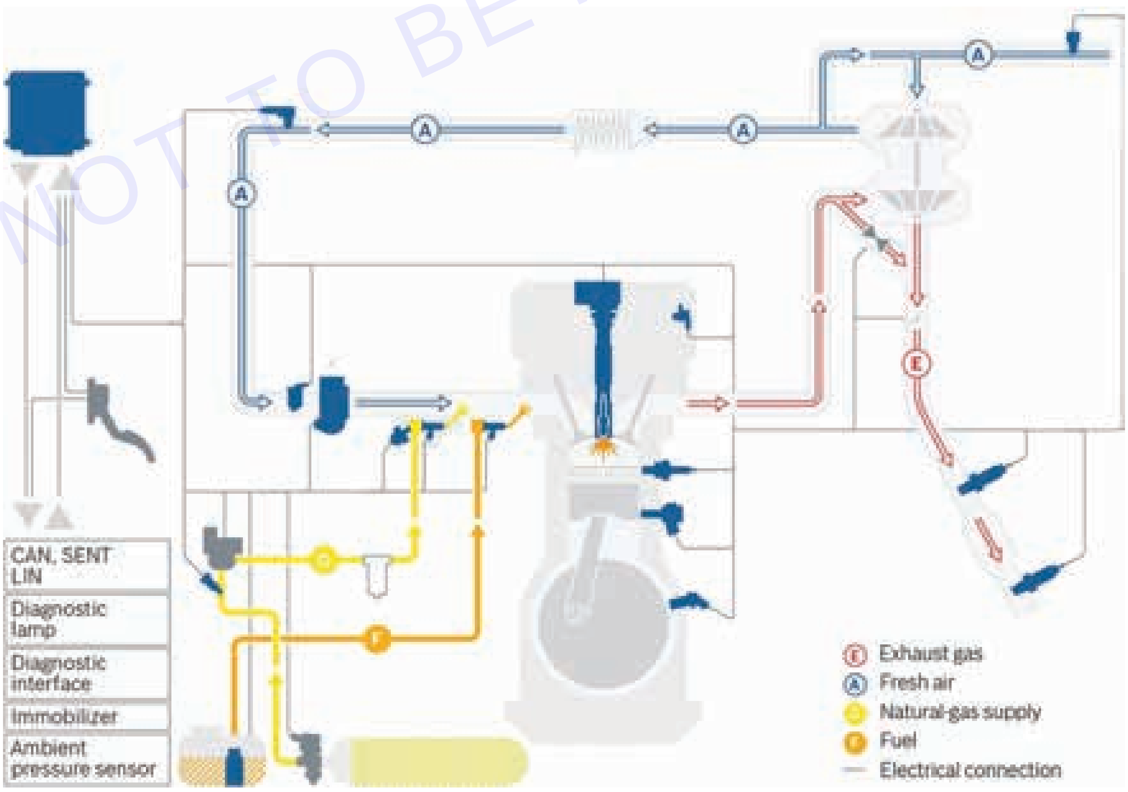
To Use CNG, A Separate Kit Is Required, Which Can Be Installed Without Modifying the Original Fuel Supply System of the Petrol Engine. Both LPG and CNG Can Replace Petrol, And Separate Kits Are Available for Each. Different Types of Fuel-Injected Kits Are Used for Vehicles Like Cielo or Opel Astra. The CNG Kit Typically Includes Components Such as A Gas Cylinder, Heating Pad, Filter, And Pressure Gauge Assembly.

- Gas Cylinder
- Heating Pad
- Filter
- Pressure Gauge Assembly
- Electronic Switch
- Gas Solenoid
- Petrol Solenoid
- Gas Cylinder at The Side of the Petrol Tank in The Dickey at The Rear of the Mixer Vehicle.

Is Kept 15 Km in Cylinder. Gr. Full of Gas. A Heating Pad (Heater) Is Fitted Next to The Cylinder and It Works to Heat the Cylinder. Due to That, Proper Amount of Gas Is Released from The Cylinder. A Filter And Pressure Gauge Assembly Is Fitted On the Gas Cylinder Outlet Pipe. The Pressure of the Gas in The Cylinder Is Indicated by A Pressure Gauge. The Gas Pressure in The Cylinder Is About 200 Km. Gr. / Sq. Sec. I. There Is the Function of Cleaning the Gas Coming Out of the Cylinder Is Done by The Filter.

A Gas Solenoid Is Fitted Under the Bonnet in The Engine Compartment of the Vehicle. The Gas Pipe from The Filter In the Dickey Is Connected to The Gas Solenoid. A Petrol Solenoid Is Attached to One Side of the Carburetor, While A Mixer and Pressure Reducer Vaporizer Are Fitted to The Other Side. Hot C from Gas Solenoid. N. G. The Flow Is First to The Vaporizer and Then to The Mixer. As The Outlet Pipe of the Mixer Is Connected to The Carburetor, This Gas Is Supplied to The Cylinder Through the Carburetor. An Electronic Switch Is Fitted Near the Steering Wheel in The Driver's Compartment to Switch On the Fuel Supply System or C. N. G. The Fuel Supply System Can Be Operated. C. N. G. Precautions to Be Taken While Using the Kit

Constructional details of Gas injection type



In CNG systems, the injector is supplied by the CNG fuel rail. Injection is initiated by the electronic control unit through a signal calculated by the engine management system, ensuring precise dosing of the required gas quantity. The NGI2 injector was developed to meet CNG operation needs, featuring an electromagnetic valve for higher gas volume, rapid flow speed, and wear resistance, even when used with oil-free gas. Its quality and service life are comparable to fuel injectors, with very low leakage that decreases further over its lifespan.

LPG Engine and advantages. LPG conversion kit, function, constructional details

LPG Engine: A mixture of hydrocarbons made from light petroleum is called LPG. LPG is made from propane and butane.

LPG Liquid of Liquefied Petroleum Gas is being used as an alternative fuel for petrol engines due to the increasing price of petrol fuel and its shortage as well as increasing pollution due to an exhaust gas.

Advantages:

1 LPG Auto gas engines have lower running costs.

2 LPG is typically less expensive than petrol or diesel.

3 Engine oil and spark plugs need changing less often with LPG vehicles, for reduced service costs.

4 Environmental benefits of LPG vehicles include reduced particulate, CO2 and NOx emissions.

Conversion kit: Converting a petrol engine to LPG engine does not require any modification to the original engine only by using a separate LPG kit the petrol engine can be run on LPG fuel The LPG kit includes the following

1 L. P. G. Tank,

2 Multi-Function Valve,

3 High Pressure Tubing (Pipe),

4 Gas - Petrol Change Over Switch,

5 L. P. G. solenoid valve,

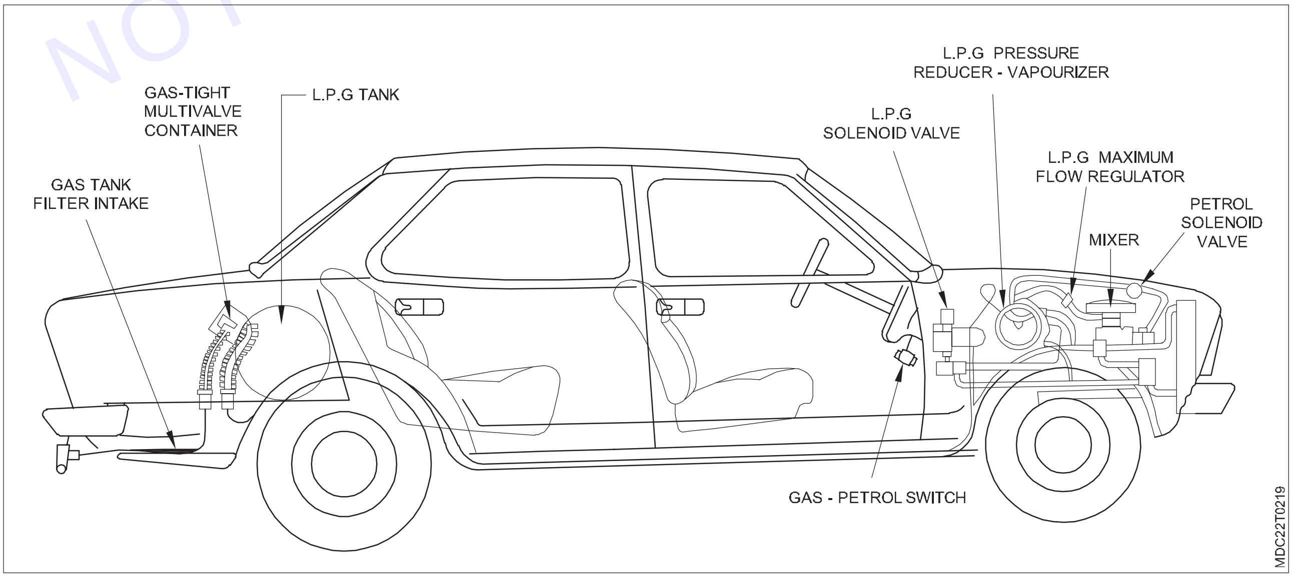
6 Petrol Solenoid Valve,

7 Pressure Reducer - Vaporizer,

8 Low Pressure Tubing,

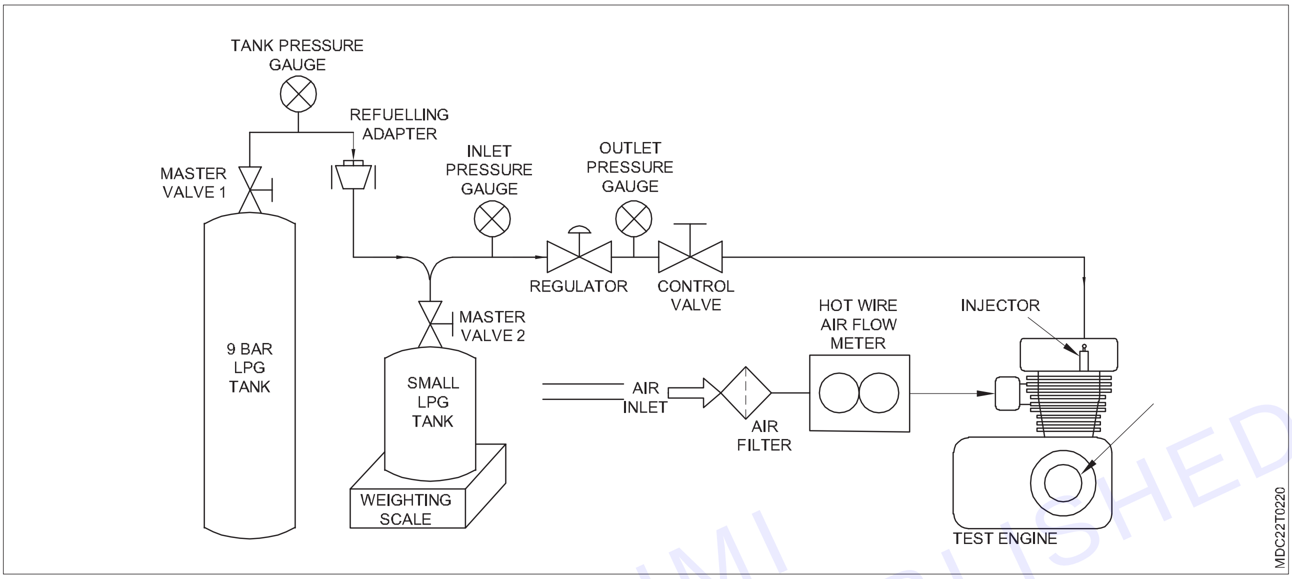
10 Mixer

Components

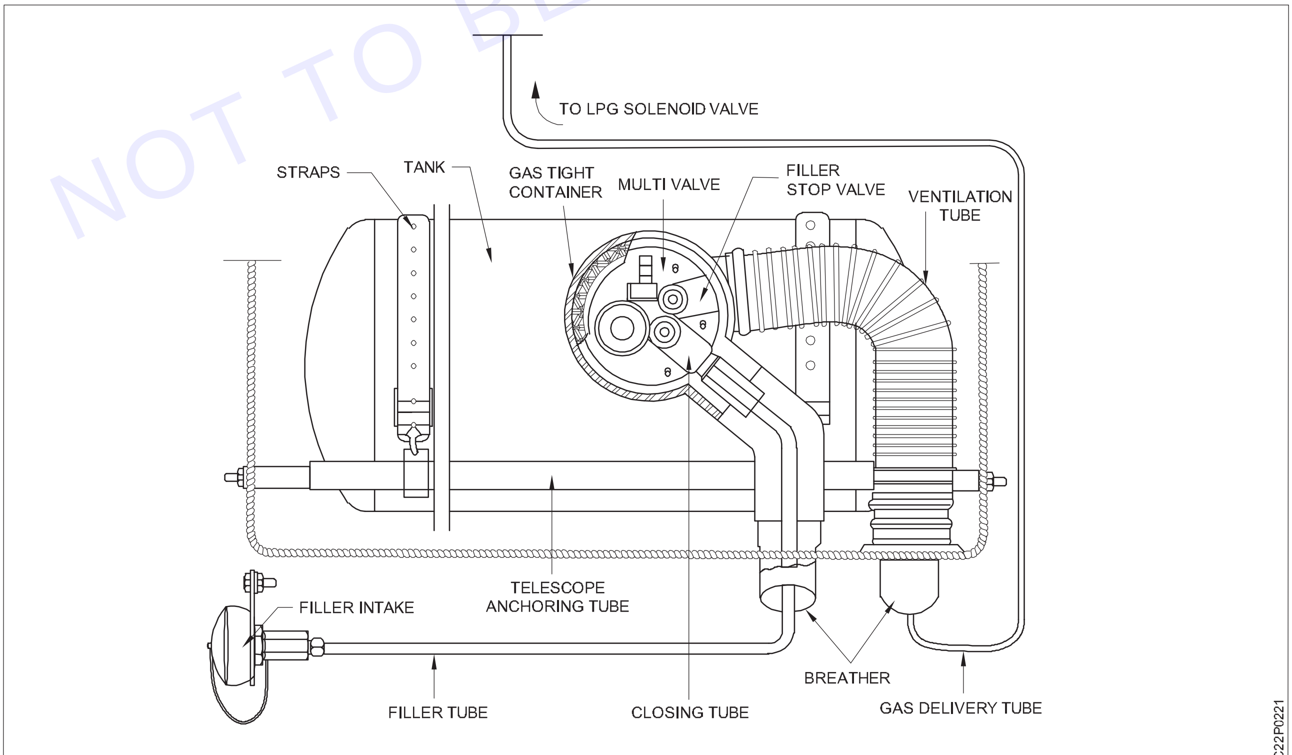


Function: Liquefied LPG from LPG tank flows through high pressure tube to reducer vaporizer LPG flow is controlled by solenoid wall when engine is off or running on petrol this wall remains closed Liquid LPG in pressure reducer vaporizer is reduced in pressure and converted into LPG The energy required to vaporize the LPG is taken from the hot water coming from the engine cooling system. The LPG, reduced in pressure and converted into vapor in the pressure reducer vaporizer, enters the mixer in the carburetor through the connecting tube and is properly mixed with the suction air.

Construction Details



1 **L. P. G. Tank:** L. P. G. The tank is made of good quality steel and has the name of the tank manufacturer, serial number, tank capacity etc. There is an information board. Tanks of different lengths and diameters are available for different cars. Each tank is tested to an internal hydraulic pressure of 45 bar. The vehicle is equipped with a tack mounted compartment separate from the driver and passenger. Plastic coated tension straps and telescopic stays are used to prevent the tank from shifting or moving. Ducts and tubes are provided to keep air circulating around the tank or container body.



ASSEMBLY DIAGRAM OF MULTIVALVE

L. P. G. A multi valve is fitted on the tack. This valve is used to fill the gaps in the tank, forward the gas in the tank, prevent gas leakage and show the gas level in the tank. Next in this valve Components include:

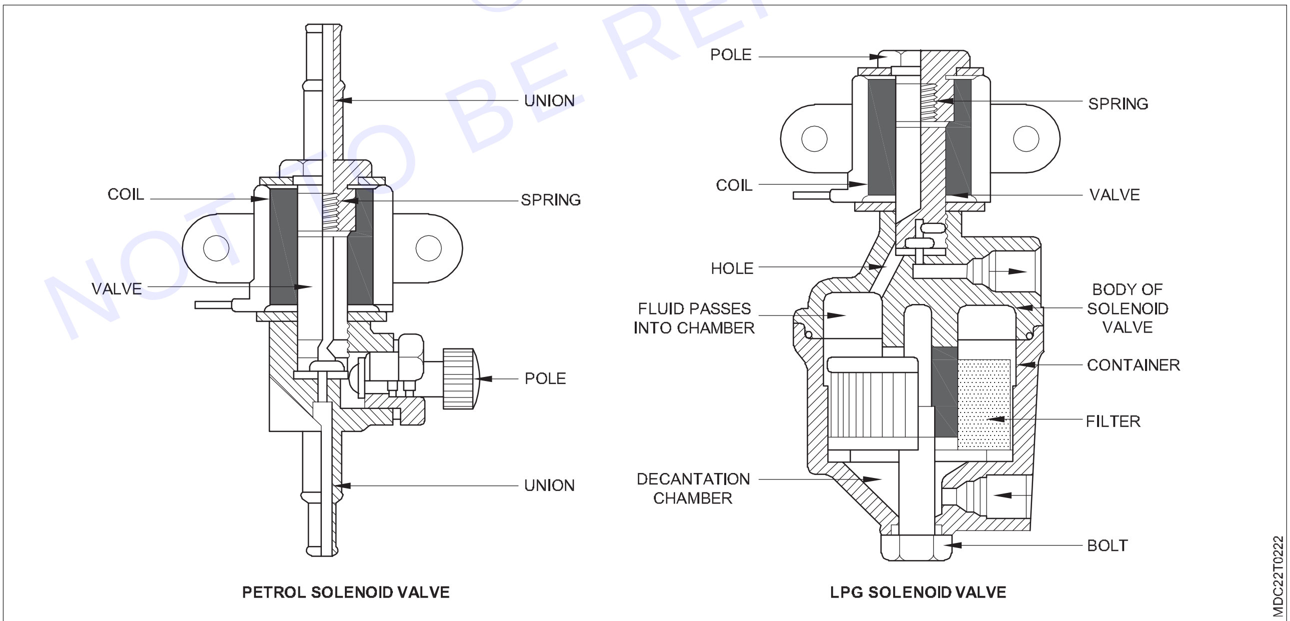
- Filler intake and manually closable filler closing tap to fill the tank with gas.
- Filler stop valve to stop the gas filling operation after filling the tank to a certain level.
- Check valve provided to prevent gas leakage.
- A gauge on the top surface of the tank to indicate the level of gas in the tank and pointer, consists of float, pinion gear, gear, permanent magnet and metal diaphragm mounted inside the multi valve body. In Tank. L.P.G. of gas when the temperature rises after filling 80% + 5% limit in tank to avoid tank explosion due to volume expansion L. P. G. It has to be paid. L more than 80% of tank capacity. P. G. When filling the tank, the multivalve stops the flow of gas beyond 80%. A multivalve prevents gas from escaping from the tank when the gas tube supplying the engine breaks in an accident.

2 **High Pressure Tube:** High pressure tubes of annealed copper are used to convey the gas from the tack to the solenoid valve and from the solenoid valve to the pressure reducer. The working pressure of these tubes is 45 bar and they are connected with the help of special union. They are fitted with clips in alignment so that they are separated from the exhaust pipe and the car body.

3 **Gas-Petrol Change Over Switch:** Switching on Gas Supply System or Petrol Fuel Supply System

A push button type electric switch is provided for this. This switch is mounted on the dash board so that it can be easily operated by the driver from the driving seat.

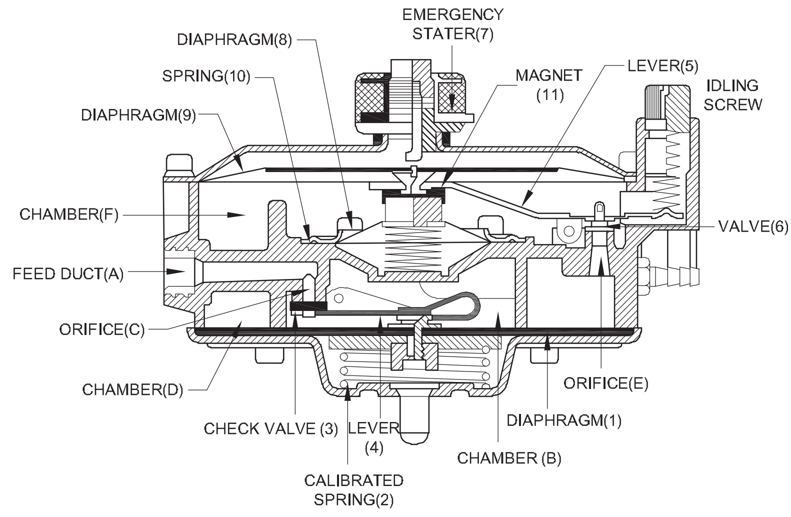
4 **L. P. G. Solenoid Valve:** This L is the element acting on the electromagnet. Figure no. It has a structure as shown in Fig. 22.11 B. L. P. G. An electromagnetic spring loaded valve L is fitted on the gas outlet path of the solenoid valve. When the engine is off, or petrol is being supplied to it, L P. G. The valve is seated in its seat by spring pressure in the outlet passage to keep the supply closed. When the gas-petrol changeover switch is turned on to gas, the electromagnetic coil is energized by the battery and pulled on the valve and the gas outlet path is opened and gas is supplied to the pressure reducer. The valve is fitted with its bracket in a vertical position in the engine compartment but away from the engine heat.



PETROL SOLENOID VALVE LPG SOLENOID VALVE

5 **Petrol Solenoid Valve:** L. P. G. A petrol solenoid valve operating on an electromagnet, similar to a solenoid valve, is constructed as shown in Fig. No. 22.11 A. This valve is fitted between the petrol fuel pump and the carburettor. When the gas-petrol changeover switch is turned on the petrol side, the supply of petrol to the carburettor starts and the supply of gas stops.

6 **Pressure Reducer-Vaporizer:** L. P. G. coming in liquid state from solenoid valve. L.P.G. A pressure reducer and vaporizer element is provided to reduce the pressure of the fuel and convert it into steam and is fitted at the carburetor side as shown in figure no.22.6. An inlet and an outlet water heating tube (pipe) are fitted on it to circulate the hot water from the engine cooling system through the body. (See Insect No. 26.6.)



SECTION THROUGH PRESSURE REDUCER-VAPORIZER

Internal structure of pressure reducer and vaporizer figure No. 22.12 is as shown. Liquid and pressurized L from the tank through the solenoid valve. P. G. It enters the first stage reduction chamber (B) through the feed duct (A) or inlet port of the pressure reducer and vaporizer. As the gas spreads in this chamber and on the diaphragm (1), its pressure decreases to 0.45-0.65 bar. As the calibrated spring (2) below the diaphragm (1) is set at a certain pressure, as soon as the gas pressure in the reduction chamber (B) decreases to a certain amount, the calibrated spring (2) presses the diaphragm (1) and the lever on the diaphragm (1) A check valve (3) from (4) stops the gas by sitting on the inlet or feed orifice (8). As the gas expands in the reduction chamber, its heat is reduced. But the heat lost by the gas is replaced by the heat of the cooling system water circulating through the chamber (D) and due to this heat the low pressure gas in the reduction chamber (B) is converted into a gas and then passes through the valve (6) in the orifice or passage (E) to the chamber (F). comes in This chamber has a wick (9) and the outlet of this chamber is connected to a mixer mounted above the carburetor throttle valve. By the amount of vacuum or induction created when the engine is running, the diaphragm (9) is pulled in and the lever (5) at its center is pressed and the valve (6) on it is pressed into the feed orifice (E) and the gaseous gas passes from the first stage to the second stage i.e. the chamber (comes in F). When the suction from the mixer decreases, back pressure is generated on the diaphragm (9) and the valve (6) is closed by the lever (5). When the engine is not running, the spring (10) acts on the lever (5) and the valve (6) is closed by the lever (5). Diaphragm due to the vacuum created near the carburetor throttle valve when the engine is started (8) is pulled and the spring (10) is pressed into its seat. A magnet (11) is attached to the diaphragm (8). When the engine starts, the lever (5) is momentarily pulled by this magnet. This can lead to excess gas supply to the mixer or carburetor. This mechanical design allows the engine to start easily in any weather. Some companies' pressure reducer vaporizers are designed with a primary solenoid or electric emergency starter (7). A pressure reducer is used to actuate the vaporizer in case the mechanical or electrical parts of the engine are not functional to start the engine, or when needed.

L. P. G. Pressure reducer-vaporizer is an important component in the system. Then it is necessary to take care of it as follows.

1 Fittings of pressure reducer and related pipes should be tight.

2 The pressure reducer should be installed below the water level in the radiator. Also it should be fitted in such a way that the drain plug of the pressure reducer does not come over the distributor or ignition coil.

3 Any kind of dirt, dust etc. Care should be taken that the pressure does not go into the reducer and the connection of the tube on it remains clean.

4 If the pressure reducer heats up quickly, check the operation of the thermostat valve in the cooling system. Add an anti-freeze solution to the cooling system water in the winter. Care must be taken when refilling the cooling system after draining it to ensure that there are no air bubbles in the cooling system or air bubbles in the hot water circulating through the body of the pressure reducer vaporizer. take it

5 Pressure reducer supplying gas to the mixer in the carburettor - The outlet pipe of the vaporizer should be a metal lined rubber pipe. And the fitting should be such that it remains on the upper side without much twisting or bending, so that the gas can flow easily.

6 Approximately 20,000 km. I. Overhaul the pressure reducer - vaporizer after running. Pressure reducer Clean all parts first with gasoline and then with pressurized dry air. Replace diaphragm, rubber pad if damaged. Consider the position and height of the rocker when fitting the rubber pad and rocker. Then check the air tightness of the seals and rockers as well as the functioning of the diaphragm.

Comparison Between Gasoline, Diesel, LPG and CNG

Characteristics of Gasoline

Following are the main properties of gasoline-

1 **Volatility -** Gasoline is highly volatile. It evaporates at 90°C with a vapor pressure of 0.5 to 1.0 kg/cm². Due to this quality, the engine becomes very easy to start and run. Acceleration also happens quickly.

2 **Purity -** It should not contain impurities like water, grease, dust particles etc.

3 **Sulfur Content -** Crude oil contains sulfur content. even after refining it Some amount of sulfur remains in gasoline, which causes rust in various parts of the engine. The amount of sulfur in gasoline should be up to 0.1%.

4 **Gum Content -** The amount of gum in gasoline should also be controlled. Excessive amount of glue causes valves to stick, piston rings to stick, carburetor jets to jam, intake manifold to clog.

5 **Anti-lock Quality -** If the octane number of gasoline is high, there is no knocking in the engine.

6 **Calorific Value** - Calorific value of gasoline should be high. it usually It is 24000 CHU/Kg.

Economic Profit - Gasoline should be profitable from economic point of view also. Due to this, the car should run more kilometers in one liter.

Properties of Diesel Fuel

Following are the main properties of diesel fuel-

1 **Grade -** Grade Number ID Diesel Engine Fuel is high volatile distilled fuel. Grade No. 2D diesel engine fuel is a low distilled fuel.

2 **Gravity -** It displays specific gravity.

3 **Pour Point -** This is the minimum temperature at which fuel will flow under a certain test condition.

4 **Volatility -** This is the measure of the volatile state of the fuel.

5 **Flash Point -** This is the temperature at which the fuel gives enough vapor to burn.

6 **Distillation Recovery -** This is the volume of fuel that is obtained by heating it till boiling point and then condensing the vapor.

7 **Cetane Rating -** This shows the ignition quality of the fuel and how fast it burns.

8 **Viscosity -** This is the measure of the flow resistance of the fuel.

9 **Water and Sediment -** The amount of water mixed in the fuel causes rust in the injection system. Filters get clogged with sediments.

10 **Ash -** It is a non-flammable substance in fuel.

Liquid Petroleum Gas (LPG)

There are two types of liquid petroleum gas used in automobile engines – propane and butane. A mixture of both is also used. They are used in buses, trucks, railways and factories. Propane boils at 44°F. Therefore, it can be used in any climate where the temperature is not lower than this. Butane is liquid below 32°F. Therefore, it cannot be used where the temperature is lower than this. If it remains liquid, it will vaporize and not reach the fuel system.

Propane and butane are obtained from oil and gas wells. They are obtained by the petroleum industry from natural gas plants, cycling condensing plants and refinery processes. These are condensed and stored as liquid in sealed pressure tanks. They are extremely flying at low pressure. A special fuel system is required to bring the fuel from the fuel tank to the engine cylinder.

CNG means Compressed Natural Gas, like Crude Oil is obtained from the ground and after purifying that mineral oil, various substances like petrol, diesel, kerosene oil are extracted from it, similarly this gas is also obtained from the ground. is received. This mineral oil is found in nearby deposits. It is called natural gas because it is used in the same form in which it is found, without any adulteration or alteration. It is a mixture of hydrocarbon gas and vapor. Methane (CH_{12}) is compressed and used in vehicles, which is stored in the cylinder by increasing the pressure (2000 to 2200 N/cm²). CNG contains 80 to 90% methane, 4.5% ethane, 0.7 to 0.8% butane, 1.7 to 2% and many other gases in small quantities. The main quantity is methane.

CNG had a slow start but after the Supreme Court issued guidelines, it became famous as a fuel for motor vehicles. In India, it has been used only in big cities. Because in Delhi, air pollution was increasing day by day due to the smoke coming out of petrol and diesel vehicles, which was polluting the environment and many diseases were increasing. But after using CNG in vehicles, the level of air pollution has continuously decreased. There are many CNG stations in Delhi which are connected to each other through pipelines. This gas is sent by tanks to the remaining gas stations. The government is making plans to use CNG in many other cities of India, because pollution due to diesel and petrol smoke is increasing day by day in big cities.

	Petrol/gasoline	**Diesel**	**LPG**	**CNG**
Chemical formula	CXH2.0X	CXH2.0X	C3H8	CH4
Octane/cetane number	85-95 octane no	45-55 cetain no	94-112 octane no	120-130 octane no
Method of ignition	Spark ignition	Compression ignition	Spark ignition	Spark ignition
Molar mass (kg/mol)	109	204	0.4	17.3
Stoichemetric (A/F) s mass	14.7	14.6	17	17.2
Stoichemetric mixture density (kg/m³)	1.42	1.46	1.88	1.25
L.H.V. (MJ/kg)	43.5	42.7	42-47	47.5
L.H.V. of stoichemetric mixture (MJ/kg)	2.85	2.75	2.61	2.62
Combustion Energy (MJ/m³)	42.7	36	42	24.6
Flammability limit in air (vol% in air)	1.4-7.6	1-6	Approx. 4.8	4.3-15.2
Flame propagation speed (m/s)	0.5	_	2.2-4.7	0.41
Adiabatic Flame Temp. (°C)	2150	2054	1967	1890
Auto-ignition Temp. (°C)	258	316	410-580	540
Wobbe Index (MJ/m³)	_	_	39	51-58

Electric car and Hybrid car

Objectives: At the end of this lesson you shall be able to

- differentiate between Electric car and Hybrid Car
- demonstrate components of Electric Car
- demonstrate components of Hybrid Car.

Introduction to Hybrid and Electronic Vehicles

The early 20th century saw its sisters having electric as well as internal combustion engines. The most common of all these types of buses were electric buses.

The main reason for this was that to start vehicles with internal combustion engines, their cranks needed to be turned, which was a difficult task. This problem was solved with the invention of the electromechanical ICE starter.

The main advantage of the ICK was that it could be filled with fuel in the tank and could travel a long distance. This was the reason why ICE vehicles soon put electric vehicles out of use.

But as the number of vehicles increased, the negative sides of ICE vehicles also started appearing. Air quality and noise pollution, mainly in urban areas, deteriorated significantly with the increase in the number of vehicles.

Keeping all these things in mind, the need arose to find alternatives for 10 vehicles. Thus, electric vehicles came back to the center stage again.

First of all, in the year 1906, General Motors introduced an electric vehicle model called EVI-1 and in the next 3 years more than 1000 units were sold but due to reasons like limited battery technology, reduction in battery capacity and low starting distance (about 100 km) etc. it's a long journey

Made unsuitable for. To eliminate all these problems, hybrid electric vehicles were invented. In the year 1997, Japan introduced the first hybrid electric vehicle, Toyota Prius.

The main advantage of this vehicle is that in urban environments it can be run on battery power and during long journeys it can be run on internal combustion engine. The battery can also be charged while running the internal combustion engine.

However, the next challenge was how to charge the vehicle's battery without an internal combustion engine and fuel. This led to the development of the idea of hybrid electric vehicles that could be charged from electric grids.

Currently, plug-in hybrid electric vehicles (PHEVs) that can be charged from electric grids are being developed rapidly.

The main advantage of these vehicles is that the user is not at all required to use fuel for daily needs. Most of these vehicles have a battery autonomy of around 50 km. Which meet the needs of an average consumer?

Although 'plug-in' hybrid electric vehicle technology is at the cutting edge, the manufacturing of batteries used in these vehicles still requires high technology. There is a possibility of increase in hybrid-electric type vehicles in the coming time but this will not happen overnight. This is a process that can be leveraged for decades. What speeds up this process is society's willingness to accept and support these changes.

Hydrogen Fuel Cell Vehicle

Hydrogen fuel cell vehicles are zero emission vehicles. The vehicle operates on compressed hydrogen fed into a fuel cell 'stack', which supplies electricity to power the vehicle. Fuel cells can be used in conjunction with electric motors to drive a vehicle quietly, powerfully and cleanly.

A hydrogen fuel cell vehicle is powered by a group of fuel cells. These fuel cells are called fuel cell tanks. The stack is designed to contain enough cells to provide the power required for automotive applications. A fuel cell, like an internal combustion engine, continues to produce power as long as fuel is available in it.

The electricity generated by the fuel cell tank powers the electric motor that propels the vehicle. Each fuel cell consists of an anode, a cathode and a proton exchange membrane. Hydrogen from the tank installed on the vehicle enters the anode side of the fuel cell and oxygen taken from the air enters the cathode side.

As soon as the hydrogen molecule hits the membrane, a catalytic force splits the hydrogen molecule into electrons and protons. The proton moves through the fuel cell ‘stack’ while the electrons follow an external circuit providing current to the electric motor and other components of the vehicle. At the cathode side the protons and electrons recombine and combine with oxygen to form the vehicle’s only tailpipe emission, water.

Types of Hybrid cars.

1 **Parallel hybrid:** Combine the gasoline or engine or electric motor to run the vehicle. Both the motor or engine can work together or separately depends upon driving condition.

2 **Series hybrid:** The gasoline engine acts like a generator, it charges the battery which supply the power to the electric motor that propels the vehicle.

3 **Plug-In hybrid Electric Motor (PHEV):** Similar to a parallel hybrid but with a large battery that can be charged by plugged into an external power source, allowing for longer electric-only driving range.

4 **Full Hybrid:** It can operate only on the electric motor, the gasoline engine, or a combination of both. It can also recharge its own battery through regenerative braking and engine power. It is also known as strong hybrid.

5 **Mild hybrid:** Use a small electric motor mainly for assisting the gasoline engine, rather than being able to propel the vehicle only on electric power. They typically offer fuel efficiency improvements but don’t offer electric only driving.

MODULE 15 : Diesel Fuel System

LESSON 94 & 95 : Importance of testing the pumps

Objectives

At the end of this lesson you shall be able to

- explain importance of testing the pumps.

- To check whether the pressure from the fuel pump is generally from 0.176to 0.264 kg/cm.
- To check if vacuum is created in fuel pump.
- To test the capacity of the fuel pump.
- For checking pump phasing or delivery.
- To check if the control rod and gear in the pump are worn.
- To check if there is leakage in high pressure pipeline.
- If the low pressure pipe is obstructed.
- If the pump injection timing is wrong.
- If the pump makes noise.
- If the opening pressure of the injector is higher.
- In case of high consumption of diesel.
- If excessive fuel is burned at idling speed.

Procedure for testing before dismantling pump

Objectives : At the end of this lesson you shall be able to

- state about the procedure for testing before dismantling pump

Introduction

Inside the diesel engine, pure air is taken through the inlet valve and compressed in the cylinder. Due to higher compression ratio in the compression stroke, its temperature and pressure increases and when the piston is about to reach the compression stroke, diesel is sprayed into the combustion chamber by the injector.

That spray is in atomization form. By injecting diesel, compressed air and automated diesel are ignited, providing the power stroke to the engine. Diesel engine is also called ‘compression ignition’ engine. It is very important to spray diesel at the right time. Diesel is one of the heavier oils and it must have the properties of flowing smoothly and burning quickly in the pipelines of the fuel system. Burning of diesel is based on cetane number, the diesel which has higher cetane number burns more quickly and the diesel which has lower cetane number will require more compression heat to burn. Low speed and high speed diesel engines are made on the basis of this principle....

Testing a fuel pump typically involves checking its pressure output and flow rate to ensure it’s functioning properly. You’ll need a fuel pressure gauge and possibly a flow meter, along with a vehicle-specific manual for the correct pressure specifications.

Testing a fuel pump

1 Safety First: Always work in a well-ventilated area away from sparks, open flames, or sources of ignition. Disconnect the battery's negative terminal to prevent accidental sparks.

2 Access the Fuel Pump: Locate the fuel pump. It's usually in the fuel tank, accessible through either an access panel under the rear seat or by dropping the tank itself. Refer to the vehicle manual for specific instructions.

3 Relieve Fuel System Pressure: Before testing, relieve the fuel system pressure. This is typically done by locating the fuel pump relay or fuse in the engine compartment fuse box and removing it. Then, start the engine and let it run until it stalls. Crank the engine a few more times to ensure any remaining pressure is released.

4 Prepare Testing Equipment: Gather the necessary tools, including a fuel pressure gauge and a flow meter if needed. Make sure they're compatible with your vehicle's fuel system.

5 Connect the Pressure Gauge: Follow the manufacturer's instructions to connect the fuel pressure gauge to the fuel rail or fuel line. This usually involves removing the fuel line and attaching the gauge with adapters.

6 Turn on the Ignition: Turn the ignition key to the "ON" position without starting the engine. This will activate the fuel pump and pressurize the system.

7 Check Pressure Reading: The fuel pressure gauge should display the pressure within the specified range for your vehicle. Refer to the service manual for the correct pressure specifications. If the pressure is too high or too low, it could indicate a problem with the fuel pump or other components.

8 Test Flow Rate (Optional): If needed, you can test the fuel pump's flow rate using a flow meter. This involves collecting fuel pumped by the fuel pump for a specified time period and measuring the volume. Compare the result to the manufacturer's specifications.

9 Inspect for Leaks: While the fuel pump is running, inspect the fuel lines, connections, and fittings for any signs of leaks.

10 Shut off the Ignition: Once testing is complete, turn off the ignition and disconnect the fuel pressure gauge. Reinstall any components that were removed.

11 Verify Repairs: If you found any issues during testing, make the necessary repairs or replacements to ensure the fuel pump is functioning properly.

12 Reconnect Battery: Reconnect the battery's negative terminal and start the engine to verify that the fuel system is operating correctly.

Procedure as per the Manufacturer for Dismantling, Inspecting and Assembling Inline Pump

Objectives : At the end of this lesson you shall be able to

- service Inline fuel pump as per manufacturer procedure.

Step -1

Prepare: Prepare necessary equipment and safety equipment. Make sure the pump is off and the power source is off.

Step - 2

- Remove any protective covers.
- Disconnect the pump from the piping system.
- Remove any fluid remaining in the piping and pump.
- Remove the bolts holding the pump casing together.
- Carefully separate the cover to expose the internal components.
- Remove the shaft, bearings, impeller, seals and other internal parts.

Inspection:

- Check each component for wear, corrosion or damage.
- Measure critical dimensions to ensure they meet specifications.
- Check gaskets and seals for wear and replace if necessary.
- Check for proper alignment and clearance.
- Clean all components thoroughly.

Assembly:

- Following the manufacturer's guidelines, begin reassembling the internal components in the reverse order of disassembly.
- Lubricate components as required by the manufacturer.
- Tighten the fasteners to the specified manufacturer's torque value.
- Make sure that seals and gaskets are installed properly and are in good condition.
- Reconnect piping system and pipe.
- Fill the pump with the correct fluid as recommended by the manufacturer.
- Check the pump for leaks, vibration and abnormal noises for proper operation.

Test:

- Before operating the pump, perform a thorough test to ensure proper operation.
- Check for abnormal vibration, abnormal noise and leakage.
- Monitor the performance of the pump to ensure that it meets the required specifications.

Precaution

Safety: Wear personal protective equipment (PPE), such as gloves, protective clothing, to avoid injury.

Shutdown: Before beginning work ensure the pump is completely shut down and disconnected from any power source.

Tools: Use tools recommended by the manufacturer to avoid damage to parts or accidents.

Cleaning: Clean the pump and surrounding area of contaminants during the inspection and assembly process.

Always follow safety precautions and consult your vehicle's service manual for detailed instructions specific to your make and model. If you're unsure or uncomfortable with any step of the process, it's best to consult a professional mechanic.

LESSON 96 & 97 : Detailed description of procedure of servicing mechanically controlled distributor type, electronically controlled distributor type and solenoid valve controlled distributor type pumps details of start assist systems

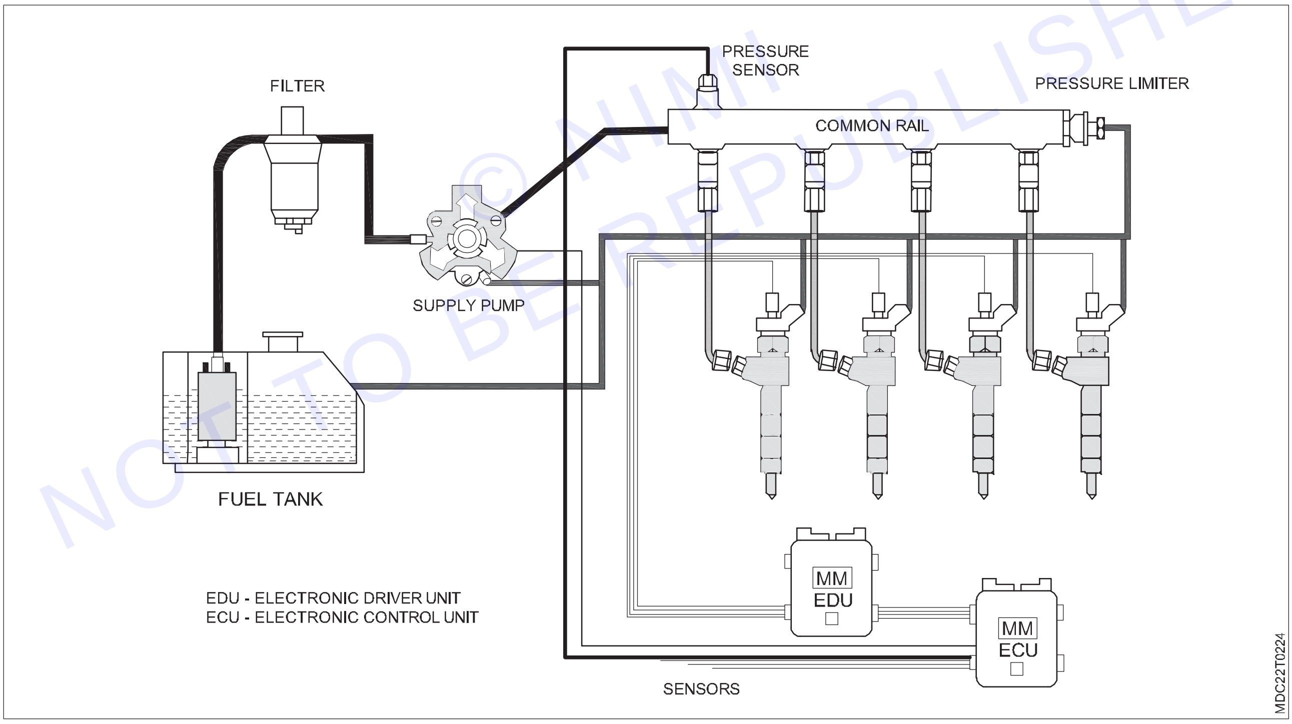
Objectives

At the end of this lesson you shall be able to

- service all types of Distributor type FIP.

A detailed description of servicing procedures for mechanically controlled distributor types and electronically controlled distributors.

Mechanically controlled distributor Of course, here is a detailed description of the servicing process for both mechanically controlled distributor types and electronically controlled distributors:



1 **Preparation:** Park the vehicle on a level surface and allow the engine to cool.

2 **Disconnect the battery:** Disconnect the negative terminal of the battery to avoid accidental sparks.

3 **Find a distributor:** Find a distributor on Engine. It is usually located at the rear of the engine block.

4 **Inspect Components:** Inspect distributor cap, rotor, points and condenser for wear, corrosion or damage.

5 **Replace components:** If any components are damaged or worn, replace them with new components.

6 **Adjust the points:** Check and adjust the spacing of the points as per the manufacturer's specifications using a feeler gauge.

7 **Check Timing:** Using the timing light, check and adjust the ignition timing if necessary.

8 **Clean Components:** Clean the distributor cap and rotor with a brush and electrical contact cleaner to remove any dirt or rust.

9 **Lubrication:** Apply a small amount of dielectric grease to the inside of the distributor cap to prevent moisture build-up.

10 **Reassemble:** Put the distributor cap and rotor back in place and secure them properly.

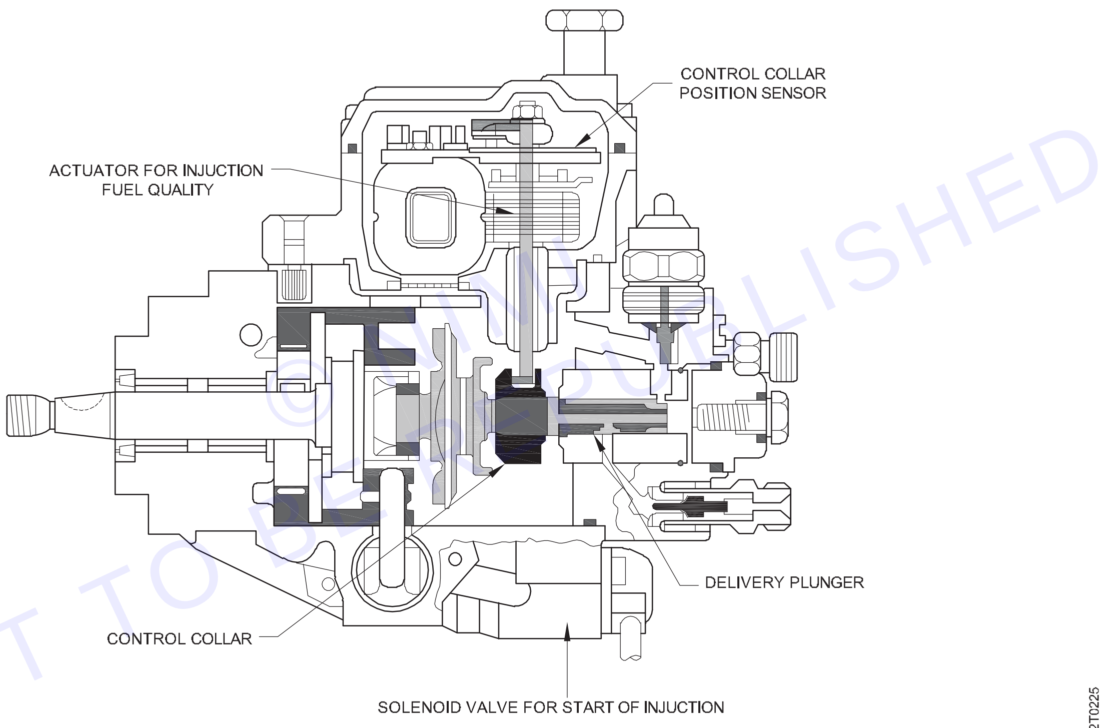
11 **Reconnect the battery:** Reconnect the negative terminal of the battery.

12 **Start the engine:** Start the engine and check for smooth running.

13 **Recheck Timing:** Using the timing light, recheck to make sure the ignition timing is within the specified limits.

14 **Test Drive:** Take the vehicle for a test drive to make sure everything is working properly.

15 **Final Inspection:** Once the test drive is complete, inspect the distributor and surrounding components for any signs of leakage or deformation.



ELECTRONIC DIESEL CONTROL EDC

Electronically Controlled Distributor:

1 **Preparation:** Follow steps 1-3 from mechanically controlled distributor type procedure.

2 **Diagnostic Scan:** Connect the diagnostic scanner to the vehicle's 080-11 port and retrieve any trouble codes related to the distributor or ignition system.

3 **Inspect components:** Check distributor cap, rotor, ignition coil and wiring harness for any visible damage or signs of wear.

4 **Test Sensors:** Test the crankshaft position sensor, camshaft position sensor, and ignition control module for proper operation using a multimeter.

5 **Check the wiring:** Inspect the wiring harness for any broken wires, loose connections, or corrosion. Repair or replace any damaged wiring as necessary.

6 **Replace components:** If any components are found to be defective during testing, replace them with new components.

7 **Reset the ECU:** Use the diagnostic scanner to reset the engine control unit (ECU) to clear any stored trouble codes and reset the ignition timing parameters.

8 **Adjust the timing (if necessary):** Using a diagnostic scanner or manufacturer-specific tools, adjust the ignition timing to the specified value.

9 **Reassemble:** Put the distributor cap and rotor back in place and secure them properly.

10 **Reconnect the battery:** follow step 11 from the mechanically controlled distributor type procedure.

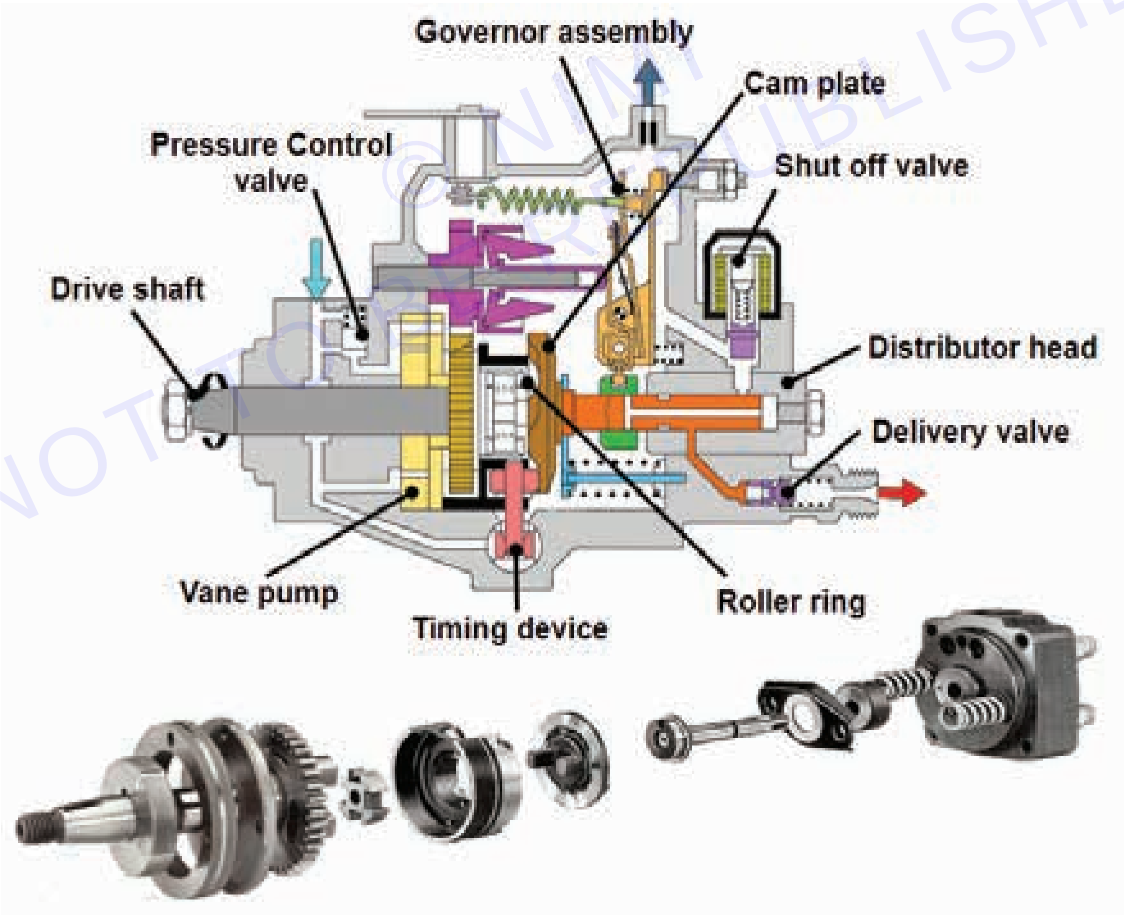
11 **Start the engine:** Follow steps 12-15 from the mechanically controlled distributor type procedure.

These steps should help ensure proper service of both types of distributor, keeping the vehicle's ignition system in good condition.

Detailed description of procedure of servicing solenoid valve controlled distributor type pumps details of start assist systems

Distributor type pump

Distributor pumps are also known as rotary pumps. This distributor pump has a single pumping element to supply fuel to all the cylinders. A single inlet rotor is used to supply fuel to each injector. But for delivery, as many outlets are given as many ejectors and as many pipe lines are connected to Papa. So that all the injectors are supplied with the same amount of diesel at regular intervals. The piping element has two cylindrical plungers against each other. It has a straight hole connected to a horizontal hole. This horizontal bore is provided with as many delivery ports as the number of cylinders, all the parts are fitted in an aluminum housing with a governor, this pump is currently used on most diesel engines.



Servicing and over-oiling

After dismantling the FIP all the parts should be first flushed with diesel and then cleaned with pressurized air. Camshaft nose wear should be checked with dial test indicator. End play, side play should be checked and necessary changes should be made. Check working clearance between plunger and barrel. Check the wear of the idler cont gear and the gear on the control lever. Check the delivery valve and its seat by checking the tension of the delivery valve return spring. The FIP is assembled and fitted on the testing machine and taken as per the three testing charts of the FIP.

Safety precaution

1 **Phase Angle:** Testing Diesel is delivered from one pump element and diesel is delivered from another pump element after a certain interval or angle. The distance or angle between these two successive injections is called the phase angle. So setting it is called phase angle setting.

   While setting it check head clearance i.e. clearance from plunger top surface to delivery valve seat base. It is set by increasing or decreasing the number of adjusting screws or sims from 0.5 mm to 1.00 mm.

2 **Calibration:** Each pump element delivers a specific volume of diesel at a specific speed at a specific interval. This diesel is taken in measuring tubes and the level of diesel in each tube is checked. This diesel should be same in all tubes. The volume should not vary by more than 0.4 cc. If so, setting the delivery quantity by loosening the screw on the trolled cone and changing the position of the plunger helix as required is calibration.

3 In Stop, Idling, Maximum as well as Speed Lock setting, the traveling position of the control rod is set to the Stop Idling Maximum position. Also, speed lock means setting the maximum distance limit of the control rod, so that the vehicle will not accelerate beyond that distance covered in a specified period of time. This is called speed lock.

   When servicing solenoid valve controlled distributor type pumps and start assist systems, it's crucial to prioritize safety to prevent accidents and ensure the well-being of yourself and others. Here are some safety precautions to consider:

   1 **Personal Protective Equipment (PPE):** Always wear appropriate PPE such as safety glasses, gloves, and protective clothing to protect against chemical exposure, electrical hazards, and mechanical injuries.

   2 **Isolation and Lockout-Tagout:** Before servicing any equipment, ensure it is properly isolated from power sources and energy hazards. Follow lockout-tagout procedures to prevent accidental startup or release of stored energy.

   3 **Ventilation:** Work in a well-ventilated area or use exhaust systems to prevent the buildup of fumes, vapors, or gases from cleaning solvents or fuels.

   4 **Handling Chemicals:** Handle cleaning solvents, fuels, and other chemicals with care, following manufacturer recommendations and safety data sheets (SDS). Avoid skin contact and inhalation of vapors.

   5 **Electrical Safety:** When working on electrical components or systems, ensure power is turned off and circuits are de-energized. Use insulated tools and avoid working alone in case of emergencies.

   6 **Mechanical Hazards:** Be mindful of moving parts, sharp edges, and pinch points when disassembling or reassembling equipment. Follow proper lifting techniques and use appropriate tools to prevent injuries.

   7 **Fire Safety:** Keep fire extinguishers nearby and be aware of potential fire hazards, especially when working with flammable materials such as fuel or cleaning solvents.

   8 **Proper Equipment Use:** Use equipment and tools only for their intended purposes and in accordance with manufacturer instructions. Inspect tools for damage before use and replace worn or damaged equipment.

   9 **Training and Supervision:** Ensure all personnel involved in servicing procedures are properly trained and supervised. Provide clear instructions and guidelines for safe work practices.

   10 **Emergency Procedures:** Familiarize yourself with emergency procedures and evacuation routes. Have a first aid kit readily available and know how to respond to accidents or injuries.

By adhering to these safety precautions, you can minimize risks and ensure a safe working environment when servicing solenoid valve controlled distributor type pumps and start assist systems.

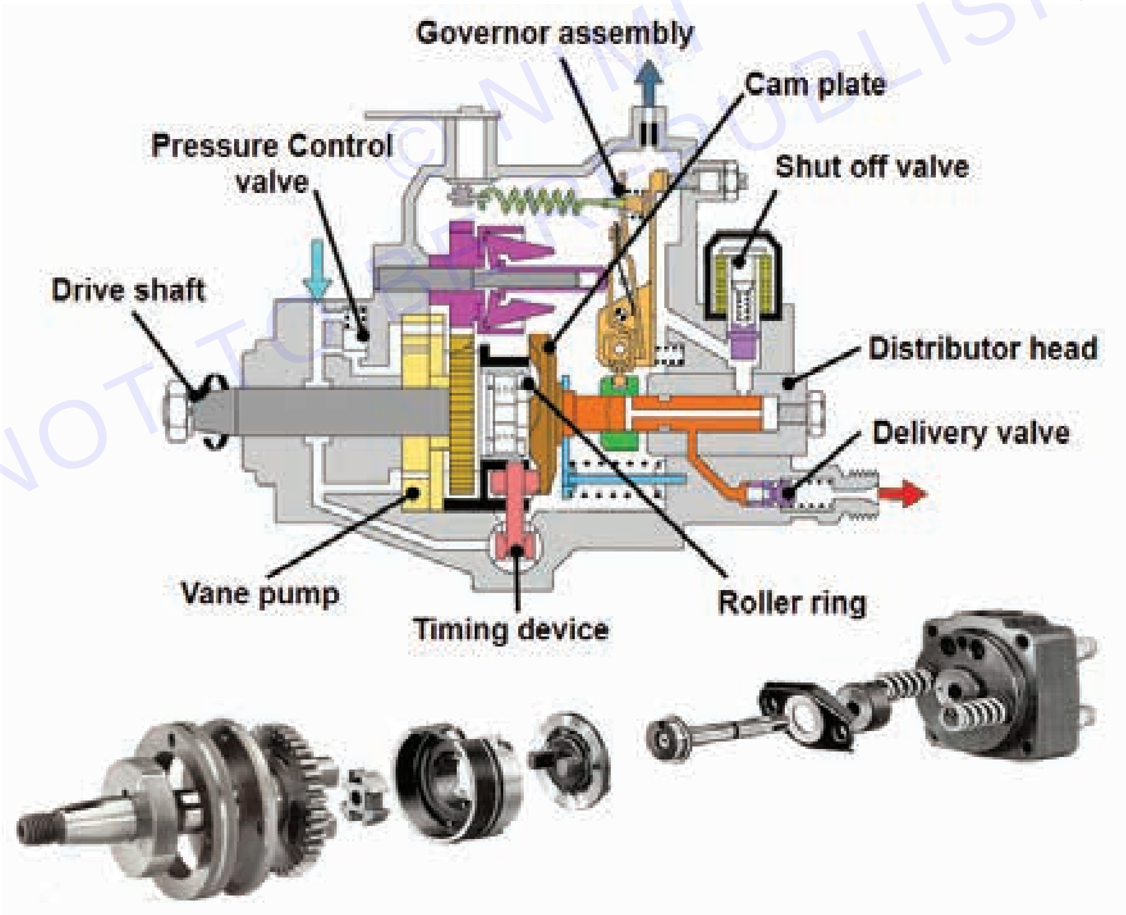
Procedure as per the Manufacturer for Dismantling, Inspecting and Assembling Distributor Pumps

Objectives : At the end of this lesson you shall be able to

- service Distributor type FIP as per manufacturer procedure.

Main part of distributor pump:

- Rotor
- Plunger
- Distributor valve
- Injection line
- Fuel control Rack
- Camshaft
- Governor assembly
- Pressure control valve
- Roller ring
- Delivery valve



Dismantling of distributor type Pump

Following is the method of dismantling distributor type fuel pump.

Prepare: Make sure the pump is disconnected from any power source and that the area is clean and safe to work in.

Remove the cover: Begin by removing the pump's cover or casing to access the internal components.

Disconnect the power: If the pump is electrically powered, disconnect any electrical connections or wires.

Remove the impeller: Depending on the type of pump, you may need to remove the impeller. This may involve unscrewing the nuts or bolts holding it in place.

Take apart the main mechanism: Take apart the pump's housing to access the distributor mechanism.

- Take apart and inspect the lever
- Open and inspect the governor assembly
- Open and check the timing device
- Open and inspect the delivery valve

Take apart the distributor: Carefully remove the distributor assembly, paying attention to how it is positioned and any components attached to it.

Inspect the Components: After removing the distributor, inspect each component for wear, damage or buildup that could affect the pump's performance.

Clean the Components: Clean all components thoroughly using appropriate solvents or cleaning agents to remove any debris or buildup.

Inspection and Replace or Repair: Replace any damaged components or repair any worn parts as needed.

Assembling distributor pumps: Once all components have been cleaned and inspected, reassemble the pump in the reverse order of disassembly, making sure everything is properly aligned and tightened.

Assembling a distributor pump requires precision and care. Here are general following steps

Clean: Make sure the workplace and components are clean to prevent contamination.

Inspect the parts: Check all parts for damage or wear. Replace any defective components.

Assemble the components: Follow the manufacturer's instructions to assemble the pump components in the correct order.

Lubrication: Apply appropriate lubricant to moving parts to ensure smooth operation.

Tighten the bolts: Use a torque wrench to tighten the bolts to the specified torque values. Over-tightening can damage parts.

Testing: After assembly, test the pump to make sure it works correctly and does not leak.

Quality check: Perform a final inspection to make sure everything is assembled correctly and meets quality standards.

MODULE 16 : Engine Management System

LESSON 98 - 103 : Engine management system Definition, Function, Types of system available

Objectives

At the end of this lesson you shall be able to

- define engine management system
- explain functions and types of engine management system.

Engine management system

- **Definition -** The engine management system is the arrangement of the devices for controlling a vehicle's engine.

  If the car is stolen, the unit will block the vehicle's engine management system and prevent the engine being restarted.

  The engine management system shuts down four of the eight cylinders when the power isn't needed.

  The engine management system gets the timing and fuel ratios correct for every eventuality.

  Engine Management System (EMS) comprises of Electronic Control Unit (ECU), sensors, actuators and control algorithms that determine the performance of the Engine as a whole and as part of the vehicle.

  The Electronic Control Unit consist of t microprocessor with peripheral devices like ignition driver, ADCs device and I/O drivers. Microprocessor controls the injection parameters as well as some of the vehicle related outputs such as Fan, AC drivability in gears, variable turbine turbocharger, EGR etc. The ECU receives input from various sensors located on the engine and the vehicle, and decides the injection quantity, injection timing, number of injections best suited for the engine to work with maximum efficiency and safety. It is the 'Brain' of the Engine Management System. Being the most important component of the Engine management system, ECU apart from ensuring the optimum working of the Vehicle, also keeps an eye on the working of the sensors and actuators. Whenever a malfunction/fault occurs in the component or the system the ECU alerts the user by glowing MIL indicator on instrument cluster. ECU also does the following:

  Stores a DTC in its memory (indicates the faulty component/system).

  Stores a context frame (list of parameters indicating the operating condition during the fault generation) in its memory.

  When the malfunction poses a threat to the vehicle, the ECU with its control algorithms operates the vehicle in Limp Home Mode (safe mode). This protects the component from damage with some degradation in performance of the vehicle.

- **Function:** Controls the running of an engine by monitoring the engine speed, load, and temperature. It also provides the ignition spark at the right time for the prevailing conditions and metering the fuel to the engine in the precise amount required.

- **Components OF Engine management system**

  1 electronic control unit (ECU),

  2 sensors

  3 actuators,

  4 communication system.

Sensors for engine management system

1 Mass Airflow Sensors.

2 Wheel Speed Sensors.

3 Camshaft Sensors.

4 Crankshaft Sensors.

6 Knock Sensors.

7 Pressure Sensors.

8 Oxygen Sensors.

9 Eccentric Shaft Sensors.

Parts of Engine Management System (All sensors, actuators, pumps) & their function

Objectives: At the end of this lesson you shall be able to

- locate and explain parts of engine management system.

Engine management system sensors, actuators and pumps

Sensor

In automotive vehicles, sensors are used to measure the operating conditions and changes of the vehicles. Mainly following types of sensor are used in vehicles:

1 **Oxygen sensor:** Oxygen sensor is used to estimate the proportion of analysed oxygen. The concentration of the gases emitted can also be measured.

2 **Crank sensor:** This electronic device is used to monitor internal combustion engines and their rotational speed. Through this, the pulverizing speed of the piston and valve can also be monitored. Cold temperature sensor: This type of sensor is used to measure the temperature of lubricant present in the engine of vehicles.

3 **Cold Temperature sensor:** This type of sensor is used to measure various temperatures like fuel temperature, coolant temperature, intake temperature, coolant temperature etc.

4 **Vehicle speed sensor:** The speed of vehicles is measured with this sensor.

5 **Injection pump speed sensor:** This type of sensor is used to monitor the rotation speed of the pump.

6 **Fuel rack position sensor:** This type of sensor is used to monitor the position of the fuel bank.

7 **Air flow sensor:** Air flow sensor is used to measure the rate of air flow coming into the fuel injection engine.

Apart from all the above sensors, some other sensors like fuel pressure sensor, air cleaner vacuum pressure sensor, brake pedal sensor, clutch pedal sensor, driver input switch sensor are also used in vehicles.

Actuators:

Actuators are used to transfer electrical signals into mechanical action. Electromagnetic actuators are used in electronic diesel control systems. These types of actuators are located on the fuel pump. Sensors are used in boost pressure actuators, butterfly valve actuators, exhaust gas recirculation actuators etc. to transfer electrical signals into mechanical action.

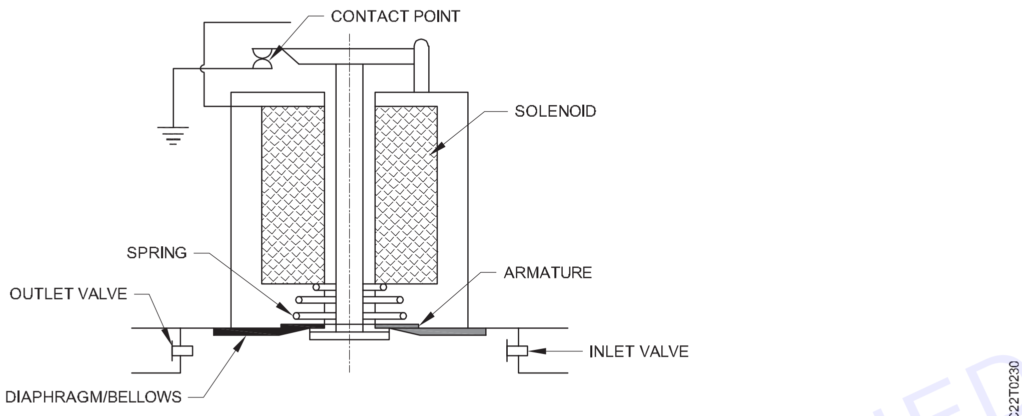
Electrical Fuel Feed Pump:

Battery operated fuel pump can be installed at any convenient location. These are of two types – diaphragm and Bellows.

Operation of Electric Fuel Feed Pump

When the ignition switch is on, the solenoid of the pump is energized and the ammeter is attracted towards the magnetic core against the spring tension thereby bending the diaphragm/ bellows. This creates a partial vacuum in the pumping chamber.

The pump sucks (sucks) fuel from the tank into the thin Inlet Valve chamber. When the actuator reaches the stopped position, the bronze plunger contact point cuts off the electrical connection to the solenoid. As a result, the solenoid does not operate.



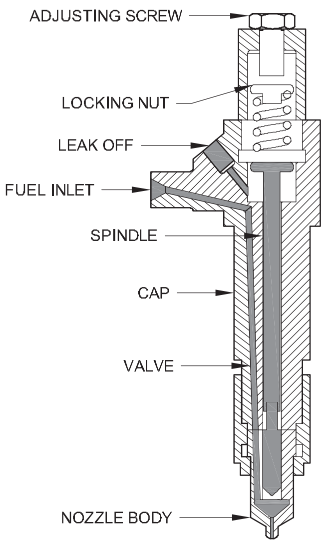
ELECTRICAL FUEL FEED PUMP

Now the spring pressure drives the armature downwards along with the diaphragm/bellows and fuel flows from the chamber to the carburettor through the outlet valve. The movement of the armature closes the contact point and the cycle is repeated 50 to 60 times per minute until the float chamber is filled.

Idling action

As soon as the float chamber is filled, the needle valve located in the float chamber closes the inlet passage of the carburettor. As a result, back pressure is generated in the pipeline. Due to this back pressure, the armature is always pressed in the upper position, which keeps the contact joint open. Thus, until the fuel level in the float chamber decreases, the pump remains in idle state.

Injector



FUEL INJECTOR

It is also called nozzle, atomizer or fuel valve. A cap nut is fitted at the top point of the injector and a nozzle is fitted at the bottom point. Parts like spindle, pressure adjusting screw, nozzle, nozzle spring etc. are fitted inside the injector. Injecting a flowing object into a limited space is called injection, that is, in diesel engines, introducing diesel fuel in the form of a spray of small particles into the hot air of the combustion chamber is called injection.

This injection is done by injector. It is also called fuel spray valve or atomizer. Injection is done through the injector at a pressure of 1500 to 2000 per square inch (PSI), because at the end of the compression stroke the air pressure in the combustion chamber is approximately 550 pounds per square inch and the temperature of the compressed air at that time is 500°C. It remains at 700°C. As soon as this injection takes place, the diesel gets burnt when it comes in contact with hot air, which provides power.

Closed and open loop system, cold start system, Air flow measurement, Variable intake manifold system, EFI wiring system, Electronic control unit, pre heaters for inlet manifold, Data link connector, On board diagnostic system

Objectives: At the end of this lesson you shall be able to

- explain about closed and open loop system, cold start system, air flow measurement & variable intake manifold system
- explain EFI wiring system, electronic control unit, pre heaters for inlet manifold
- use data link connector & on board diagnostic system.

Closed and open loop system, cold start system, Air flow measurement, Variable intake manifold system.

Closed and Open Loop Systems

Closed-loop system: Also known as feedback control system, it uses feedback from the output to control the input. It adjusts itself based on the difference between the actual output and the desired output.

Open-loop system: Also known as feedforward control system, it doesn't use feedback to adjust the input. It relies solely on the input command and doesn't consider the actual output.

Cold start system: Cold start systems provide additional fuel during starting. conditions, according to engine temperature.

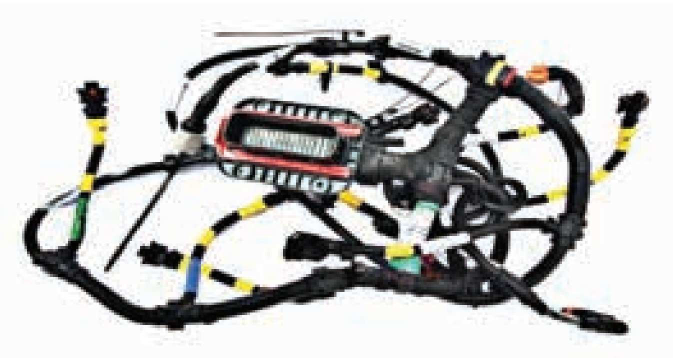
Air measurement: The vane - type airflow sensor measures the quantity of air flowing into the engine by deflecting a spring - loaded vane across a potentiometer. This provides a signal voltage to the ECU.

Air flow monitoring: Depending on the application, different kinds of sensors measure different properties of the air entering the engine, including its temperature, volume, density and mass.

Variable intake manifold system: Variable intake manifold systems vary the effective manifold pipe length, to extend the torque curve over a wider RPM range.

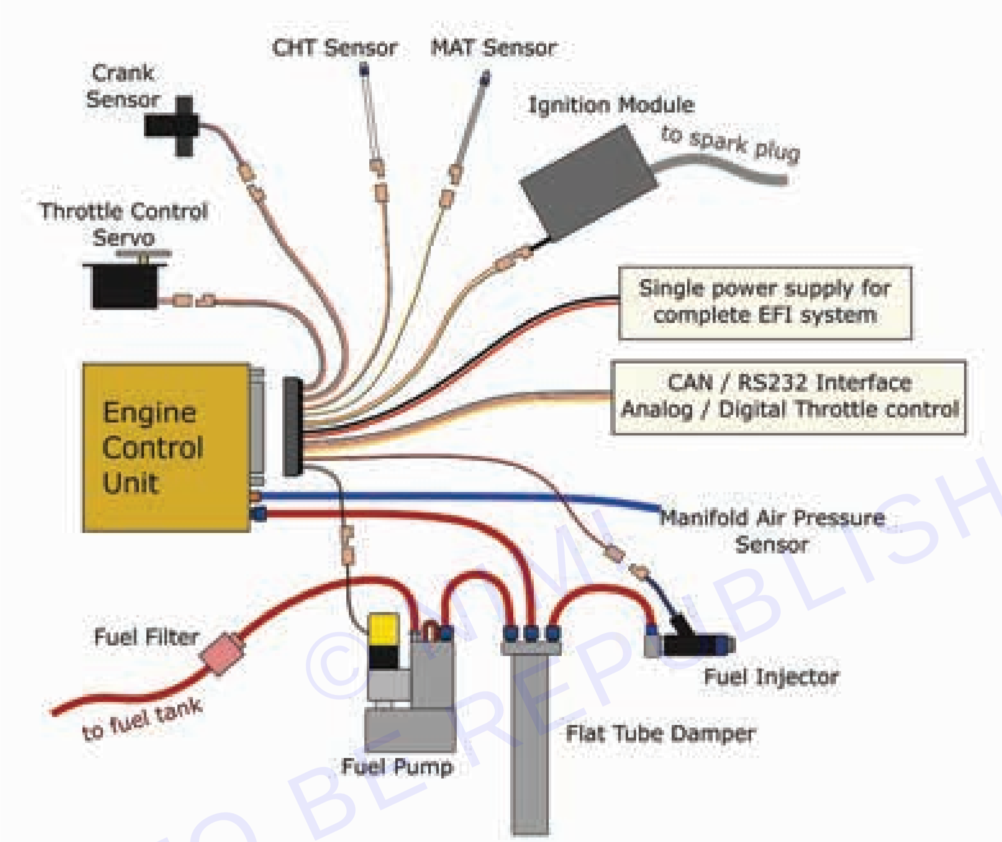
EFI (Electronic Fuel Injection) wiring system, Electronic control unit, Pre heater for inlet manifold.

EFI (Electronic Fuel Injection)



For manual operation engine have an inline pump and system work there for individual diesel supply in engine cylinder. For new updated engine use EDC system, it means electronic fuel supply system use in modern engine. These type engines install some wiring harness for different types of working. These system is known as EFI (Electrical Fuel Injection) system.

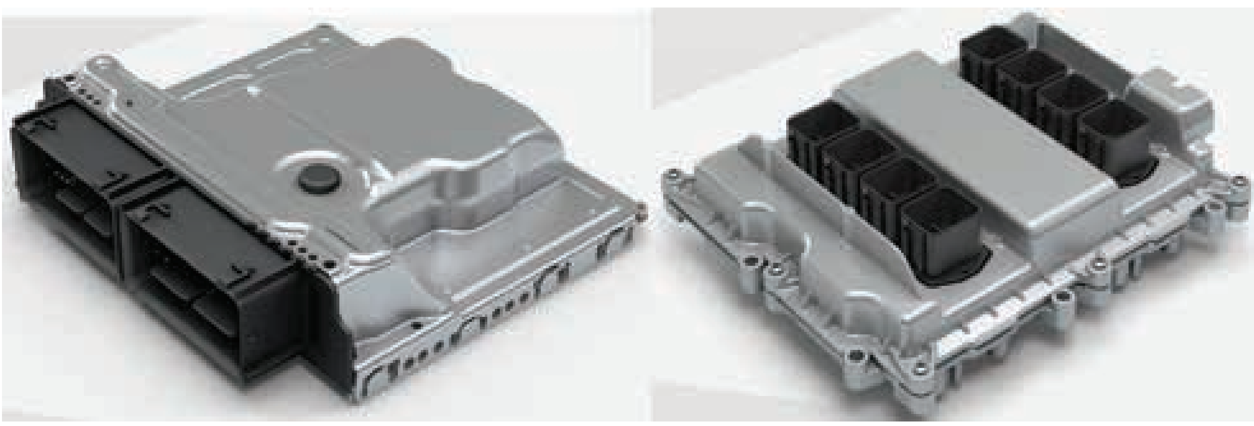
EFI system requirements have system rely on various sensors to keep thing smoothly. From crank and cam sensors to coolant and intake air temperature sensors, these components work together to ensure your engine receives the right amount of fuel at any given movement.



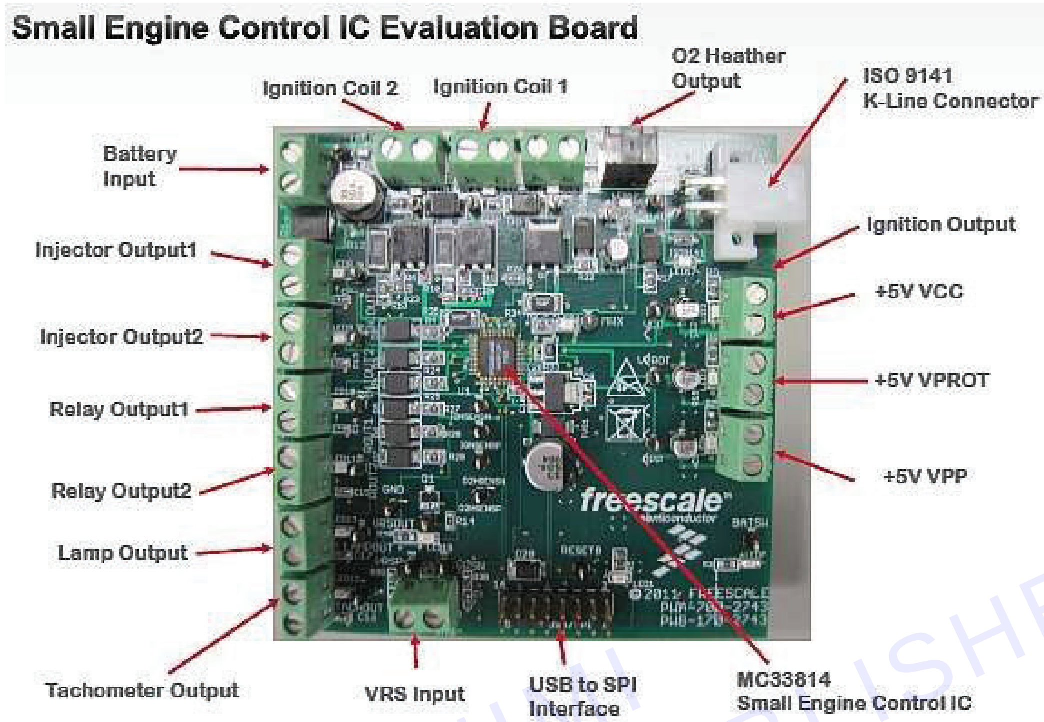
EFI includes sensors, actuators, wiring harness and an engine control engine (ECU) to precisely regulate fuel flow based on various engine parameters such as temperature, airflow and throttle position. It is a vital part of improving engine performance, fuel efficiency and emission control compared to older carburetor system.

The wiring connection in engine always directly connected with ECU to battery. Due to these reason, you should always connect the main power and ground for the ECU directly to the vehicles battery. By the connecting the unit's main power and ground this way, the battery acts as a capacitor, which filters the power going into the ECU.

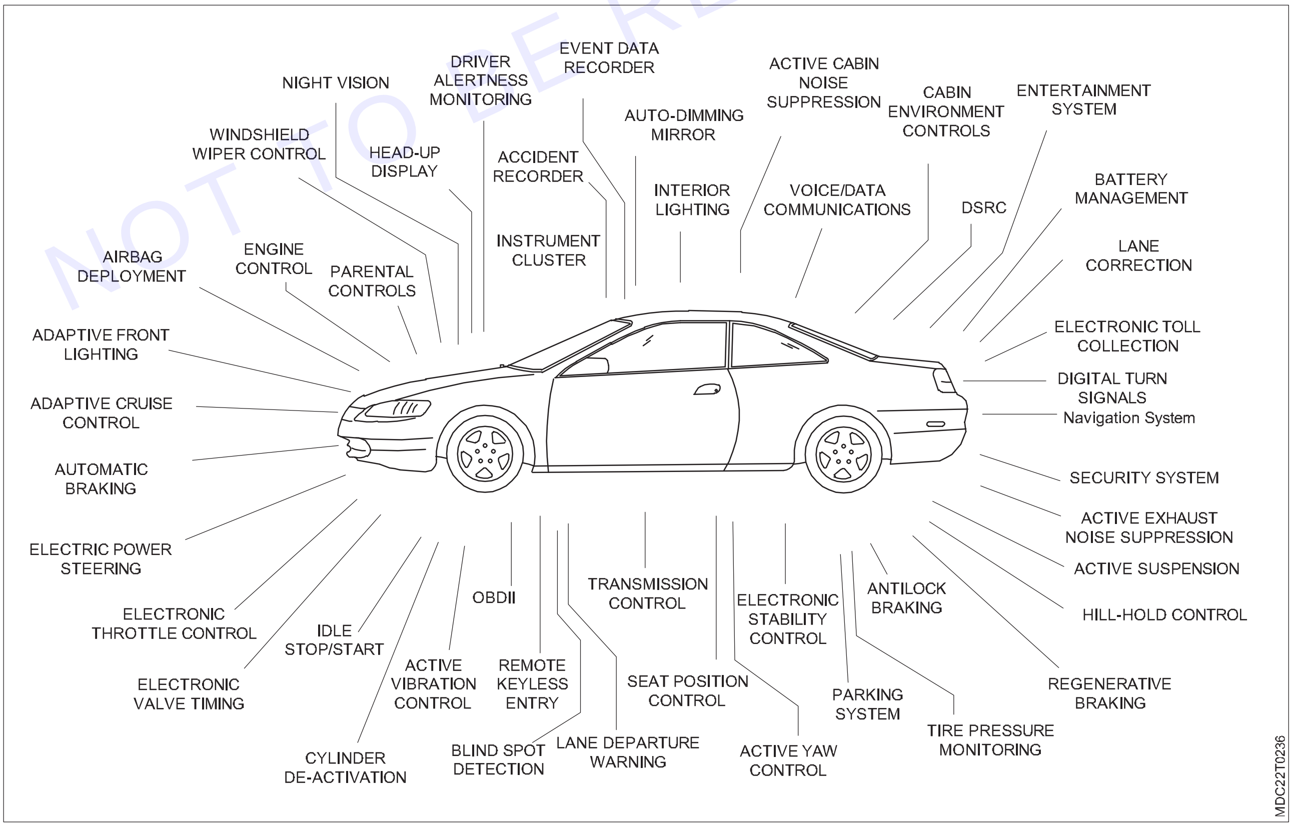
Electrical control units (ECU)



ECU is an electronic control unit that ensures the optimal work of an I.C engine. It control fuel supply and injection, fuel-to-air ratio, ignition, idle speed and the timing of valve opening and closing.



The ECU is a name given to a device that control one or more electrical system in a vehicle. It operates much like the BIOS (Basic Input /Output System) does in computer. The ECU provides instruction for various electrical system, instructing them on what to do and how to operate.

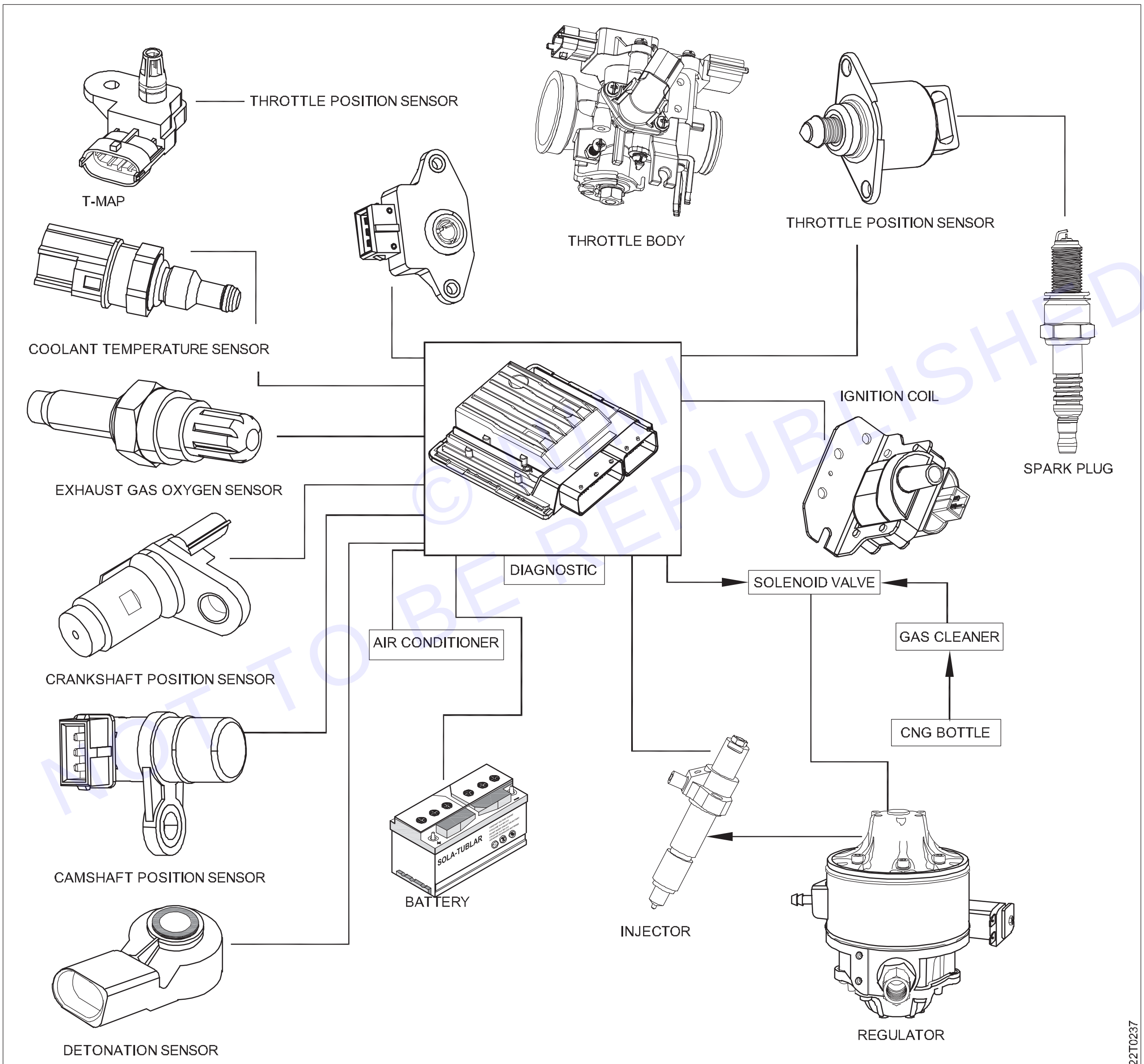


Work done by ECU (Electronic Control Unit)

An ECU is essentially a small computer that manages the actuators flawlessly. The ECU controls everything in the engine, including the wheel speed, braking power, ignition timing, idle speed and air/fuel mixture.

An electronic control unit receives input from one or several parts of the vehicle and uses that information to take action if needed. For example, an airbag ECU receives information from crash sensors and seat sensors. When there is a crash, the ECU decides which airbags to deploy depending on where passengers are sitting. Then it tells the actuators to deploy them. Then the actuators convert the electrical signal into the physical value needed, using valves, injectors or relays.

Examples of such systems include circulation pumps, compressors, manufacturing systems, refrigeration plant and motor control panels. Input devices such as sensors gather and respond to information and control a physical process by using electrical energy in the form of an output action.



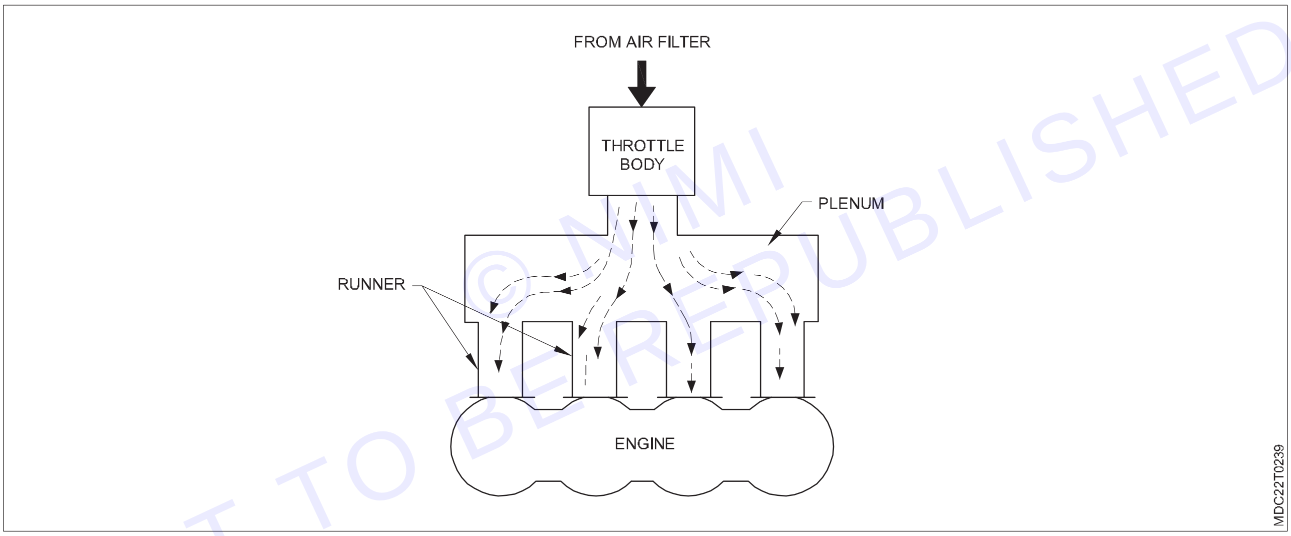
ENGINE CONTROL UNIT

Pre-heater for inlet manifold

Heated air intake systems operate on the principle of increasing the temperature of the air. The fuel will more effectively stay in suspension in the air rather than falling out of suspension and forming droplets on the floor of the manifold.

In a cold weather engine is unable to quick start, but operator need a quick performing of engine and warm combustion also need their therefore pre-heater unit works there.

Pre-heater helps to warm up the engine faster during cold weather. It is typically installed in the intake manifold of the engine, which is the part that distributes the air-fuel mixture to the cylinders.



The engine produces power by combusting air and fuel mixture and a heat source, and today we shall discuss the component responsible for passing air into the engine.

Intake Manifold can be defined as a series of tubes that are attached forming a single body and placed overhead of engine head, the air enters the engine passing through the air filter then through the throttle body and then finally paving its way into the intake manifold.

As the air enters the intake manifold it is passed through a series of sensors that are located to determine various components of air coming in, for example, its density, oxygen amount, moisture and various other characteristics that are very important for achieving proper air-fuel mixture and hence highly optimized engine performance.

The intake manifold consists of mainly 2 components

1 Plenum

The plenum is the large cavity at the top of the manifold.

2 The runners.

Runners are individual tubes running each to the cylinder head.

Working

The design of the intake manifold is very important for achieving good volumetric efficiency.

Abrupt contours in an intake manifold result in pressure drops and some of the fuel droplets in spark-ignition engines form pools in the interior part of intake manifolds surface which results in the uneven air-fuel mixture to enter for combustion. High-performance cars use manifolds with smooth contours for increased volumetric efficiency.

The design of manifold uses Helmholtz Resonance in which first, the air flows at considerable speed through the open valve. When the valve closes, the air that has not entered the valve yet still has a lot of momentum and compresses against the valve, creating an area of high pressure. This high-pressure air begins to equalize with lower-pressure air in the manifold. Due to air's inertia, the equalization will tend to oscillate, at first, the air in the runner will be at a lower pressure than the manifold. The air in the manifold then tries to equalize back into the runner, and the oscillation repeats. This process occurs at the speed of sound, and in most manifolds travels up and down the runner many times before the valve opens again.

Data link connecter, On board diagnosis system

The OBD connector, also known as the On-Board Diagnostics connector, is a standardized port used in vehicles to communicate with the onboard computer systems. It's typically located under the dashboard, and it allows mechanics and technicians to access diagnostic information and perform various tests on the vehicle's systems.

The OBD port is a universal connector that mechanics can use to tap into a vehicle's computer for running all sorts of tests and diagnostics. The history of the device goes as far back as 1968, when Volkswagen introduced its first form of on-board computer system.

OBD stands for On-Board Diagnostics and is a computer system inside of a vehicle that tracks and regulates a car's performance. This on-board computer system collects information from the network of sensors inside the vehicle, which the system can then use to regulate car systems or alert the user to problems. A technician can then simply plug into the OBD system to collect vehicle data and diagnose the problem. OBD systems have been a great help in helping users better understand vehicle diagnostics.

The history of OBD begins in the 1980s. During this time, vehicle monitoring systems were developed in response to several factors, including:

Emissions control: One of the biggest reasons for developing OBD was to help reduce vehicle emissions. OBD systems help in this area by monitoring the performance of major engine components for any system failures that could result in increased emissions. OBD is so helpful in this area that it is incorporated into EPA literature on the implementation of the Clean Air Act.

Electronic fuel injection: In the 1980s, automakers began the widespread production of vehicles with electronic fuel injection. Unlike mechanical fuel injection systems, electronic fuel injection works via computer control, with the computer system monitoring and determining the fuel flow into the engine.

Electronic components: As electronic fuel injection gained popularity, more electronics became commonplace in cars, increasing the need for more sophisticated monitoring systems to help identify problems more accurately.

Since its initial development, vehicle monitoring systems have undergone several iterations. Today, OBD serves as a standardized system that dictates the connectors and trouble codes used, making it easy for technicians to service a wide range of vehicles quickly and accurately.

How Does OBD Work?

A basic OBD system consists of a central system, a network of sensors, a connection point and indicators, creating a complete monitoring system with standardized access and readability. The OBD system consists of the following components:

ECU: The central part of the OBD system is the Electronic Control Unit, or ECU. The ECU collects input from various sensors throughout the vehicle. The ECU then uses this data to either control parts of the vehicle, like fuel injectors, or monitor for issues.

Sensors: There are sensors throughout vehicles covering every area from the engine and chassis to the electronic system itself. Each one of these systems sends codes to the ECU, specifying the source and the parameters of the signal. The ECU then "reads" and interprets this signal.

DTC: If a sensor sends information to the ECU that falls outside of the normal range, the ECU saves the information as a code called a Diagnostic Trouble Code, or DTC. The DTC code essentially is a list of letters and numbers, which indicate the source and nature of the problem. DTC codes are usually standardized but may be manufacturer-specific. When a DTC is saved, the ECU sends a signal to your indicator light to state that a problem has been found. The DTC can also be pulled by linking a sensor to the connector for the OBD system.

MIL: When the ECU collects a DTC code, it sends a signal to the vehicle dashboard to turn on the appropriate indicator lights. These lights, known formally as Malfunction Indicator Lights or MILs, provide an early warning system for vehicle malfunctions. Generally speaking, if the light turns on and stays on, the problem is minor. If the light flashes, the problem is urgent.

DLC: All of the data and DTC codes collected by the ECU can be accessed via the Diagnostic Link Connector or DLC. The DLC port is the point of access for vehicles with OBD systems and is often found beneath the dashboard on the driver's side of the vehicle, though it may be located elsewhere in commercial vehicles. Current vehicles are made with a standard OBDII system so that any scan tool with a type 2 cable can connect to the type 2 connector.

How does OBD work

How Has On-Board Diagnostics Changed Over the Years?

OBD has changed significantly over the years since its introduction in the 1980s. Originally, the system would notify the user that there was a problem using the MIL, but wouldn't store any information as to the nature of the problem. As cars became more advanced, the number of sensors installed in vehicles expanded, as did the amount of information stored inside the system.

The evolution of OBD systems can be split into two distinct phases based on the type of system popular at the time. These are described in more detail below:

1 OBD-I

The first OBD systems were proprietary in nature, so they differed between manufacturers. Prior to 1990, the codes, systems and information gathered by each OBD system varied widely from manufacturer to manufacturer. While these systems proved useful, they were unnecessarily complex for technicians to work with — technicians had to purchase a new tool and cable for every vehicle make or had to invest in a scanner that had an array of adapter cables for multiple vehicle makes. Due to the proprietary nature of these systems, users were often forced to go to dealership technicians to diagnose issues.

The push to standardize OBD systems didn't start until the California Air Resources Board mandated OBD capability in all cars in 1991. The board didn't issue any standards for these OBDs, however, causing increased difficulties for vehicle manufacturers and users. When the OBD-II standard was implemented in 1994 in response to this need, all previous forms of OBDs were retroactively classified as OBD-I systems.

2 OBD-II

In 1994, the California Air Resources Board issued OBD-II as a set of standards for OBD systems for all vehicles sold in California. This mandate was officially implemented in the 1996 model year and has been in use ever since. The Society of Automotive Engineers and the International Standardization Organization, known as the SAE and ISO, respectively, also issued standards for how digital information should be exchanged between ECUs and a diagnostic scan tool. The EPA further expanded the use of OBD-II following the passage of the Clean Air Act — as of 2001, 33 states and local areas require regular vehicle inspections to ensure that they meet emission standards, and OBD-II systems are a key part of these inspections.

The OBD-II standards are characterized by several requirements, including the following:

OBD-II Connector: Modern OBD systems use standardized DLCs called Type 2 Connectors. This allows technicians to use the same cable, a Type 2 Cable, to access the digital communications stored in the OBD system through a port. The location of this port is not standard, but it is usually located under the dashboard on the driver's side of the vehicle.

System Monitoring: The EPA requires that OBD systems monitor problems that affect vehicle emissions. Many systems look into other metrics that are not included in this scope as a way to make it easier to find and fix vehicle issues, but the minimum requirement is set.

With this set of standards in place, technicians can service a wider variety of vehicles quickly and easily without the need for manufacturer-specific tools.

What Are the Applications of OBD?

OBD is commonly used across a wide range of vehicle types as an easy way to diagnose vehicle problems. However, the applications of OBD have expanded to cover more specific areas of vehicle monitoring and maintenance, especially over the past few years. Some more specific applications of OBD include:

Driver behavior monitoring: Automotive-related industries have increasingly used OBD systems as a way to monitor driver behavior. For example, some auto insurance companies offer reduced premiums for drivers that use vehicle data loggers to prove that they exhibit safe driving practices. Additionally, companies may install similar data loggers in their fleet or delivery vehicles to keep an eye on their drivers' behavior in real time, which can help reduce their liability in the event of an accident or traffic infringement.

Emissions testing: OBD-II testing is now a common method of testing vehicles for emissions in parts of the U.S. that require it. As part of the OBD-II standard, these systems closely monitor emissions, so inspectors can simply use a scan tool to check for emissions-related trouble codes to ensure that the vehicle is compliant.

Supplementary instrumentation: Vehicle enthusiasts and professional drivers often use OBD systems to keep an eye on metrics that are not normally displayed in standard vehicles. These metrics may be displayed on custom installations in the vehicle or broadcast to the drivers' phone.

Commercial vehicle telematics: Commercial vehicle companies commonly use what is referred to as Generic OBD II to gather information about their fleet. This includes fleet tracking, fuel efficiency monitoring, driver behavior monitoring, remote diagnostics, and more.

What are the applications of OBD?

How OBD Relates to Commercial Vehicles

Possibly the most extensive use of OBD has been in the commercial vehicle industry, as careful vehicle maintenance is a key aspect of this industry. Commercial vehicle companies have broadly implemented the use of advanced scan tools for OBD2 systems, particularly for the following benefits that OBD-II provides:

Fast diagnosis: With standardized connectors and DTCs, as well as a detailed DTC system through SAE J1939, commercial vehicle problems can be identified in a matter of minutes. By connecting a diagnostic software or scan tool to the connector port, technicians can pull valuable diagnostic information that can be used to identify and solve problems before they become expensive repairs.

Accurate information: With the OBD system, information is collected through the use of sensors rather than by human technicians. This increases the accuracy of the information pulled, reducing the chances that a critical system error may be missed.

Variety of metrics: OBD systems can be used to collect a wide range of metrics beyond those relating to vehicle maintenance. OBD systems can track driver behavior to ensure that drivers are following legal requirements as well as company protocols. Systems can also be used to broadcast metrics over a secure line, allowing central control to monitor drivers and their vehicles from a remote location with ease.

Improved compliance: As of 2010, the standards set by the EPA and the Clean Air Act also apply to heavy-duty engines used in trucks over 14,000 pounds. Vehicles operating in certain states need to be inspected regularly to ensure that they comply with these standards. OBD systems monitor emissions to ensure that vehicles meet minimum requirements at all times. They also alert users when emissions exceed acceptable limits so that the issue can be addressed and fixed before an inspection.

Reduced costs: Between faster, more accurate diagnoses, expanded monitoring capabilities and improved vehicle compliance, OBD systems have helped commercial vehicle companies to reduce costs.

How OBD relates to commercial vehicles

Takeaways

While the above benefits of OBD2 are impressive, commercial vehicle companies can gain even more benefits when they use OBD systems to their fullest potential.

Precautions to be observed while working with engine emission control systems details of OBD-description of data link connect or study about schematic and routing diagram of emission control system flow diagram of control systems-terminal arrangement of ECM

Objectives: At the end of this lesson you shall be able to

- demonstrate precautions to be observed while working with engine emission control systems
- study about schematic and routing diagram of emission control system.

Precautions to be observed while working with engine emission control systems

The exhaust gas of diesel engine vehicles contains high amount of nitrogen oxide (NOx), sulfur dioxide and particulate matter. For pollution control of vehicles with diesel engines, attention should be paid to the following aspects.

1 Engine oil should be changed after regular intervals. Use the correct grade of oil as per the vehicle manufacturer's instructions.

2 Change the oil filter, fuel filter and air filter after certain period and use good quality and good company.

3 Proper grade of fuel should be used. Fuel pump and fuel injector should be serviced after a certain period of time. Also other works related to engine servicing (eg tappet setting etc.) should be done.

4 Maintain the entire vehicle as per service manual.

5 Avoid driving with over load and over speed.

6 Emission level should be checked regularly.

The Government of India has decided the Emission Norms (GLKM) from 1st April 2000 and they are (EIRO - I, II, III, IV) as Bharat Stage 1, Bharat Stage II, Bharat Stage III, Called Bharat Stage IV. While issuing PUC (Pollution Under Control) certificate, the amount of harmful element in the exhaust gas is checked with the help of exhaust gas analyzer. According to the revised rules, the transport department allows the vehicle to be driven on the road only if it is in the right amount.

Details of OBD-description of data link connect or study about schematic and routing diagram of emission control system

The On-Board Diagnostics (OBD) system is an internal part of vehicles as it is monitors the engine, transmission, and other emissions-related systems. This system utilizes a standardized digital communications port known as the data link connector (DLC), to provide real-time data and diagnostic information.

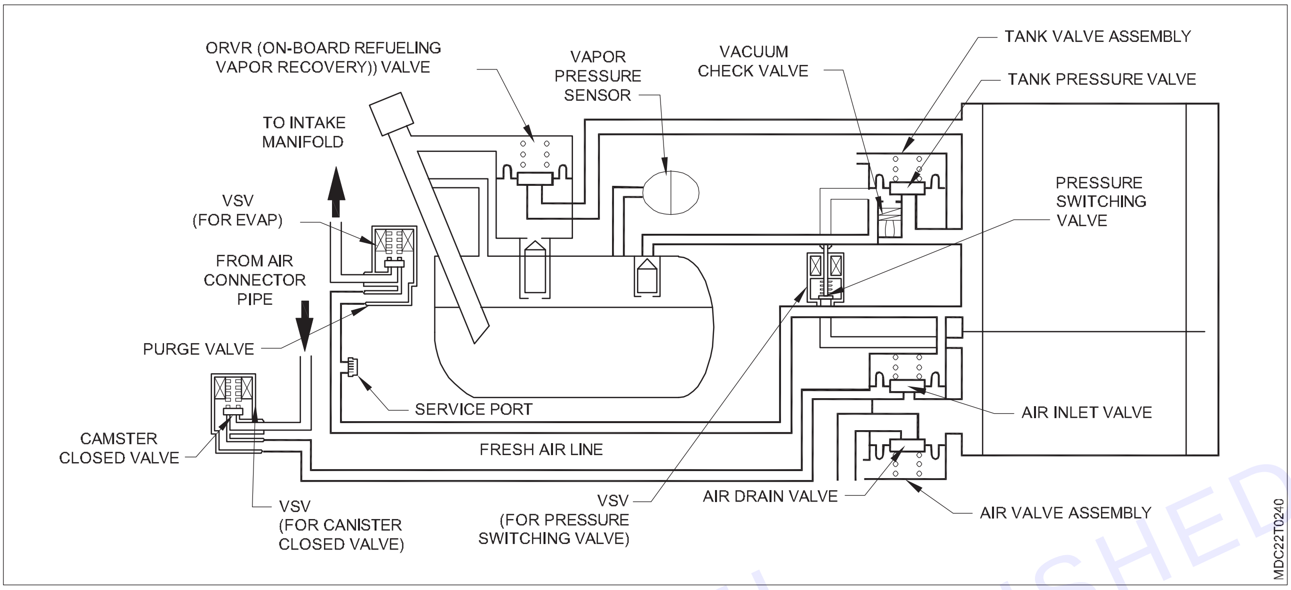
The DLC serves as the physical connector or port where an OBD scanner or diagnostic tool is connected to access the vehicle's data. Typically located beneath the dashboard, near the driver's seat, the DLC follows a standardized format across vehicles and is commonly a 16-pin connector. However, older vehicles may feature a 12-pin connector instead.

Each pin within the DLC has a specific purpose:

- Pin 4 and Pin 5: Ground
- Pin 16: Battery voltage
- Pin 7: K-Line (ISO 9141-2 and ISO 14230-4)
- Pin 2: Bus+ (SAE J1850 PWM and VPW)
- Pin 10: Bus- (SAE J1850 PWM only)
- Pins 6, 14, and 15: CAN High, CAN Low, and CAN Ground (ISO 15765-4)
- Pins 1, 3, 8, 9, 11, 12, 13: Manufacturer discretion for additional functions

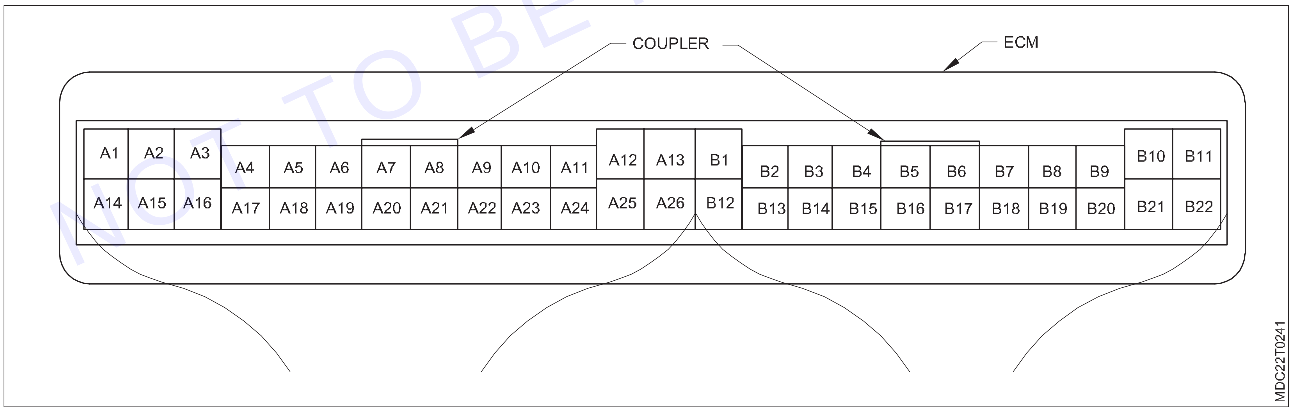
The specific pinout and communication protocol utilized depend on the make, model, and year of the vehicle. In the United States, OBD-II has been the standard since 1996 for vehicles sold, and it typically employs pins 4 and 5 for ground, pin 16 for battery voltage, and pins 6 and 14 for CAN bus communication. Other pins may be utilized for specific functions or protocols.

diagram of emission control system



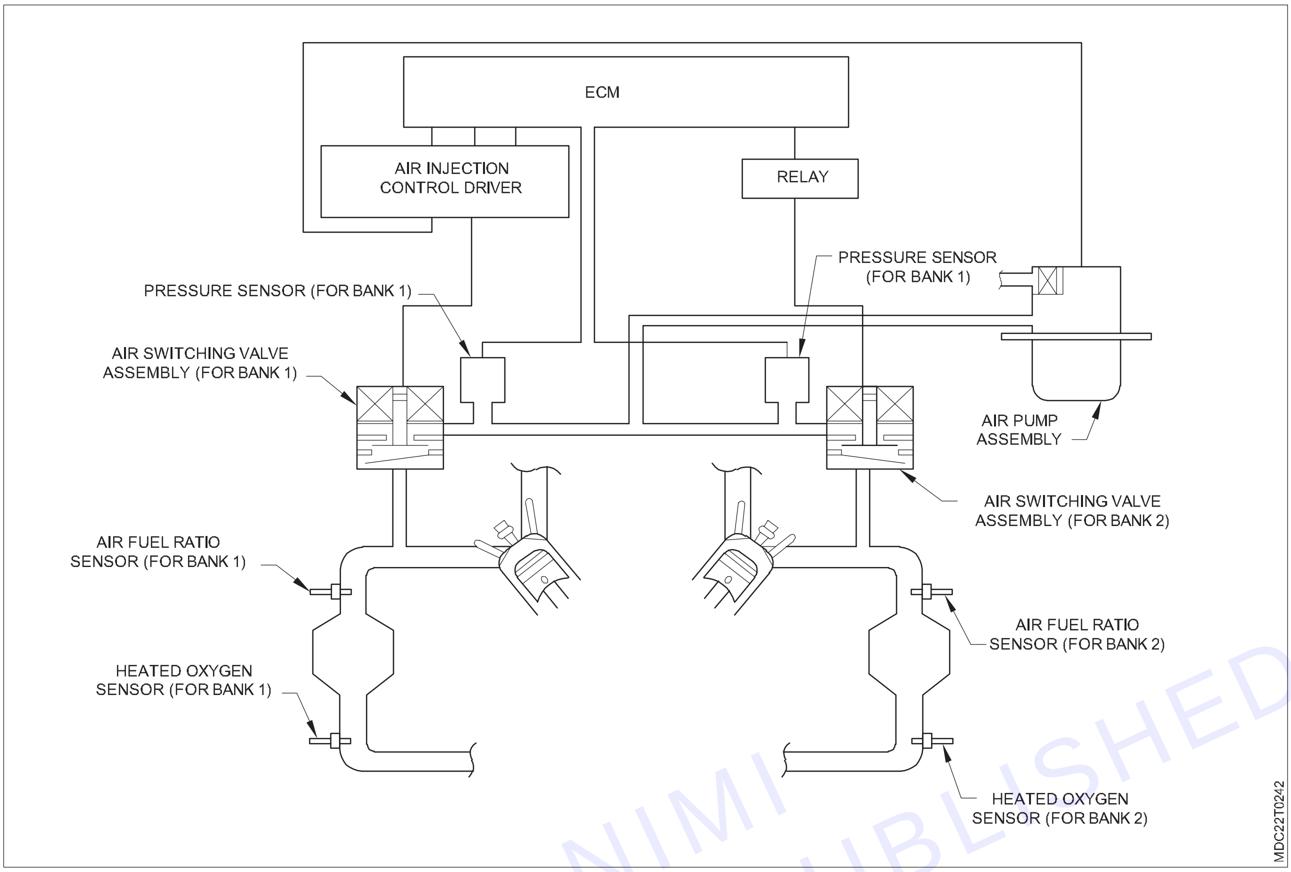
Flow diagram of control systems-terminal arrangement of ECM

The Engine Control Module (ECM) is a black box-like electronic part located in the instrument panel box near the driver's seat. It contains a microprocessor, an Analog-to-Digital converter (A/D converter), and input/output components. The ignition switch supplies current to the battery. The ECM is connected to various electronic sensors and switches on the engine, and all related circuits are grounded to the engine. The ECM is responsible for controlling the engine's overall operation.



The Electronic Control Module (ECM) functions similarly to the cerebellum in the brain. It receives sensory information from various sensors, much like how the cerebellum receives situational sensations from the body's senses. The ECM then analyzes this information, makes decisions, and sends commands to ensure the right actions are taken. For example, sensors on the engine transmit data about its conditions to the ECM, which processes the information and sends appropriate signals back to control various functions, such as fuel injection.

The ECM stores standard data about the engine's entire operation, including functions like four-stroke operation, cooling, lubrication, and fuel systems. If the engine deviates from this standard data, the ECM diagnoses faults and sends necessary signals. In serious malfunctions, it can shut down the engine. It also controls ignition timing. The ECM is not serviceable, and if it malfunctions, it needs to be replaced.


ECM
AIR INJECTION CONTROL DRIVER
RELAY
PRESSURE SENSOR (FOR BANK 1)
PRESSURE SENSOR (FOR BANK 1)
AIR SWITCHING VALVE ASSEMBLY (FOR BANK 1)
AIR PUMP ASSEMBLY
AIR SWITCHING VALVE ASSEMBLY (FOR BANK 2)
AIR FUEL RATIO SENSOR (FOR BANK 1)
AIR FUEL RATIO SENSOR (FOR BANK 2)
HEATED OXYGEN SENSOR (FOR BANK 1)
HEATED OXYGEN SENSOR (FOR BANK 2)
MDC22T0242

LESSON 104 - 107 : Details of trouble codes functions of sensors and actuators-details of scan tool-precautions while working with sensors and actuators

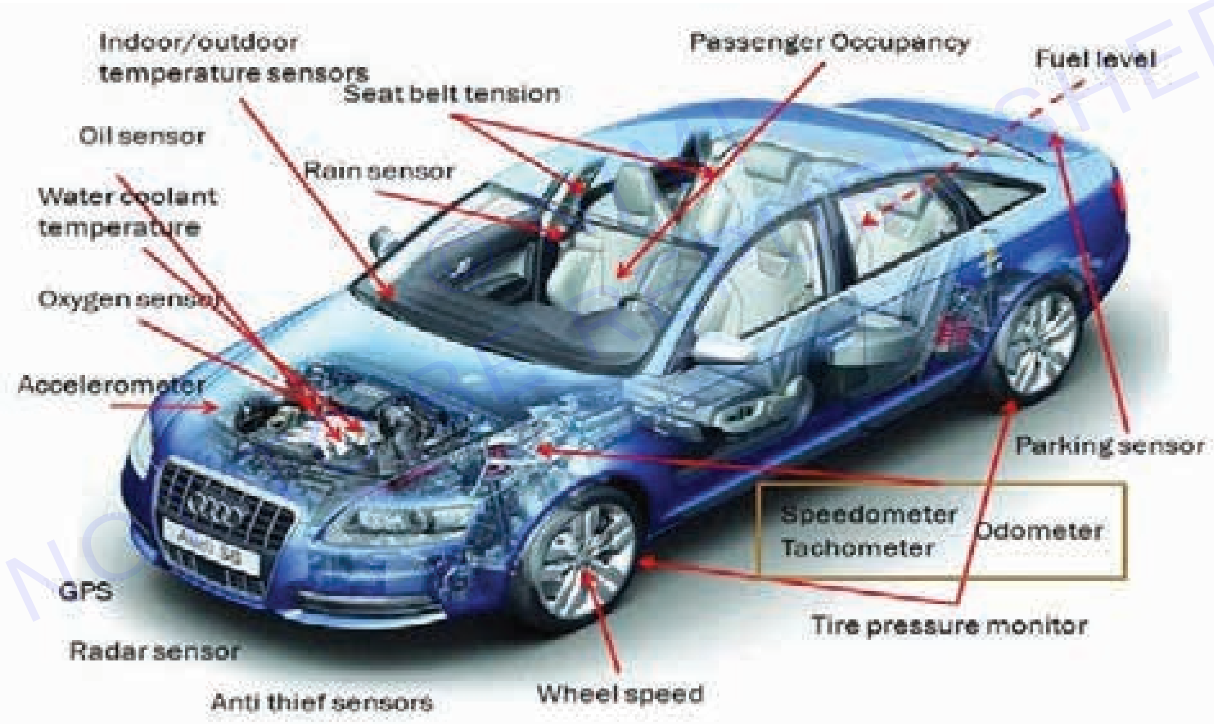
Objectives

At the end of this lesson you shall be able to

- read trouble codes of sensors and actuators.
- demonstrate use of scan tool.

Sensors: Sensors are the components of the system that provide the inputs that enable the computer (ECM) to carry out the operations that make the system function correctly.

In the case of vehicle sensors, it is usually a voltage that is represented by a code at the computer's processor. If this voltage is incorrect the processor will probably take it as an invalid input and record a fault.



Engine development has become a challenge mainly because the user expects improved performance levels with reduced fuel consumption. Further, environmental considerations necessitate adopting the use of methods which lower emissions. Achieving the twin goal of low emissions with good performance and drivability is a difficult task. It is in this context that electronic engine management has gained importance. The principal aims of an engine developer is to achieve:

i High reliability and durability with lowest possible initial cost

ii High power output and torque

iii Low levels of gaseous and particulate emissions

iv Low fuel consumption

v Low noise levels and vibrations

Over the years, lots of developments in electronics have taken place. Therefore, in gasoline engines control of the following parameters is easily monitored by using sensors and actuators linked to an electronic control module. The important parameters that can be controlled are:

i Air-fuel ratio

ii Mixture distribution between cylinders

iii Ignition timing

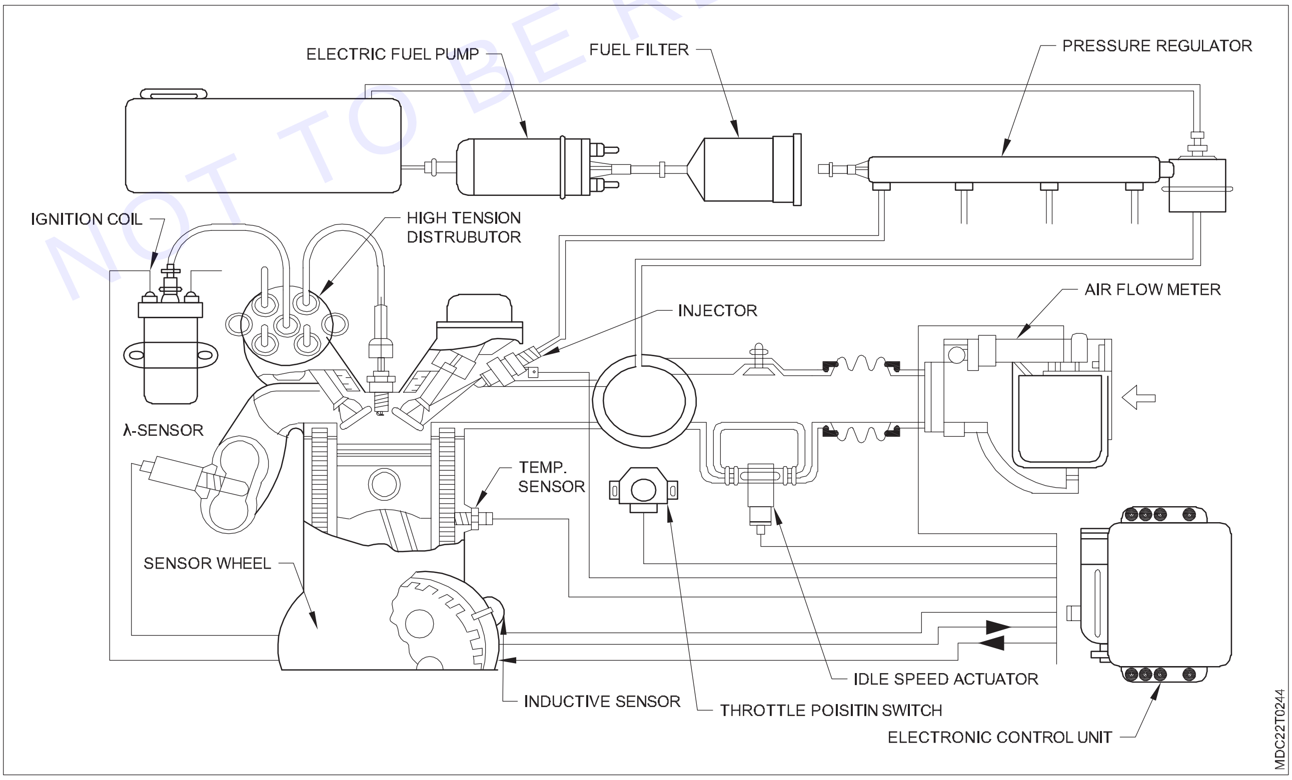
iv Injection timing of the fuel

v Idle speed

As known a diesel engine uses a heterogeneous fuel air mixture. The load is controlled by varying the amount of fuel injected. The fuel that is injected has to be atomized and mixed with air without leaving rich pockets so that combustion can take place properly. Too much mixing may lead to very lean mixtures. Again the fuel will not burn completely and this will result in hydrocarbon emission. Insufficient mixing will lead to high smoke, HC, CO emissions and fuel consumption. Proper timing of the ignition can lead to low combustion temperatures and smooth engine operation. This will also reduce NO x emissions.

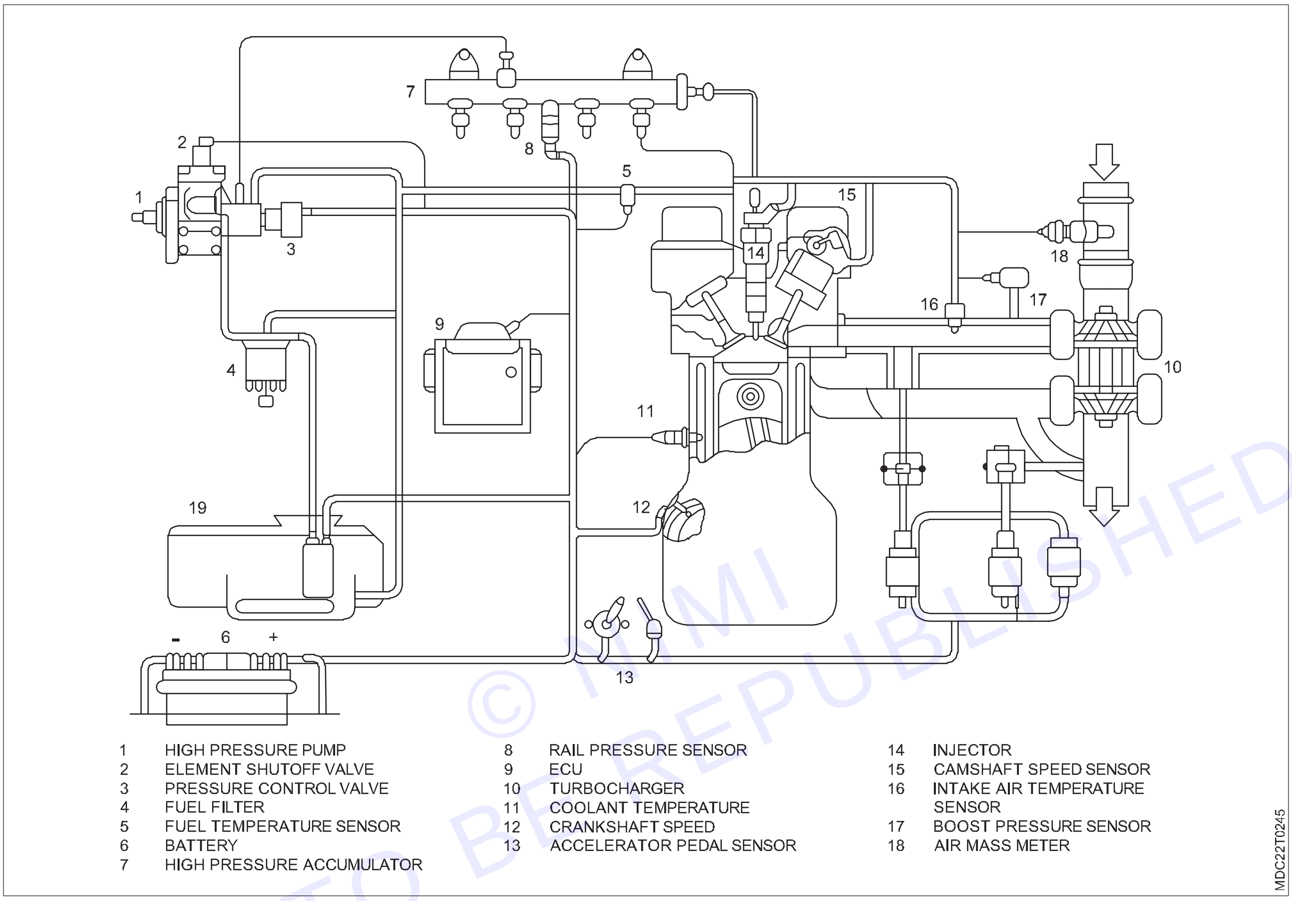
Modern emission standards and performance requirements cannot be met by conventional fuel injection systems operated mechanically. Injection timing, pressure, duration etc. can be easily controlled electronically to minimize fuel consumption and emissions. Here again a set of sensors determines the engine operating conditions and this data is fed to the electronic control module to take suitable steps in order to control the engine operation via actuators. Electronic controls can also be used for engine speed governing. These systems can give very close control over the engine speed under transients and wide load fluctuations. In both SI and CI engines the electronic control module works on software specially developed which uses sensor inputs and previously stored data about the engine. Using this information, it controls various parameters. The control is achieved through actuators. The data about the engine is stored as a table that is analyzed to take appropriate decisions. In most cases the electronic control module has to work in conjunctions with mechanical systems. In this chapter we will introduce different instrumentation and sensors that can be used in practice.

Typical engine management systems



In order to get an idea of the different types of sensors that are used in an engine let us take the example of a typical gasoline fuel injection system as shown in We can see that different sensors are used to detect crank shaft position, coolant temperature, engine speed, air flow rate, exhaust oxygen level, camshaft position, EGR valve position, exhaust manifold pressure, knock, manifold air pressure and manifold temperature.

Shows a typical common rail diesel fuel injection system. In this case we have sensors for engine speed, air mass flow, crank speed, cam shaft position, turbo air boost pressure, fuel rail pressure, air temperature,



1 High pressure pump

2 Element shutoff valve

3 Pressure control valve

4 Fuel filter

5 Fuel temperature sensor

6 Battery

7 High pressure accumulator

8 Rail pressure sensor

9 ECU

10 Turbocharger

11 Coolant temperature sensor

12 Crankshaft speed

13 Accelerated pedal Sensors

14 Injector

15 Camshaft speed sensor

16 Intake air temperature sensor

17 Boost pressure sensor

18 Air mass meter.

Bosch common rail diesel injection system

coolant temperature, accelerator pedal position etc. Thus it is clear that the functioning of all electronically controlled fuel control systems depends on the inputs from different types of sensors. The ECU (Electronic Control Unit) receives these signals from sensors and after manipulation and calculations sends outputs to vary the injection timing, fuel quantity, ignition timing etc. It also controls systems like the fuel injection pump, idle speed control unit, particulate trap regenerator (in a diesel engine), coolant supply etc. Thus any engine management system consists of the following main units: sensor, signal conditioner, analogue to digital converter, electronic control unit, output signal, driver and actuator. There will be more than one input and also more than one output which will be involved in controlling the engine at any given instant. We will look at different kinds of sensors that are normally used along with their measuring principle. For clarity, the discussion is divided depending on the parameter that is measured and applicable sensors in under each category.

3 Position displacement and speed sensing

Position displacement and speed sensing are very important in the engine management system. For such sensing inductive, hall effect, potentiometric, electro optical, differential transformer and strain gauge sensors are extensively used for these applications particularly in automobiles and engine laboratories.

Types of Sensors used

1 Mass air flow (MAF) rate

2 Exhaust gas oxygen concentration (possibly heated)

3 Throttle plate angular position

4 Crankshaft angular position/RPM

5 Coolant temperature

6 Intake air temperature

7 Manifold absolute pressure (MAP)

8 Differential exhaust gas pressure

9 Vehicle speed

10 Transmission gear selector position

Computer-Process Interface to implement process control, the computer must collect data from and transmit signals to the production process

Components required to implement the interface

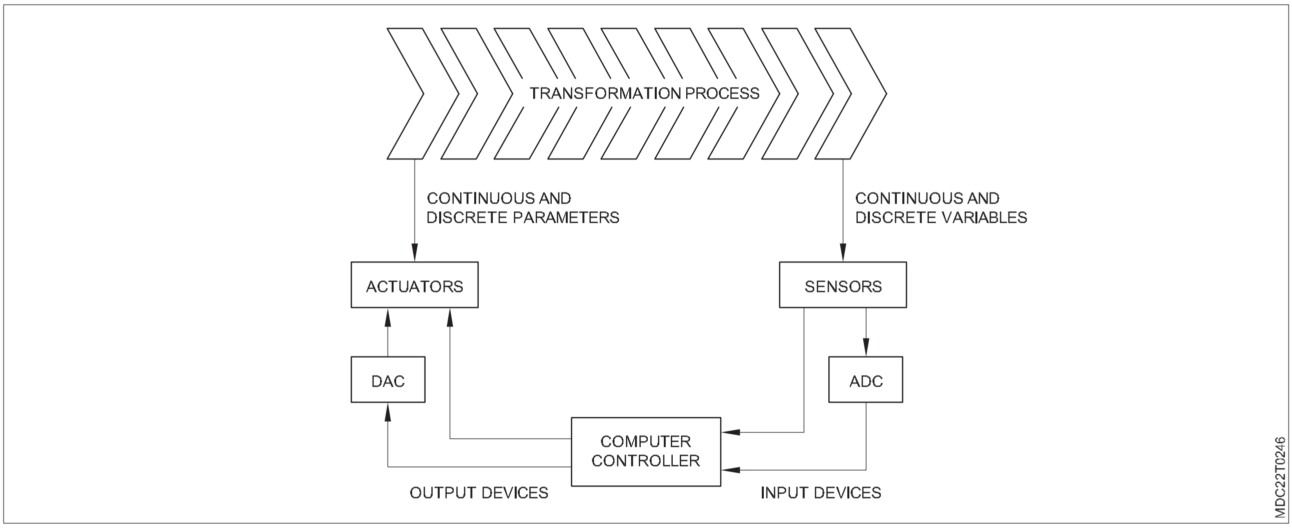
1 Sensors to measure continuous and discrete process variables

2 Actuators to drive continuous and discrete process parameters

3 Devices for ADC and DAC

4 I/O devices for discrete data

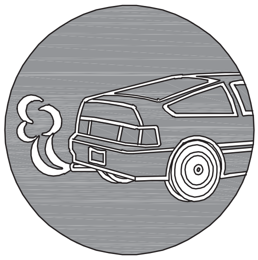
Computer Process Control System



Scan tool using safety first!

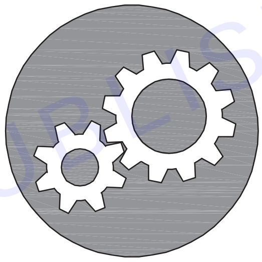
This manual describes common test procedures used by experienced service technicians. Many test procedures require precautions to avoid accidents that can result in personal injury, and/or damage to your vehicle or test equipment. Always read your vehicle's service manual and follow its safety precautions before and during any test or service procedure. ALWAYS observe the following general safety precautions:

1 When an engine is running, it produces carbon monoxide, a toxic and poisonous gas. To prevent serious injury or death from carbon monoxide poisoning, operate the vehicle ONLY in a well-ventilated area.



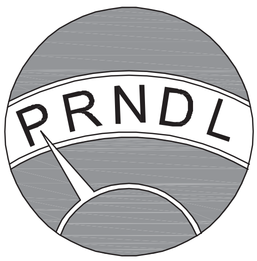
2 To protect your eyes from propelled objects as well as hot or caustic liquids, always wear approved safety eye protection.

3 When an engine is running, many parts (such as the coolant fan, pulleys, fan belt etc.) turn at high speed. To avoid serious injury, always be aware of moving parts. Keep a safe distance from these parts as well as other potentially moving objects.



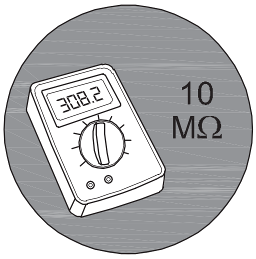
4 Engine parts become very hot when the engine is running. To prevent severe burns, avoid contact with hot engine parts.

5 Before starting an engine for testing or troubleshooting, make sure the parking brake is engaged. Put the transmission in park (for automatic transmission) or neutral (for manual transmission). Block the drive wheels with suitable blocks.



6 Connecting or disconnecting test equipment when the ignition is ON can damage test equipment and the vehicle's electronic components. Turn the ignition OFF before connecting the Scan Tool to or disconnecting the Scan Tool from the vehicle's Data Link Connector (DLC).

7 To prevent damage to the on-board computer when taking vehicle electrical measurements, always use a digital multimeter with at least 10 megOhms of impedance.



8 Fuel and battery vapors are highly flammable. To prevent an explosion, keep all sparks, heated items and open flames away from the battery and fuel / fuel vapors. DO NOT SMOKE NEAR THE VEHICLE DURING TESTING.

9 Don't wear loose clothing or jewelry when working on an engine. Loose clothing can become caught in the fan, pulleys, belts, etc. Jewelry is highly conductive, and can cause a severe burn if it makes contact between a power source and ground.

10 Be extra cautious when working around the ignition coil, distributor cap, ignition wires and spark plugs. These components produce hazardous voltages when the engine is running.

11 Put blocks in front of the drive wheels and never leave the vehicle unattended while running tests.

12 Put the transmission in PARK (for automatic transmission) or NEUTRAL (for manual transmission) and make sure the parking brake is engaged.

13 Keep a fire extinguisher suitable for gasoline/chemical/ electrical fires nearby.

14 Don't connect or disconnect any test equipment while the ignition is on or the engine is running.

15 Keep the scan tool dry, clean, free from oil/water or grease. Use a mild detergent on a clean cloth to clean the outside of the scan tool, when necessary.

16 Put blocks in front of the drive wheels and never leave the vehicle unattended while running tests.

17 Keep clothing, hair, hands, tools, test equipment, etc. away from all moving or hot engine parts.

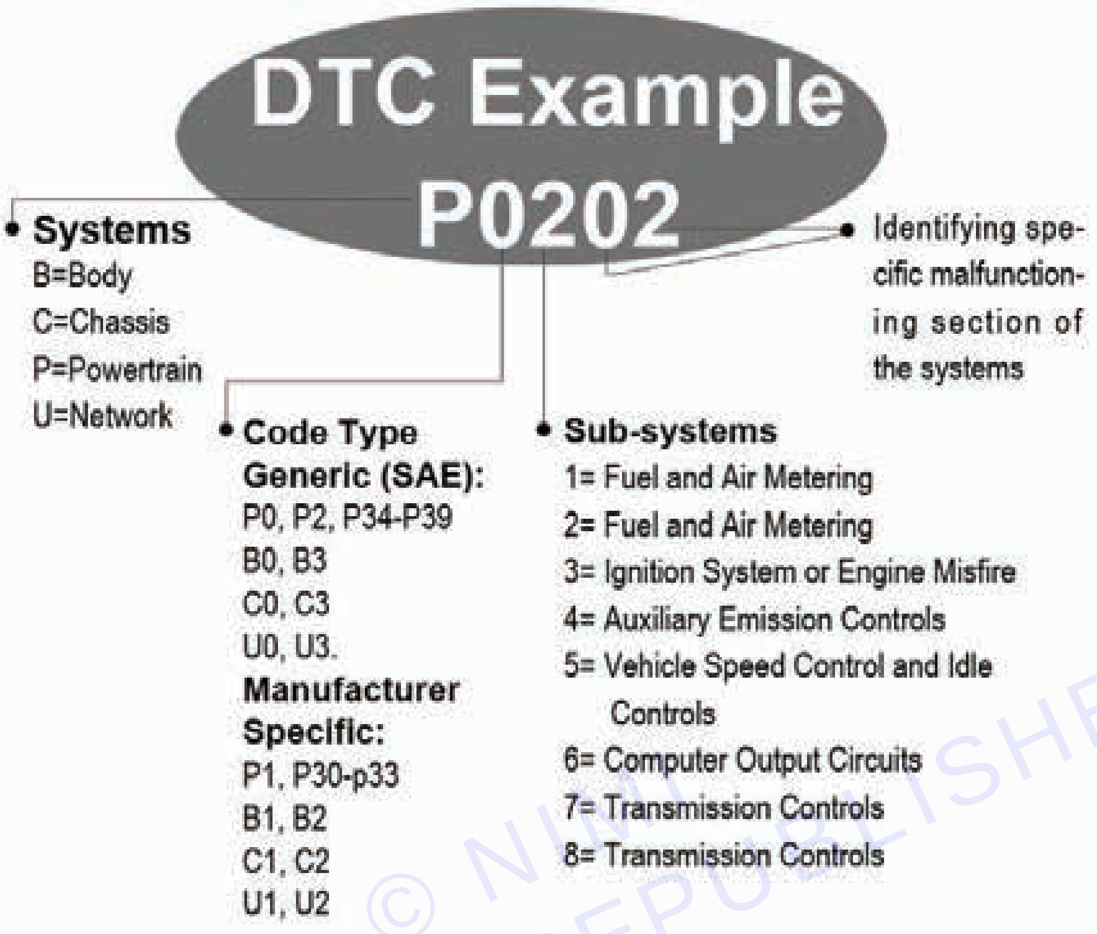
18 Keep clothing, hair, hands, tools, test equipment, etc. away from all moving or hot engine parts.

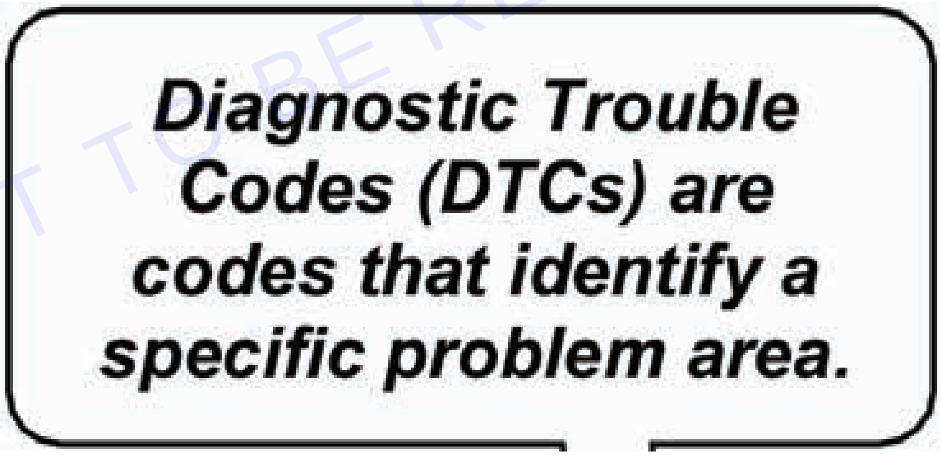
Diagnostic Trouble Codes (DTCs)

OBD II Diagnostic Trouble Codes are codes that stored by the on-board computer diagnostic system in response to a problem found in the vehicle. These codes identify a particular problem area and are intended to provide you with a guide as to where a fault might be occurring within a vehicle. OBD II Diagnostic Trouble Codes consists of a five-digit alphanumeric code. The first character, a letter, identifies which control system sets the code. The other four characters, all numbers, provide additional information on where the DTC originated and the operating conditions that caused it to set. Here below is an example to illustrate the structure of the digits:

Diagnostic Trouble Codes (DTCs) are meant to guide you to the proper service procedure in the vehicle's service manual. DO NOT replace parts based only on DTCs without first consulting the vehicle's service manual for proper testing procedures for that particular system, circuit or component.

DTCs are alphanumeric codes that are used to identify a problem that is present in any of the systems that are monitored by the on-board computer (PCM). Each trouble code has an assigned message that identifies the circuit, component or system area where the problem was found.





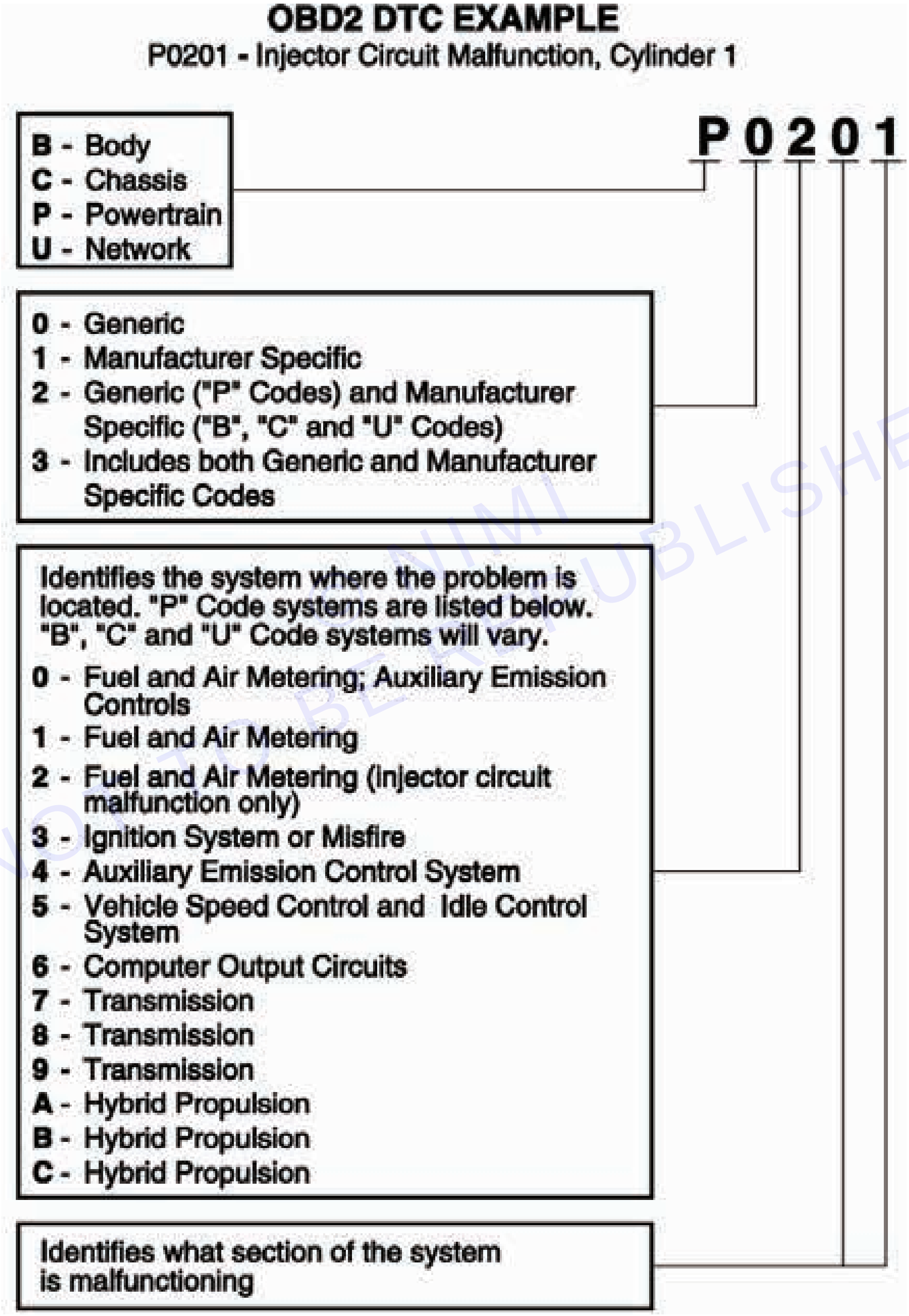
OBD2 diagnostic trouble codes are made up of five characters:

The 1st character is a letter (B, C, P or U). It identifies the “main system” where the fault occurred (Body, Chassis, Powertrain, or Network). The 2nd character is a numeric digit (0 thru 3). It identifies the “type” of code (Generic or Manufacturer-Specific). Generic DTCs are codes that are used by all vehicle manufacturers. The standards for generic DTCs, as well as their definitions, are set by the Society of Automotive Engineers (SAE).

Manufacturer-Specific DTCs are codes that are controlled by the vehicle manufacturers. The Federal Government does not require vehicle manufacturers to go beyond the standardized generic DTCs in order to comply with the new OBD2 emissions standards. However, manufacturers are free to expand beyond the standardized codes to make their systems easier to diagnose.

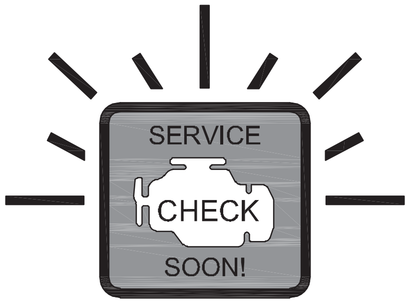
The 3rd character is a letter or a numeric digit (0 thru 9, A thru F). It identifies the specific system or sub-system where the problem is located.

The 4th and 5th characters are letters or numeric digits (0 thru 9, A thru F). They identify the section of the system that is malfunctioning.



DTCs and MIL Status

When the vehicle's on-board computer detects a failure in an emissions-related component or system, the computer's internal diagnostic program assigns a diagnostic trouble code (DTC) that points to the system (and subsystem) where the fault was found. The diagnostic program saves the code in the computer's memory. It records a "Freeze Frame" of conditions present when the fault was found, and lights the Malfunction Indicator Lamp (MIL). Some faults require detection for two trips in a row before the MIL is turned on.



The "Malfunction Indicator Lamp" (MIL) is the accepted term used to describe the lamp on the dashboard that lights to warn the driver that an emissions-related fault has been found. Some manufacturers may still call this lamp a "Check Engine" or "Service Engine Soon" light.

There are two types of DTCs used for emissions-related faults: Type "A" and Type "B." Type "A" codes are "One-Trip" codes; Type "B" DTCs are usually Two-Trip DTCs.

When a Type "A" DTC is found on the First Trip, the following events take place:

1 The computer commands the MIL "On" when the failure is first found.

2 If the failure causes a severe misfire that may cause damage to the catalytic converter, the MIL "flashes" once per second. The MIL continues to flash as long as the condition exists. If the condition that caused the MIL to flash is no longer present, the MIL will light "steady" On.

3 A DTC is saved in the computer's memory for later retrieval.

4 A "Freeze Frame" of the conditions present in the engine or emissions system when the MIL was ordered "On" is saved in the computer's memory for later retrieval. This information shows fuel system status (closed loop or open loop), engine load, coolant temperature, fuel trim value, MAP vacuum, engine RPM and DTC priority.

When a Type "B" DTC is found on the First Trip, the following events take place:

1 The computer sets a Pending DTC, but the MIL is not ordered "On." "Freeze Frame" data may or may not be saved at this time depending on manufacturer. The Pending DTC is saved in the computer's memory for later retrieval.

2 If the failure is found on the second consecutive trip, the MIL is ordered "On." "Freeze Frame" data is saved in the computer's memory.

3 If the failure is not found on the second Trip, the Pending DTC is erased from the computer's memory.

The MIL will stay lit for both Type "A" and Type "B" codes until one of the following conditions occurs:

1 If the conditions that caused the MIL to light are no longer present for the next three trips in a row, the computer automatically turns the MIL "Off" if no other emissions-related faults are present. However, the DTCs remain in the computer's memory as a history code for 40 warm-up cycles (80 warm-up cycles for fuel and misfire faults). The DTCs are automatically erased if the fault that caused them to be set is not detected again during that period.

2 Misfire and fuel system faults require three trips with "similar conditions" before the MIL is turned "Off." These are trips where the engine load, RPM and temperature are similar to the conditions present when the fault was first found.

After the MIL has been turned off, DTCs and Freeze Frame data stay in the computer's memory.

MODULE 17 : CRDI System

LESSON 108 - 113: Description of CRDI systems and its components. Precautions to be observed before removing the CRDI fuel system-study about the low and high pressure fuel supply circuits

Objectives

At the end of this lesson you shall be able to

- describe the CRDI system and its components
- demonstrate precaution to be observed while servicing fuel supply system
- study about low and hight pressure circuits in fuel supply system.

Description of CRDI systems and its components

Common Rail Diesel Injection (CRDI) System: In this system, single injection pump and injector are used for each cylinder. These are in the form of a unit; hence they are also called unit injectors. The action of the unit injector is via a rocker arm and spring, similar to the engine valves. Fuel is drawn from the fuel tank by the feed pump and supplied to the unit injectors through a filter at low pressure and excess fuel is returned to the fuel tank through the relief valve. It has a manifold with the help of which the engine is fed with pressure in the drive pump. As shown in the following picture. The injector pump is fed by pipes connected to the rail.

In this type of system, a low pressure electric fuel pump draws diesel from the fuel tank and sends the diesel through a filter to a high pressure pump. This high pressure pump creates high pressure in the common rail through a pressure regulator valve.

The electronic control unit controls this pressure regulator valve through a pressure sensor. In this way the diesel pressure created in the common rail is free from the influence of engine speed. The flow limiters installed in the system protect against the consequences of any diesel leakage from the injector. In this system, pressure control valve (pressure limiter valve) works to prevent excess diesel pressure. Diesel is injected into the engine combustion chamber through the injection nozzle of an injector controlled by a solenoid valve. In this system, the amount of diesel injected depends on the diesel pressure, injection duration, size and shape of the injection nozzle.

Components of CRDI System

1 **Fuel injection pump** - pressurizes fuel to high pressure

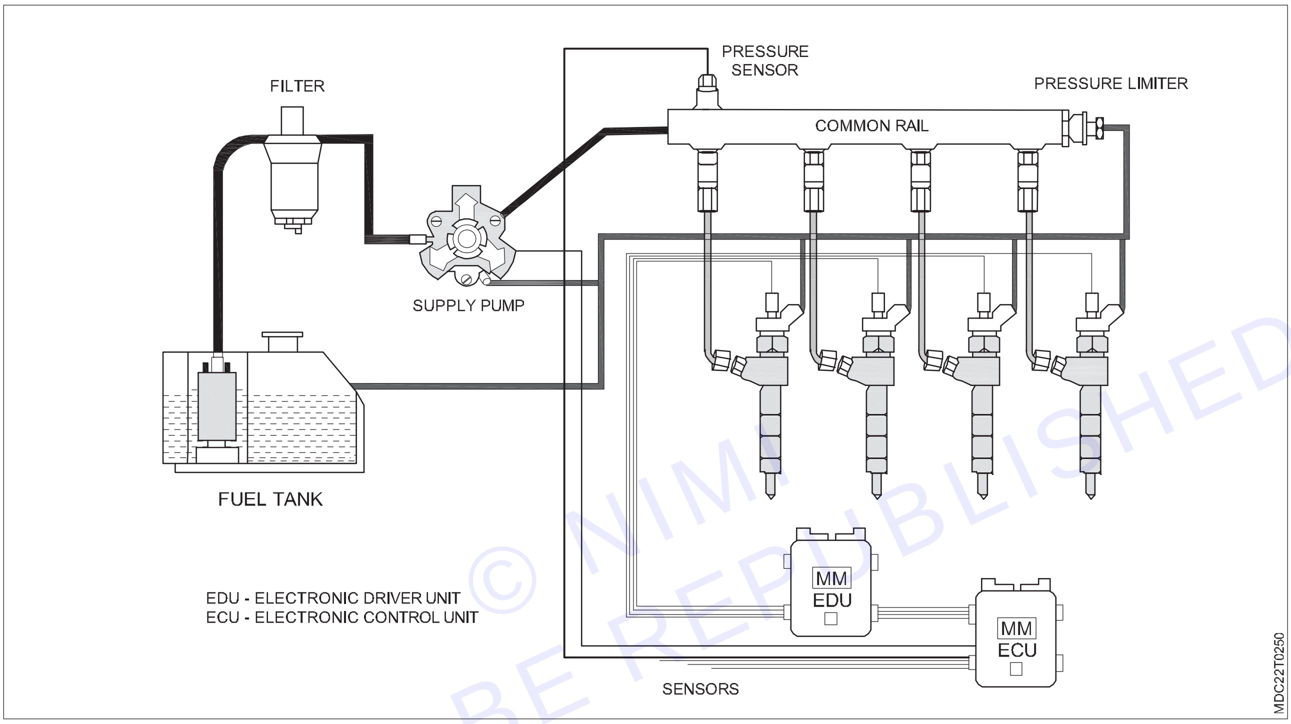
2 **High-pressure pipe** - sends fuel to the injection nozzle

3 **Injection nozzle** - injects the fuel into the cylinder

4 **Feed pump** - sucks fuel from the fuel tank

5 **Fuel filter** - filtrates the fuel

6 **Engine control unit (ECU)**



Precautions to be observed before removing the CRDI Fuel system

Before removing a CRDI fuel supply system, several precautions should be followed to ensure safety and prevent damage:

1 **Disconnect the Battery:** Ensure the vehicle's battery is disconnected to prevent any electrical mishaps during the removal process.

2 **Depressurize the Fuel System:** Relieve pressure from the fuel system by following the manufacturer's recommended procedure. This typically involves removing the fuel pump relay or fuse and then running the engine until it stalls.

3 **Ensure Proper Ventilation:** Work in a well-ventilated area to avoid inhaling fuel vapors, which can be harmful to health.

4 **Wear Personal Protective Equipment (PPE):** Use appropriate PPE such as gloves and safety glasses to protect yourself from fuel and other contaminants.

5 **Handle Fuel Carefully:** Handle fuel components with care to avoid spills and leaks. Have a container ready to catch any fuel that may leak during the removal process.

6 **Use Proper Tools:** Use the correct tools and equipment specified by the manufacturer to avoid damaging components or causing injury.

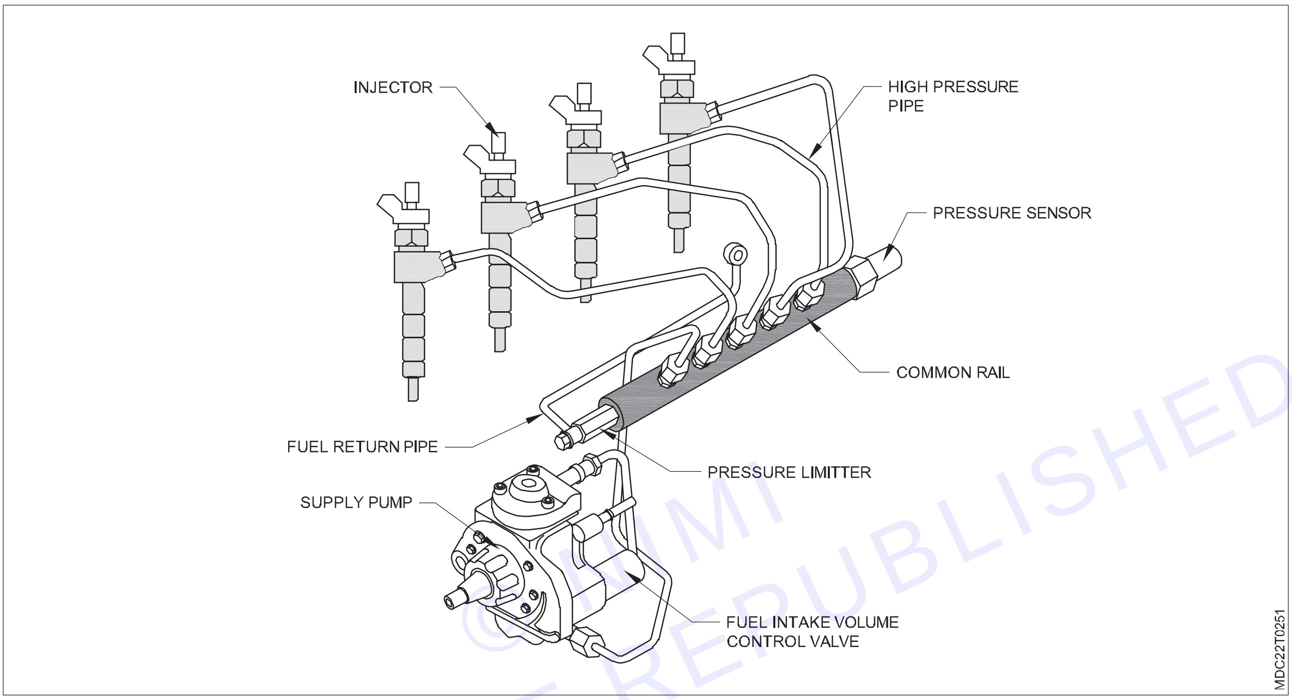
7 **Follow Manufacturer's Instructions:** Always refer to the vehicle manufacturer's service manual for specific instructions and precautions related to the removal of the fuel supply system.

8 **Take Note of Connections:** Take pictures or label connections before removing them to ensure proper reassembly later.

9 **Inspect for Leaks:** Before starting work, inspect the fuel system for any signs of leaks or damage. Address any issues before proceeding with the removal process.

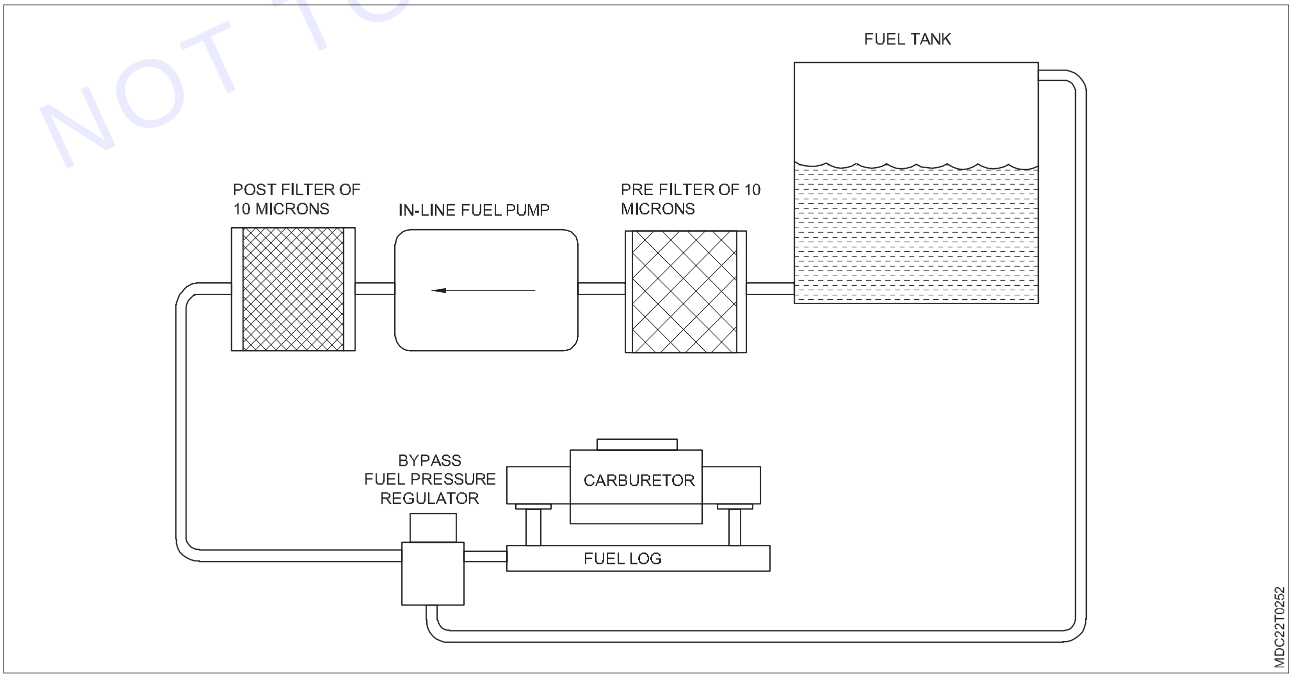
10 **Work Methodically:** Take your time and work methodically to avoid mistakes or accidents during the removal process.

Following these precautions will help ensure a safe and successful removal of the CRDI fuel supply system.



Study about the low and high pressure fuel supply circuits

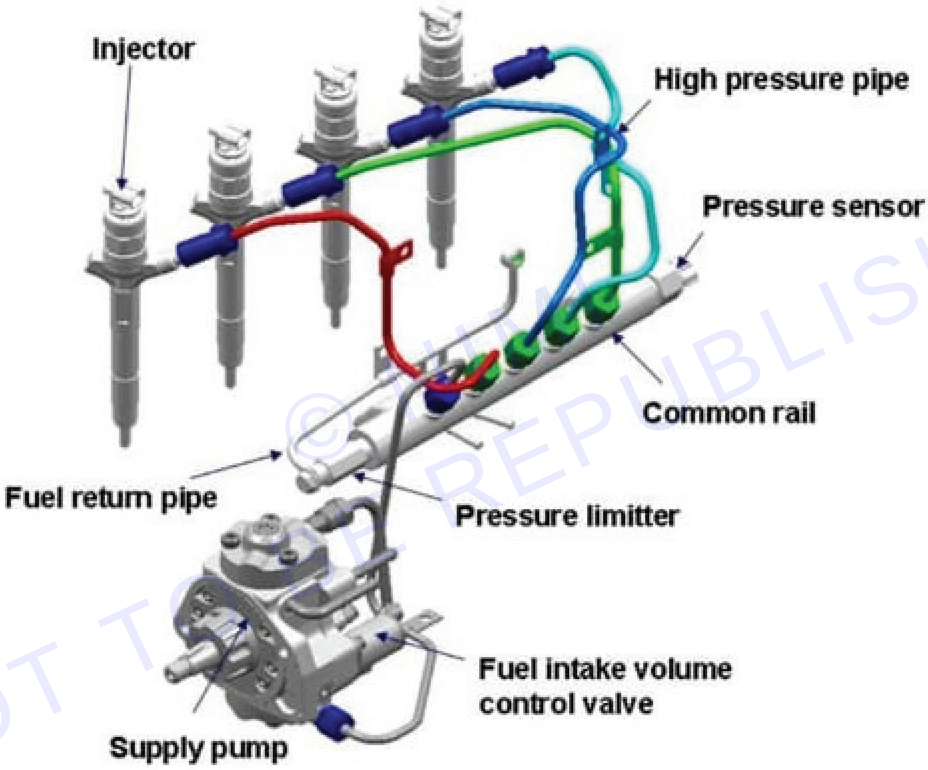
Low pressure fuel supply circuit



In a fuel supply system, the low-pressure circuit is responsible for delivering fuel from the fuel tank to the high-pressure circuit, typically found in systems like CRDI. This circuit consists of components such as the fuel tank, fuel filter, fuel pump, and fuel lines. The fuel pump, usually submerged in the fuel tank, draws fuel and sends it through the fuel filter to remove impurities. From there, the fuel is delivered to the high-pressure pump or fuel rail, where it undergoes pressurization before being injected into the engine cylinders. The low- pressure circuit ensures a steady supply of clean fuel to the high-pressure circuit, optimizing engine performance and longevity.

Parts: Fuel tank, Fuel log, Carburetor, Bypass fuel pressure regulator, Inline fuel pump,

High pressure fuel supply circuit: In a common rail direct injection (CRDI) system, the high-pressure line circuit is a crucial component responsible for delivering pressurized fuel to the fuel injectors. This circuit typically consists of high-pressure fuel lines, a fuel rail, a high-pressure pump, and fuel injectors. The high-pressure pump pressurizes the fuel, which is then stored in the fuel rail before being delivered to the injectors. This setup allows for precise control over the timing and quantity of fuel injection, enhancing engine performance and fuel efficiency.



Parts: Injector, high pressure pipe, Pressure sensor, Common rail, Pressure limitter, Fuel intake volume control valve, Supply pump, Fuel return pipe

LESSON 114 - 117: Electronic Diesel control- Electronic Diesel control systems, Common Rail Diesel Injection (CRDI) system, hydraulically actuated electronically controlled unit injector (HEUI) diesel injection system

Objectives

At the end of this lesson you shall be able to

- explain about electronic diesel control system
- demonstrate about CRDI system
- explain about HEUI.

Electronic diesel control systems, Common Rail Diesel Injection (CRDI) system

Electronic diesel Control (EDC) System

EDC system

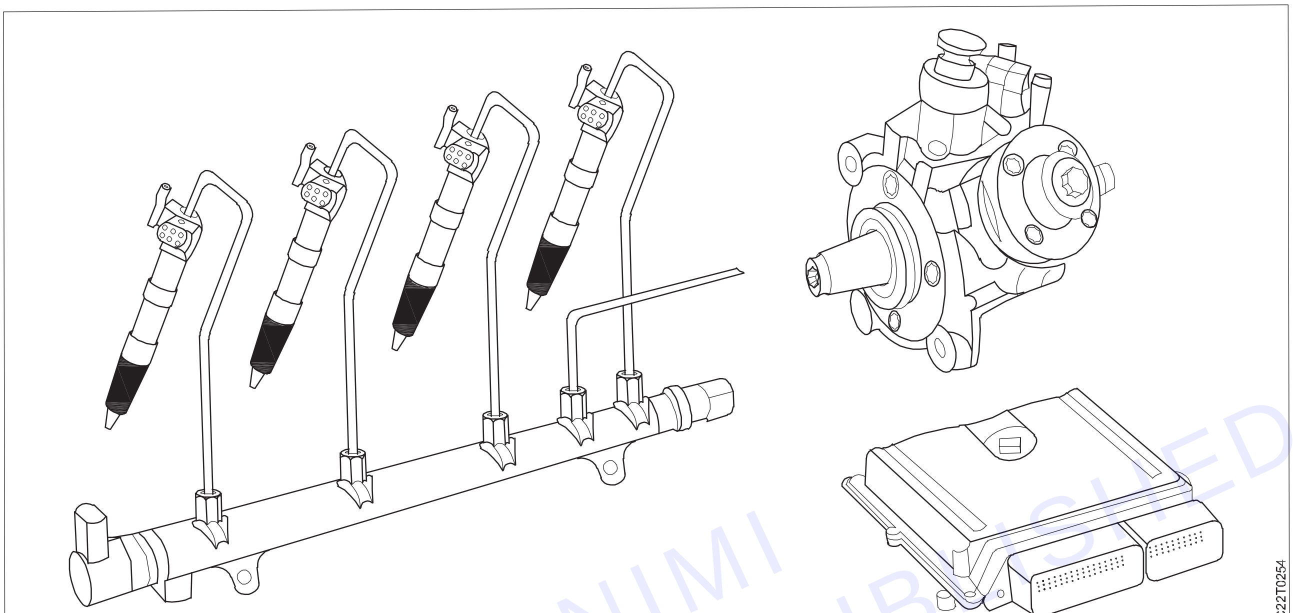
Electronic diesel control (Fig 1 to 2) is a diesel engine fuel injection control system for the precise metering and delivery of fuel into the combustion chamber of modern diesel engines used in trucks and cars.

The electronic control, the system which provides greater ability for precise measuring, data processing environment flexibility and analysis to ensure efficient diesel engine operation.

- It receives the information from sensor, analyze/ calculate it and sends the instructions to the actuators.
- It converts information from analog to digital.
- It consists of microprocessors to process the information from sensor to ECM and ECM to actuators.
- Number of microprocessors are depending upon the number of sensors and actuators.
- It also consists of memory to store the data.
- Speed is in the form of 8 Bit, 16 Bit, 32 Bit, 64 Bit etc., to pass the information from sensor to ECM, ECM to actuator and also in networking system.
- Individual programmers have to be made for each sensor and actuator.

Main control systems in diesel engine

- It controls the fuel for idling.
- It controls the fuel for high speed.
- It controls the fuel according to the speed and load conditions.
- It controls the exhaust gas recirculation (EGR) valve.



COMMON RAIL WITH FUEL INJECTORS

Working

It gets the input from the different sensors named are as follows.

1 Throttle position TP (intake air quantity)

2 Cam position CMP (for valve timing)

3 Crank positon CKP (for RPM and firing order)

4 Engine coolant temperature ECT (Cylinder temperature)

5 Inlet air temperature IAT (temperature of inlet air)

6 Manifold absolute pressure MAP (inlet air pressure)

7 Oxygen O2 (percentage of oxygen in exhaust gas)

After receiving the above inputs, it analyzes/calculates the amount of fuel is required for the cylinder, accordingly it supplies the voltage to the injector solenoid. The solenoid will open the injector to supply the fuel into the combustion chamber. The minimum injector opening period is 1/10th second.

Minimum 3 important sensors (TP, CKP & CMP) inputs are required at the time of starting, if any one of the sensor fails, engine does not start.

Rest of the sensors (IAT, ECT, MAP, and O2) fails; engine will start but the performance of the engine will affect.

Note:

- **In a vehicle minimum one EDC/ECM is required**
- **More than one EDC/ECM are used depends on number of controls.**

Example of control units EDC/ECM in a vehicle

1 Engine management

2 Automatic transmission

3 Power steering

4 SRS (Air Bag) supplemental restraint system

5 ABS (Antilock braking system)

Exhaust gas recirculation (EGR) EGR valve allows the exhaust gases into the inlet manifold, to burn the unburn gases to reduce the emission.

The opening angle of the valve is controlled by the EDC, depending upon the amount - (%) of oxygen passing through exhaust gases.

EDC gets the percentage of oxygen from the oxygen sensor.

Sensor

It senses the information in the form of physical or chemical variables and sends that information to the ECM in the form of voltage i.e. between 0-6 volts or 0-12 volts.

Ex: Throttle valve opening position (angle) information sends to the ECM in the form of voltage.

ECM

It analyzes or calculates the information which have come from the sensors and gives the instruction to the actuators.

Ex: It supplies the current to the solenoid to open the injector opening duration depends on Inputs.

Actuators: Based on instructions from the ECM, it does the mechanical work.

Ex: Injector open duration depends on ECM instruction.

Schematic layout system components

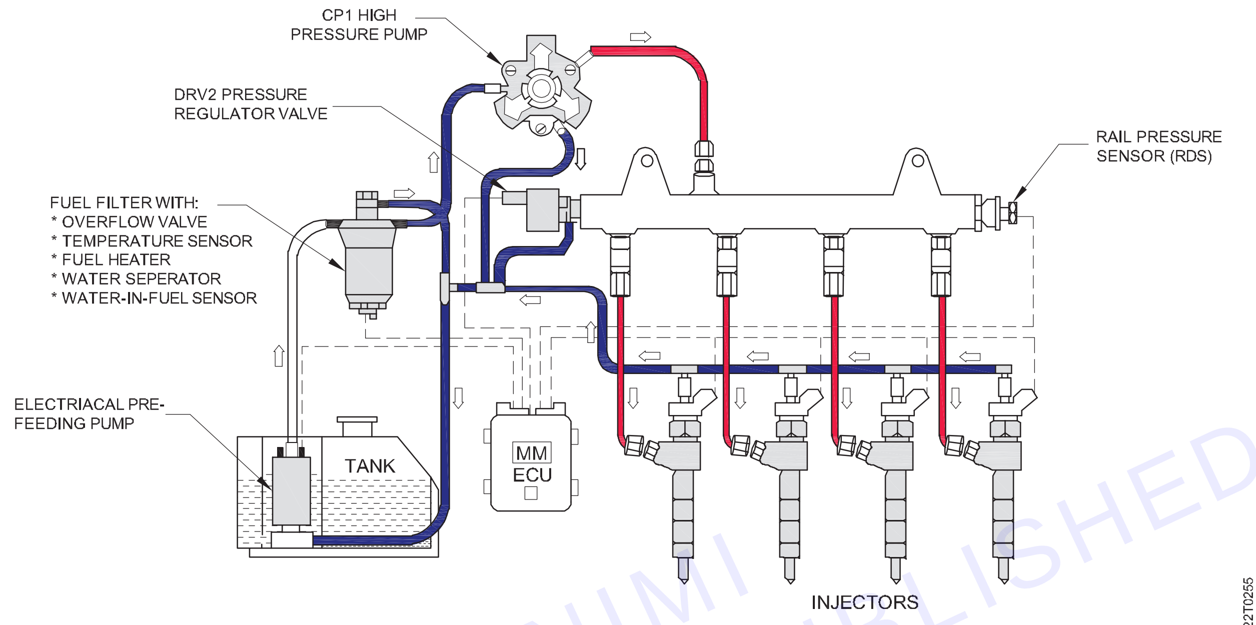
Input from sensors and switches	Output from ECU
Engine speed sensor CKP	Fuel Pump relay
Hall Sensor CMP	Fuel Pump for resupply
Accelerator pedal position APP	Injection Valves
Air mass meter HFM	Valve for Fuel dosage
Intake air Temperature IAT	Fuel pressure regulating Valve
Coolant Temperature ECT	Solenoid valve for charge pressure control
Radiator Outlet Coolant Temperature	Intake manifold flap motor
Charge Pressure Sensor G31	Throttle Valve module
Fuel Temperature Sensor	Exhaust Gas Recirculation Valve
Fuel Pressure Sensor	Radiator Fan

Common Rail Diesel Injection (CRDI)

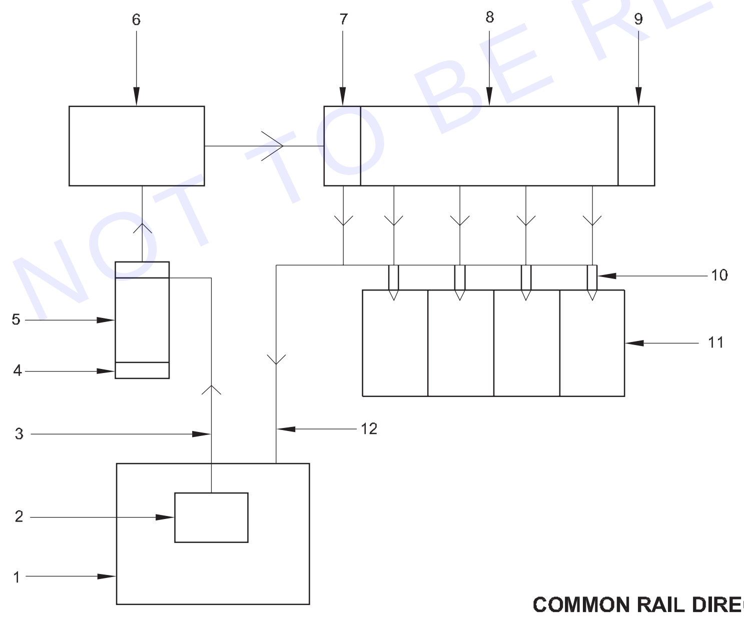
Construction and working of CRDI system

The common rail consists of fuel tank, electrical fuel pump (low pressure) is placed inside the fuel tank, it develops pressure up to 6 bar and supplies to the high pressure fuel pump (CRDI) through fuel filter and water separator. The high pressure fuel pump develops pressure 200 to 2000 bar and supplies to the common rail and common rail to fuel injectors. The injectors are injecting fuel into the combustion chamber. Fuel injector are operator by ECM through solenoid valve. Common rail consists of fuel pressure regulator rail pressure sensor and fuel pressure regulator supplies the excess amount of fuel to the fuel tank (< 1 bar pressure) Common rail pressure sensor will give the information to ECM /EDC the existing pressure in the common rail. Then common rail will control the RPM of the fuel pump. Common rail will distribute the fuel to all the cylinder with equal pressure, then all cylinders will develop uniform power, which will reduce vibration and noise of the engine.

Diesel Direct injection system



DIESEL DIRECT INJECTION SUSTEM (DDIS) -- FUEL SYSTEM LAYOUT



1. FUEL TANK
2. ELECTRICAL FUEL PUMP
3. FUEL SUPPLY LINE
4. WATER SEPARATOR
5. FUEL FILTER
6. HIGH PRESSURE FUEL PUMP (CRDI PUMP)
7. FUEL PRESSURE REGULATOR
8. COMMON RAIL
9. FUEL RAIL PRESSURE SENSOR
10. FUEL INJECTOR
11. ENGINE
12. FUEL RETURN LINE

COMMON RAIL DIRECT INJECTION SYSTEM (CRDI) FUEL SUPPLY SYSTEM

Hydraulically actuated electronically controlled unit injector (HEUI) diesel injection system

HEUI (Hydraulically Actuated Electronically Controlled Unit Injector)

HEUI Fuel System represents one of the most significant innovations in diesel engine technology in the diesel technology. HEUI made easy of many limitations of mechanical and conventional electronic injectors, and sets new standards for fuel efficiency, reliability and emission control. The highly sophisticated HUEI system uses hydraulic energy instead of mechanical energy to operate fuel injectors. Working along with the engine's ECM (Electronic Control Module), the HEUI system provides extremely accurate control of fuel metering and timing, so that it ensures unmatched engine performance and economy.

Unmatched engine performance and economy.

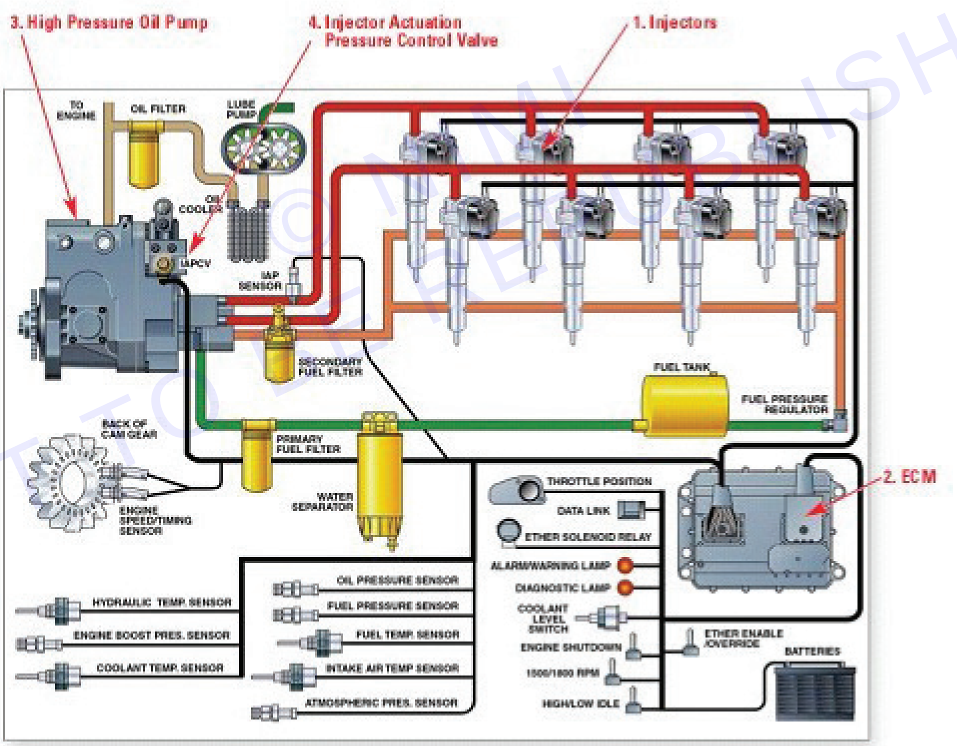
In the traditional common rail fuel system, the entire fuel line is under high pressure. With the HEUI system, fuel remains at low pressure until it is injected into the cylinder. Fuel pressure is created hydraulically in response to a signal from the Electronic Control Module (ECM).

The HEUI fuel system consists of four basic components

HEUI (Fig 1) Injector Uses hydraulic energy (as opposed to mechanical energy from the engine camshaft) from pressurized engine lube oil for injection. The pressure of the incoming oil (800 to 3300 psi) controls the rate of injection, while the amount of fuel injected is determined by the ECM.

Electronic Control Module (ECM) This sophisticated on-board computer precisely manages fuel injection and other engine systems. The HEUI injector solenoid is energized by an electronic signal generated in the ECM. Using input from multiple sensors, the ECM's dual microprocessors use proprietary software and customer supplied performance parameters to produce maximum engine performance under any conditions.

High Pressure Oil Pump The variable displacement axial pump features a built-in reservoir to immediately supply oil at cold starts.



Injector Actuation Pressure Control Valve. This electronically operated valve controls oil pump output and injection pressure.

Working principle

HEUI is divided in two sections. One is low pressure fuel chamber. Another one is high pressure oil chamber, fuel is supplied at low pressure and oil is supplied at high pressure to the respective chamber.

At the time of injections allows the high pressure oil in to the injection body and actuates the intensifier. The intensifier in turn pressurizes the diesel on the other side of it. So that the intensifier pressurizes seven times of the oil pressure and increases the pressure of the diesel. After then the injector lifts the spindle and injects the diesel through the holes of an injector.

Improved fuel economy The ability to inject fuel at any crank angle results in up to 2.7 percent better fuel economy compared to scroll mechanical injectors. Optimum fuel economy also means reduced gaseous emissions and less white smoke during cold engine starts.

Optimum performance The control of fuel delivered during ignition delay and main injection, known as rate shaping, is made possible by the HEUI's ability to operate independent of engine speed. Rate shaping modifies engine heat release characteristics, which also helps reduce emission and noise levels. Rate shaping optimizes engine performance by varying the idle and light load rate characteristics independent of rated and high load conditions.

Reduced smoke and particulate emissions

Since the HEUI injector's performance does not depend on engine speed, it can maintain high injection pressures through a wide operating range. Electronic control of these pressures helps improve emissions and low-speed engine response.

Reduced engine noise A split injection feature leads to a more controlled fuel burn and lower noise levels. Additional benefits include reduced shock loads as well as less wear and tear on drive train components.

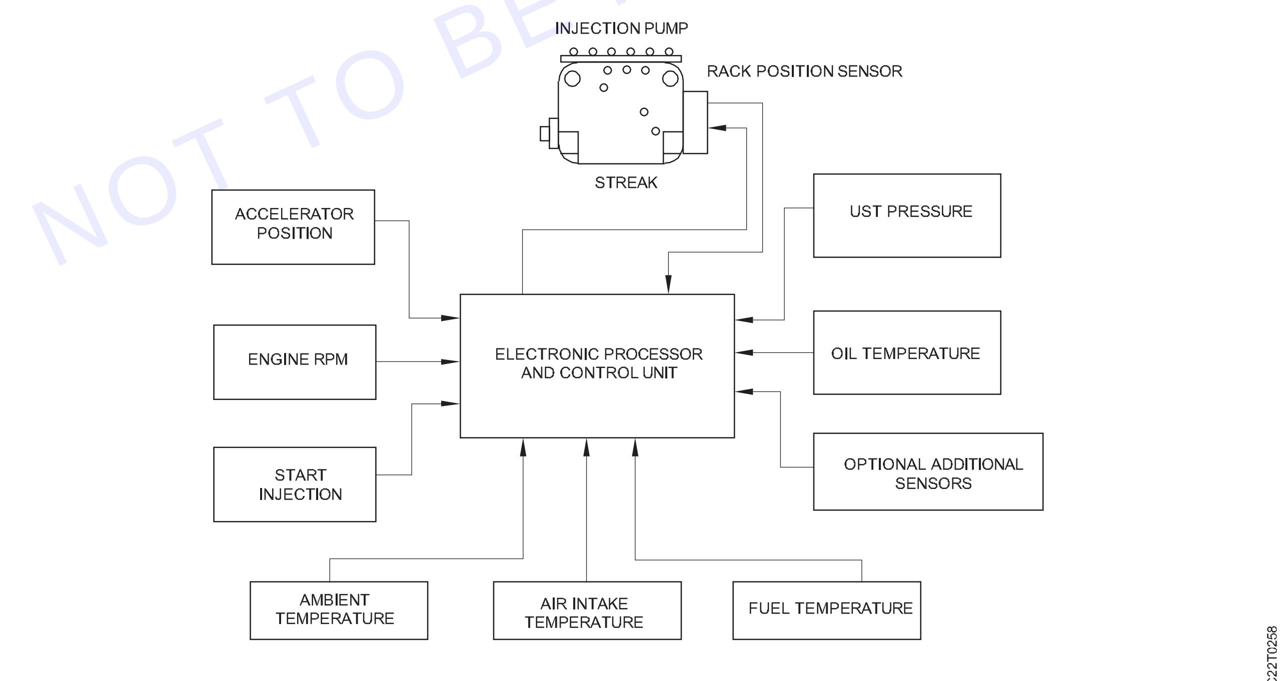
Sensors, actuators and ECU (Electronic Control Unit) used in Diesel Engines

Objectives: At the end of this lesson you shall be able to

- explain about Sensors, Actuators and ECU used in Diesel Engines.

Electric control unit

It is a system by which the operation of diesel injection is controlled. Sensors and actuators are mainly used under this system. This unit receives the signals and decides the opening time of the injector land, due to which the injection volume also remains under control. This system collects on-board action signals. It usually consists of microprocessor, memory unit, analog to digital converter.



BLOCK DIAGRAM OF ELECTRONIC CONTROL UNIT

Sensors

In automotive vehicles, sensors are used to measure the operating conditions and changes of the vehicles. Mainly following types of sensors are used in vehicles

Oxygen sensor: Oxygen sensor is used to estimate the proportion of analyzed oxygen. The concentration of gases emitted through it can also be measured.

Frank sensor: This electronic device is used to monitor internal combustion engines and their rotational speed. Through this, the rotational speed of the piston and valve can also be monitored.

Cold temperature sensor: This type of sensor is used to measure the lubricant temperature **present in the vehicle engine**.

Temperature sensor: This type of sensor can be used to detect different temperatures; Such as fuel temperature, coolant temperature, intake temperature, used to measure air temperature etc.

Vehicle speed sensor: The speed of vehicles is monitored with this sensor.

Injection pump speed sensor: This type of sensor is used to monitor the rotation speed of the pump.

Fuel rack position sensor: This type of sensor is used to monitor the position of the fuel rack.

Air flow sensor: Air flow sensor is used to measure the rate of air flow coming into the fuel injection engine.

Apart from all the above sensors, some other sensors; Such as fuel pressure sensor, air cleaner vacuum pressure sensor, brake pedal sensor, clutch pedal sensor, driver input switch sensor are also used in vehicles.

Actuators

Actuators are used to transfer electrical signals into mechanical action. Electromagnetic actuators are used in electronic diesel control systems. These types of actuators are located on the fuel pump. To transfer the electric signal into mechanical action, sensors like boost pressure actuators, throttle valve actuators, exhaust gas recirculation actuators etc. are used.

LESSON 118 - 120: Importance of measuring/ inspecting the engine components for wear to decide serviceability

Objectives

At the end of this lesson you shall be able to

- measure and Inspect engine components for wear
- decide serviceability for engine components.

- Regular inspections help identify engine components before major breakdowns occur
- Periodic inspection of engine components reduces the risk of accidents caused by engine components
- Proper engine inspection and maintenance keeps the engine running well
- Inspection of friction in engine components enables timely repairs and minimizes financial losses
- Proper type inspection increases engine life
- Proper inspection of engine components reduces the chances of engine failure and car break down
- Regular inspection also reduces the maintenance cost of the engine
- Proper maintenance of the car and engine helps in getting good resale value of the car
- If the engine is well maintained, the pollution emitted from the engine is less and thus does not harm the environment
- Identifying worn out engine components helps reduce future risk
- Helps identify worn components that affect engine performance thereby increasing fuel consumption and pollution
- Regular inspections help maintain engine performance consistency over time
- Regular inspections ensure that the engine is reliable enough to allow the vehicle to be used for emergency or industrial work.
- Regular inspections help reduce the cost of vehicle breakdowns
- Proper maintenance of the engine leads to less breakdowns and makes customers happy
- A regular inspection helps in solving problems in the engine
- Regular inspection keeps abreast of new changes and improvements in engine technology

MODULE 18 : Stationary Engine and Sub System

LESSON 121 - 125: Study about PT fuel system, definition, function, components, function and working of each component and advantages and disadvantages of PT system

Objectives

At the end of this lesson you shall be able to

- study about PT fuel system
- explain advantages and disadvantages of PT system.

Study about PT fuel system. definition, function, components

The PT fuel system, often found in diesel engines, refers to the Pressure-Time fuel injection system. It's designed to precisely control the timing and pressure of fuel injection into the combustion chamber. Its function is to optimize fuel combustion for improved engine performance and efficiency while reducing emissions.

Components typically include a high-pressure fuel pump, fuel injectors, fuel lines, pressure regulators, and electronic control unit (ECU) for managing injection timing and quantity. This system ensures the right amount of fuel is injected at the right moment, enhancing engine power, fuel economy, and emissions control.

1 **High-pressure fuel pump:** This pump pressurizes the fuel to a high level, typically several thousand psi (pounds per square inch). The high pressure is necessary to atomize the fuel into fine mist for efficient combustion.

2 **Fuel injectors:** These are responsible for delivering precise amounts of pressurized fuel directly into the combustion chamber or intake port. They are controlled by the engine's electronic control unit (ECU), which determines the timing and duration of fuel injection based on various engine parameters such as engine speed, load, and temperature.

3 **Fuel lines:** These are the conduits through which pressurized fuel travels from the fuel pump to the fuel injectors. They must be designed to withstand high pressure and be properly insulated to prevent fuel from vaporizing due to engine heat.

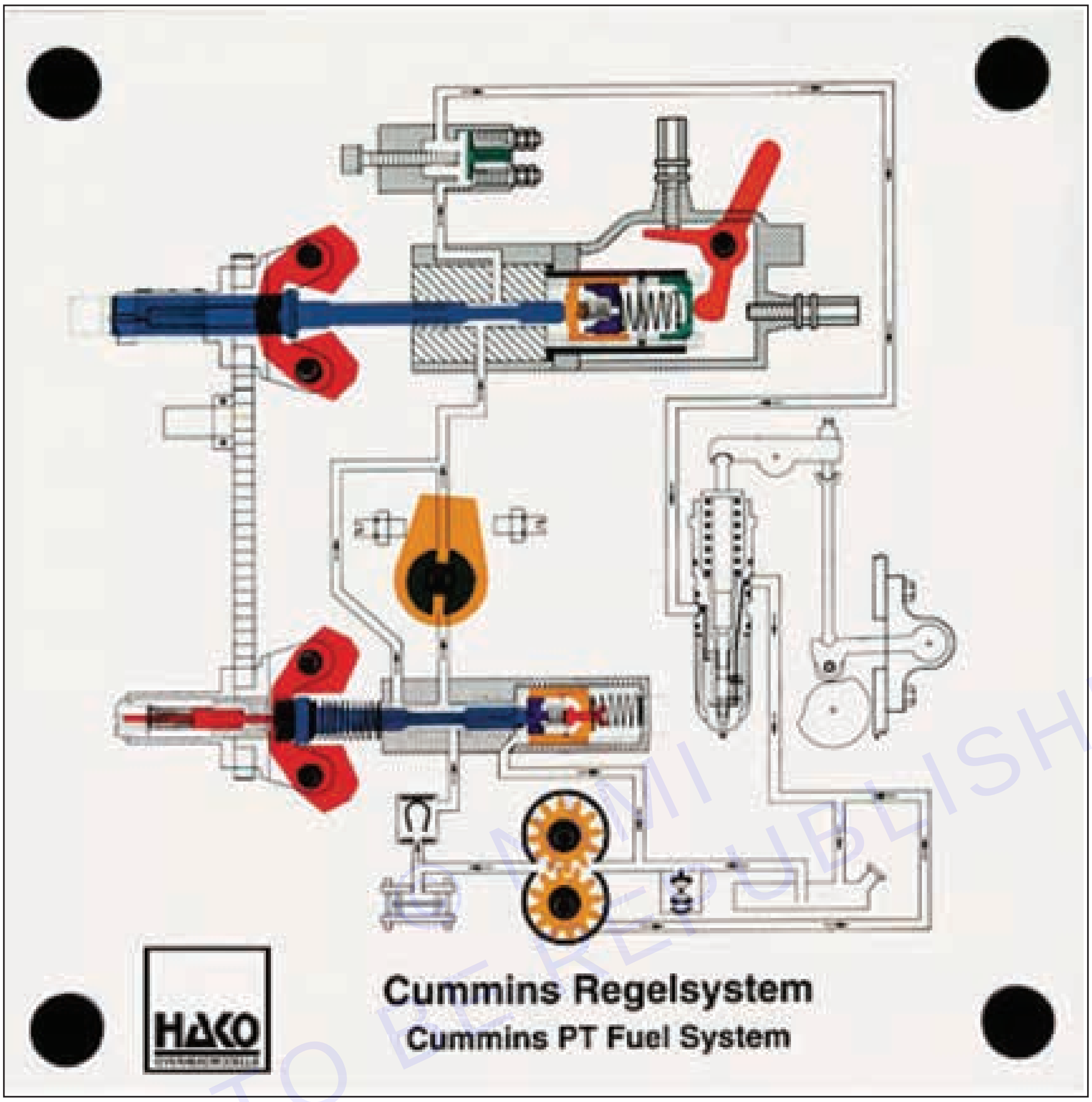
4 **Pressure regulators:** These components help maintain a consistent pressure in the fuel system, ensuring that the fuel injectors receive a steady supply of pressurized fuel. They regulate fuel pressure by either bypassing excess fuel back to the fuel tank or by adjusting the speed of the fuel pump.

5 **Electronic Control Unit (ECU):** The ECU is the brain of the fuel system. It receives input from various sensors throughout the engine and calculates the optimal timing and duration of fuel injection. It then sends signals to the fuel injectors to precisely control the amount and timing of fuel delivery.

Overall, the PT fuel system is a sophisticated mechanism that allows for precise control of fuel delivery, leading to improved engine performance, fuel efficiency, and reduced emissions....

Function and working of each component and advantages and disadvantages of PTO system

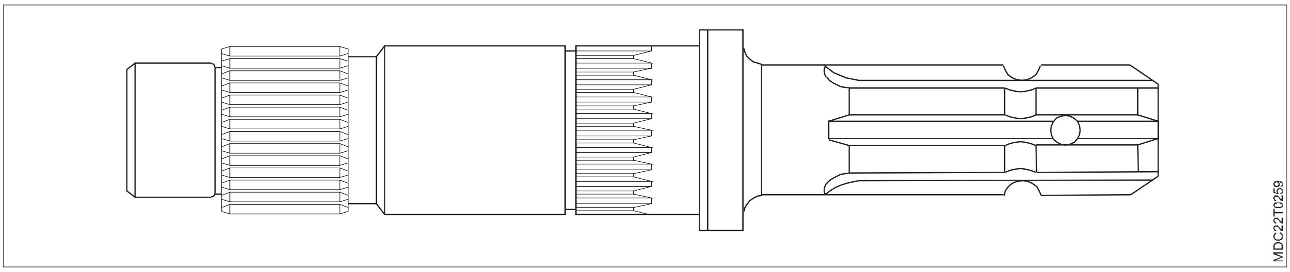
Working: The power take-off (PTO) system works by transferring power from the engine of a vehicle or machine to an attached auxiliary device. This is typically accomplished through a rotating shaft that connects to the PTO output on the engine or transmission. When engaged, the PTO shaft transfers rotational power, allowing the auxiliary device to operate. The engagement of the PTO is usually controlled by a lever or switch inside the vehicle's cabin or on the machine itself.



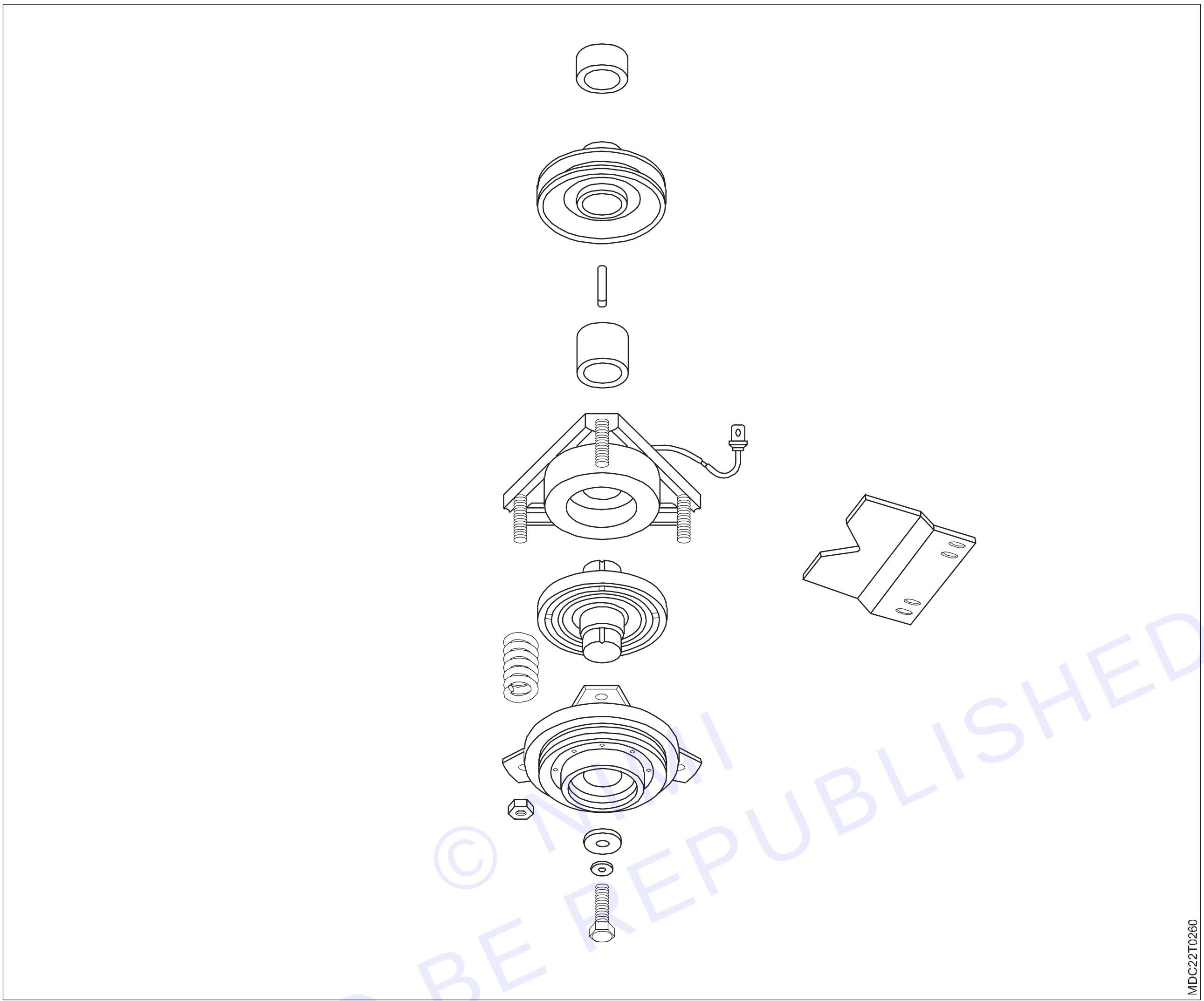
Function: The primary function of a power take-off (PTO) is to transfer power from the engine of a vehicle or machine to operate auxiliary equipment. This could include powering hydraulic pumps, generators, winches, agricultural implements, or other machinery. The PTO system allows for efficient use of the vehicle or machine's power source to drive additional equipment without needing separate engines or motors for each device.

Component: The main components of a power take-off (PTO) system typically include:

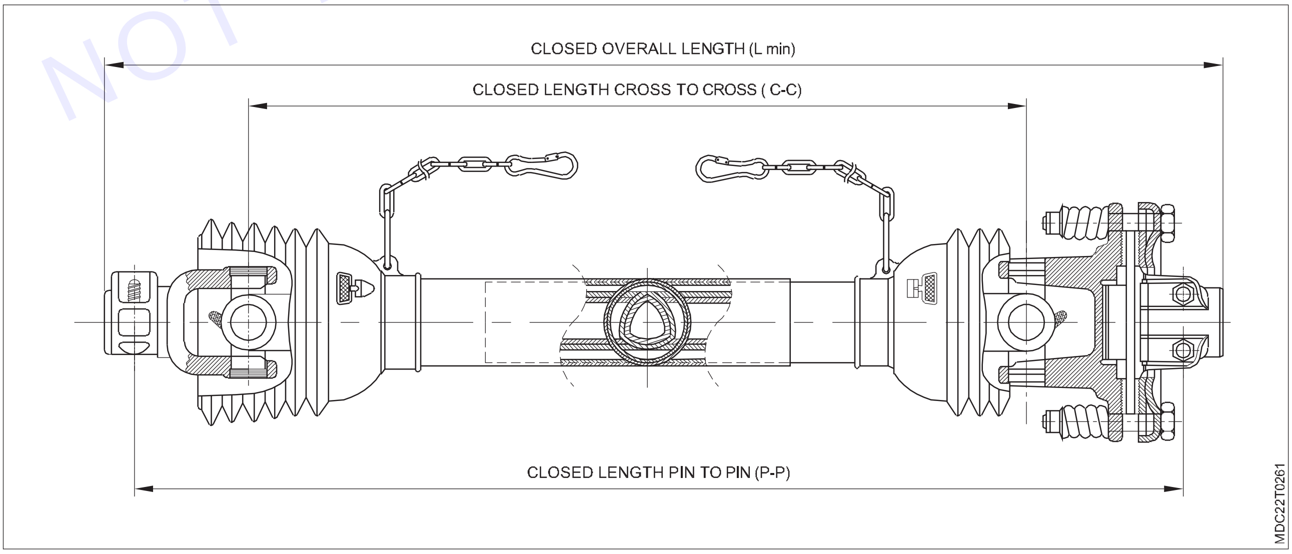
1 **PTO Output Shaft:** This shaft extends from the vehicle's transmission or engine and transmits power to the attached auxiliary equipment.



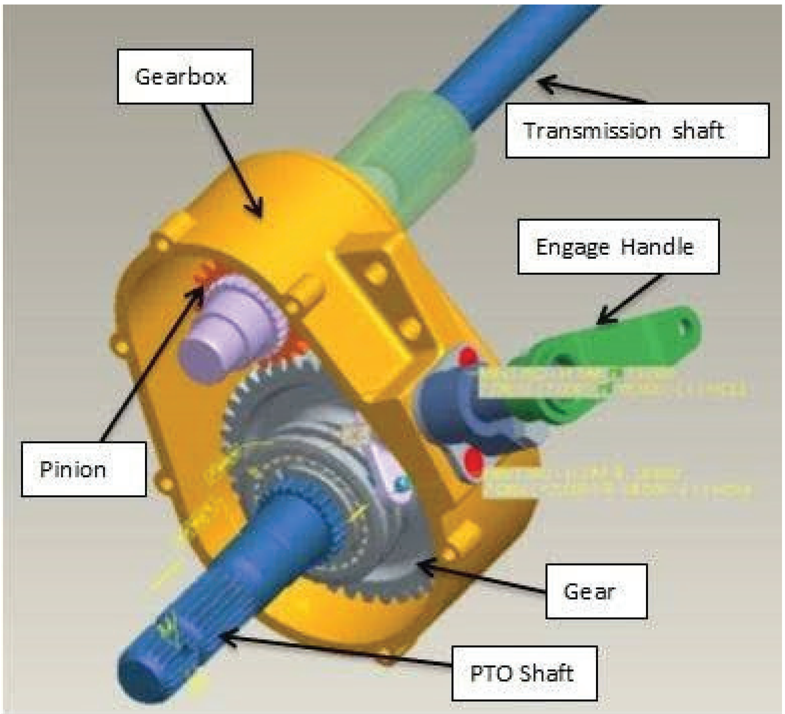
2 **PTO Clutch:** The clutch engages and disengages the PTO shaft, allowing the operator to control when power is transferred to the auxiliary equipment.



3 **PTO Driveline:** This consists of a driveshaft, universal joints, and any necessary support bearings. It transmits power from the PTO output shaft to the driven equipment.



4 **PTO Gearbox (optional):** In some cases, a gearbox may be used to adjust the speed and torque of the PTO output to match the requirements of the driven equipment.



These components work together to efficiently transfer power from the vehicle or machine's engine to operate various auxiliary devices.

Advantages of a power take-off (PTO) system

1 **Versatility:** PTO systems enable vehicles and machinery to power a wide range of auxiliary equipment, making them highly versatile for various applications such as agriculture, construction, and transportation.

2 **Cost-effectiveness:** By using a single power source to operate multiple auxiliary devices, PTO systems can reduce the need for additional engines or motors, resulting in cost savings.

3 **Efficiency:** PTO systems allow for the direct transfer of power from the vehicle or machine's engine to auxiliary equipment, minimizing energy loss and maximizing efficiency.

4 **Convenience:** Operators can easily engage and disengage the PTO as needed to power auxiliary equipment, providing flexibility and convenience in operation.

Disadvantages of a power take-off (PTO) system

1 **Safety risks:** PTO systems can pose safety hazards if not used properly, as they involve rotating shafts and machinery. Accidental engagement or improper operation can lead to serious injuries.

2 **Maintenance requirements:** PTO systems require regular maintenance to ensure proper function and safety. This includes inspecting and lubricating components, as well as monitoring for wear and tear.

3 **Complexity:** PTO systems add complexity to vehicles and machinery, which can increase the risk of mechanical failures or malfunctions if not properly designed, installed, and maintained.

4 **Limited power transfer:** The amount of power that can be transferred through a PTO system is limited by the capacity of the vehicle or machine's engine, which may not be sufficient for some heavy-duty applications.

LESSON 126 - 128 : Read and interpret the name plate details-selecting ohmmeter for proper range-advantages of using megger-residual magnetism-residual voltage and current

Objectives

At the end of this lesson you shall be able to

- select ohm meter for proper range and Use of ohmmeter
- use megger.

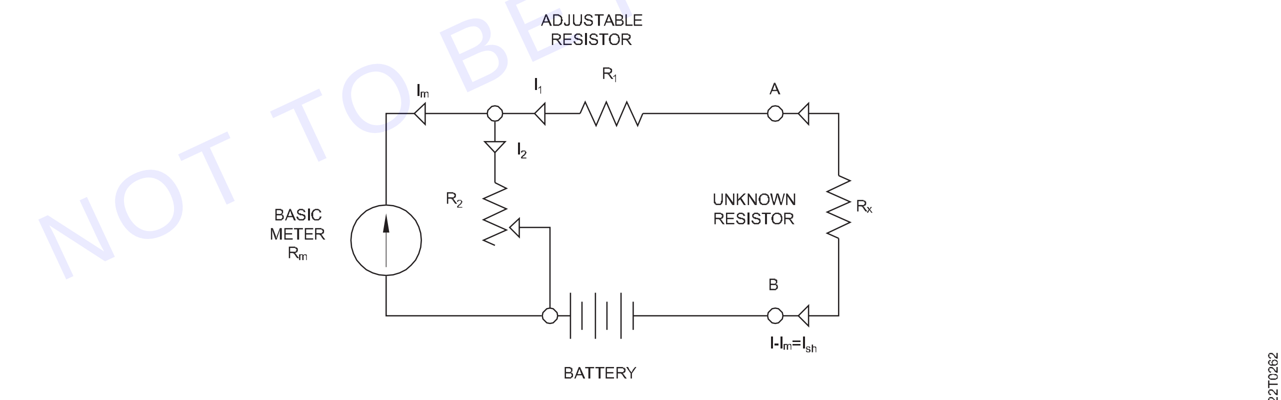
Read and interpret the name plate details-selecting ohmmeter for proper range

Ohmmeter

Ohmmeter is a direct reading device for calculating resistance. The precision of this instrument is less, although less precision does not affect the efficiency of the instrument. This instrument is used to find the approximate value of resistance.

Structure

Ohmmeter mainly consists of a micro-ammeter, battery current regulator, resistor, zero adjusting resistor (potentiometer) and 'probes'. These instruments are of two types: 1. Series type 2. Shunt type. In series type instrument, the unknown resistor is connected in series with the battery and micro-ammeter. It is used to measure medium and high resistance values. In a shunt type instrument, an unknown resistor is connected in parallel with a micro-ammeter. It is used to measure low and medium resistance values.



SERIES TYPE OHMMETER

1 **Check Resistance Range:** Look for the resistance range specified on the equipment. It might be given in ohms (Ω) or kilohms (KΩ).

2 **Maximum Value:** Identify the maximum resistance value the ohmmeter can accurately measure. This is crucial to avoid damaging the equipment.

3 **Minimum Value:** Note the minimum resistance value the ohmmeter can measure accurately. This ensures accurate readings for low-resistance components.

4 **Accuracy:** Determine the accuracy of the ohmmeter within its specified range. This ensures precise measurements.

5 **Resolution:** Consider the resolution of the ohmmeter. Higher resolution allows for more detailed readings.

6 **Range Selection:** Select a range on the ohmmeter that covers the resistance you intend to measure, without exceeding its maximum range.

Methodology

A and B Conjunction When the value is zero, maximum electric current flows through the circuit. In this method the oscillator indicator of the zero adjustment resistor is adjusted to the zero position of the scale. 'Zero' on the scale is on the right. When connections A and B are kept apart from each other, the indicator shows zero electric current and infinite resistance on the scale.

When an unknown resistance is connected between connectors A and B, the indicator of the instrument directly shows the resistance in 'Ohm' on the scale. The scale of this instrument is not proportional.

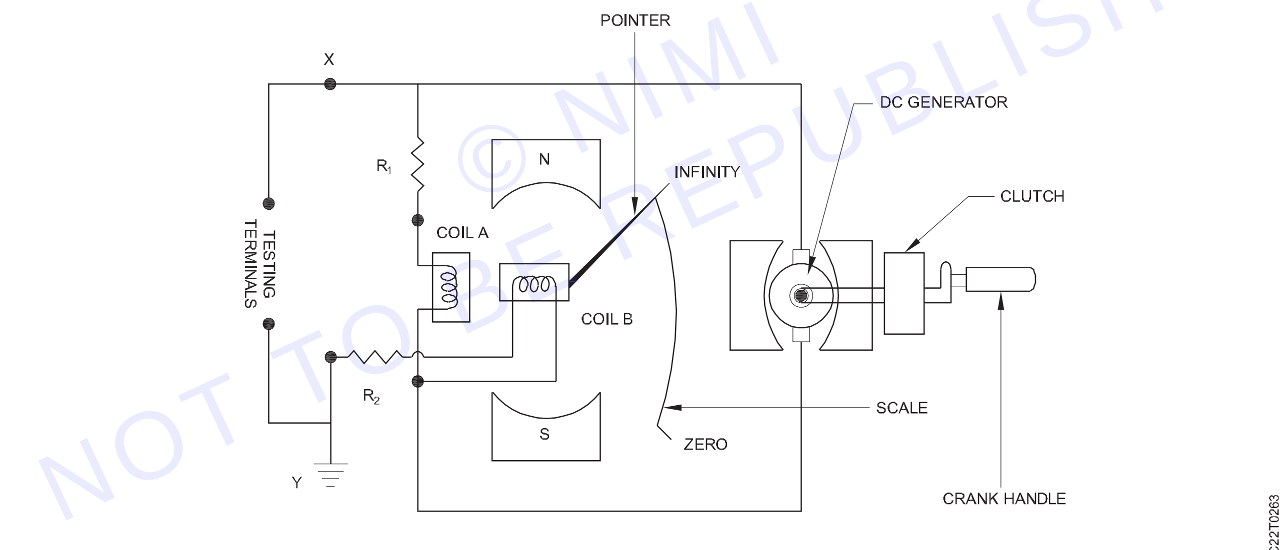
Features

1 Through this instrument, the value of unknown resistance can be read directly in 'Ohm' and there is no need to do any kind of calculation.

2 Many measuring ranges can be made in this instrument by connecting additional resistors and batteries. For each scale there is a 'multiplier' which is marked on the switch positions of the instrument; Like – R_1 = 1, R_1 = 1000 etc.

Advantages of using megger-residual magnetism-residual voltage and current

Using a megger (insulation resistance tester) with a residual voltage test feature offers several advantages:



DIRECT CURRENT GENERATOR

1 **Enhanced Safety:** It ensures safety by confirming that the insulation is safe to test, as residual voltage could pose a risk during testing if not properly discharged.

2 **Accurate Results:** The residual voltage test helps in obtaining more accurate insulation resistance measurements by ensuring that any residual voltage is dissipated before conducting the test.

3 **Prevents Damage:** It helps prevent damage to the insulation or the tester itself by discharging any residual voltage, thus extending the lifespan of both.

4 **Compliance:** Some regulations or standards may require residual voltage testing to ensure compliance with safety guidelines.

5 **Diagnostic Capability:** It can provide diagnostic insights into the condition of the insulation by detecting any residual voltage, which could indicate underlying issues such as leakage or degradation.

Overall, incorporating a residual voltage test into megger testing procedures improves safety, accuracy, and reliability of insulation resistance measurements.

In the context of magnetism, residual voltage and current refer to the remaining magnetic flux or current in a magnetic circuit or device after the removal of the excitation source.

Residual Voltage: In magnetic circuits or devices such as transformers or inductors, residual voltage refers to the voltage that remains across the terminals or windings after the excitation (applied voltage or current) has been removed. This residual voltage is often caused by residual magnetism in the core material.

Residual Current: Similarly, residual current refers to the current that continues to flow through the circuit or device after the excitation has been removed. This residual current is typically due to residual magnetization in the core material or leakage currents in the insulation.

Understanding and managing residual voltage and current are crucial in designing and operating magnetic circuits and devices effectively. It's essential to consider residual magnetism when designing transformers, motors, or any other magnetic devices to ensure proper operation and prevent issues such as magnetic saturation or undesired residual effects.

LESSON 129 - 131: Importance of pumps in agricultural & industrial applications. Classification of pumps, parts, constructional details and its working

Objectives

At the end of this lesson you shall be able to

- demonstrate Importance of pump in agricultural and industrial application
- explain classification of pumps and locate parts of pump
- explain construction and working of different pumps.

Importance of pumps in agricultural & industrial applications

Importance of pumps in agricultural

1 Irrigation for crops

In irrigation systems, pumps are used to lift water from a water source, such as a well, river, or reservoir, and deliver it to the fields where crops are grown. These pumps can vary in size and type depending on factors such as the distance the water needs to be transported, the terrain, and the amount of water required by the crops. Common types of pumps used in irrigation include centrifugal pumps, submersible pumps, and turbine pumps.

- Surface irrigation

- Sprinkler irrigation

- Drip irrigation

2 **Cleaning sludge or sediment from small bodies of water:** Pumps are especially used to remove all the dirt or sludge from the pond. This type of pump is used with small sources of water.

3 **Dewatering of crops:** Dewatering of crops typically refers to the process of removing excess water from fields or crops to prevent waterlogging, which can lead to root suffocation and crop damage. This can be achieved using various methods, including surface drainage systems such as ditches and furrows, as well as subsurface drainage systems like tile drains or French drains. Additionally, pumps may be used to remove excess water from low-lying areas or during periods of heavy rainfall to help maintain optimal soil moisture levels for crop growth

4 **Flood control:** Pumps can quickly remove excess water from fields after heavy rains or flooding, preventing waterlogging and damage to crops.

5 **Soil health:** Proper drainage prevents waterlogging, which creates unfavorable conditions for plant growth and promotes diseases.

6 **For spraying medicine and increasing the yield:** In agriculture, pumps are used in medicine through applications such as irrigation systems for delivering precise amounts of water and nutrients to crops, ensuring optimal growth and health. Additionally, pumps are used in pharmaceutical agriculture for precise dosing and distribution of fertilizers, pesticides, and herbicides to prevent diseases and enhance crop yields.

7 **Fish farming:** In fish farming, pumps are used to fill the pond and to remove water from the pond.

Importance of pumps in industrial applications

Pumps play a vital role in industrial applications by facilitating the movement of liquids, gases, or slurries. They are essential to processes such as hydro, chemical processing, oil and gas production, and manufacturing. Pumps ensure the efficient transport of materials within industrial systems, maintain proper pressure levels, and enable precise control over flow rates, all of which are critical to smooth operations and productivity across a variety of industries. The versatility and adaptability of pumps make them indispensable in these areas.

Here are some figure of pump use in industry:

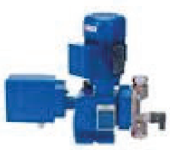

ANSI Centrifugal


Lobe/Sanitary


Self Priming Centrifugal


Rotary Gear

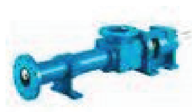

Horizontal Split Case


Metering/Dosing


Reciprocating Plunger/Piston


Air Operated


High Pressure

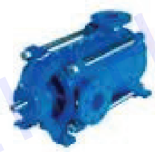

Progressing Cavity


Submersible


Vertical Pumps


High Pressure Diaphragm


Magnetically Driven


Multistage

Classification of pumps, parts, constructional details and its working

Introduction

A pump may have defined as, a mechanical device which when interposed in pipeline converts mechanical energy supplied to it from some external source (say an electric motor) into hydraulic energy and transfers the same to the fluid flowing through the pipeline, thereby increasing the pressure energy of flowing fluid, which is subsequently converted into potential energy to lift fluid from lower side and deliver it to higher side.

In another words, pump is a device used to,

1 Lift the liquid to required height against the force of gravity.

2 Overcome the resistance of fluid to flow through pipe and the pump itself.

Classification of pumps

1 **Positive displacement pumps**

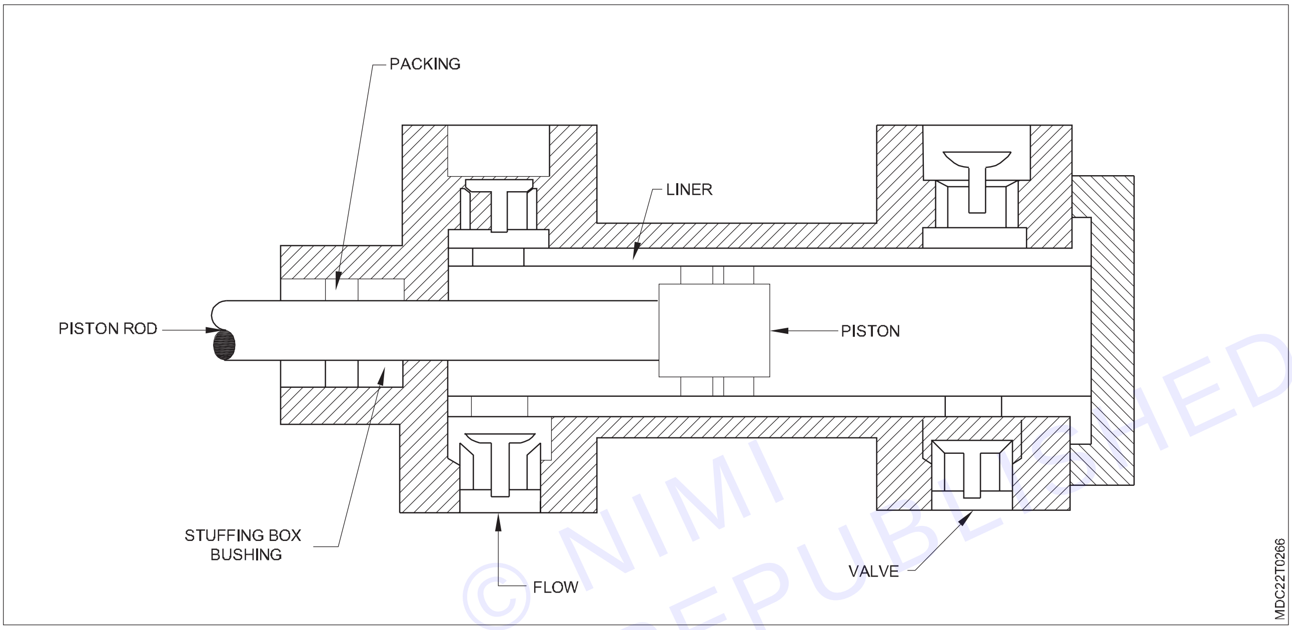
Reciprocating pump

2 **Rotodynamic pump**

Centrifugal pump

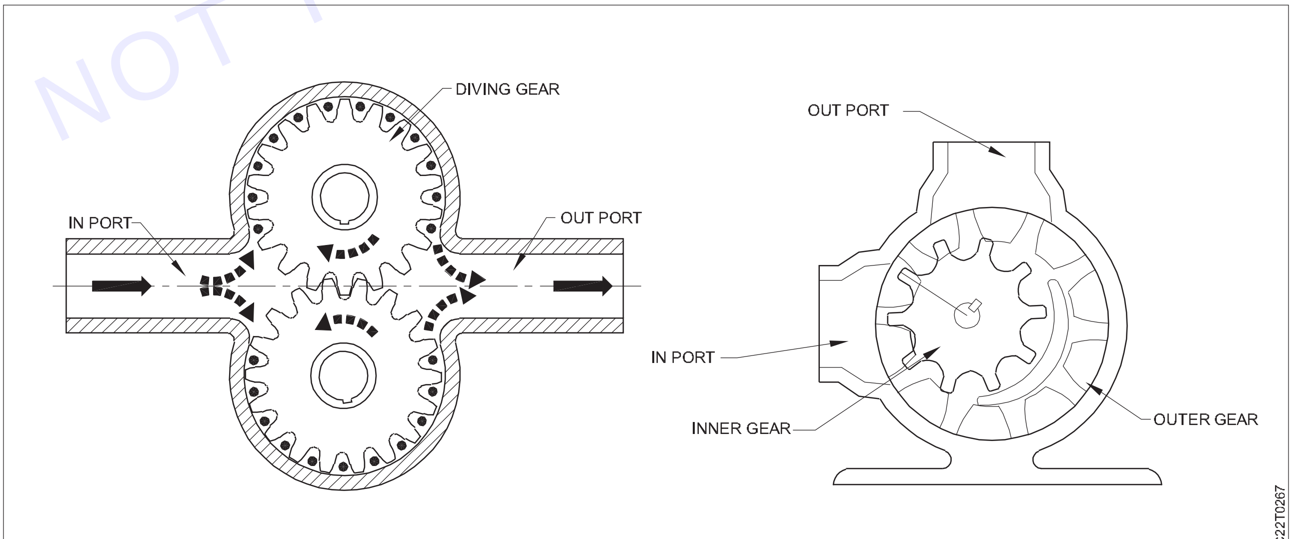
Positive displacement pumps

Liquid is sucked and pushed or displaced due to thrust exerted on it by a moving member (piston) which results in lifting the liquid to the required height.



Rotodynamic (Rotary type) pump

Liquid passes through a rotating element, which is called impeller. When the liquid passes through the impeller, its angular momentum changes. Due to this, pressure energy of liquid is increased, which results in lifting the liquid to the required height.



EXTERNAL GEAR PUMP

INTERNAL GEAR

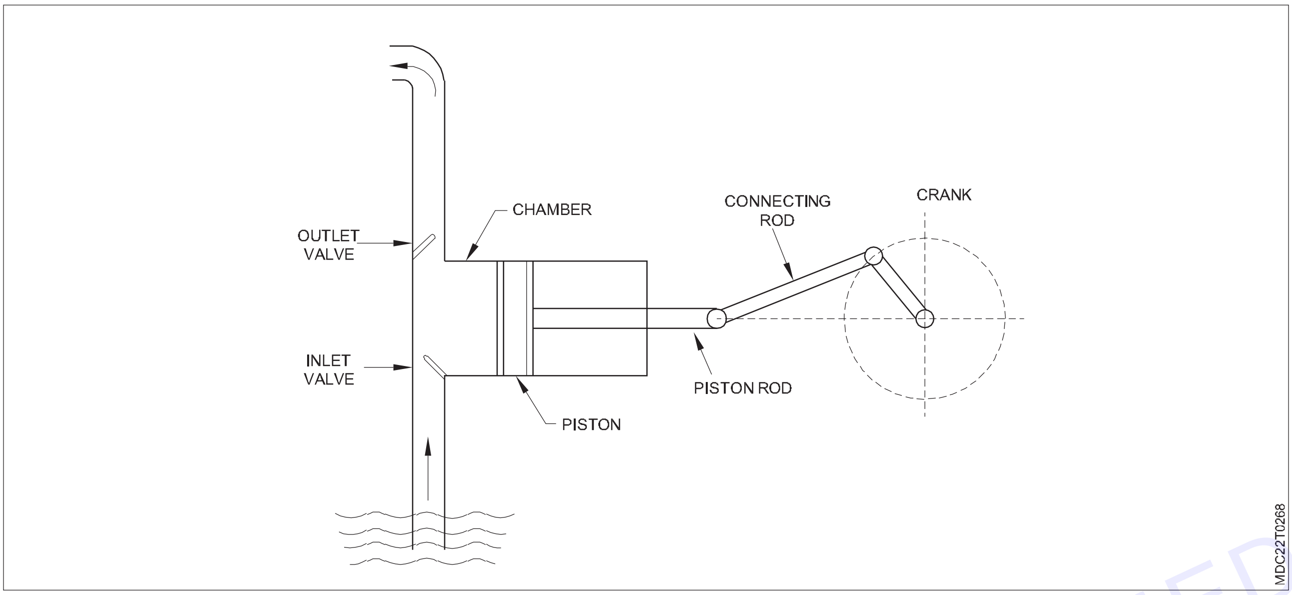
Classification of pumps

Types of Classification	Positive displacement pump	Rotary type pump
Movement	Liquid suck and push	Liquid passes through a rotating element
Displacement	Displaced through thrust	Rotating by external force
Moving member(type)	Piston	Impeller (turbine)
Speed	Draw fluid into a cavity, or displace the fluid, and then force the liquid out of the cavity trough suction.	Have a spinning impeller that draws the fluid into the pump and forces it out of the outlet point at an increased velocity
Handling	It can handle highly viscous fluid and shear sensitive fluids- or fluids that change when force, stress and pressure is applied	Unable to handle viscous fluid as well as positive displacement pump because of the frictional losses
Flow rate	1 Flow rate can increase as the fluid gets thicker 2 Maintain a constant flow rate even as a pressure changes	1 Need liquid in the unit to kick-start the pressurized control 2 The fluid moving out of is varying flow rate based on pressure
Application	1 Municipal sewage system 2 Oil processing centers 3 Manufacturing centers	1 Municipal water supply departments 2 Air conditioners 3 Irrigation 4 firefighters
Power of volume	Low pumping water volume	High pumping water volume
Maintenance	Frequent maintenance	Low maintenance
Pressure	Lower flow rates and higher head than centrifugal pump	Volume of fluid is dependent on static head/ pressure
Improvement of flow rate	As a water viscosity increase, flow rate also increase	As the water viscosity increase, the flow rate decrease
According to types of casing	Cylindrical shape	Volute or constant velocity
According to stage	Single /Multi cylinder	Single/ multi stage
According to working head	a low head- 0.4 to 55000 lpm b total head pressure- between 0.7 to 6800 bar c horsepower range- between 0.5 to 4900 HP	a low head- upto 15m b medium head- between 15m to 40m c high speed-beyond 40m
According to liquid handle	Vertical in-closed cylindrical shape	Shrouded or enclosed impeller type

Construction and working of positive displacement pump

In positive displacement pumps, the division of reciprocating assists the liquid to flow forward from the lake. The reciprocating parts of these pumps are a plunger, a piston otherwise a diaphragm. This type of pump includes different types of valves such as the inlet valve and outlet valve. In the fluid suction method, the inlet valve opens & the outlet valve stays closed.

When the piston turns in the right direction, then the cavity of the pump increases, as well as the liquid, can be sucked into the cavity. These pumps are classified into three types namely plunger pumps, piston pumps, and diaphragm pumps.



Principle of reciprocating pump (positive displacement pump)

The principle behind a reciprocating pump is based on positive displacement, where a piston or diaphragm moves back and forth within a cylinder to create pressure changes that force fluid through a system. Here's how it works:

1 **Suction Stroke:** During this phase, the piston or diaphragm moves away from the inlet valve, creating a vacuum in the cylinder. This vacuum causes the inlet valve to open, allowing fluid to enter the cylinder.

2 **Compression Stroke:** As the piston or diaphragm moves back towards the inlet valve, it compresses the fluid inside the cylinder. This compression increases the pressure of the fluid, causing the outlet valve to open and allowing the fluid to be discharged from the pump.

3 **Discharge Stroke:** Once the fluid reaches a certain pressure, the outlet valve closes, preventing backflow. The piston or diaphragm continues to move towards the outlet valve, pushing the fluid out of the cylinder and into the system.

4 **Return Stroke:** After the fluid is discharged, the piston or diaphragm reverses direction again, moving back towards the inlet valve to begin another suction stroke. This cycle repeats to create a continuous flow of fluid through the system.

The key principle is that each stroke of the piston or diaphragm displaces a fixed volume of fluid, ensuring a consistent flow rate regardless of changes in pressure or viscosity.

A reciprocating pump is a type of positive displacement pump that uses a piston or diaphragm to move fluid through a system. Here's a basic construction outline:

1 **Cylinder**

This is where the reciprocating motion occurs. It houses the piston or diaphragm.

2 **Piston or Diaphragm**

The piston moves back and forth within the cylinder, creating pressure changes that move the fluid. In diaphragm pumps, a flexible diaphragm is used instead of a piston.

3 **Inlet and Outlet Valves**

These valves control the flow of fluid into and out of the pump. In a reciprocating pump, they typically consist of one-way valves to ensure that fluid only moves in one direction.

4 Drive Mechanism

This could be an electric motor, engine, or other power source that provides the energy to move the piston or diaphragm back and forth.

5 Seals and Gaskets

These components prevent leakage of fluid and maintain pressure within the pump.

6 Support Structure

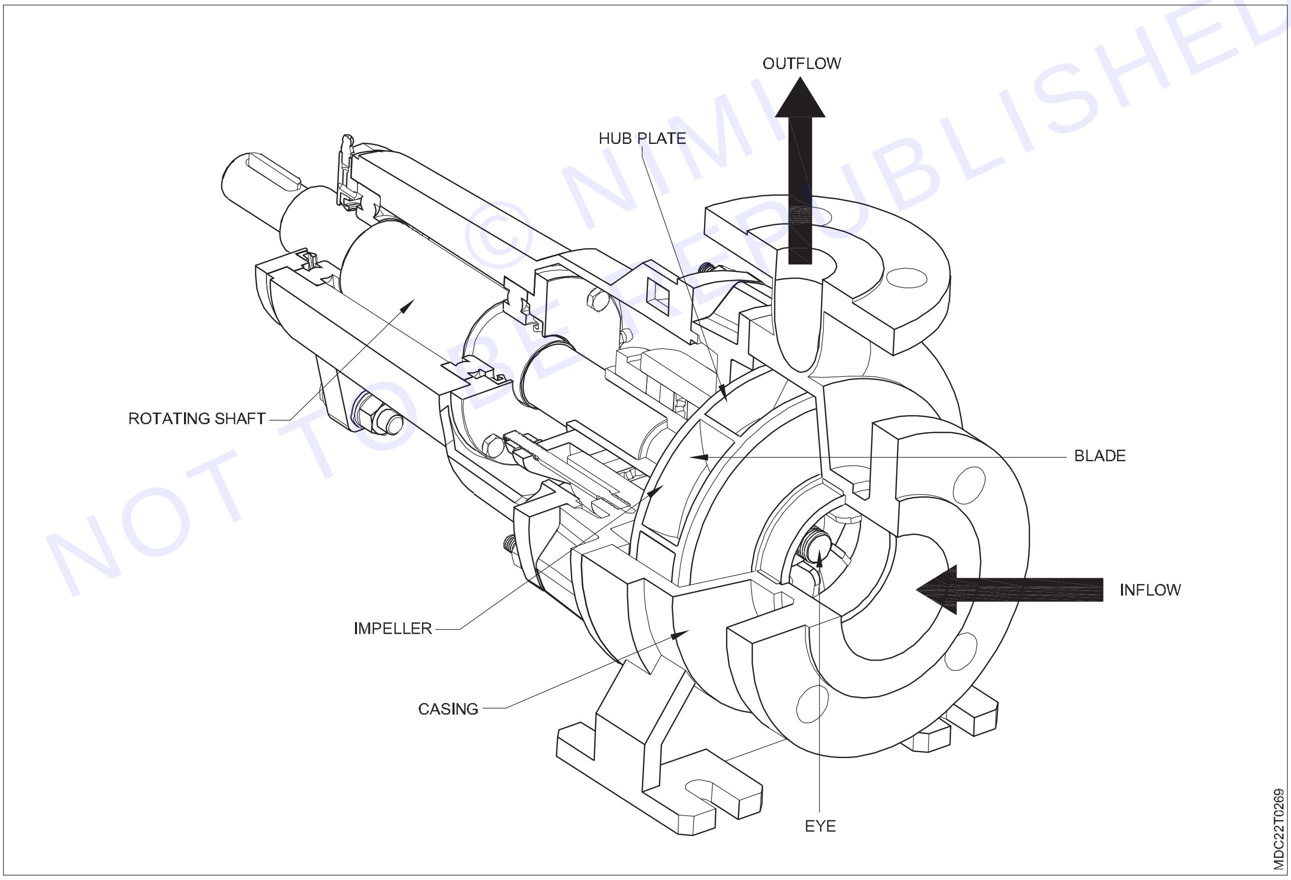
The pump is usually mounted on a sturdy frame or base to provide stability and support during operation.

Reciprocating pumps are commonly used in various applications, including hydraulic systems, water supply, and oil extraction.

- The plunger pumps are mainly used for pushing water.
- The piston pump is inbuilt with a piston which is used for pumping the liquid
- The diaphragm pump works similar to plunger pump however it includes diaphragm for suction & expulsion of liquid.

Construction and working of centrifugal pump

A centrifugal pump is dynamic pump that uses rotational energy to move fluid through a system. Here, we have to study about centrifugal pump construction and working.



Impeller

- Impeller is a rotor having series of backward curved vanes.
- It is mounted on the pump shaft, which is usually coupled to electric motor or generator.

Casing

- Casing is airtight chamber surrounding the pump impeller.
- It has delivery pipe on one side and suction pipe on other side (called as eye of impeller)

Function of casing:

I To guide the water to and from impeller.

II To partially convert the kinetic energy into pressure energy.

Suction pipe with strainer and foot valve

- Suction pipe connects Centre of eye of impeller to sump from which liquid is to be lifted.
- Strainer (filter) is provided at the lower end of pipe to prevent the entry of any debris (mass of loose mud, soil, rock and other) into the pump.
- A non-return valve is also providing at the lower end if pipe which allows the flow of water only in upward direction.

Function of NRV (non-return valve)

i This valve does not allow the liquid to drain out from suction pipe when pump is not working.

ii This valve is help in priming.

Delivery pipe

- Delivery pipe is connected at its lower end to the outlet of pump and delivers the liquid to required height (Overhead tank).
- A delivery valve is provided in the delivery pipe near the outlet of pump.

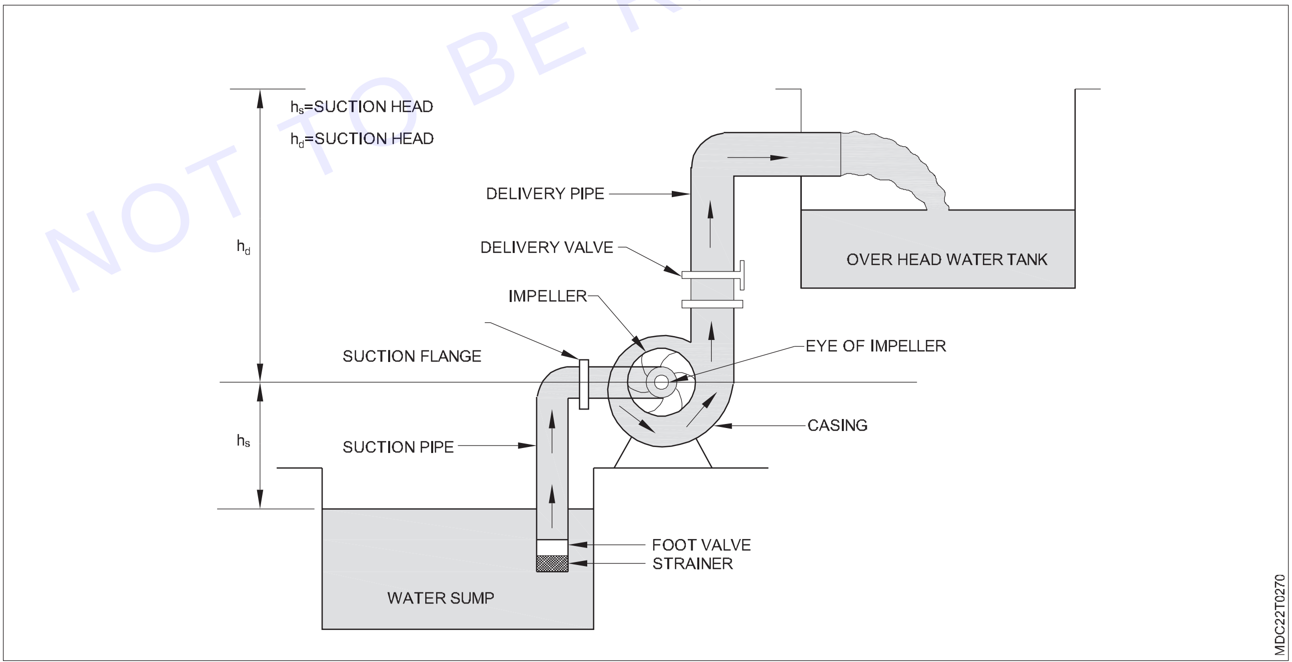
Function of delivery pipe

To regulate the supply of liquid from pump to delivery pipe.

Principal of centrifugal pump

When a certain mass of fluid is rotated by an external source, it is thrown away from the central axis of rotation and centrifugal head is impressed, which enables the fluid to rise to a higher level

Working of centrifugal pump



a Initially, delivery valve is closed to reduce starting torque of motor and pump is primed, like suction valve, casing and portion of delivery pipe up to the delivery valve are completely filled with liquid to be pumped. This is done to ensure that, no air pocket is present in this portion.

b Now, electric motor is started to rotate the impeller. The rotation of impeller in a casing (full of liquid), produces a forced vertex. This force vertex is responsible for imparting the centrifugal head to the liquid. It creates vacuum at the eye of impeller and causes the liquid to rise into the suction pipe from the water sump.

c The speed of impeller is gradually increased, so that, it can produce sufficient centrifugal head, which can initiate discharge from delivery pipe.

d When the liquid is being continuously sucked and passes through eye of casing enters at the Centre of impeller or at inlet tips of vanes of impeller, the delivery valve is opened. This liquid is impelled out by the rotating vanes and liquid pumps out into the casing.

e Due to impeller action, the pressure head and velocity head of liquid both are increased and liquid passes through delivery pipe from casing and is lifted to required height and discharge into the overhead tank.

f The liquid is continuously sucked from sump to impeller eye and delivered through the delivery pipe as long as motion is given to impeller.

g Before stopping the pump delivery pipe should be closed otherwise there may be some backflow of pressurized liquid from reservoir.

Classification of reciprocating pump, construction and operation. Installation technique of reciprocating pump. Tools and equipment required & procedure

Objectives: At the end of this lesson you shall be able to

- explain classification of reciprocating pump, construction and operation
- eemonstrate installation techniques of reciprocating pump
- select tools and equipment required for installation of pump.

Classification of reciprocating pump, construction and operation

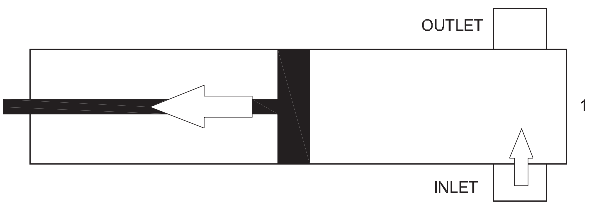
Reciprocating - Reciprocating pumps are used where a precise amount of fluid is required to be delivered, also where the delivery pressure required is higher than can be achieved with other types.

The fluid is moved by the means of a piston that travels in a cylinder. After being drawn into the cylinder through an inlet valve, the piston continues moving down the cylinder. As the piston moves back up the cylinder, the liquid is discharged at a preset pressure, controlled by a delivery valve.

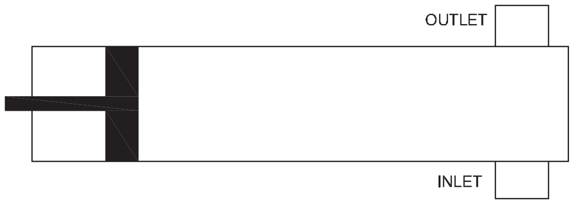
The liquid is ejected from the cylinder into the piping system in pulses, which are transmitted to the suction and discharge piping; therefore, hold-down supports could be required on the piping system on the suction and the discharge side of the pump. The three classes of reciprocating pumps are piston, plunger, and diaphragm.

Working

To help visualize how a reciprocating pump works, let's look at a single piston and split the process into four parts.

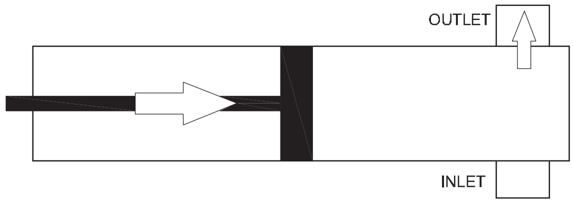


Action 1: The plunger or piston is pulled back. The action increases the volume of the cavity. As the cavity volume expands, fluid is drawn in through the inlet to fill the expanding cavity.



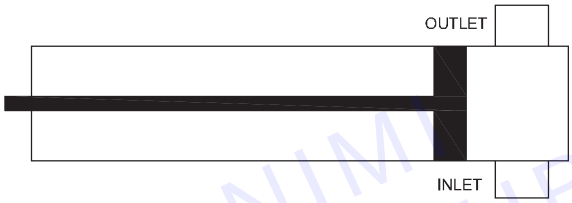
2

Action 2: The piston has reached its maximum displacement. Since it is not moving into or out of the cavity, fluid is not flowing through the inlet or the outlet.



3

Action 3: After reaching its maximum position, it is then pushed back into the cavity. During this process, the piston applies enough pressure to the fluid to overcome the pressure in the outlet of the pump. This pressure differential pushes the fluid from inside the cavity through the outlet of the pump.



4

Action 4: The piston reaches its maximum extension into the cavity. Here the volume of the cavity is at a minimum and fluid is not flowing through the inlet or the outlet. The next action repeats the process, starting again with action

Components

1 **Water reservoir -** it is not a part of reciprocating pump, however, it is the main source where from the reciprocating pump takes the water. It may be a source of other fluid as well.

2 **Strainer -** It removes all impurities from the liquid to avert chocking the pump.

3 **Suction Pipe -** It is a pipe by which pump takes the water from the reservoir.

4 **Suction Valve -** It is a non-return type valve installed on the suction pipe and helps to flow from reservoir to pump not the vice versa.

6 **Cylinder or liquid cylinder -** The main component where pressure is increased. It is a hollow cylinder with coatings. It consists of a piston along with piston rings.

7 **Piston or plunger and Piston rod -** Piston is directly connected to a rod that is the piston rod. This piston rod is again connected to the connecting rod. Piston makes the reciprocating motion in forward and backward motion and creates pressure inside the cylinder.

8 **Piston rings -** Piston rings are small but one of the vital parts to protect the piston surface as well as cylinder inner surface from wear and tear. It helps to operate the pump smoothly.

9 **Packing -** Packing is necessary for all pumps, to have a proper sealing between cylinder and piston. It helps to stop leakage.

10 **Crank and Connecting rod -** Crank is connected to the power source and connecting rod makes connection between crank and piston rod. These component helps to change the circular motion into linear motion.

11 **Delivery valve (non-return valve) -** Like suction valve delivery valve is also non return type and it helps to build up the pressure. It protects the pump from back flow.

12 **Delivery pipe -** It helps to supply the fluid at destination.

13 **Air Vessel -** Few reciprocating pumps may have an air vessel; it helps to reduce the frictional head or acceleration head.

Classification

1 **Piston:** Piston pumps generally are used where medium to high delivery pressures are required, such as for a high-pressure flushing of vessel interiors and tanks. These can be obtained in multi cylinder form and can be single or double acting

2 **Plunger:** Plunger pumps usually are used for metering or proportioning a fluid. Frequently, a variable speed drive or stroke adjusting mechanism is provided to vary the flow as desired.

3 **Diaphragm:** Diaphragm pumps are invariably air driven and very compact, also no seals or packing is exposed to the liquid being pumped, which makes them ideal for handling hazardous or toxic liquids. These often are used for sump pump out.

4 **Single-acting reciprocating pump:** This has one suction valve and one discharge valve. When the piston is moved backward, suction happens and when it moves forward, the delivery valve opens up to discharge the liquid.

Double-acting reciprocating pump: Unlike a single acting pump, here there are two suction and delivery valves. When the piston is moved forward or backward, with each stroke, both suction and expulsion happen simultaneously. Thus it requires two inflow pipes and two outflow pipes. Some of the common applications of these kinds of pumps are in Salt Water Disposal, Well Service, Descaling, Hydraulic Fracturing, and Oil & Gas Pipelines.

5 **Double - acting:** These are double-acting pumps where steam, air, or gas is used to transmit power to the liquid through the piston. The ratio of total steam force (steam pressure per unit area x area of the steam piston) to total liquid force (pump head x area of the liquid piston) helps determine the efficiency with which the pump produces pressure. They can operate at any point of pressure and flow, within a flexible range. Because of these features, steam-driven pumps are mostly used in the refineries for pump-out service, with low NPSH and the fluids used are hydrocarbons mostly with high viscosity and high temperature. National, Gardner Denver, Oilwell, Gaso, and Wheatley are known as key manufacturers of such pumps.

6 **Simplex, Duplex, Triplex, Quintuplex Pumps:** Many reciprocating type pumps are simplex(one), duplex (two), or triplex (three) cylinder. Duplex pumps are usually used where the two pumps can be used alternatively. Such pumps are commonly used in oil-line pumping, mine de-watering, and chemical and petroleum products transfer, but has many more applications. A triplex pump consists of three plungers, with the aim of reducing the pulsation of a single reciprocating pump. Quintuplex pumps are designed with a gear case that assists in a high-pressure task. Common applications of which are in cement slurries, sand-laden fluids, crude oil, acids, mud, and other oil well-servicing fluids. Well known manufacturers for these types of pumps are National, Gardner Denver, FMC, SPM, Oilwell, Kerr, Union, Gaso, Emsco, Aplex, and Wheatley.

7 **Metering Pumps:** A metering pump is usually used where the rate of flow of the liquid needs to be adjusted in a specific time period. Most of the metering pumps are piston-driven and are called Piston pumps. Piston pumps can pump at a constant flow rate against any kind of discharge pressure. Both Piston pumps and Plunger pumps are reciprocating positive displacement pumps that use a plunger or piston to move fluid/ substance through a cylindrical chamber. Manufacturers such as Lewa, Watson Marlow, and Bredel offer metering pumps at competitive prices.

Application of reciprocating pumps

- Vessel, pipe, tank, tube, condensate pipe, heat exchanger etc cleaning,
- Oil drilling, refineries, production, disposal, injections.
- Pneumatic pressure applications.
- Vehicle cleaning.
- Sewer line cleaning.
- Wet sandblasting
- Boiler feeding
- High-pressure pumps for the RO system (Reverse osmosis)
- Hydro testing of tanks, vessels, etc.

- Firefighting system.
- Wastewater treatment system.

Installation technique of Reciprocating Pump, Tools equipment required & procedure

Tools & Equipment

Open ended spanner, Ring spanner, Socket set, Feeler gauge, Allen key, Torque wrench, Rubber hammer, Snap Ring pliers, Measuring Tape, Pipe Wrench, Sealant, etc.

Installation procedure of Reciprocating Pump on Engine

Installing a reciprocating pump on an engine involves several steps to ensure proper alignment.

1 Gather all necessary tools, equipment, and materials.

2 Make sure the engine is off and cool before starting work.

3 Review the pump and engine manual for specific installation instructions.

4 Securely install the engine on a stable base using appropriate bolts and fasteners.

5 Make sure the engine is level and securely mounted to prevent movement during operation.

6 Place the pump in a suitable location near the engine.

7 Align the pump shaft with the output shaft of the engine.

8 Use a coupling device or adapter as necessary to connect the pump shaft to the engine shaft.

9 Use an alignment tool such as a dial indicator or laser alignment device to ensure precise alignment between the pump and engine shaft.

10 Adjust the position of the pump as necessary to achieve proper alignment.

11 Securely install the coupling device, making sure it is properly aligned with both the pump and engine shafts.

12 Tighten the coupling bolt evenly to ensure a secure connection without any disturbance.

13 Connect the suction and discharge pipes to the pump, ensuring tight seal and proper alignment.

14 Use proper fittings and gaskets to prevent leakage and maintain flow efficiency.

15 Prime the pump to remove air from the system and ensure proper suction.

16 Fill the pump casing and suction line with liquid using a priming device or manual filling method.

17 Remove trapped air from the system to ensure smooth operation.

18 If the engine has an electric starter or controls, wire them according to the manufacturer's instructions.

19 Ensure that proper grounding and electrical safety measures are followed.

20 Test the pump-engine system to check for leaks, unusual noises or vibrations.

21 Monitor pump performance, including flow rate and pressure, to ensure it meets specifications.

22 Make any necessary adjustments to optimize performance and resolve any issues identified during testing.

23 Secure all connections, fittings and fasteners.

24 Install any additional safety devices or accessories required for operation.

25 Document the installation process and any adjustments made for future reference.

26 Establish a regular maintenance schedule for the pump-engine system, including inspection, lubrication and component replacement.

27 Trained personnel on proper operating and maintenance procedures to ensure safe and efficient operations.

By following these steps, you can successfully install a reciprocating pump on the engine, creating a reliable and efficient pumping system.

Installation procedure of Reciprocating Pump on Floor / Foundation

1 Gather all necessary tools, equipment and materials.

2 Make sure the installation area is clean, dry and well ventilated.

3 Review the pump's installation manual for specific instructions.

4 Prepare a stable foundation that can support the weight of the pump and withstand vibration.

5 Follow the manufacturer's recommendations for foundation dimensions and materials.

6 Pour concrete or place foundation base according to pump specifications.

7 Place the pump at the desired location on the foundation.

8 Use a level to ensure the pump is aligned horizontally.

9 Align the pump shaft with the drive mechanism (e.g., electric motor or engine).

10 Securely attach the pump to the foundation using bolts or fasteners.

11 Tighten the bolts evenly to prevent misalignment or deformation.

12 Connect the suction and discharge pipes to the pump using appropriate fittings and seals.

13 Prime the pump to remove any air from the system and create suction.

14 Fill the pump casing and suction line with liquid using a priming device or manual filling method.

15 Release trapped air from the system to assure proper operation.

16 Wire the pump motor according to manufacturer's instructions.

17 Make sure proper grounding and electrical safety measures are in place.

18 Test the pump to check for leaks, unusual noises or vibrations.

19 Monitor pump performance, including flow rate and pressure, to ensure that it meets specifications.

20 Secure all connections and fittings.

21 Document the installation process and any adjustments made in the future.

22 Trained personnel on proper operating and maintenance procedures to extend pump lifetime and ensure safe operation.

Safety Precautions

1 Before beginning any work, familiarize yourself with the safety guidelines provided in the pump manufacturer's installation instructions and manual.

2 Wear appropriate PPE such as safety glasses, gloves and steel-toed boots to protect against potential hazards such as moving parts, chemicals or high-pressure fluids.

3 Make sure the installation area is clean, well-lit and properly ventilated. Remove any obstacles or tripping hazards from the work area to prevent accidents.

4 Use proper lifting equipment such as cranes, hoists or forklifts when handling heavy components to avoid injuries. Follow proper lifting technique and use assistance if necessary.

5 Make sure the foundation where the pump will be installed is strong, stable, and level to support the weight of the pump and prevent vibration during operation.

6 Align the pump with the drive mechanism (e.g., electric motor, engine) according to manufacturer's specifications to ensure smooth operation and minimize wear.

7 Securely attach the pump to the foundation using appropriate bolts or fasteners. Make sure the pump is securely fastened and does not move during operation.

8 If the pump is electrically powered, follow electrical safety procedures when connecting the wiring and motor. Ensure proper grounding and insulation to prevent electrical hazards.

9 Use caution when handling fluids used to prime the pump. Avoid falls and clean up any spills immediately to prevent slips and falls.

10 Before starting the pump, make sure all pressure relief valves and safety devices are installed and working correctly to prevent accidents caused by overpressure.

11 Thoroughly test the pump installation in a controlled environment. Monitor for leaks, unusual noises, or vibrations during testing. Keep spectators away from the testing area.

Follow these safety precautions, you can reduce the risk of accidents and ensure safe installation of the reciprocating pump.

LESSON 132 - 135: Classification of rotary Pumps- Construction and operation repairing procedure. Brief description of turbine & stage pumps, positive displacements and their advantages

Objectives

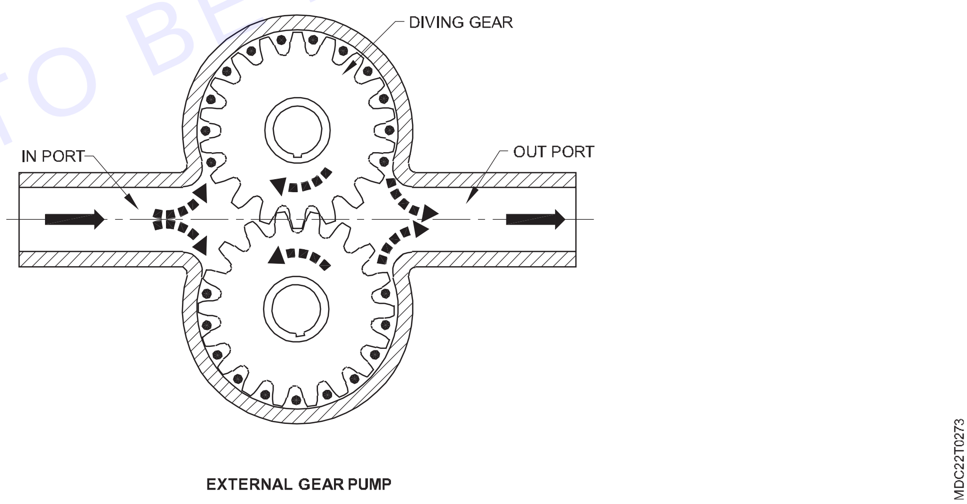
At the end of this lesson you shall be able to

- explain about rotary pump
- demonstrate repairing procedure of rotary pump
- describe about turbine, stage pump and positive displacement pump.

Classification of rotary Pumps-Construction and operation - repairing procedure

Rotary pump: A rotary pump is a type of positive displacement purs, vanes, screws, lobes, or rollers. These pumps trap fluid in a mp that moves fluid using rotating mechanisms such as geaconfined space and then force it through the pump to create flow. Rotary pumps are known for their ability to handle various viscosities of fluids and provide a steady, continuous flow. They are widely used in industries such as automotive, oil and gas, chemical processing, and food production.

1 **Gear Pumps:** These pumps use interlocking gears to move fluid from the inlet to the outlet. They are simple, reliable, and suitable for high-pressure applications.

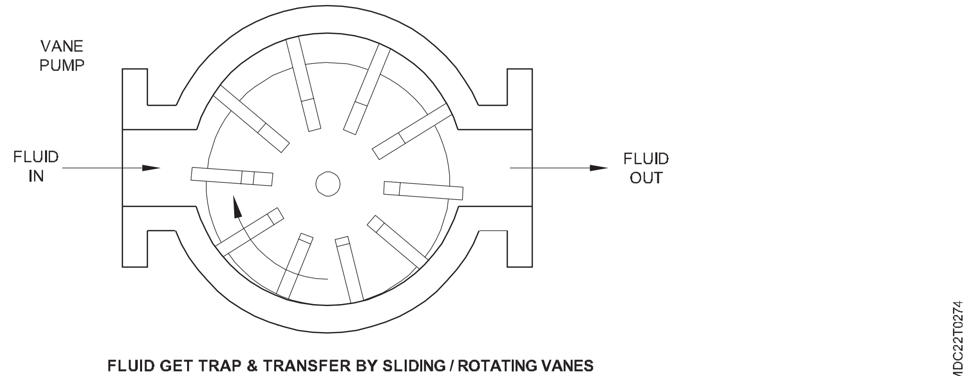


EXTERNAL GEAR PUMP

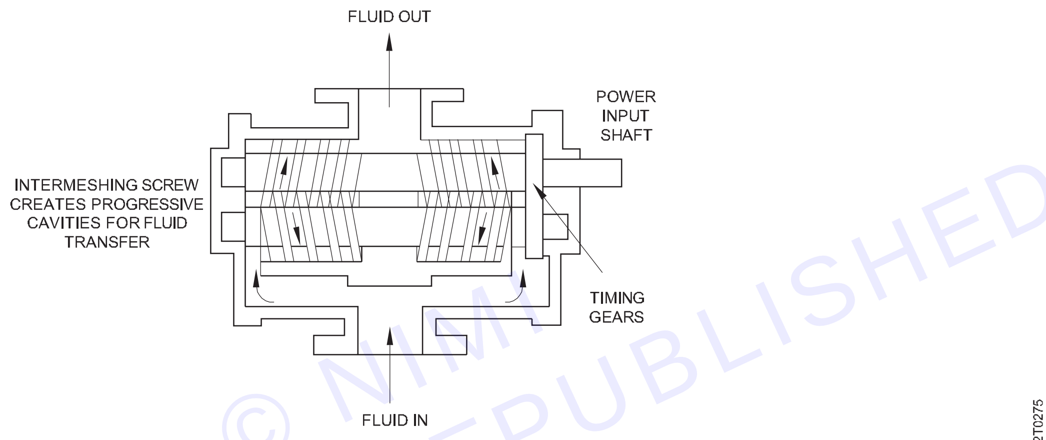
2 **Vane Pumps:** Vane pumps utilize rotating vanes (blades) to push fluid through the pump. They are often used for low to medium pressure applications and are known for their quiet operation.

3 **Screw Pumps:** Screw pumps use one or more screws to move fluid along the screw's axis. They are suitable for high-viscosity fluids and can handle abrasive materials.

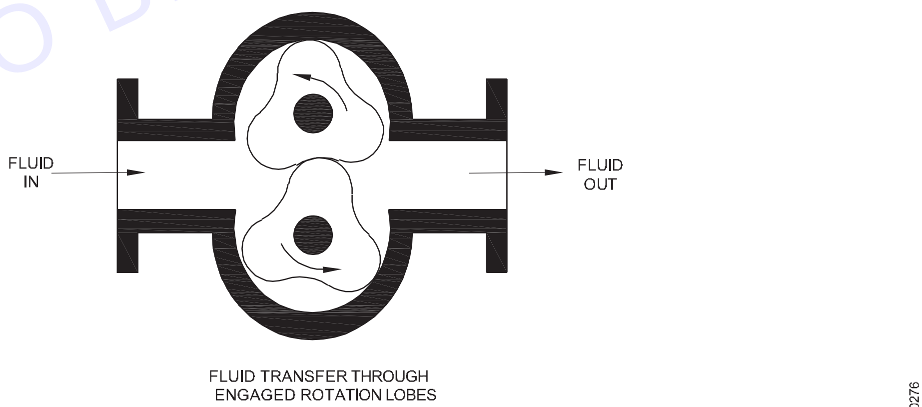
4 **Lobe Pumps:** Lobe pumps consist of two or more lobes that rotate to create suction and discharge fluid. They are commonly used in food processing and pharmaceutical industries due to their gentle handling of delicate fluids.



FLUID GET TRAP & TRANSFER BY SLIDING / ROTATING VANES



SCREW PUMP



LOBE PUMP

5 **Peristaltic Pumps:** Peristaltic pumps use rollers or shoes to compress flexible tubing, creating a vacuum to draw fluid through the tube. They are ideal for pumping shear-sensitive or abrasive fluids.

6 **Progressive Cavity Pumps:** Also known as eccentric screw pumps, progressive cavity pumps use a rotating screw inside an elastomeric stator to move fluid through the pump. They are capable of handling highly viscous fluids and solids.

Repairing Procedure

Repairing a rotary pump typically involves the following steps:

1 **Diagnosis:** Identify the issue with the pump, whether it's leaking, making unusual noises, or failing to operate.

2 **Disassembly:** Carefully disassemble the pump, following manufacturer guidelines and using appropriate tools.

3 **Inspection:** Thoroughly inspect all components for wear, damage, or corrosion. Pay close attention to seals, bearings, and shafts.

4 **Replacement:** Replace any damaged or worn parts with new ones. Ensure replacements are compatible with the specific pump model.

5 **Cleaning:** Clean all components, removing any debris, dirt, or residue. Use appropriate cleaning agents and methods for different materials.

6 **Reassembly:** Reassemble the pump, following the disassembly steps in reverse order. Pay attention to proper alignment and torque specifications.

7 **Testing:** Test the pump to ensure it operates correctly. Check for leaks, abnormal noises, and proper pressure or flow rate.

8 **Adjustment:** Make any necessary adjustments to ensure optimal performance, such as adjusting clearance or tightening fittings.

9 **Maintenance:** Provide recommendations for ongoing maintenance to prevent future issues, such as regular lubrication or seal replacements.

10 **Diagnostic Inspection:** Identify the issue by inspecting the pump and surrounding components.

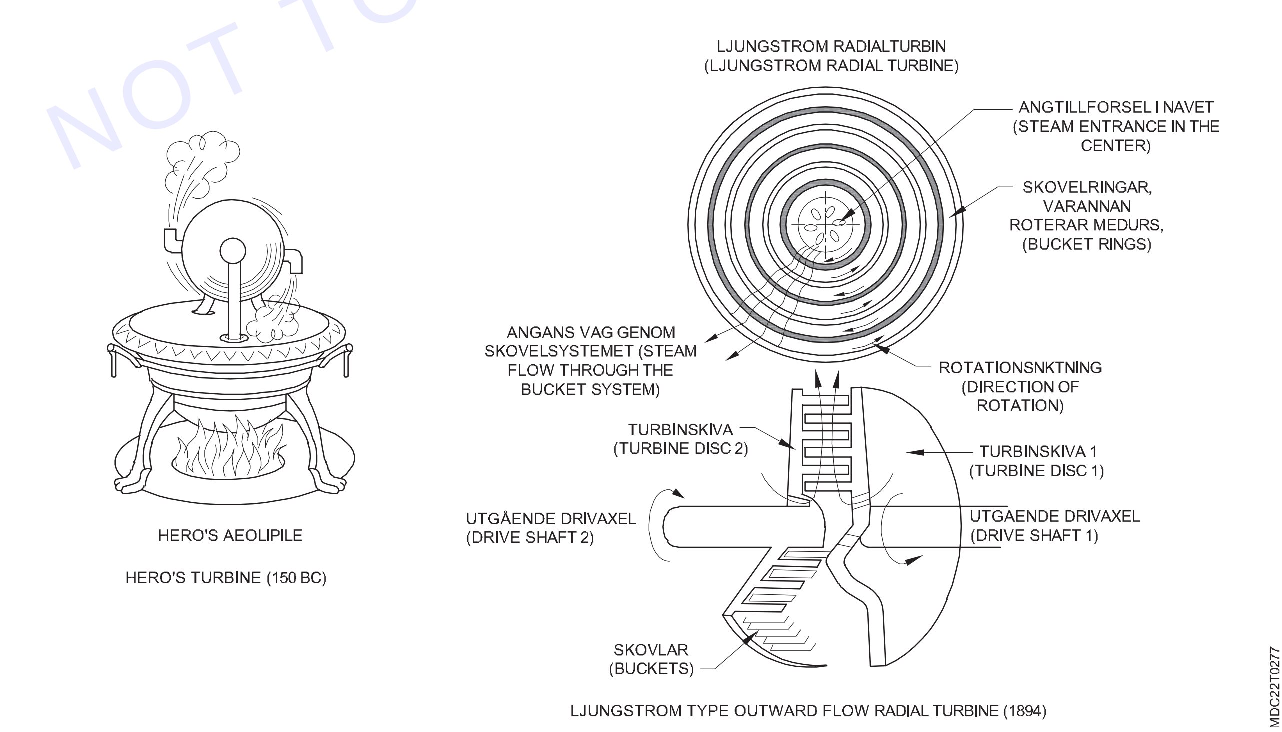
11 **Final Inspection:** Conduct a final inspection to confirm the pump is functioning correctly and safely.

12 **Documentation:** Document the repair process, including any parts replaced, adjustments made, and test results, for future reference.

Brief description of turbine & stage pumps, positive displacements and their advantages

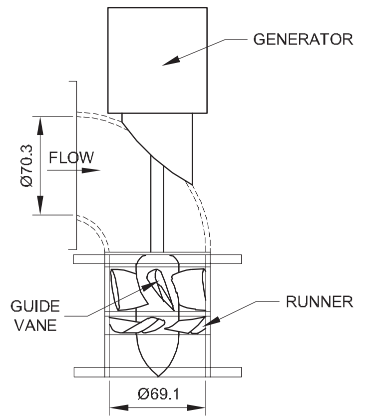
Tangential Flow Turbine: In this air turbine the air flow through tangent of runner. The air jet strikes the runner tangentially and rotates the turbine. Example Pelton wheel turbine Pelton Turbine

b **Radial Flow Turbine:** In this type of turbine, the air flows in radial direction. This is subdivided into two types. The first one is known as inward radial flow in which the air flows from periphery to the center. Example Francis turbine. Second one is known as outward flow radial turbine in which air flow towards periphery from center.

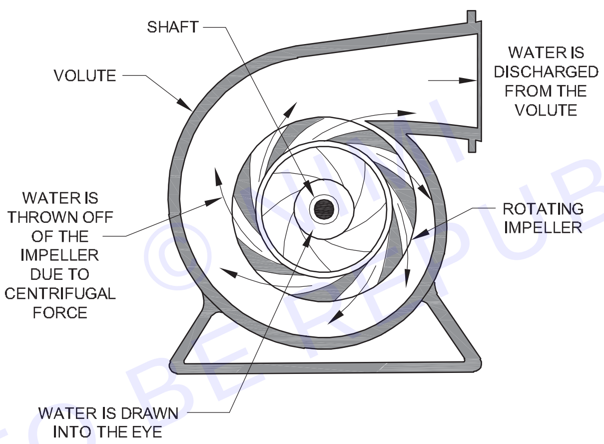


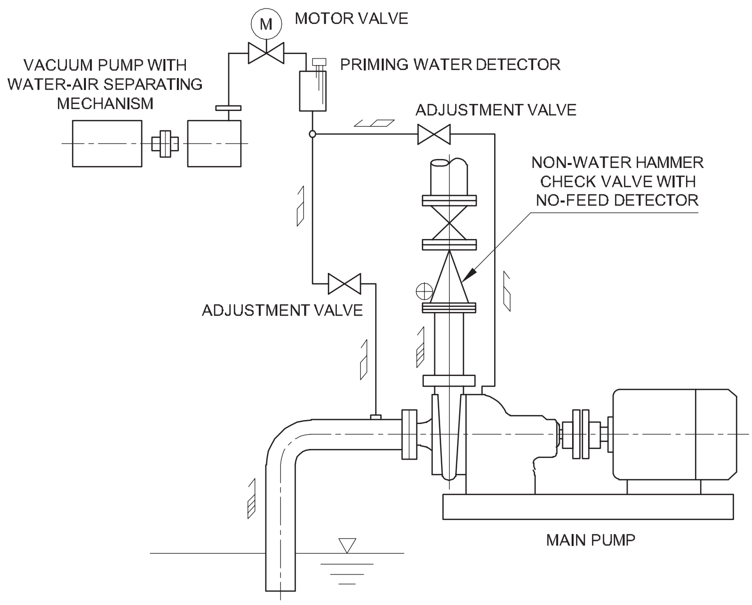
HERO'S TURBINE (150 BC)

LJUNGSTROM TYPE OUTWARD FLOW RADIAL TURBINE (1894) c **Axial Flow Turbine:** In this air turbine, the air flow from the axis of turbine. Example: Kaplan turbine



c **Mixed Flow Turbine:** When the air enters the turbine radically and exit axially or vice versa, it is known as mixed flow turbine.





3 According to Head of air Available at Inlet:

Medium Head Turbine: If the water level varies from 100 m from the axis of the turbine, it is known as medium head turbine. Example Francis Turbine Low Head Turbine: If the air level is below 30 meter from the axis of turbine, it is known as low head turbine. These air turbines required high discharge rate to work efficiently. Example Kaplan turbine.

4 According to Specific Speed of Turbine:

Low Specific Speed Turbine: If the specific speed is less than 50 the turbine is considered as low specific speed turbine. Example Pelton wheel. Medium Specific Speed Turbine: If the specific speed is between 50 – 150, it is considered as medium specific speed turbine. Example Francis Turbine High Specific Speed Turbine: If the specific speed of turbine is above 250 it is known as high specific speed turbine. Example Kaplan Turbine

Meaning of priming and its effect. Installation techniques of rotary pump-procedure, tools and equipment's required

Objectives: At the end of this lesson you shall be able to

- explain about the meaning of priming and its effect
- state about the procedure of installation techniques of rotary pump
- state about the tools and equipments required in installation of the pump

Meaning of priming and its effect

Priming and its effect

Priming refers to the subconscious activation of certain associations, influencing subsequent behavior or thoughts. For example, seeing words related to elderly people might make you walk slower without consciously realizing it. The effect is that priming can influence attitudes, perceptions, and behaviors without conscious awareness.

Meaning of priming: Priming is a psychological phenomenon where exposure to one stimulus influences a response to a subsequent stimulus, often without conscious awareness. It can involve words, images, or concepts and can affect attitudes, perceptions, and behaviors.

Effect: The effect of priming can vary depending on the context and the specific stimuli involved. Generally, priming can lead to changes in behavior, attitudes, and perceptions. It can also influence decision-making and judgments, sometimes in subtle ways that individuals may not even be aware of. Priming effects can be short-term or have longer-lasting impacts, depending on various factors such as the strength of the priming stimulus and individual differences.

Priming effect

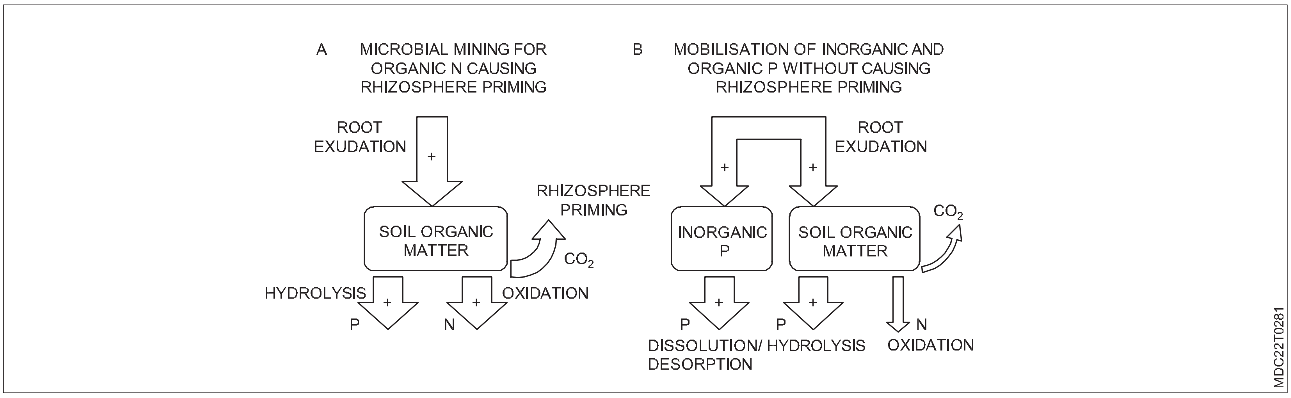
- When labile organic matter (LOM) such as glucose, callouses, or root exudates are in the soil.
- It changes the mineralization rate of recalcitrant organic matter (ROM) present.
- Therefore altering the amount of CO_2 released in the atmosphere.
- Priming effect can enhance the recalcitrant organic matter mineralization rate anywhere from 10% to 500%.

Installation techniques of rotary pump-procedure, tools and equipment's required

Installing a rotary pump involves several steps, and the specific procedure can vary depending on the type and model of the pump. However, here's a general overview of the installation process along with the tools and equipment typically required:

1 Preparation

- Ensure the work area is clean, well-ventilated, and free from any hazards.
- Gather all the necessary tools and equipment.



2 Positioning

- Decide on the optimal location for the pump, considering factors like accessibility, ventilation, and proximity to the fluid source.

3 Mounting

- Securely mount the pump on a stable surface or foundation using mounting brackets or bolts. Make sure the pump is level and properly aligned.

4 Connections

- Connect the inlet and outlet pipes to the pump using appropriate fittings, seals, and gaskets.
- Ensure all connections are tight and leak-free.

5 Electrical Wiring

- If the pump is motor-driven, connect the electrical wires according to the manufacturer's instructions.
- Ensure proper grounding and electrical safety measures are followed.

6 Testing

- Before starting the pump, perform a thorough inspection to ensure everything is properly installed and connected.
- Prime the pump if necessary, following the manufacturer's guidelines.
- Start the pump and monitor its operation for any unusual noises or vibrations.
- Check for leaks and verify that the pump is delivering the expected flow rate.

Tools and Equipment Required

- Wrenches or spanners for tightening bolts and fittings
- Screwdrivers for electrical connections
- Pipe wrenches or adjustable pliers for pipe fittings
- Teflon tape or pipe dope for sealing threaded connections
- Level for ensuring proper alignment
- Electrical tester for checking wiring connections
- Safety equipment such as gloves and goggles

It's essential to refer to the specific installation instructions provided by the pump manufacturer, as different pumps may have unique requirements and considerations. Additionally, following all safety guidelines and local regulations is crucial to ensure a safe and successful installation.