GOVERNMENT OF TAMIL NADU

HIGHER SECONDARY FIRST YEAR

VOCATIONAL EDUCATION

Basic Automobile Engineering

THEORY & PRACTICAL

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Department of School Education

Untouchability is Inhuman and a Crime

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PREFACE

We take pride in presenting this text book on Basic Automobile Engineering Theory for the students of Higher Secondary and express our deepest gratitude to the learners, teachers and the SCERT for their enthusiastic support and response.

In the preparation of this text book enough care has been taken to introduce the fundamentals concepts to make the students to understand the subject, in addition to dispensing advanced topics to keep the students updated with the modern developments.

The interesting facts related to the subject are highlighted under "Do you Know" box item. Suitable activities have been suggested to the students to familiarise them with various components of the Engine and able to obtain sufficient practical exposure.

Activities are included at the end of each chapter to encourage the students to have an additional exposure in the process of learning. It is mainly to make the students to acquire analytical skills and improve their understanding and also to help them for the purpose of examination. Students are encouraged to learn the new topics from the related know old topics and to practice critical thinking to get innovative idea required for vocational education.

To facilitate further learning, reference books and websites have been suggested for each chapter. Suggestions and constructive criticism are most welcome to be duly considered and incorporated in future.

HOW TO USE THE BOOK

Learning Objectives:	Learning objectives are brief statements that describe what students will be expected to learn by the end of school year, course, unit, lesson or class period.
Chapter Outline	Illustrate the complete overview of chapter
DO YOU KNOW?	Amazing facts, Rhetorical questions to lead students to Automobile inquiry
Case Study	To encourage you, the role model students who studied in this group and achieved in various fields such as employment, self-employment and higher studies are mentioned in this case study.
Activity	Directions are provided to students to conduct activities in order to explore, enrich the concept.
Infographics	Visual representation of the lesson to enrich learning .
Evaluation	Assess students to pause, think and check their understanding
EJ38Y6	To motivate the students to further explore the content digitally and take them in to virtual world
Concept Map	Conceptual diagram that depicts relationships between concepts to enable students to learn the content schematically
Career corner	List of professions related to the subject
References	List of related books for further details of the topic
Web links	List of digital resources
Glossary	Explanation of scientific terms
Competitive Exam questions	Model questions to face various competitive exams

Career Guidance

Vertical Mobility		Horizontal Mobility	
Engineering	***Arts***	***Employments***	***Self-Employment***
1. Directly to Join 2nd year Diploma Engineering in Government Aided and private polytechnics and select any other major Engineering course. 2. 10% of the Seats are allotted to Government and Government Aided and Private Engineering colleges to Join Ist year graduate engineering. 3. Distance Education Directly under go the course AMIE which is equal to Government Engineering Courses. Maximum Duration Six years.	1. +2 Vocational Groups Student are eligible to Join Ist year Diploma Teacher Training Course. 2. Directly Join B.A. Arts Group Except – Physic Chemistry, Biology major all other science group. 3. Directly Join B.Sc Math's group.	1. Directly Join to Reputed Industries as Apprentice Training/Factory Training like a) Ashok Leyland. (Chennai and Hosur) b) TVS Groups. (Chennai, Hosur, Madurai, etc.) c) Simpson Engineering Groups. (Chennai, Hosur, Redhills, etc.) d) Hyundai Car Company. (Sriperumbudar, Irrangatukdtai, Chennai) e) Ford India Ltd. (Maraimalai Nagar) f) All Reputed Service centers like TVS, VST and Hyundai, Ford etc. g) All Automobile leading manufacturing, repairing and servicing centers.	1. Vocational Students after getting Apprentice Training Industry Training are eligible to get small scale Industry Loan from Hudco, TIDCO, SIDCO etc. 2. After Adequate required experience in the field getting they are eligible to minimum loans under the scheme of a) NRY (Nehru Rozhar Yogana) b) PMRY (Prime Minister Rozhar Yogana) c) TRYSEM (Training for Rural Youth and Self Employment) d) PMKVY (Pradhan Mantri Kaushal Vikas Yojana)

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BASIC AUTOMOBILE ENGINEERING

TKK8WB

E-book

TKNVK8

Assessment

B196_11_AUT.M_EM

DIGI links

TN_QR_ENG

Lets use the QR code in the text books ! How ?

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- Once the scanner button in the application is clicked, camera opens and then bring it closer to the QR code in the text book.
- Once the camera detects the QR code, a url appears in the screen.Click the url and goto the content page.

Unit 1 Safety Rules

Contents

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Learning Objectives

- To learn the relief procedure in case of emergency situations to the living beings.
- To learn the road safety rules.
- To learn the handling of tools and equipments in the workshop.

1.0 INTRODUCTION

Safety rules are necessary to ensure owners and employees not to injure themselves or customers during operation in machines. Perfection is required before doing the job, during the job and after doing the job. For perfection in work, an operator should know the handling of machine and equipment in a safe manner. For example, a welder can use goggles to protect the eyes from the heat and ultraviolet radiation produced by the welding. Other safety devices can be used depending upon the job. Such procedures to use proper safety in devices and operation is called as safety rules. The following are the classification of safety rules depends on the place of work.

1. Safety in Shop floor
2. Self-Safety
3. Safety in Machines
4. Safety in Tools
5. Road safety rules
6. Vehicle safety rules

1.1 WORKSHOP SAFETY RULES

The following rules have been followed in the workshop to ensure the safety of all employees while operating machines. The majour safety equipments are shown in Fig 1.1.

1. Always wear helmet and shoe in the workshop.
2. Always walk on the designated path.
3. Don't talk or distract the other employees during work.
4. Without prior notice, do not disconnect or connect an electrical connection.
5. Operate the machine after proper training and permission from authorities.
6. Keep the tools in their designated places only.
7. Keep the board "Under Fault" in the faulty machines.
8. Keep the first aid box at appropriate places
9. Use appropriate dress code inside the work premises.
10. When working with machine tools or other equipment with rotating spindles, watches, rings, jewellery, loose clothing etc., are prohibited and long hair must be completely covered.
11. Use proper material handling equipments to transfer raw material.
12. Maintain clean and hygiene canteen, water and restrooms.
13. An operator should not operate the machine continuously for more than 8 hours. Provide break at the specified intervals.

14. Don't allow an ill operator to operate the machine.
15. Exit path should be clearly marked and the pathway should be kept clear of any obstacles.
16. All the safety rules and procedures should be meticulously followed by all the employees.

Figure 1.1 Safety Equipments

1.2 SELF–SAFETY

An operator should prepare himself to do the work correctly, effectively within the stipulated time. This preparation will prevent the operator from accidents and such safety measure is called as self-safety. Figure 1.1 shows self-safety items and Figures 1.2 and 1.2(a) show their practice. The following are self-safety rules and should be followed.

1. Always wear fit clothes.
2. Don't have long hair.
3. Always wear shoe.
4. Operate a machine tool after getting proper training.
5. Sharp tools should be kept only at the designated place.
6. Handle sharp tools with proper safety wear.
7. Operate the machine/vehicle after pre – checkup.
8. Don't wear watches, rings during work.
9. Wear a helmet while travelling on a two-wheeler. Wear a seat belt while travelling in the car.

Figure 1.2 Self-Safety in Work Place

Figure 1.2(a) Wear Fit Cloths in Self-Safety

10. Avoid having food, chats in the workplace.
11. Ensure proper lighting and ventilation at the workplace.
12. Don't work with illness.

1.3 SAFETY PRECAUTION IN MACHINES

The following are the safety rules to be followed before the process, during the process and after the process. Refer Figures 1.3, 1.3(a) and 1.3(b).

1. Don't lean on the machine during its working.
2. Operate the machine after ensuring the working condition of the machine.
3. Equipment should be used with proper safety guards, especially for rotating parts.
4. Ensure proper grease and lubrication oil before the start of any operation.
5. Stop the machine, if an unusual sound is heard.
6. Lubrication should be made periodically.

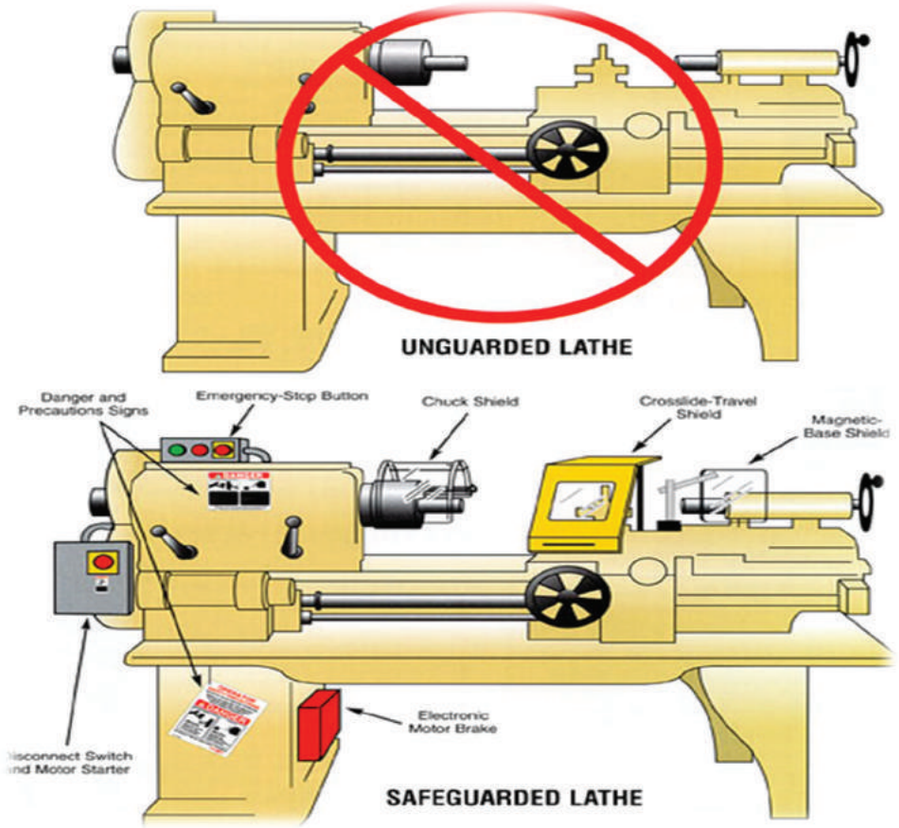

Figure 1.3 Safety Precaution in Machines

7. Operate the new machine after understanding its operation.
8. Lay proper foundation based on speed, weight and its operating features.
9. Don't service the machine during its operation.
10. Clear visible note should be attached to the machine when it is out of order.

Figure 1.3 (a) Safety Precaution in Machines

Grinder Safety (cont)

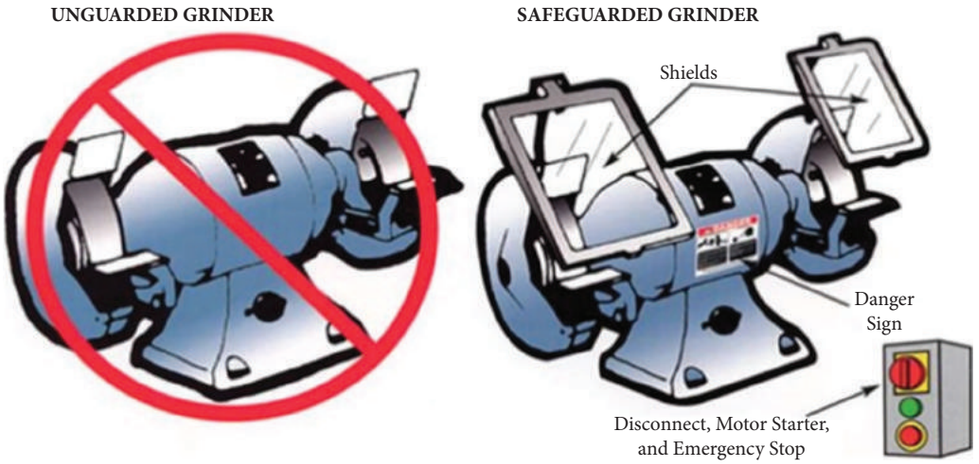

Figure 1.3 (b) Safety Precaution in Machines

1.4 SAFETY PRECAUTION IN USING TOOLS

Hand tools are a common part of our daily work lives. Hand tools like Hammers, wrenches, chisels, pliers, screwdrivers etc., may look harmless, but they are the cause of many injuries. These injuries can be serious, including loss of fingers or eyesight. Hence proper safety measure should be taken while in use. Refer Figures 1.4 and 1.4(a).

1. Use files, chisels or other hand tools with proper handle.
2. Use appropriate coolants during cutting operation.
3. Keep the sharp tools securely in their protective covers before and after use.
4. Select and Use the right tool for the job. Substitutes increase the chance of having an accident. For example, Don't use a wrench as a hammer, screwdriver as a chisel, file as lever etc.,
5. Don't over tight the hacksaw blade.
6. Always provide training on how to choose the right tool for the job, how to correctly use each tool, and how to identify when tools need repair.
7. Use good quality tools and Keep tools in good condition at all times. Inspect tools for defects before use. Replace or repair defective tools.
8. Carry tools in a sturdy toolbox to and from the worksite.
9. Wear safety glasses or goggles, or a faceshield (with safety glasses or goggles)

Figure 1.4 Safety Precaution in Using Tools

Figure 1.4(a) Safety Precaution in Using Tools

and well-fitting gloves wherever required.

10. Do not apply excessive force or pressure on tools.
11. Do not use tools during electrical work unless they are designed for electrical work (e.g., properly insulated).
12. Keep the workspace clean and tidy. Store tools properly when not in use.

1.5 ROAD SAFETY

Road safety refers to the methods and measures that are used to prevent road users from being killed or seriously injured. Typical road users include: pedestrians, cyclists, motorists, vehicle passengers and passengers on public transport mainly buses. Shown in Figure 1.5 and 1.5(a).

The following are basic road safety rules.

1. Pedestrians should walk on the footpath.
2. Use subway or foot over bridge to cross the road.
3. Use separate lane for the cyclist, low-speed vehicle, high-speed vehicle and trucks.

Figure 1.5 Road Safety

Figure 1.5(a) Road Safety

4. Ensure proper drainage of rainwater during the rainy season.
5. Usage of barricades to prevent animals running on roads.
6. Obey traffic signals especially at junctions.
7. Laying of speed breaker at school zones / crossing roads.
8. Sharp curve warning signal by the signboard.
9. An indication of bridges, narrow roads through sign boards.
10. An indication of hospitals, tollgate, fuel bunk, airport, railway station, unmanned level crossing etc., at appropriate places through signboards.

What Is the 5S System?

5S is the name of a work-place organization method that uses a list of five Japanese words: seiri, seiton, seiso, seiketsu, and shitsuke. In English, these words are often translated to Sort, Set in Order, Shine, Standardize and Sustain.

5S system is a lean manufacturing tool that improves workplace efficiency and eliminates waste. Managers and workers achieve greater organization, standardization, and efficiency-all while reducing costs and boosting productivity.

1.5.1 Mandatory Signs

Mandatory signs are road signs which are used to set the compulsions of all traffic which use a specific area of road. Mandatory signs tell traffic what it must do. Most mandatory road signs are circular a white background with a red symbol or white symbols on a blue background with white border. The violators are punishable under law. Shown in Figure 1.5.1.

Some of the mandatory signs are given below.

Figure 1.5.1 Mandatory Signs

1.5.2 Cautionary Signs

These signs are used to alert and warn the driver to understand the upcoming road condition. These symbols are black in colour within the red triangle on white background. Shown in Figure 1.5.2.

Figure 1.5.2 Cautionary Signs

1.5.3 Informatory Signs

Informatory signs are used to indicate the location, direction and distance of fuel bunk, hospital, toilet, alternative path etc., to the driver. This symbol is located along the direction of travel. They are square in shape. Shown in Figure 1.5.3.

Figure 1.5.3 Informatory Signs

1.6 VEHICLE SAFETY

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At present, usage of the vehicle is highly mandatory. Further, people are travelling a large distance in a shorter time. Hence, they are using their own vehicle to travel at the required place without using the public transport. It would be highly beneficial for the vehicle owner if they understand the condition of their vehicles or else the vehicle may breakdown during the travel. To avoid vehicle breakdown, to safeguard the people travelling, safety and warning devices are installed. Situations like vehicle theft, an accident during reversing the vehicle, on the four road junctions etc., can be avoided with the help of warning devices. This is called as Vehicle safety. Shown in Figure 1.6.

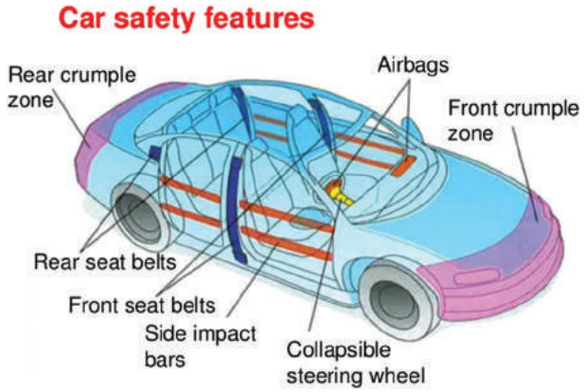

Figure 1.6 Vehicle Safety

1.6.1 Warning Indicator Used In Vehicles

The following indicators are used to indicate operating condition of engine and vehicle with the help of gauges and warning symbols. Shown in Figure 1.6.1.

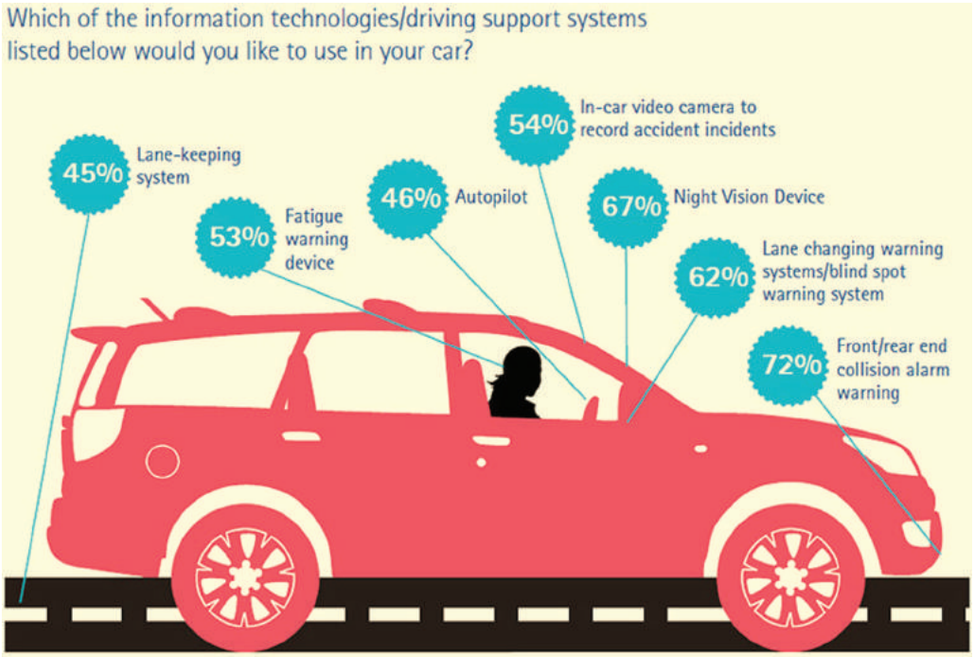

Figure 1.6.1 Warning Indicator used in Vehicles

1. Lubricating Oil Pressure Gauge
2. Engine Temperature Gauge
3. Fuel Gauge
4. Door Open Signal Indicator
5. Handbrake signal indicator

The following indicators are used to alert the driver through sound with the help of buzzer.

1.6.1.1 Seat Belt Alarm System

One should wear a seat belt while driving. If a driver or person forgets to wear the seat belt, then it will alert the driver. Shown in Figure 1.6.1.1.

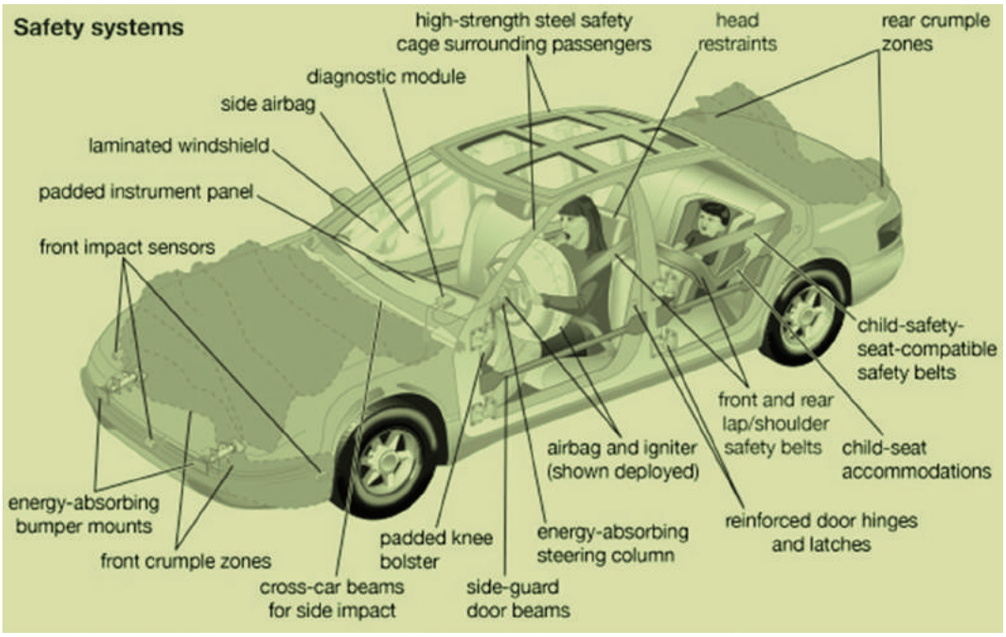

Figure 1.6.1.1 Seat Belt Alarm System

1.6.1.2 Headlight Alarm System

Most modern vehicles have inbuilt headlight alarms or automatic headlight switch off functions. Sounds an audible alarm when the ignition is turned off while the head lights are turned on.

1.6.1.3 Reverse Parking Sensor

Parking sensors are proximity sensors for road vehicles designed to alert the driver to obstacles while parking. Car Parking Sensor suitable for parallel parking, backing up your car, distance keeping, especially in dark, rain or any other poor rear visibility conditions.

1.6.1.4 Anti-Theft Car Alarm

Anti-theft systems are designed to prevent your vehicle from being stolen. It generates a loud alarm when there is a theft attempt. When the intruder opens the door, the circuit senses the attempt of theft and the alarm will be activated. An anti-theft system may also integrate a car alarm or it might be just an engine immobilizer.

1.7 Safety Devices

1.7.1 Air Bag

An airbag is a type of vehicle safety device and is an occupant restraint system. The airbag module is designed to inflate extremely rapidly and then quickly deflate during a collision or impact with a surface or a rapid sudden deceleration. It consists of the airbag cushion, a flexible fabric bag, inflation module and impact sensor. The purpose of the airbag is to provide the occupants with a soft cushioning and restraint during a crash to prevent any impact or impact-caused injuries between the failing occupant and the interior of the vehicle like steering wheel, instrumental panel, structural body frame, headliner and windshield. Refer Figure 1.7.1.

Figure 1.7.1 Airbag

1.7.2 Anti-Lock Braking System (ABS)

An anti-lock braking system (ABS) is an automobile safety system that allows the wheel to maintain tyre contact with the road surface while sudden braking. It prevents the wheels from locking up and it will avoid skidding of vehicles. Refer Figure 1.7.2.

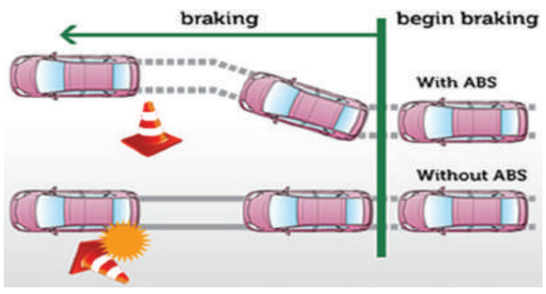

Figure 1.7.2 Anti-lock Braking System (ABS)

1.7.3 Automatic Door Lock

Automatic door locks will lock all the door simultaneously if the driver forgets to lock the doors. This will increase the safety of the car as well as things kept inside the car.

1.7.4 Steering Wheel Lock

Modern vehicles are fitted with a steering lock and it is an anti-theft device. It is fitted to the steering column usually below the steering wheel. The lock is combined with the ignition switch and engaged and disengaged either by a mechanical ignition key or electronically from the vehicles electronic control unit.

2.0 FIRST AID

Even a person following safety rules, there may be chances of an accident due to sudden failure of hand tools or machines. In such case, the medical assistance given to such person before taking to the hospital is called as First aid. First aid is provided to preserve life, prevent the condition from worsening or to promote recovery. First aid is generally performed by the layperson, with training in basic levels of first aid.

First Aid was started by S. Mark in the year 1823. A First Aid Kit should have the following contents. Shown in Figure 2(a).

1. Tincture Iodine
2. Tincture Benzene
3. Dettol
4. Burnol
5. Boric Powder
6. Meshed Cloth

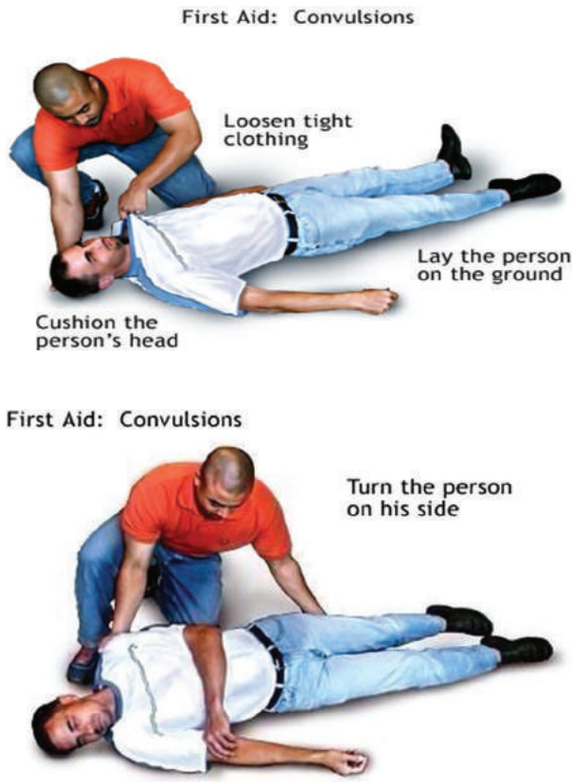

Figure 2 First Aid

7. Cotton
8. Small Scissor
9. Knife
10. Plaster
11. Small bamboo strips
12. Blade
13. Hydrogen peroxide, etc.,

2.1 Important Things to Notice

1. If patients are severely injured, he has taken immediately to the hospital or arrange for a doctor visit.
2. Level of first aid depends upon the severity of the injury.
3. Bleeding of blood should be stopped, especially if the patient is in the unconscious.

Figure 2(a) First Aid

2.2 If Dust Falls on Eye

1. If dust or metal chip falls on the eye, do not press or squash the eye.
2. Pull the upper eyelash down.
3. If the dust in the eye reaches one end of the eye, the dust can be removed with the help of a clean wet cloth.
4. Consult the eye doctor, if necessary.

3.0 PROCEDURE TO HANDLE VEHICLE DURING EMERGENCY

A lot of developments are made in the field of automobile engineering. It is easy to operate a vehicle and journey is more comfortable, hence most of the people preferred self – driving when travelling to their required place. Hence it is highly essential to understand the principle of operation of the warning system, dashboards instruments, indicators etc., of an automobile. Refer Figures 3 and 3(a).

Figure 3

Figure 3(a)

Ministry of Labour and Employment (India)

Ministry of Labour & Employment

The Ministry of Labour and Employment is India's federal ministry which is responsible to protect and safeguard the interest of workers in general and the poor, deprived and disadvantaged sections of the society.

The Ministry aims to create a healthy work environment for higher production and productivity and to develop and coordinate vocational skill training and employment.

However, Skill Development responsibilities, such as Industrial Training and Apprenticeship responsibilities were transferred to the Ministry of Skill Development and Entrepreneurship from 9 November 2014

The Ministry launched the National Career Service portal on 20 July 2015 to help bridge the gap between job providers and job seekers

Running a vehicle AC when a vehicle at a stop, locking all the doors and windows when kids are inside is not advisable. This may cause injuries and accidents and difficult to come out when vehicle catches fire, or during suffocation. In such case, with the sharp edge on the detachable vehicle headrest can be used to break a vehicle's window glass. It is better to avoid sleeping inside the car, lock the kids inside the car, chatting long hours inside the locked car.

Student Activity

I. Students have to follow the following safety precautions:

1. Students should visit micro, small and central workshops to learn the machine safety precautions, self-safety precautions and vehicle safety rules and should submit a report on it.
2. Students should learn the first aid procedures to be followed in case of any accident from the experienced medical individuals and should submit a report on it.

Glossary

Radiation	-	கதிர்வீச்சு
Spindles	-	தண்டு
Prohibited	-	தடுப்பு
Hygiene	-	சுத்தமான
Meticulously	-	கண்டிப்பான
Clean visible	-	தெளிவான பார்வை
Features	-	வசதிகள்
Ensure	-	உறுதி படுத்துதல்
Works Space	-	பணிபுரியும் இடம்
Signboards	-	அறிவிப்பு விளக்கு பலகை

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SAMPLE QUESTIONS

Choose the correct answer:

1. Name the rules that are used to ensure the employees and equipment's from accident
   a) Vehicle safety rules
   b) First aid
   c) Safety rules
2. Name the device which is to be used during welding to protect eyes.
   a) Airbag b) Goggles
   c) Helmet
3. Which device is to be used to protect from Head injury?
   a) Cap b) Goggles
   c) Helmet
4. Maximum working hour for an Operator should not exceed
   a) 4 hours b) 6 hours
   c) 8 hours
5. What is the abbreviation of ABS?
   a) Anti-lock Braking System
   b) Anti Brake System
   c) Air Brake System

Answer the following questions:

1. Explain about safety Precaution.
2. Classify the types of safety precautions.
3. Write any five points on precautions about safety in shop floor.
4. Define self-safety precaution.
5. Explain any five points on self-safety precaution.
6. Explain any five points on machine safety precaution.
7. Explain any five-safety precaution on the tools.
8. Define First Aid.
9. what are the basic materials required for First Aid?
10. Explain some important points of the First Aid.
11. what is road safety?
12. Write five points to be considered on road safety.
13. What is meant by mandatory symbol of the traffic signals?
14. Draw and explain any three-mandatory symbol used in traffic signals.
15. What is meant by cautionary symbol of the traffic signals?
16. Draw and explain any three-cautionary symbol used in Traffic signals.
17. What is meant by Informatory symbol of the traffic signals?
18. What are the various precautionary alarms used in the vehicle?
19. What are the various instruments that are connected with Dangerous sound alarms?
20. Explain about ABS.

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Unit 2

Instruments and Measurements

Contents

TL2EAS

Learning Objectives

- To learn the importance of present day tools.
- To learn the range and characterisation of measuring instruments.

2.0 INTRODUCTION:

Whenever we do any work, we need to keep in mind that the work should be done in a simple and quality manner with minimum time and material damage. To complete the work as per the above statement, we need instruments. At the same time the amount of pressure, temperature, fuel and electricity which applied on the job at each stage should be known, for this purpose measuring tools are used. By the use of measuring tools, the supply pressure, temperature, fuel supplied and electricity consumption is monitored and controlled and the job is done with good quality. The most important thing in choosing the instruments and measuring tools is based on the nature of the work and working environment. Depends on the conditions, instruments, and measurements are classified into many types.

- In automobile service stations, various types of tools, equipment and machines are used. To understand the purpose of tools, they are mainly classified into two types. Figure 2(a), 2(b) shows Ordinary and Power Tools, Tool Trally

  They are,

  1. Ordinary Tools
  2. Power Tools

Figure 2(a) Ordinary and Power Tools

Figure 2(b) Tool Trally

2.1 ORDINARY TOOLS

In the automobile industry, the tools which are used to handle the small defects in the vehicle are called as ordinary tools. Depends on the handling, these tools are classified into many types.

They are,

1. Hand tools
2. Bench tools
3. Machine tools
4. Special tools.

2.1.1 Hand Tools

In automobile industries or in factories, the tool which are able to carry in hand, in and there where the defected vehicle is located and by means of which the defects are cleared is known as hand tools. Depends on the handling, hand tools are classified into many types.

1. Spanners
2. Pliers
3. Hammers
4. Punches
5. Screwdrivers
6. Hacksaw
7. Files
8. Drill Bit

2.1.1.1 Spanners and Wrenches

a) Open-Ended Spanners
b) Ring Spanners
c) Box Spanner
d) Adjustable Wrench/ Pipe Wrench
e) Spark Plug Spanner (Or) Tubular Spanner
f) Allen Wrench

a) Open-Ended Spanner

Both single-ended spanner and double ended spanner are inclusive of this type. Figure 2.1.1.1 shows Spanners. It is used to

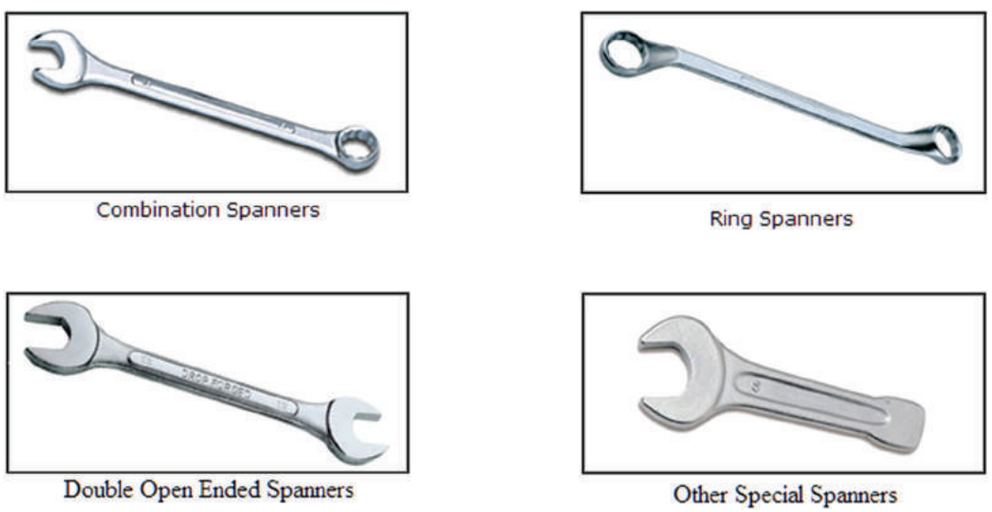


Figure 2.1.1.1 Spanners

loosen and tighten the four and six flat head bolt and nuts. It is made up of with Chromium, Vanadium and Alloy Steel metals. In all the spanners their sizes are mentioned in terms of mm or inch. Open Ended Spanners are shown in Figure 2.1.1.1(a).

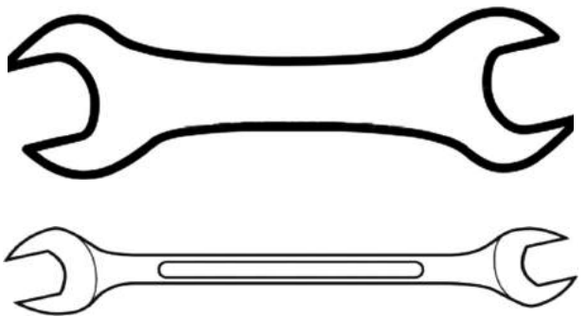


Figure 2.1.1.1(a) Open Ended Spanner

Sizes of Spanner

- 6-7 mm
- 8-9 mm
- 10-11 mm
- 12-13 mm
- 14-15 mm
- 16-17 mm
- 18-19 mm
- 20-22 mm
- 21-23 mm
- 24-27 mm
- 25-28 mm
- 27-32 mm

b) Ring Spanner

This type of spanner has ring shape on both the ends or at one end, with the ring portion is subdivided into 12 flat. It is used to loosen and tighten the four flat and six flat bolts. It is used in crucial and critical places where the other spanners are not able to loosen and tighten the bolts and nuts. Shown in Figure 2.1.1.1(b).

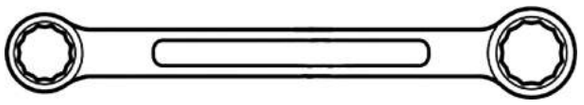


Figure 2.1.1.1(b) Ring Spanner

c) Box Spanner

It consists of with two portions namely head (Box or Socket) and handle. Different combination of socket and handles might be used for different purpose. Small Handle, T Handle, Long Handle, and 'U' Joint Reversible Ratchet are the handles which are commonly used. Shown in Figure 2.1.1.1(c)

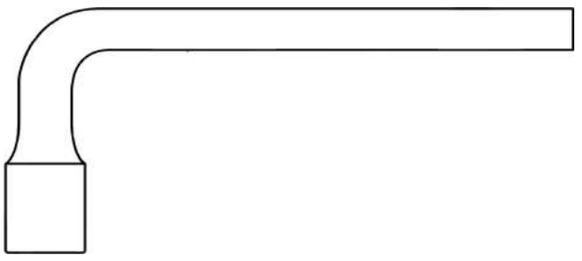


Figure 2.1.1.1(c) Box Spanner

d) Adjustable Wrench and Pipe Wrench

This is an arrangement in which the holding edge can be varied. There will be a fixed jaw and a moving jaw. By rotating knurled nut the moving jaw can be moved to the desired extent. An adjustable wrench can be used in rotating the bolt and nut. It is made up of high carbon steel. The pipe wrench is used for tubular cross section. Shown in Figure 2.1.1.1(d)

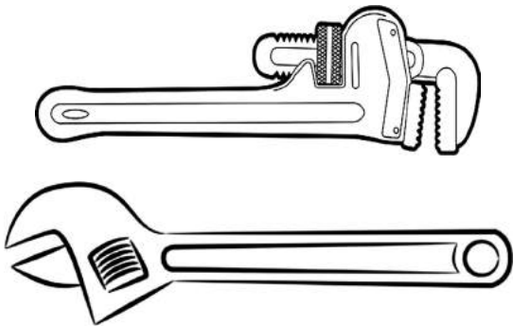


Figure 2.1.1.1(d) Adjustable Wrench and Pipe Wrench

e) Spark Plug (Or) Tubular Spanner

It is used to tighten or loosened the BOLT or NUT which are in pits. And also It is used to tighten or loosen the spark plug. So that, It is also called as Sparkplug spanner. Fig 2.1.1.1(e) shows Spark Plug Spanner.

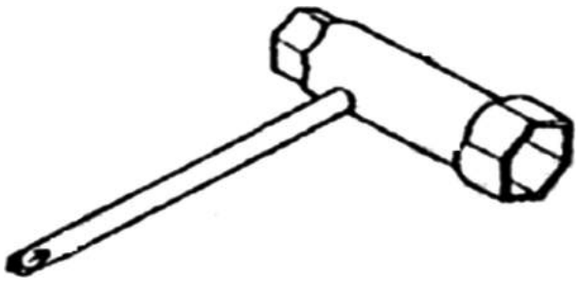


Figure 2.1.1.1(e) Spark Plug Spanner

f) Allen Key

It looks like 'L' shape which had the six edges. It is used to loosen or tighten the bolts which are having the six edges of the bolt head. It is available in both metric and inch scales. Likewise, it is also available in 'mm'. It is made up of high graded alloy steel. Fig 2.1.1.1(f) shows Allen Key.

Figure 2.1.1.1(f) Allen Key

Various Sizes of Allen Key

- 2.5 mm
- 3 mm
- 4 mm
- 5 mm
- 6 mm
- 7 mm
- 8 mm
- 10 mm
- 12 mm

2.1.1.2 Pliers

Plier is the tool which is used to do the bending, tearing, hardening of the thin wire, cutting, squeezing and pressing of the wires. Types of Pliers shown in Fig 2.1.1.2.

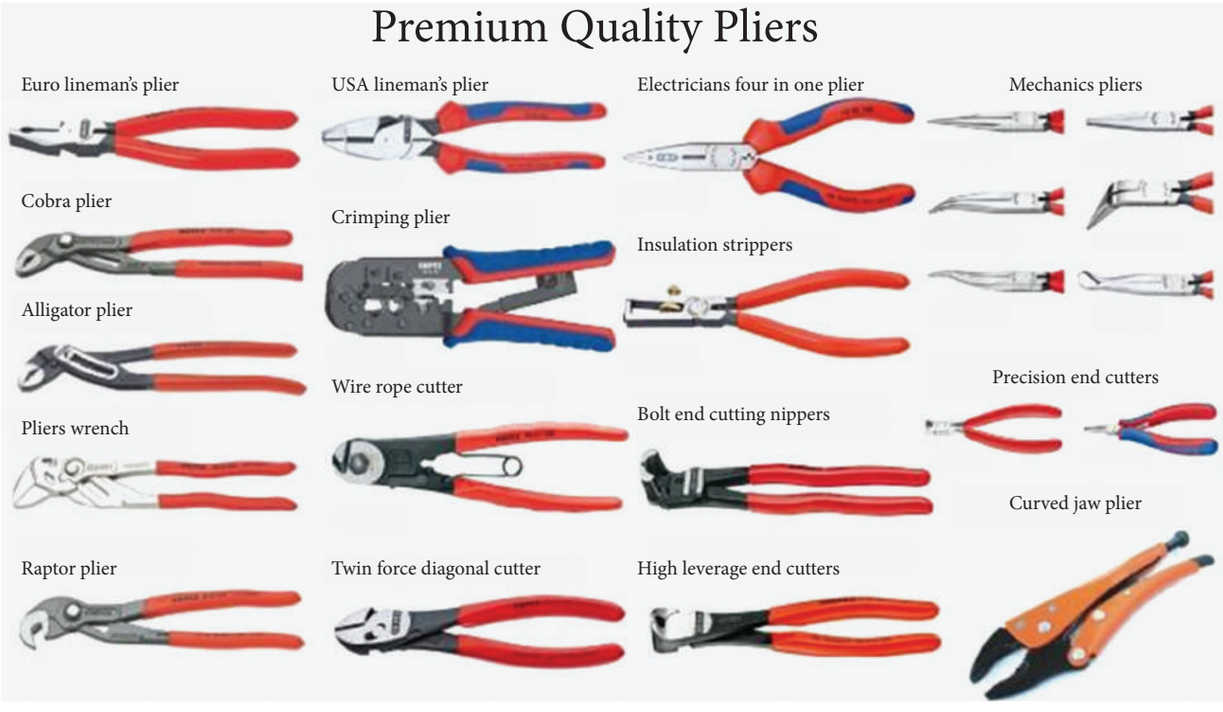


Figure 2.1.1.2 Plier

Types of Plier

a) Electrician Plier
b) Long Nose Plier
c) Circlip Plier

a) Electrician plier

In this two jaws are able to open to a certain limit. Inside of this have groves which are cut in terms of lines. These pliers handles are insulated with plastic material. Due to the above reason, these types of pliers are called as electrician plier and are used by the electricians. Electrician Plier is shown in Fig 2.1.1.2(a).

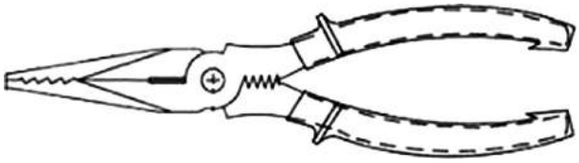


Figure 2.1.1.2(a) Electrician Plier

b) Long Nose Plier

This is mostly used for twisting the wires. That is, to grab and enlarge the wire in a tight way. It is made up of with Iron Alloy metals. Long Nose Plier shown in Fig 2.1.1.2(b).

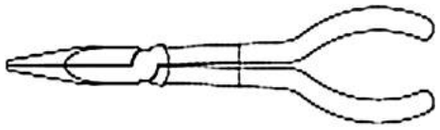


Figure 2.1.1.2(b) Long Nose Plier

2.1.1.3 Hammer

According to the need of the work, hammers may be used with different shapes and weights. The main purpose of using a hammer is to perform the operations like punching, bending and riveting. Hammer is shown in Fig 2.1.1.3.

Types of Hammer

a) Ball Peen Hammer
b) Cross Peen Hammer
c) Straight Peen Hammer
d) Sledge Hammer
e) Mallet Hammer
f) Claw Hammer

a) Ball Peen Hammer

Its head is in the round like shaped. Due to this structure, it is called a ball peen hammer. It is mainly used for to perform the riveting operation. Ball Peen Hammer shown in Fig 2.1.1.3(a).

Figure 2.1.1.3 Hammers

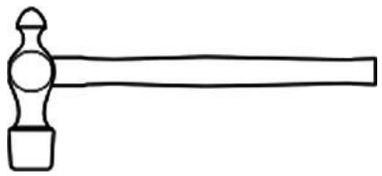


Figure 2.1.1.3(a) Ball Peen Hammer

b) Cross Peen Hammer

A cross PEEN hammer is a hammer used by blacksmiths to complete metal work. The wedge-shaped end of the hammer allows you to make the metal puller when used with heat. The main functions of a cross peen hammer are forging and riveting. Forging is a process in which you heat a single piece of metal and use tools to obtain a particular shape. Fig 2.1.1.3(b) shows Cross Peen Hammer.

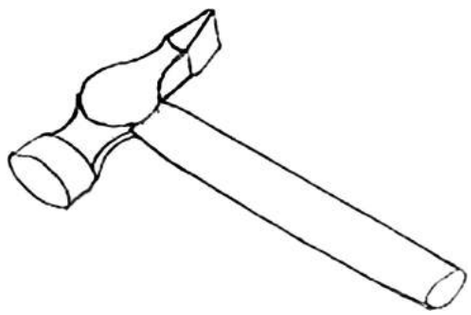


Figure 2.1.1.3(b) Cross Peen Hammer

c) Straight Peen Hammer

In this hammer, either side of the face does not have any projections, unlike other hammer types. This is used for general purpose. Fig 2.1.1.3(c) shows Straight Peen Hammer

Figure 2.1.1.3(c) Straight Peen Hammer

d) Sledge Hammer

The weight of this hammer is two or three times more than the ordinary type hammer. This is mainly used for blacksmith purpose. Their handles are made only of wood. Fig 2.1.1.3(d) shows Sledge Hammer.

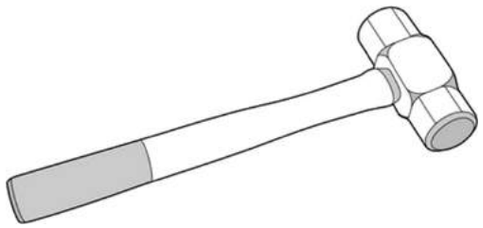


Figure 2.1.1.3(d) Sledge Hammer

e) Mallet Hammer

This is often used for SHEET METAL jobs. MALLET HAMMER can be used to adjust curves in some sophisticated and smooth objects. This makes the vehicle more useful during tinker. Fig 2.1.1.3(e) shows Mallet Hammer.

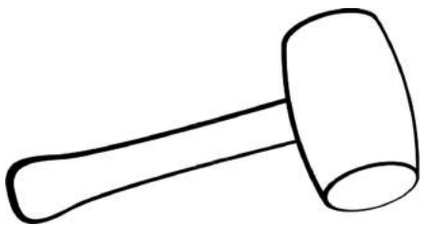


Figure 2.1.1.3(e) Mallet Hammer

f) Claw Hammer

It is used to split the nail and to general jobs. Figure 2.1.1.3(f) shows Claw Hammer

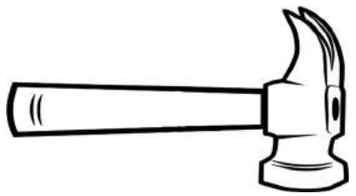


Figure 2.1.1.3(f) Claw Hammer

2.1.1.4 Punches

Punch is used to place a punch at the drilling point before drilling an object. It makes drilling easier. Its node will be at many angles. It is categorized as such.

a) Centre Punch
b) Dot Punch
c) Prick Punch
d) Hollow Puch
e) Letter / Number Punch

a) Centre Punch

In the drilling jobs, the edge of the drill unit has to be at and rotate. For this small and wide punch is made at the center. It is called as center punch. It's angle 90^0. Fig 2.1.1.4(a) shows Centre Punch.

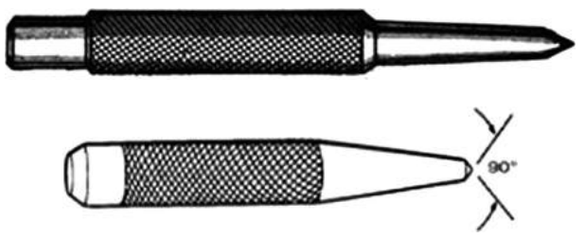


Figure 2.1.1.4(a) Centre Punch

b) Dot Punch

The lines which are drawn by the scriber can be made clearly visible by using dot punches. In this dots are put over the line. Its angle is 60^O. Fig 2.1.1.4(b) shows Dot Punch

Figure 2.1.1.4(b) Dot Punch

c) Prick Punch

Deep points are made of the soft metals and some tactical works with the help of prick punch. Its angle is 30^0. Figure 2.1.1.4(c) shows Prick Punch.

Figure 2.1.1.4(c) Prick Punch

d) Hollow Punch

The tool which has a hollow section inside the nose is used to cut the hole in the skin, rubber card etc. This tool is called as hollow punch. Fig 2.1.1.4(d) shows Hollow Punch.

Figure 2.1.1.4(d) Hollow Punch

e) Letter and Number Punch

In this punch, the letters or numbers are labeled or cut over the punch in order to punch letter and number in places where we need them. These types of punches are made up of high carbon steel. Fig 2.1.1.4(e) shows Letter and Number Punch.

Figure 2.1.1.4(e) Letter and Number Punch

2.1.1.5 Screw Drivers

The screw driver is used to fix or remove the screw based on the requirement. Refer Figure 2.1.1.5(a). The screwdrivers are classified mainly based on their tip shape and their types are given below.

Types of Screw driver

a) Star Screw Driver

b) Ratchet Screw Driver

c) Offset Screw Driver

Different types of Screw Drivers are shown in Fig 2.1.1.5(2).

Figure 2.1.1.5(1) Screw Driver

a) Star Screwdriver

This is mainly used to screw and unscrew the star-shaped screw heads.

b) Ratchet Screwdriver

Screwdrivers with the ratchet system are often used to screw and unscrew the large number of long screws in the long run.

2.1.1.6 Hacksaw Frame with Blade

It is used to cut metal items, unnecessary portions, cutting wire, bar and tap. The frame is made up of mild steel and blade is made up of low alloy steel. The tip of the teeth, which is 250 MM to 300 MM alone, can be hardened by heat treatment process. The gap between the two tips is called pitch. Fig 2.1.1.6 shows Hacksaw Frame with Blade.

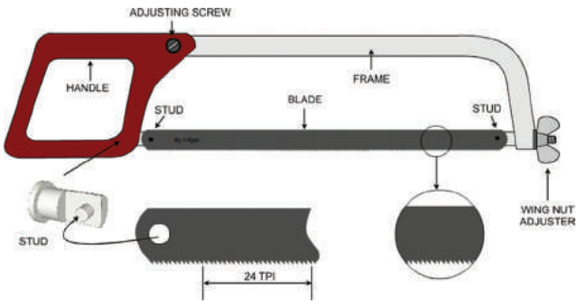


Figure 2.1.1.6 Hacksaw Frame with Blade

Type of hacksaw frame with blade:

I. Solid Type

II. Tubular Type

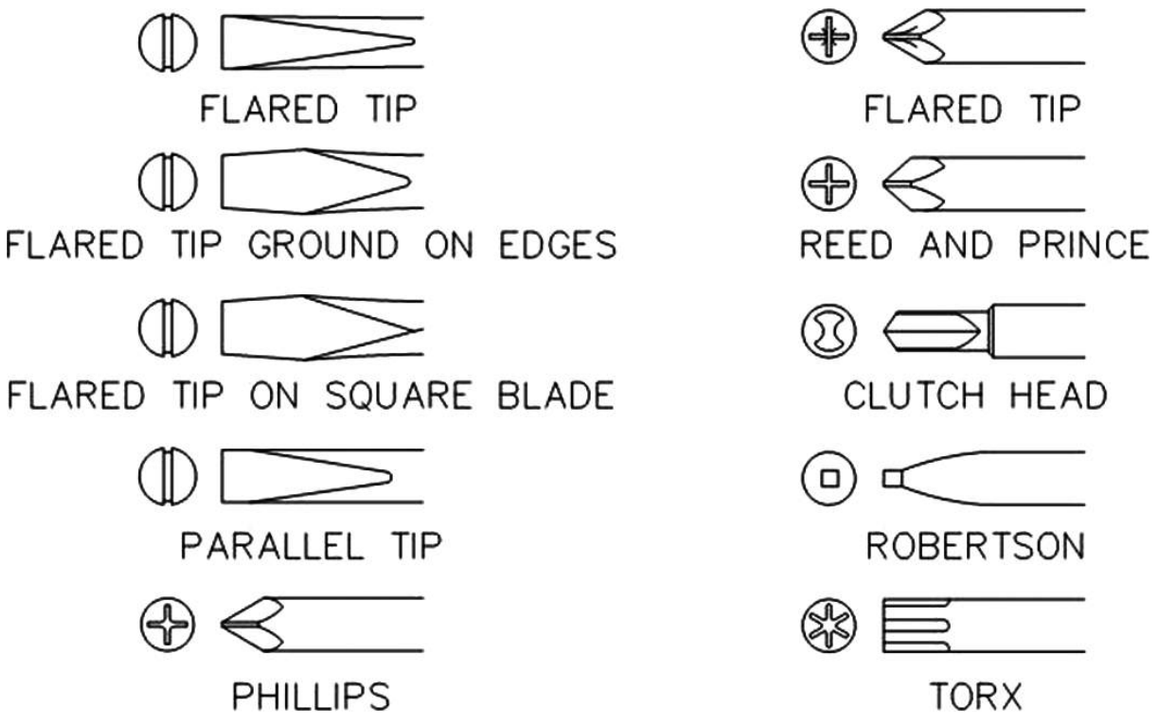


Figure 2.1.1.5(2) Different Types of Screw Driver

Solid Type

- Fixed type
- Adjustable type

Tubular type

- Fixed type
- Adjustable type

2.1.1.7 Files

The main task of this file is to removing the small size of the materials in the workshops. The metal is extracted when it is pushed forward in the workload. Fig 2.1.1.7 shows File.

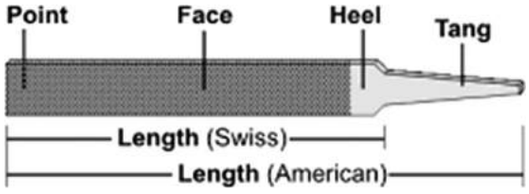


Figure 2.1.1.7 File

The files are classified based on the shape and kind of cut and are listed below.

a) Shape (or) Cross Section:

Fig 2.1.1.7(a) shows different shapes of File.

1. Square File
2. Flat File
3. Half Round File
4. Triangular File
5. Knife Edge File

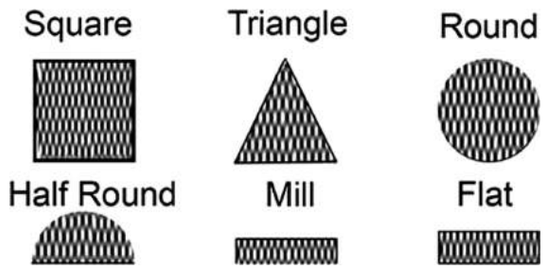


Figure 2.1.1.7(a) Shapes of file

b) Kind of Cut

Fig 2.1.1.7(b) shows different of files based on kind of cut.

1. Single Cut File
2. Double Cut File
3. Rasp Cut File
4. Curved Cut File

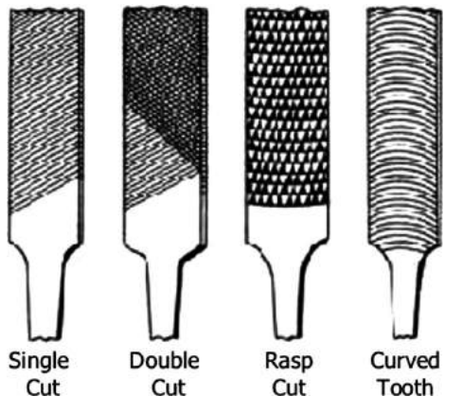


Figure 2.1.1.7(b) Files based on kind of cut

Single Cut File

The teeth of the files are cut in the same way as 60°. It is used to rub the unnecessary metal in soft metals. And it is also used to sharpen the teeth of the saw.

Double Cut File

In the facade, the teeth are cut in both directions. The overcut teeth are cut in 700's and the uppercut teeth are cut in 510. It is used to rub the hard metal, such as iron steel.

Rasp Cut File

This is a file of teeth that are separated by straight and parallel lines. The face of the teeth is slightly upward compared with the file face. It is used to work on smooth materials such as wooden, leather, aluminium.

Curved Cut File

It is capable of cutting deeply. It is used to work on smooth materials such as aluminium, tin, copper and plastic.

2.1.1.8 Drill Bits

Fig 2.1.1.8 shows the different types of Drill Bits. Round shaped rotating drill bit is called as twist drill bit. If a job is drilled from top to bottom is called through hole and if a job is partially drilled for a distance then it is called as blind hole. The drill bit is made up of High-speed steel. It has the polygonal cutting edge. The types of drill bits are given below.

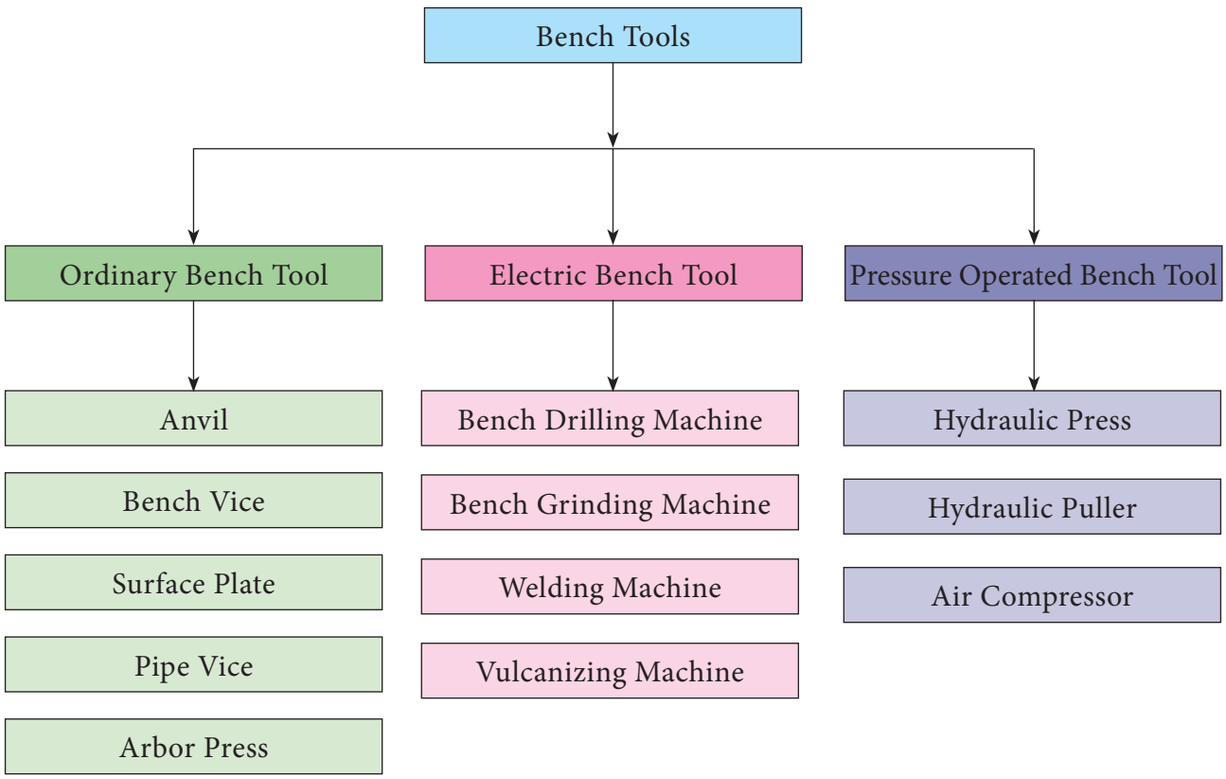
Figure 2.1.1.8 Drill Bits

Types of Drill Bits

- Straight shank twisted drill bit
- Taper shank twisted drill bit

2.1.2 Bench Tools

It is not possible to have all the corrective measures for the damaged vehicle at the particular location itself. Due to this, some defected parts are removed from the vehicle. These parts are then brought back to the



service station and repaired with the tools. This process of repairing is known as bench tools. Bench tools are classified into many types.

2.1.2.1 Ordinary Bench Tools

Tools which are used to repair the defected parts of the vehicle in the service station are known as ordinary bench tools. Tools which are used for this purpose are described below. Fig 2.1.2(a) shows Anvil.

a) Anvil

It is used to repair the Bending, shearing, and rolling of the iron and sheet metal parts in the required manner.

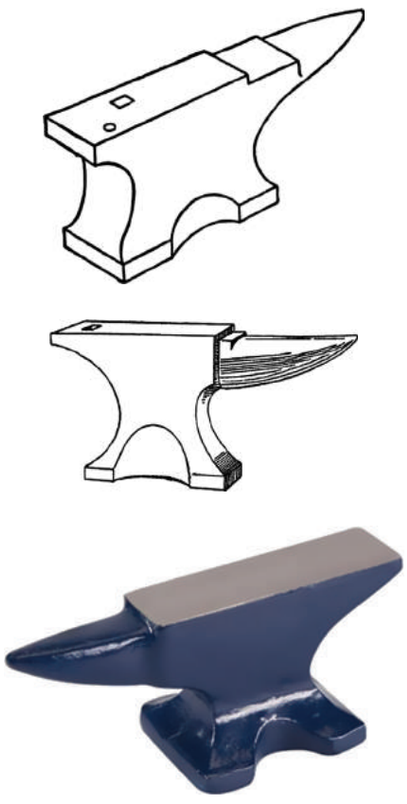


Figure 2.1.2(a) Anvil

b) Bench Vice

A bench vice is a device used for cutting or rubbing portions of the spatial part or to fold, or to tighten the bolt and nut, to retain the nipple. It is connected to the bench-lob holes in the workshop. The two jaws in it are used to tighten the object to work. Fig 2.1.2(b) shows Bench Vice.

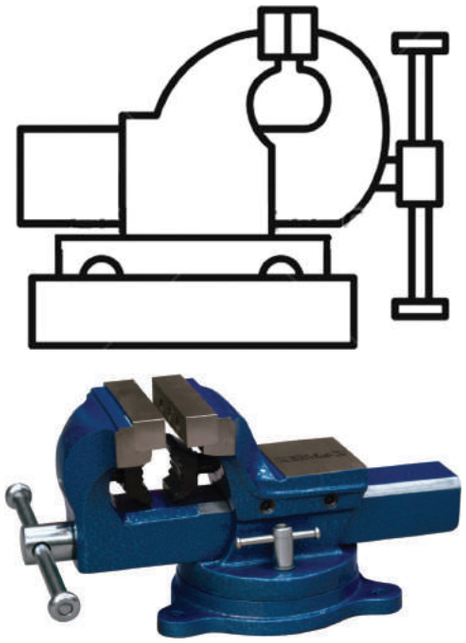


Figure 2.1.2(b) Bench Vice

c) Surface Plate

The surface plate is used to check whether the surface of the repaired part is equal to the surface plate, to adjust the size lines and to verify the corners are in the level. It is made of heavy iron plate. Its surface will be equal and erroneous. Figure 2.1.2(c) shows Surface Plate.

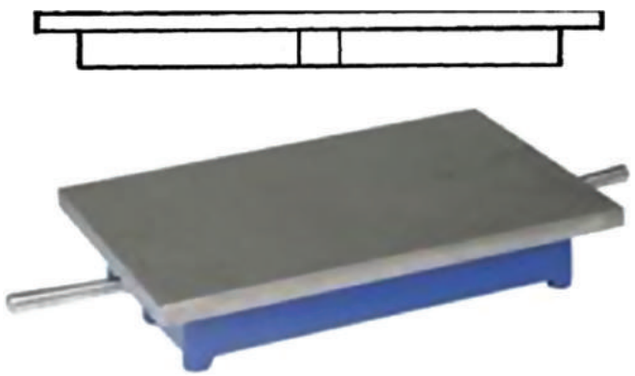


Figure 2.1.2(c) Surface Plate

d) Pipe Vice

This type of pipe vice is used to hold the cylindrical shape parts for to tighten, loosen, tear or cut. This action is similar to bench vice. Fig 2.1.2(d) shows Pipe Vice.

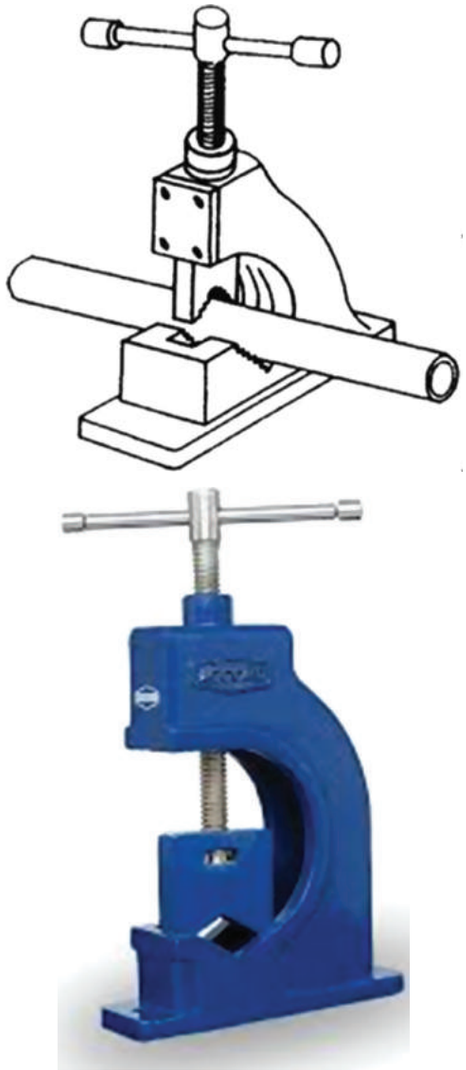


Figure 2.1.2(d) Pipe Vice

e) Arbor press

This type of bench tool is made with our hand-operated system. This type of press is used to tightening and loosening the bearing, gears, pulleys and straightening the shafts. This instrument runs on lever theory. The mechanical press is named as it operated by hand without operating by electricity, fluid or wind. Fig 2.1.2(e) shows Arbor Press.

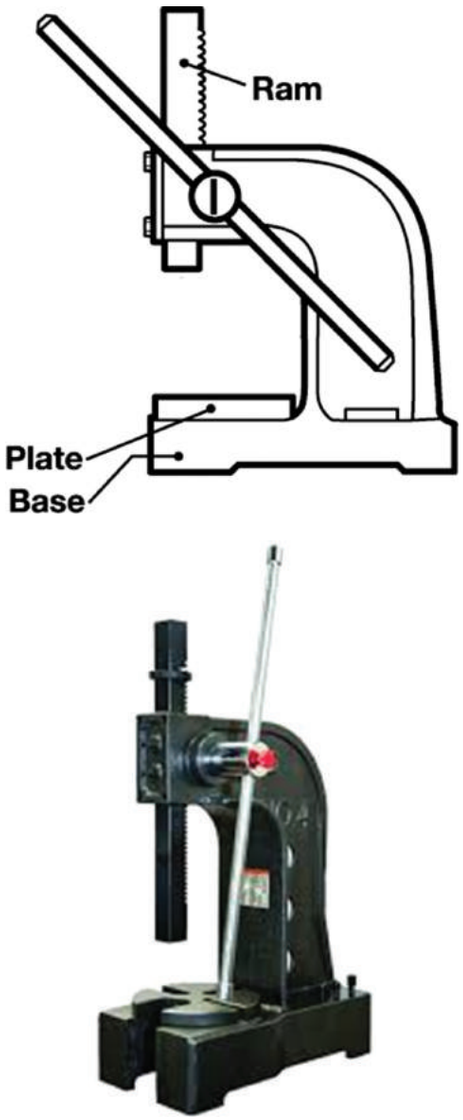


Figure 2.1.2(e) Arbor Press

2.2 POWER TOOLS

With the use of hand tools, tightening and loosening of nut and bolt and drilling is not as simple. It consumes more effort and time. To complete these types of work in an effective and quick manner, electric, hydraulic, pneumatic tools are used. It is named as power tools means. It is classified depends on the nature work. They are

1. Drilling Machine
2. Grinding Machine
3. Welding Machine
4. Vulcanizing Machine
5. Air Compressor
6. Honing Machine
7. Battery Charger
8. Cylinder Boring Machine
9. Spark Plug Tester
10. Front Shaft Grinding Machine
11. Cell Tester

2.2.1 Drilling Machine

Instead of drilling a hole by hand, drilling is made by means of an electric motor. This is done with the use of drill bit which is operated by electric motor. The to and fro motion of drill bit is controlled by a wheel. It requires minimum effort and time compared to hand drilling. Drilling machines are again classified into many types. They are,

a. Hand Drilling Machine
b. Flexible Drilling Machine

a. Hand Drilling Machine

These drilling machines are used to drill the hole in the wall and various portions of vehicles. It is also called as a Portable drilling machine. Fig 2.2.1(a) shows Hand Drilling Machine.

b. Flexible Drilling Machine:

These types of drilling machines are used to drill in the parts like crankshaft journals and in the connecting rod oil bath. These are mainly used to drill in the curved region. Fig 2.2.1(b) shows Flexible drilling machine.

Figure -2.2.1 (b) Flexible Drilling Machine

Figure 2.2.1 (a) Hand Drilling Machine

DRILL BIT

Howard Robard Hughes Sr.

Howard Robard Hughes Sr. (September 9, 1869 - January 14, 1924) was an American businessman and inventor. He was the founder of Hughes Tool Company.

He invented the "Sharp-Hughes" rotary tri-cone rock drill bit during the Texas Oil Boom.

He is best known as the father of Howard Hughes, the famous American business tycoon.

2.2.2 GRINDING MACHINE

Whenever the iron piece is subjected to cut and drill, the surface of the portion gets roughness. It is not possible to remove the roughness of the piece in hand. Instead of this, grinding machine is used to soften the iron piece and it requires minimum time and effort to do the process. It is named grinding machine because of grinding operation is done by electric means. If the grinding machine is located on the bench then it is known as bench grinding machine. If it is carried to the workplace then it is known as a portable grinding machine. Fig 2.2.2 shows Grinding Machine.

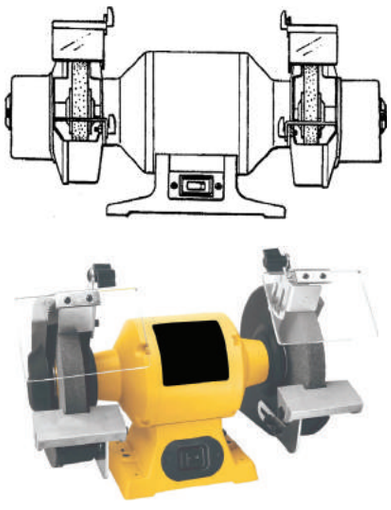


Figure 2.2.2 Grinding Machine

2.2.3 WELDING MACHINE

Two metal pieces can be joined by the use of nuts and bolts. But strength at their joined portions is in a weak manner. By joining the two metal pieces by means of welding, the strength of the material becomes strong. The machine which is used to join two metal pieces is called as welding machine. Fig 2.2.3 shows Welding Machine.

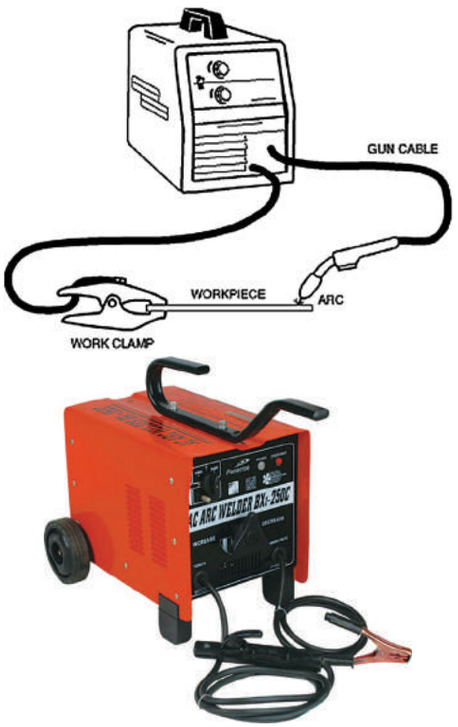


Figure 2.2.3 Welding Machine

2.2.4 VULCANIZING MACHINE

Vehicle tire and tubes should maintain in a proper manner. Otherwise severe effects may be taken place. While the vehicle is traveling on road, if a sharp object in the road gets perforated in the tire, the air in the tire tube gets deflated and due to this vehicle driving motion gets affected. If it continues its motion then the tube gets to tear off. This is known as a puncture. This type of puncture cannot be cured by the cooling method. Curing this puncture with raw rubber is called as Vulcanizing. High pressure and temperature are required to vulcanize the rubber material. The machine which is used to do this vulcanizing process is named as a vulcanizing machine. Shown in Fig 2.2.4.

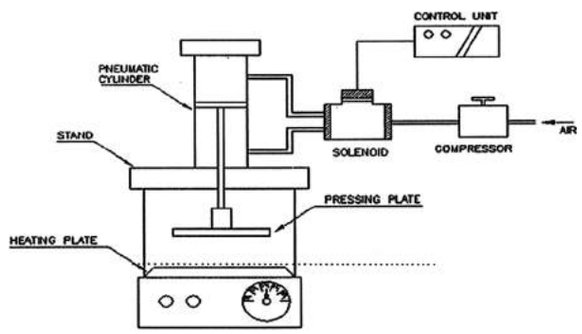


Figure 2.2.4 Vulcanizing Machine

2.3 GARAGE TOOLS

Measuring tools required for automobiles service station and garage are classified broadly two types

1. Direct tools
2. Indirect tools

2.3.1 DIRECT TOOLS

a) Steel Rule
b) Outside Micrometer
c) Vernier Caliper
d) Wire Gauge
e) Voltmeter
f) Ammeter
g) Hydrometer
h) Radius Gauge
i) R.P.M. Gauge
j) Pressure Gauge
k) Speedometer
l) Oddo Meter

a) Steel Rule

It is a metal steel rule which has both metric and British units. It is a direct measuring instrument. It is made up of spring steel

International Organization for Standardization

The International Organization for Standardization (ISO) is an international standard-setting body composed of representatives from various national standards organizations.

Founded on 23 February 1947, the organization promotes worldwide proprietary, industrial and commercial standards. It is headquartered in Geneva, Switzerland and works in 162 countries.

Use of the standards aids in the creation of products and services that are safe, reliable and of good quality. The standards help businesses increase productivity while minimizing errors and waste.

By enabling products from different markets to be directly compared, they facilitate companies in entering new markets and assist in the development of global trade on a fair basis.

The standards also serve to safeguard consumers and the end-users of products and services, ensuring that certified products conform to the minimum standards set internationally.

or stainless steel. Surface finish was done over the steel rule in order to avoid corrosion. Satin chrome is used for surface finish process. It is available in following measurements, Steel Rule shown in Fig 2.3.1(a).

- 150 mm
- 300 mm
- 600 mm

b) Outside Micrometer

It is used to measure the external diameter of a work as simple, quick, straight and accurate manner. It can be used to measure accurately 0.0001 inches or 0.01mm diameter of a screw. Besides these, micrometres are available in many formats, sizes as needed. Fig 2.3.1(b) shows Outside Micrometer.

Figure 2.3.1(a) Steel Rule

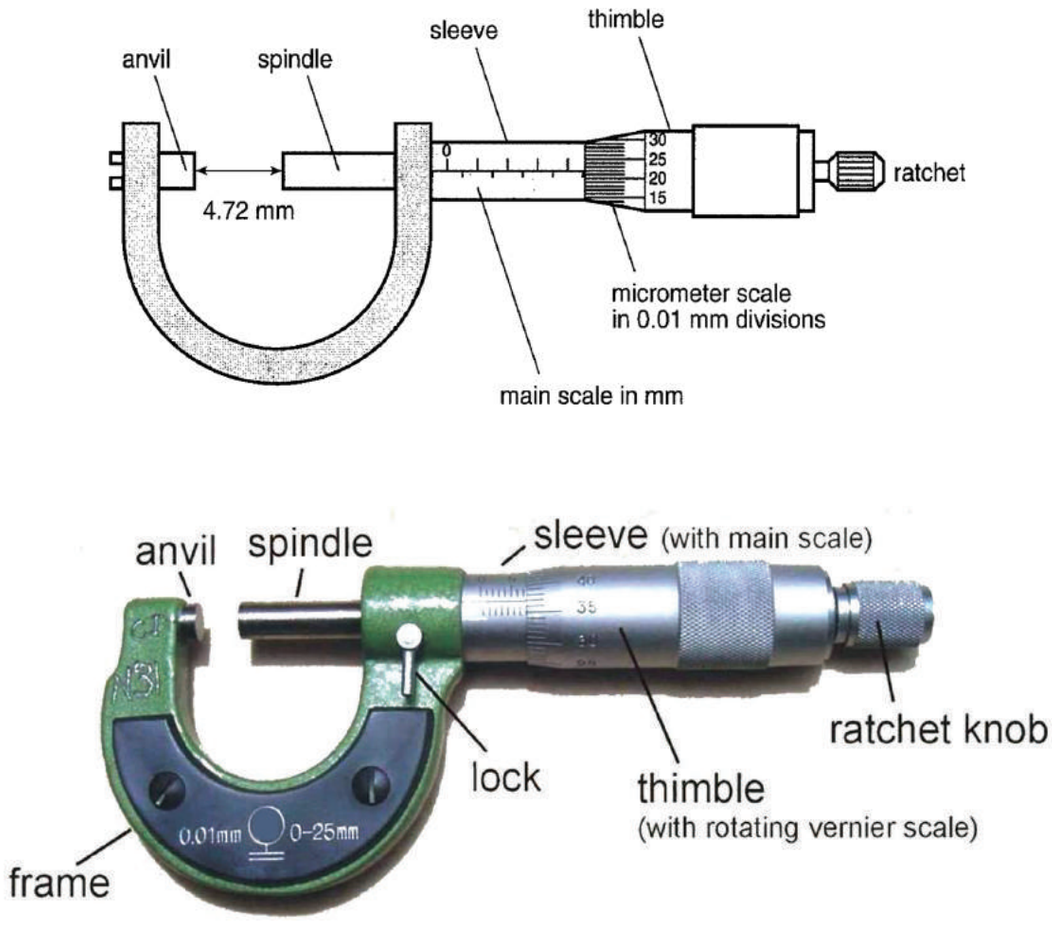
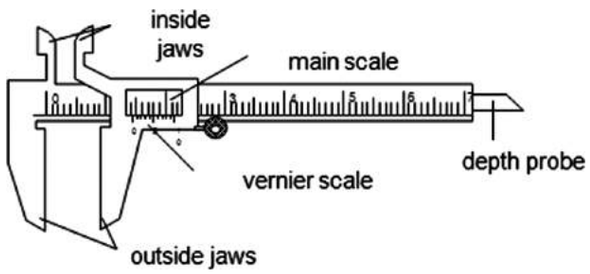


Figure 2.3.1(b) Outside Micrometer

c) Vernier Caliper

Vernier calliper is often used in factories as it is easy and convenient to measure metal components than micrometers. It helps to measure external and internal levels. It is a direct measuring instrument. Vernier Caliper is shows in Fig 2.3.1(c).



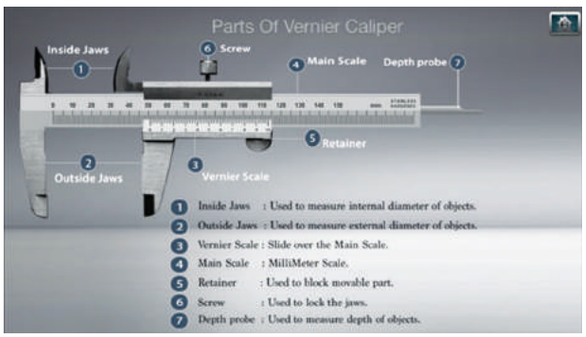


Figure 2.3.1(c) Vernier Caliper

d) Wire Gauge

The thickness of the thin wire or the plate is represented by the gauge number. If the gauge number is higher, the thickness

GAUGE BLOCK

Carl Edvard Johansson:

Gauge blocks were invented in 1896 by Swedish machinist Carl Edvard Johansson. They are used as a reference for the calibration of measuring equipment used in machine shops, such as micrometers, sine bars, calipers, and dial indicators (when used in an inspection role).

Gauge blocks are the main means of length standardization used by industry.

Gauge blocks (also known as gage blocks, Johansson gauges, slip gauges, or Jo blocks) are a system for producing precision lengths.

The individual gauge block is a metal or ceramic block that has been precision ground and lapped to a specific thickness.

Gauge blocks come in sets of blocks with a range of standard lengths. In use, the blocks are stacked to make up a desired length.

is lower and if the gauge number is lower, the thickness will be higher. Wire gauge is a rounded plate which has holes of various sizes and has a provision to insert the rounded plates at the edge. Gauge numbers are marked on the gauge plate. Shown in Fig 2.3.1(d).

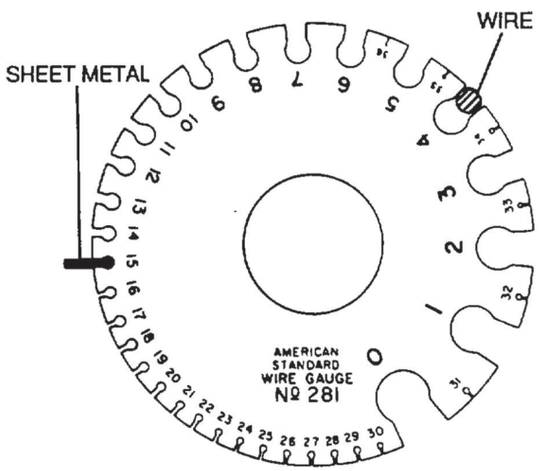


Figure 2.3.1(d) Wire Gauge

e) Voltmeter

The voltmeter is an instrument which is used to measure the voltage across the electrical circuit. The unit of voltage is "volt". It is used as 240 volts in homes and 440 volts at workstations. Fig 2.3.1(e) shows Voltmeter.

Figure 2.3.1(e) Voltmeter

f) Ammeter

It is used to measure the amount of current passing through the circuit. It is used to verify the faults of the industry and household devices. It helps to check the amount of electricity. The unit of the ammeter is "Ampere". Fig 2.3.1(f) shows Ammeter.

Figure 2.3.1(f) Ammeter

g) Hydrometer

Hydrometer is used to calculate the density of the insulating fluid (diluted sulfuric acid) in the battery. The amount of liquid in the hydrometer is used to calculate the density of the liquid. While pressing the rubber bulb in the hydrometer, the liquid come inside the cylinder from the cell. Fig 2.3.1(g) shows Hydrometer.

Figure 2.3.1(g) Hydrometer

h) Radius Gauge

Radius gauge is used to measure the specific radius of the projected surface area of the job or the corners of the job. Radius gauge is also used to measure and test the circumference of the curve in the corner or corners. Radius Gauge is shown in Fig 2.3.1(h).

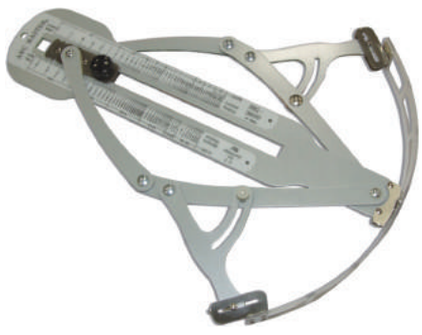


Figure 2.3.1(h) Radius Gauge

i) RPM Gauge

It is used measure the speed of the engine. RPM gauge is used to show the number of cycles per minute for each minute. The red pin is used to show the cycle of 6000 rpm to 7000 rpm. But nowadays digital displays are used. Fig 2.3.1(i) shows RPM Gauge.

Figure 2.3.1(i) RPM Gauge

j) Pressure Gauge

It is used to measure air pressure and pressure of lubricating oil in the engine cylinder. It is set on the vehicle's dashboard. Fig 2.3.1(j) shows Pressure Gauge.

Figure 2.3.1(j) Pressure Gauge

k) Speedometer

It helps to calculate the speed of the vehicles. This calculation helps the driver to increase or decrease the driving speed of the vehicle based on the situation. Figure 2.3.1(k) shows Speedometer.

Figure 2.3.1(k) Speedometer

l) Odometer

This helps to show, how much the vehicle has been running. (Eg., 15000 km). Fig 2.3.1(l) shows Odometer.

Figure 2.3.1(l) Odometer

2.3.2 INDIRECT TOOLS

a) Feeler Gauge
b) Outside Caliper
c) Inside Caliper

a) Feeler Gauge

The set of thin steel plates which are used to measure the size of the shortest spacing is called the feeler gauge. These are placed in a heat treated shell in order to separate them easily. It is very useful for measuring gaps in valve tape bed, sparkplug cape. Fig 2.3.2(a) shows Feeler Gauge.

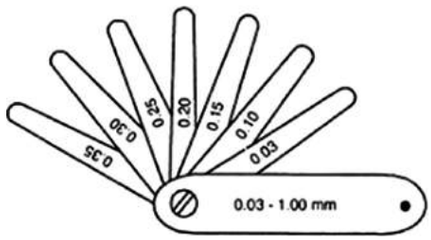


Figure 2.3.2(a) Feeler Gauge

b) Outside Caliper and Inside Caliper

This setting can be found in the picture. It is used to measure the outer diameters of the pipe and the engine cylinder. This can measure the external diameter very accurately.

Inside calliper is used to measure the inner diameter of the engine cylinder holes, pipes and the inner dimensions of the canal. It is an indirect measuring instrument. Fig 2.3.2(b) shows Outside and Inside Calipers.

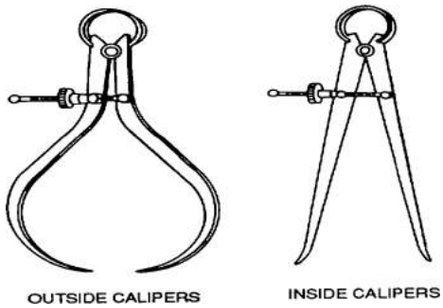


Figure 2.3.2 (b) Outside and Inside Calipers

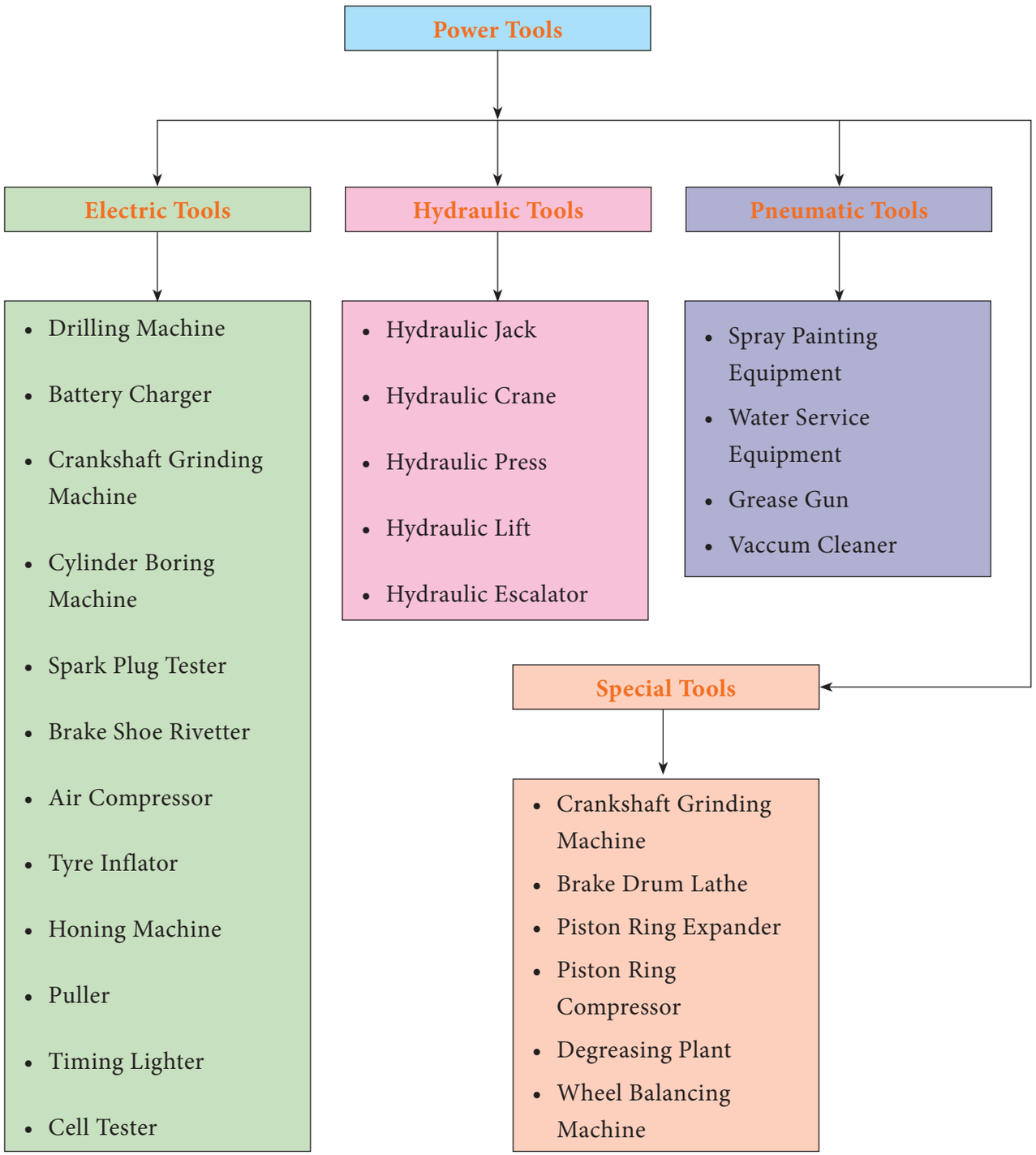
2.3.3 Machinery and Special Tools

Power tools used in automobile vehicles are classified as below,

2.3.4 Electric Tools

2.3.4(a) Drilling Machine

It helps to drill wood and metal parts. These are usually two types. i) Bench Drilling



Machine ii) Portable Drilling Machine. Fig 2.3.4(a) shows the Drilling Machine.

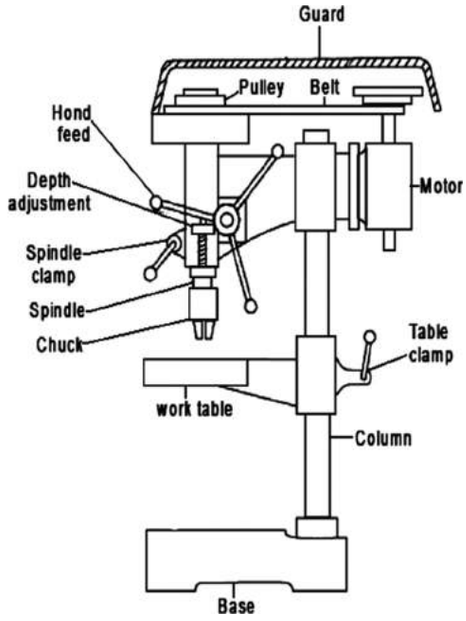


Figure 2.3.4(a) Pillar Type Drilling Machine

2.3.4(b) Battery Charger

The battery charger is used to charge the batteries. It converts the alternating current into a direct current and makes the battery to be charged. Because the battery cannot be directly charged with alternating current. Figure 2.3.4(b) shows Battery Charger.

Figure 2.3.4(b) Battery Charger

2.3.4(c) Cylinder Boring Machine

Continues operation engine leads to wear on the cylinder walls. The energy of the engine is wasted by such wearing. Therefore, Cylinder Boring Machine is used to adjust the cylinder's inner diameter. Refer Figure 2.3.4(c).

Figure 2.3.4(c) Cylinder Boring Machine

2.3.4(d) Spark Plug Tester

In petrol engine at the end of the compression stroke, spark is ignited to burn the

compressed fuel. This is done with the help of spark plug. The equipment which is used to check the spark level is in required manner is known as SPARK PLUG TESTER. Shown in Fig 2.3.4(d).

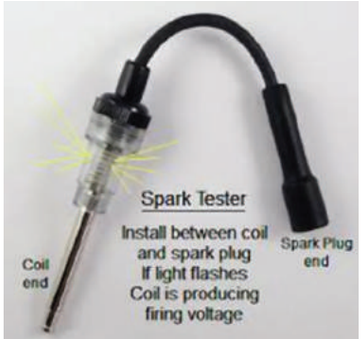


Figure 2.3.4(d) Spark Plug Tester

2.3.4(e) Caster Camber Gauge

It is used to check the wheel alignment in four wheeled vehicles.

2.3.4(f) Brake Shoe Rivetter

In the top portion of the brake shoe, the new lining is designed to fit the rivets in the hole to tighten the brake shoe parts.

2.3.4(g) Air Compressor

The machine which is used to compress and store the atmospheric air to the required pressure level is named as air compressor. Shown in Fig 2.3.4(g).

Figure 2.3.4(g) Air Compressor

Usages

1. It is used to refill the air in the tire tube.
2. It is used to clean the spark plug, carburetor and nozzle.

2.3.4(h) Tyre Inflator Gauge

It is used to measure the air pressure which is present inside the tire tube at the time of air filling by without having air leakage. Tyre Inflator Gauge is shown in the Fig 2.3.4(h).

Figure 2.3.4(h) Tyre Inflator Gauge

2.3.4(i) Honing Machine

Honing machine is used to regulate the depreciation in the IC engine cylinder, when the cylinder depreciation level is below 0.01mm. Cylinder wall which is made with the use of cylinder bearing is smoothened by cylinder honing. Fig 2.3.4(i) shows Honing Machine.

Figure 2.3.4(i) Honing Machine

2.3.4(j) Timing Lighter

This equipment is used to check whether the spark plug is producing the spark in proper firing order in the engine cylinder. Figure 2.3.4(j) shows Timing Lighter.

Figure 2.3.4(j) Timing Lighter

2.3.4(k) Cell Tester

It is used to check the life cycle of battery cell and is used to check the amount of electric charge. This is checked by connecting the positive and negative poles of the battery by wire and by doing this if it is lighted up then it is understood that battery is having charge. Fig 2.3.4(k) shows Cell Tester.

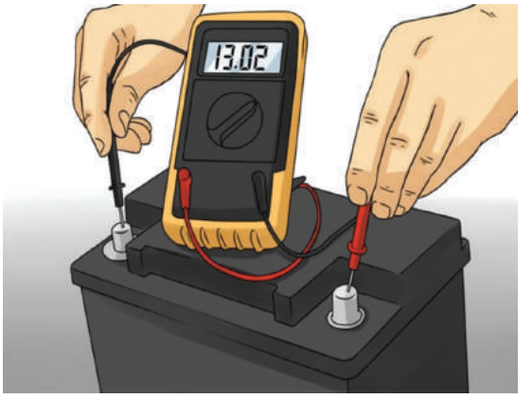


Figure 2.3.4(k) Cell Tester

2.3.5 Pneumatic Tools

2.3.5(a) Spray Painting Equipment

Spray painting equipment is used to paint the vehicle in an uniform manner with the help of air compressor. Air compressor is used in service station to clean the vehicle, by blowing the water in pressurized way. Fig 2.3.5(a) shows Spray Painting Equipment.

Figure 2.3.5(a) Spray Painting Equipment

2.3.5(b) Grease Gun

Grease gun is used in automotive vehicle to reduce the friction in the moving parts by applying the pressurized grease. This is done with the aid of air compressor. It is also used to fix a new lining in the top portion of the brake shoe. Fig 2.3.5(b) shows Grease Gun.

Figure 2.3.5(b) Grease Gun

2.3.5(c) Air Compressor

It is used in automatic machines where air pressure is required. This means by using this amount of air pressure required to restrict the passage is done. In added to this, it is used for to refill the air in the tire, paint, clean and water wash the vehicle. The amount of air which has been used for all this purpose is generated from the equipment which is named as an air compressor. Fig 2.3.5(c) shows Air Compressor.

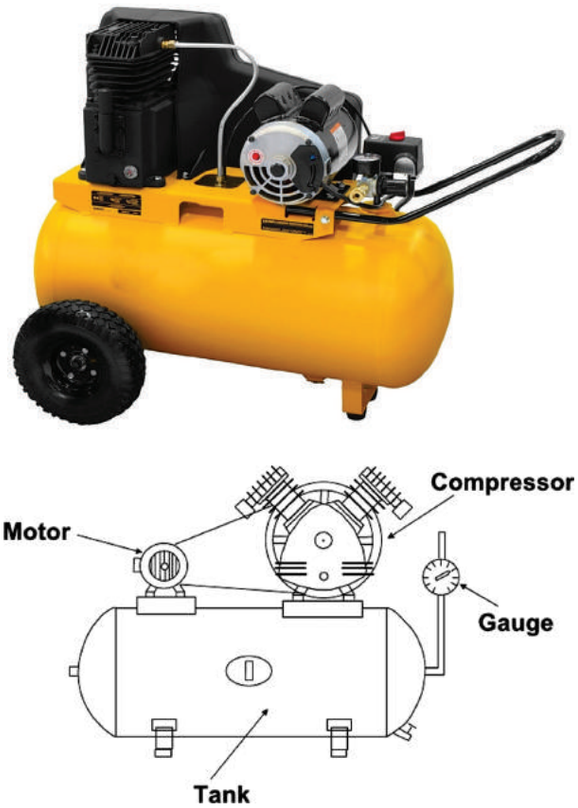


Figure 2.3.5(c) Air Compressor

2.3.5(d) Vaccum Cleaner

The vaccum cleaner is a device which is used to wipe off the dusts deposited in the vehicle parts where the cleaning process is difficult to carried out manually. Fig 2.3.5(d) shows Vaccum Cleaner.

Figure 2.3.5(d) Vaccum Cleaner

2.3.6 Special Tools

2.3.6(a) Puller

The equipment which is used to remove the components like gear shaft and bearing which are closely fitted to the shafts in an easy manner is named as puller. Shown in Fig 2.3.6(a).

Figure 2.3.6(a) Puller

2.3.6(b) Piston Ring Expander

It is used to remove the piston rings which are fitted in the piston. Fig 2.3.6(b) shows Piston Ring Expander.

Figure 2.3.6(b) Piston Ring Expander

2.3.6(c) Piston Ring Compressor

The piston ring compressor is a special tool that is specifically designed for compressing the piston rings when a piston is re-installed. This is accomplished by opening the piston ring compressor enough so that the piston will slide into the opening. Then the rings compress by tightening the tool so that it is snug around the piston. Fig 2.3.6(c) shows Piston Ring Compressor.

Figure 2.3.6(c) Piston Ring Compressor

2.3.6(d) De-Greasing Plant

Mixture of steam and hydrochloric acid is act as a degreasing agent. With the use

of this agent, grease which is deposited in the metal parts can be wiped off.

2.3.6(e) Wheel Balancing Machine

Wheel balancing machine is used to balance the unbalanced weighted wheels which are located in the front and rear axle.

2.3.6(f) Spring Tester

Sometimes tensile strength of the spring is reduced at that time by using this spring tester, spring tensile strength is improved. Fig 2.3.6(f) shows Spring Tester.

Figure 2.3.6(f) Spring Tester

2.3.6(g) Nozzle Tester

It is used to measure the diesel particle size, diesel quantity and leakages of the diesel which is coming out from the nozzle while blowing the diesel in high pressure at the end of the compression stroke inside the engine. Fig 2.3.6(g) shows Nozzle Tester.

Figure 2.3.6(g) Nozzle Tester

2.3.7 Screw Jack and Horses

Jack is used to lifting the heavyweight components which are not possible to lift with the use of hands. Fig 2.3.7(a) shows the diagram of Screw Jack.

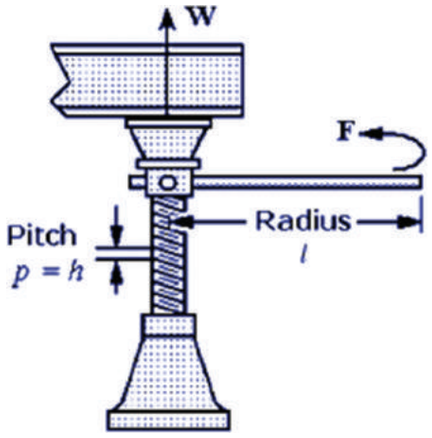


Figure 2.3.7(a) Screw Jack

Bureau of Indian Standards

The Bureau of Indian Standards (BIS) is the national Standards Body of India working under the aegis of Ministry of Consumer Affairs, Food & Public Distribution, Government of India.

It is established by the Bureau of Indian Standards Act, 1986 which came into effect on 23 December 1986.

The Minister in charge of the Ministry or Department having administrative control of the BIS is the ex-officio President of the BIS.

The organisation was formerly the Indian Standards Institution (ISI), set up under the Resolution of the then Department of Industries and Supplies No. 1 Std.(4)/45, dated 3 September 1946. The ISI was registered under the Societies Registration Act, 1860.

As a corporate body, it has 25 members drawn from Central or State Governments, industry, scientific and research institutions, and consumer organisations.

Its headquarters are in New Delhi, with regional offices in Kolkata, Chennai, Mumbai, Chandigarh and Delhi and 20 branch offices. It also works as WTO-TBT enquiry point for India.

Construction

Its shaft is made of with cast iron material. By keeping the gravitational nature in mind, the jack basement is designed. The top portion of the main shell fixed with rotating block. Rotating block consists of with holes through which the handles are fixed and we can rotate it freely. A support is attached to the square thread rod.

Function

At first, screw jack has to be placed below the lifted component. Depends on the nature of the soil and the requirement of height to be lifted, it has been supported by the wooden sleeper. Then by fixing the handle on the holes in the rotating block and rotating the handle, the vehicle will be lifted to the required height and work under the vehicle will be carried out. After finishing the work, again by rotating the handle in anti-clockwise direction vehicle will be grounded.

Capacity

Screw jack capacity is mentioned by maximum weight it can withstand. It is specified in terms of tonnage. It has to be lifted based on the given specification. If it is operated to lift more load than the specification, then severe damages will occur. Lubrication should be properly done to the moving and rotating parts.

- It is used to lift the four-wheeler to a certain height.
- The vehicle is lifted and supported by the use of this screw jack.
- With the help of this, damages on the bottom side of the vehicle are cleared and it is available in many sizes depends on the weight of the vehicle.

Horses

After lifting the screw jack to a certain height, horses have to be lifted to the same level and then the cotter pin has to be inserted. With the use of this horse, the screw jack has been removed.

It has been used depends on the weight of the vehicle. For to support the vehicle with high load, low load capacity horse should not be used. Fig 2.3.7(b) shows the diagram of Horse.

Figure 2.3.7(b) Horses

2.3.8 HYDRAULIC POWER TOOLS

In automobile industries, the work should be carried out in careful and in an unmistakable manner. In doing that, small defects in the vehicles are repaired by using hand tools. In sometimes, large defects are repaired by removing the particular defected components from the vehicle and moving down the removed components to the ground or to the bench and then repaired. Similarly, sometimes the parts located below the chassis have to be repaired, that time the vehicle is lifted to a particular height and then repaired. For this purpose, power tools are used in the automotive industries. This is due to that weight of the vehicle is high and repairing the components underneath the vehicle is complicated and too risky. Power tools are utilized depends on the nature of work. The following are some classification of power tools.

2.3.8(a) Hydraulic Crane

It is used to lift and unlift the heavy weight components like engine in an automotive vehicle and to shift the heavy weight components from one place to another place. Fig 2.3.8(a) shows Hydraulic Crane.

Figure 2.3.8(a) Hydraulic Crane

2.3.8(b) Hydraulic Jack

It works on the basic principle of Pascal's law. It is used to hold the heavyweight components in particular height and to move

the heavyweight objects from one place to another place. Components with low load can be lifted easily in hand. But it is not possible to repair the tire of the heavy load carrying capacity vehicle by lifting the vehicle in hand. For this hydraulic jack is used. It works on the hydraulic pressure. Based on this principle, some vehicles are used (eg. JCP, Crane, Bull Dozer). The hydraulic jack is used to lift the vehicle while water washes the vehicle. Hydraulic jack working is explained in the schematic diagram. Fig 2.3.8(b) shows the diagram of Hydraulic Jack.

Figure 2.3.8(b) Hydraulic Jack

2.3.8(c) Hydraulic Press

It is used to straightening the bent portion in the flat, round and tube components. It works on the principle of Pascal's law. It used in automation industries, for repairing the misaligned curved portion in the chassis, steering, and in-vehicle fork. It is used to fix the bearings which have been used on the automatic machines. Fig 2.3.8(c) shows Hydraulic Press.

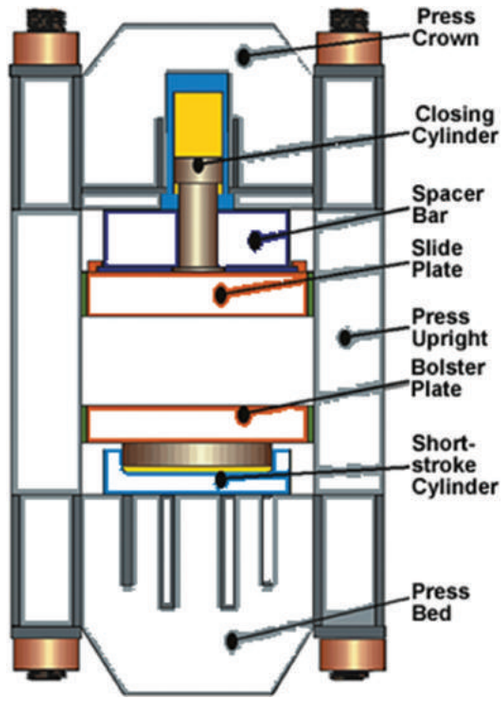


Figure 2.3.8(c) Hydraulic Press

2.3.8(d) Hydraulic jack puller

This equipment is used in the automation industries for to remove the closely fitted bearing by without having any damage in the bearing. Figure 2.3.8(d) shows the diagram of Hydraulic Jack Puller.

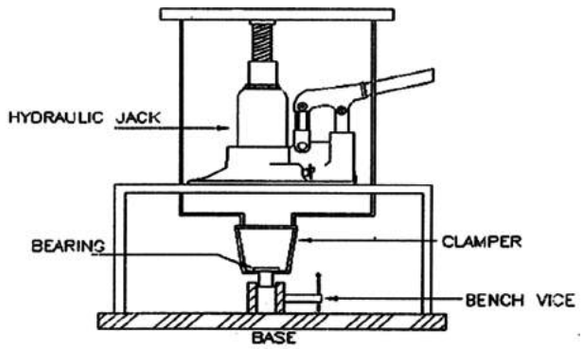


Figure 2.3.8(d) Hydraulic Jack Puller

Student Activity

1. Students should be taken to the nearby service station to learn the handling of mechanical instruments and industrial tools.
2. Students should visit any Government authorised central workshops to learn the process of drilling, overhead crane transport of materials as per the planned schedule of flow and should submit a report on it.

Glossary

Instruments	-	உபகரணங்கள்
Temperature	-	தட்பவெப்பநிலை
Measurements	-	அளவிடுதல்
Adjustable	-	சரிசெய்தல்
Tubular	-	குழாய்
Grinding	-	அரைத்தல்
Vulcanizing	-	துளை அடைத்தல்
Hydraulic	-	திரவ நிலை
International	-	சர்வ தேசம்
Standardisations	-	தர நிர்ணயம்

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SAMPLE QUESTIONS

Choose the correct answer:

1. Which principle is used in the Hydraulic Jack?
   a) Pascal law
   b) Newton law
   c) Lever principle
2. Which one is measured by Hydro meter?
   a) Voltage
   b) Density of Electrolyte
   c) Current
3. Honing machine is used to
   a) to drill the cylinder
   b) to enlarge the hole in cylinder
   c) to finish the cylinder bore accurately
4. Which device is used to check the spark intensity in petrol engine?
   a) Spark plug tester
   b) Cell tester
   c) Battery tester
5. R.P.M.gauge is used to
   a) to measure the speed of engine
   b) to measure the speed of vehicle
   c) to calculate the milage

Answer the following questions:

1. What are the Simple or Ordinary Hand Tools?
2. Name the various types of Power Tools.
3. Explain about the Bench Tools.
4. What are the types of Files?
5. What are the types of Hammers?
6. What are the different types of Punches?
7. Mention any five sizes of Double Ended Spanners.
8. Mention any five sizes of Ring Spanners.
9. Mention any five sizes of Box Spanners.
10. Name the different types of Pliers.
11. What is meant by Volt Meter?
12. What is the use of Ammeter?
13. What is the use of Hydro Meter?
14. What are the uses of Wire Gauge?
15. Explain about R.P.M.Gauge.
16. Explain about Oddo Meter.
17. What is meant by Pressure Gauge?
18. Explain the uses of Timing Light.
19. Explain the uses of Puller.
20. What are the uses of Screw Jack?
21. What are the uses of Air Compressor?

Unit 3 Fuels and their Types

Contents

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Learning Objectives

- To learn the usage and importance of various types of fuels.
- To learn about various solid, liquid and gaseous fuels.

3.0 INTRODUCTION

For a healthy body, we consume solid food, liquid food and pure air. Similarly, for an engine to operate, it requires fuel.The heat energy released during burning the fuel with air, is converted into mechanical energy via a heat engine. This mechanical energy gives the required tractive force to move the vehicle in the forward direction.

Figure 3.1.1 Solid Fuels

3.1 FOSSIL FUELS

Fossils fuels are available as Solid, Liquid and Gaseous state. Figure 3.1 shows Fossil Fuels.

Figure 3.1 Fossil Fuels

3.1.1 Solid Fuels

Solid fuel refers to various types of solid material that are used as fuel to produce energy and provide heating, usually released through combustion. Solid fuels include wood, coalare mining under the earth. Initially solid fuels are used in steam engines and boilers. They release less heat energy and emit more ash and emissions. However, the solid fuels are not used in modern automobiles. Figure 3.1.1 shows Solid Fuel.

3.1.2 Liquid Fuels

Many liquid fuels play a primary role in transportation. Liquid fuels are easy to store, easy to transport, and can be handled with relative ease. They release more heat energy and less emission. Petrol and Diesel fuels are widely used for automobiles. Figure 3.1.2 shows Liquid Fuels.

Figure 3.1.2 Liquid Fuels

DO YOU KNOW?

PETROLEUM

Robert Chesebrough

Robert Augustus Chesebrough, (January 9, 1837 – September 8, 1933) was an American chemist.

He discovered petroleum jelly which he marketed as Vaseline and he founded the Chesebrough Manufacturing Company.

Chesebrough began his career as a chemist clarifying kerosene from the oil of sperm whales.

The discovery of petroleum in Titusville, Pennsylvania, rendered his job obsolete, so he traveled to Titusville to research what new materials might be created from the new fuel.

This led to his discovery of petroleum jelly, which he trade-named as Vaseline.

In 1875, he founded the Chesebrough Manufacturing Company that in 1955 became Chesebrough-Ponds, a leading manufacturer of personal-care products. Chesebrough patented the process of making petroleum jelly (U.S. Patent 127,568) in 1872.

3.1.2.1 Petrol and Its Properties

Most liquid fuels are derived from the fossilized remains of dead plants and animals by exposure to heat and pressure in the Earth's crust.From the crude oil, by distillation process, various components like Liquid Petroleum Gas (at 40°C), petrol (40°C to 200°C), Diesel (250°C to 300°C) and residue tar (above 350°C) are extracted. Figure 3.1.2.1 shows the distilation process of various components useages.

Petrol, also known as Gasoline, is a transparent fuel derived from crude oil and is used as fuel in internal combustion engines. Petrol is separated from crude oil from 40°C to 200°C. Petrol is usually a blend of paraffin's, naphthenic, aromatics and olefins. Figure 3.1.2.1(a) shown the Line Diagram of Distilation Process of Various Components.

Table: Chemical composition of petrol by weight

Element	Percentage by weight
Carbon	79.5 – 87.1
Hydrogen	11.5 – 14.8
Sulphur	0.1 – 3.5
Oxygen	0.1 – 0.3
Nitrogen	0.1 – 2.0

The following are the properties of petrol:

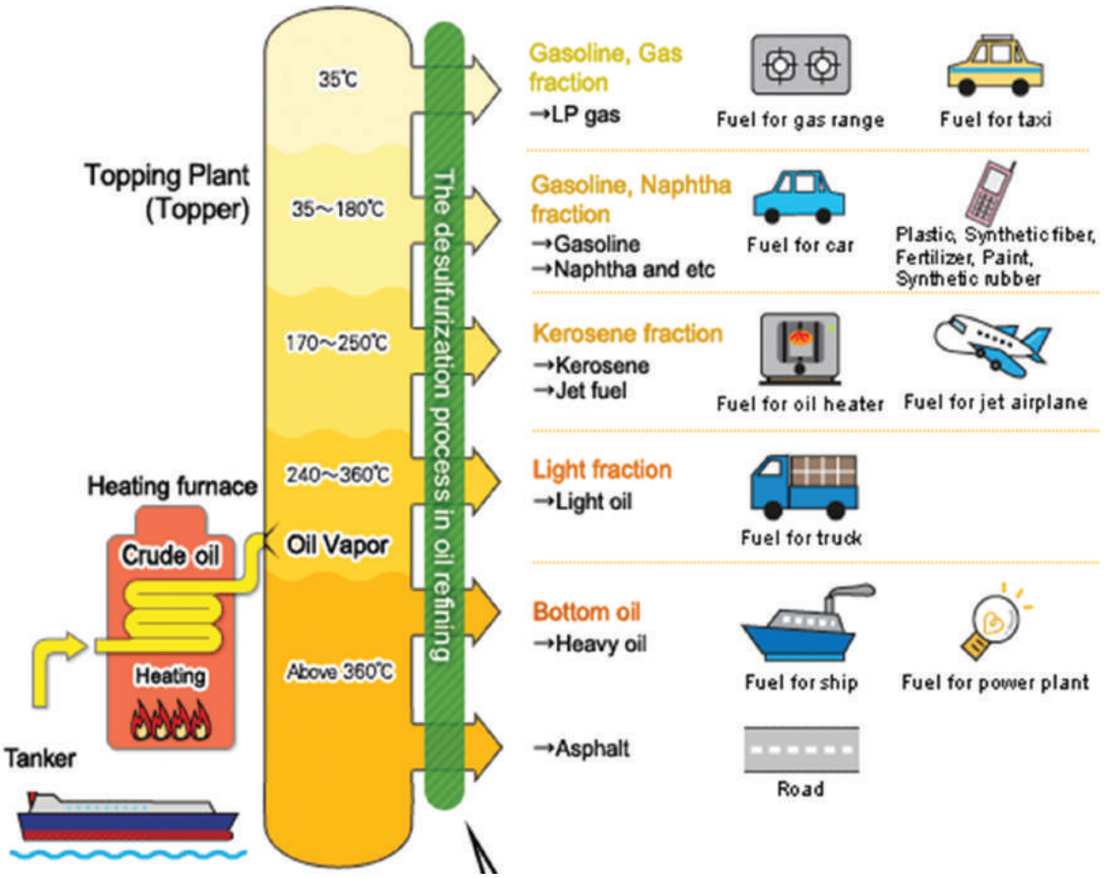


Figure 3.1.2.1 Distilation Process of Various Components Useages

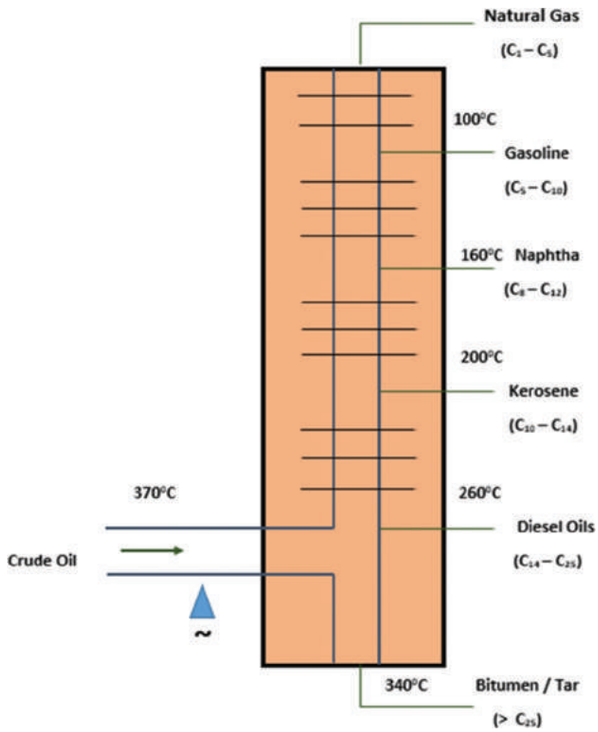


Figure 3.1.2.1(a) Line Diagram of Distilation Process of Various Components.

In petrol have Carbon 79.5% to 87.1%, Hydrogen 11.5% to 14.8%, Sulphur 0.1% to 3.5%, Oxygen and Nitrogen 0.1% to 0.3% and the following special properties are must be in petrol.

1. **Volatility:** Volatility refers to the tendency of fuel to vaporize from liquid state to gaseous state. Boiling Point is an indicator of volatility. Higher the boiling point, the less volatile the fuel. A highly volatile fuel is more likely to form a flammable. Petrol should be sufficiently volatile to form combustible vapor. Petrol must be sufficiently volatile to evaporate at low temperature, for easy starting of the engine, but not so volatile as to evaporate in fuel lines, causing vapor lock and thus preventing flow of liquid fuel.

2. **Specific Gravity:** Specific gravity is the ratio of the density of a substance to the density of a reference substance (usually water). Specific gravity of petrol should be 0.70 to 0.78
3. **Calorific Value:** The amount of heat energy produced by the complete combustion when burning 1 kg of a fuel. The calorific value of petrol is 45.8 MJ/kg.
4. **Flash and Fire Point:** The fire point of a fuel is the lowest temperature at which the vapor of that fuel will continue to burn for at least 5 seconds after ignition by an open flame. Generally flash point should be high for the fuel. The fire point of a fuel is the temperature at which the vapor produced by that given fuel will continue to burn for at least 5 seconds after ignition by an open flame. In general the fire points can be assumed to be about 15°C - 20°C higher than the flash points. For petrol, at least 10% of fuel should be burn instantly and rest in staged phase.
5. **Viscosity:** Resistance to the flow is called as Viscosity and it should be low.
6. **Sulphur Content:** Sulphur will corrode and damage the metal parts. During engine operation, Sulphur combines with oxygen to form Sulphur-di-oxide and in presence of water, it forms sulphurous acid. Hence, Sulphur content should be less than 0.1%
7. **Moisture and Sediment Content:** Petrol fuel should be free from Moisture and Sediment Content.
8. **Octane Number:** This is a measure of auto Ignition resistance in a spark-ignition engine. It represents the volume percentage of iso-octane (C_8H_{18}) in a iso-octane (C_8H_{18}) / n-heptane (C_7H_{16}) mixture. Higher the rating, higher the resistance to knock.A higher rating does not indicate more power but fuel can be used in higher compression ratio. The value of Octane number for the available fuel is between 85 to 90.

3.1.2.2 Diesel and Its Properties

Diesel fuel is the light oil and is obtain from crude oil by the distillation process at a temperature of 250°C – 300°C. Diesel consists of 85% carbon, 12% Hydrogen and 3 % others by weight. These have a boiling point between 250°C and 350°C. Diesel contains more energy than petrol. A diesel engine can be up to 40% more efficient than a spark-ignited petrol engine with the same power output and hence it is widely used in cars, trucks, buses, railway engines etc., The following are the required properties of diesel.

1. **Volatility:** The volatility of diesel is less than petrol. The volatility of diesel fuel influences density, auto ignition temperature, flash point, viscosity and cetane number. High volatility promotes vapor lock and low volatility component may not burn completely, thereby increasing smoke deposits.
2. **Specific Gravity:** Specific gravity of diesel is higher than petrol and the value should be 0.82 to 0.92
3. **Calorific Value:** The amount of heat energy produced by the complete combustion when burning 1 kg of a fuel. The calorific value of diesel is slightly lesser than petrol and the value is 45.5 MJ/kg
4. **Viscosity:** The viscosity is a measure of the resistance to flow of the fuel.

It will decrease as the temperature increases. A high viscosity fuel may cause extreme pressures in the injection systems and will cause reduced atomization and vaporization of the fuel spray. The viscosity of diesel fuel must be low enough to flow freely at its lowest operational temperature, yet high enough to provide lubrication to the moving parts of the finely machined injectors. The fuel must also be sufficiently viscous so that leakage at the pump plungers and dribbling at the injectors will not occur. Viscosity also will determine the size of the fuel droplets, which, in turn, govern the atomization and penetration qualities of the fuel injector spray.

5. **Sulphur Content:** The sulphur in fuel will cause wear of the internal components of the engine, such as piston ring, pistons, valves, and cylinder liners. In addition, a high sulphur content fuel requires that the engine oil and filter be changed more often. This is because of formation of acids when sulphur-di-oxide formed during combustion combines with water vapor. The Sulphur content should be less than 0.5%
6. **Moisture and Sediment Content:** Cleanliness is an important characteristic of diesel fuel. Fuel should not contain any foreign substances, otherwise, fuel pump and injectors will have poor performance moisturizer. Moisture in the fuel can also damage or cause seizure of injector parts when corrosion occurs.
7. **Cetane Number:** The principal measure of diesel fuel quality is its cetane number. A cetane number is a measure of the delay of ignition of a diesel fuel. Higher the cetane rating, the easier the engine will start and the combustion process will be smoother within the ratings specified by the engine manufacturer. It denotes the percentage by volume of cetane (chemical name Hexadecane) in a combustible mixture containing cetane and 1-methylnapthalene. Current diesel fuels have a cetane rating between 45 and 50.

3.2 ALTERNATIVE FUELS

The sources of fossils fuels are depleting and they are not renewable. At the same time the market requirements of this fuels are increasing day by day. Hence, alternative fuels are highly essential. Alternative fuels, known as non-conventional fuel, there are many materials or substances that can be used as fuels, other than fossil fuels like petrol, diesel. Some well-known alternative fuels include biodiesel, bioalcohol (methanol, ethanol, butanol), chemically stored electricity (batteries and fuel cells), hydrogen, non-fossil methane, non-fossil natural gas, vegetable oil, propane etc.,

3.2.1 Alternative Liquid Fuels

3.2.1.1 Alcohol

In recent days, Alcohols can be considered as the best alternative fuels. Methanol and ethanol are of high interest as fuels can be produced chemically or biologically. And they have characteristics which allow them to be used in internal combustion engines. The octane ratings are higher leads to less hydrocarbon emission. Also Sulphur content is less. Figure 3.2.1.1 shown Alcohol chemical bond.

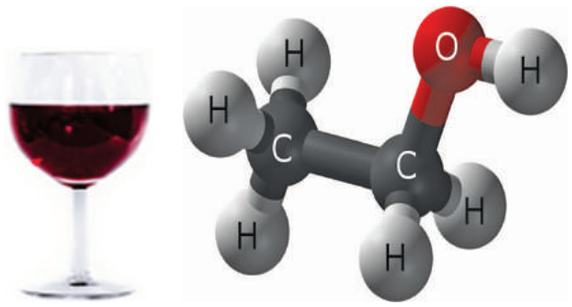
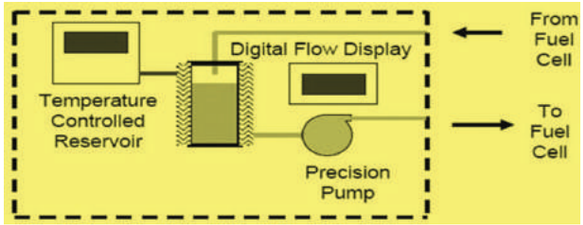


Figure 3.2.1.1 Alcohol Chemical Bond

3.2.1.2 Methanol

Methanol, also known as wood alcohol, can be used as an alternative fuel. M85 (a blend of 85 % methanol and 15 % gasoline) and M10 (a blend of 10% methanol and 90% gasoline) are used as fuel and emissions are lower than conventional vehicles. It has high octane number. Methanol is cheap to produce and has a lower risk of flammability when compared to petrol. The cost of fuel is low. However, methanol is corrosive. Fig 3.2.1.2, 3.2.1.2(a) shows Storage of Methanol and Methanol Unit respectively.

Figure 3.2.1.2 Storage of Methanol



Methanol-unit

Figure 3.2.1.2(a) Methanol Unit

3.2.1.3 Ethanol

Ethanol is also called as Ethyl alcohol. Ethanol can be produced by fermenting and distilling crops such as corn, barley or wheat. In India, Ethanol is extracted from molasses of sugarcane. It can be blended with gasoline to increase octane levels and improve emissions quality. E85 (a blend of 85 % ethanol and 15 % gasoline) and E10 (a blend of 10% ethanol and 90% gasoline) are used as fuel. Fig 3.2.1.3 shows the Carbon Cycle.

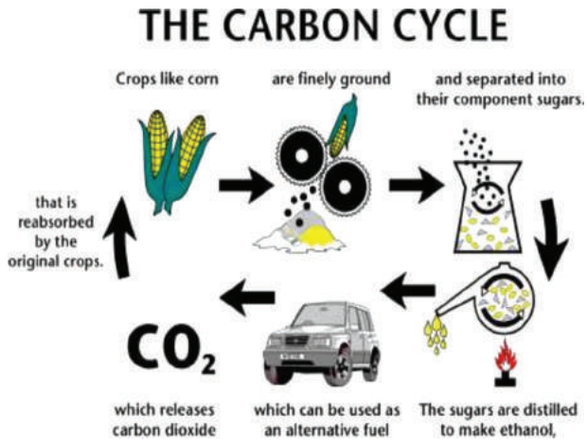


Figure 3.2.1.3 The Carbon Cycle

3.2.1.4 Bio Diesel

Bio diesel is a domestically produced, renewable fuel that can be manufactured from vegetable oils, animal fats, for use in diesel vehicles. Biodiesel can also be blended with diesel and used in unmodified engines. B20 (i.e 20% biodiesel blended with diesel) is a most common biodiesel blend. B20 has good balance of cost, emissions, cold-weather performance, materials compatibility, and ability to act as a solvent. Biodiesel is safe, biodegradable, reduces air pollutants associated with vehicle emissions, such as particulate matter, carbon monoxide and hydrocarbons. Fig 3.2.1.4 shown Bio Diesel Production Process Cycle.

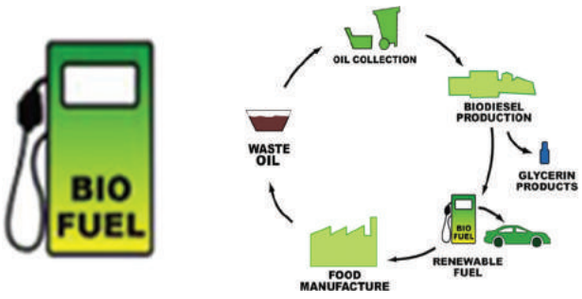


Figure 3.2.1.4 Bio Diesel Production Process

3.2.2 Gaseous Fuels

The gaseous fuels are readily mix with atmospheric air without delay and it is inducted in engine. The following gaseous fuels are presently in use.

3.2.2.1 Liquified Petroleum Gas (LPG)

Liquified petroleum gas (LPG) also called as Propane is a by product of natural gas processing and crude oil refining. LPG is widely used as a fuel for domestic cooking and heating and now it is also a popular alternative fuel for vehicles. It is stored under pressure (100psi or 680 atm) inside a special tank and is a colorless, odorless liquid. As pressure is released, the liquid propane vaporizes and turns into gas that is used in combustion.An odorant, ethyl mercaptan, is added for leak detection.Propane has a high-octane rating, making it an excellent choice for spark-ignited internal combustion engines. It provides uniform homogenous mixture for all cylinders. The carbon content in LPG is less than petrol and hence, LPG vehicles can produce lower amounts of harmful air pollutants and greenhouse gases, CO_2. The operating cost of the vehicle is reduced by 50%. The use of LPG enhances engine life. Refer Figure 3.2.2.1.

Figure 3.2.2.1 Liquified Petroleum Gas

3.2.2.2 Liquified Natural Gas (LNG)

Liquified natural gas (LNG), is natural gas in its liquid form. LNG is produced by purifying natural gas and super-cooling it to -161°C to turn it into a liquid. During the process known as liquefication, natural gas is cooled below its boiling point, removing most of the extraneous compounds found in the fuel. The remaining natural gas is primarily methane (98%) with small amounts of other hydrocarbons.

The specific gravity of LNG is higher than CNG. The calorific value of LNG is 48MJ/kg and its octane value are 110. Because of LNG's relatively high production cost as well as the need to store it in expensive cryogenic tanks, the commercial applications of LNG has been limited. Refer Figure 3.2.2.2.

3.2.2.3 Compressed Natural Gas (CNG)

Natural gas is primarily extracted from gas and oil wells. Natural gas is an odorless and it is a mixture of hydrocarbon, mainly 95% of methane and 5% of other components like butane, propane, ethane,

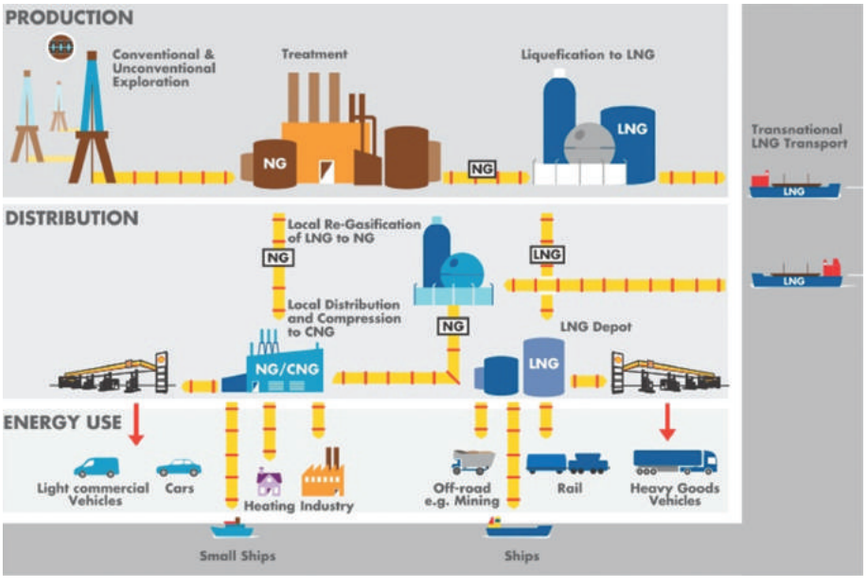


Figure 3.2.2.2 Liquified Natural Gas Plant

water vapor etc., Natural gas are stored in tanks under pressure and hence it is called as compressed natural gas. Octane rating is high. Cars and trucks with specially designed engines produce fewer harmful emissions than gasoline or diesel. CNG fuel systems are completely sealed, the vehicles produce no evaporative emissions. Operating cost of the vehicle is low. Figure 3.2.2.3 shown Compressed Natural Gas Filling Station.

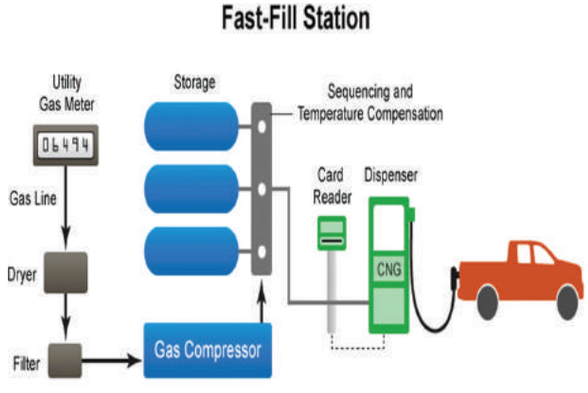


Figure 3.2.2.3 Compressed Natural Gas Filling Station

3.2.2.4 HYDROGEN

Many test engines have been developed to use Hydrogen as an alternative fuel. Hydrogen can be produced from diverse domestic resources. Hydrogen is abundant in our environment. It's stored in water

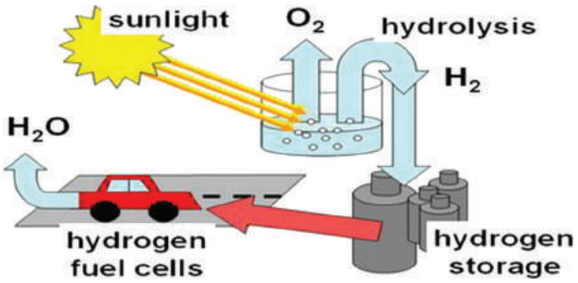


Figure 3.2.2.4 Hydrogen Preparing and Filling Process

(H_2O), hydrocarbons (such as methane, CH4), and other organic matter. One of the challenges of using hydrogen as a fuel comes from being able to efficiently extract it from these compounds. Hydrogen is also used in zero-emission electric vehicles that run on electricity generated by fuel-cell by the petrochemical reaction. Hydrogen is environmental freely. Figure 3.2.2.4 shown Hydrogen Preparing and Filling Process.

3.3 COMPARISON OF VARIOUS FUELS

Commercially fuels are available in different grades like Unleaded Petrol, Speed Petrol, White Petrol, Diesel, Speed Diesel or Premium Diesel etc., Previously, Tetra Ethyl Lead (TEL) is mixed with petrol to increase the octane rating (for antiknocking). However, the lead emission emit from the vehicle is polluting the atmosphere and lead is also poisonous. Hence addition of TEL in petrol is banned and this petrol is called as Unleaded petrol. Various additives are added with fuel to enhance the properties. Such petrol will have high octane rating and called as Speed petrol or premium petrol. Similarly, additives are added with diesel to enhance the cetane rating and such diesel is called as Speed Diesel or Premium Diesel.

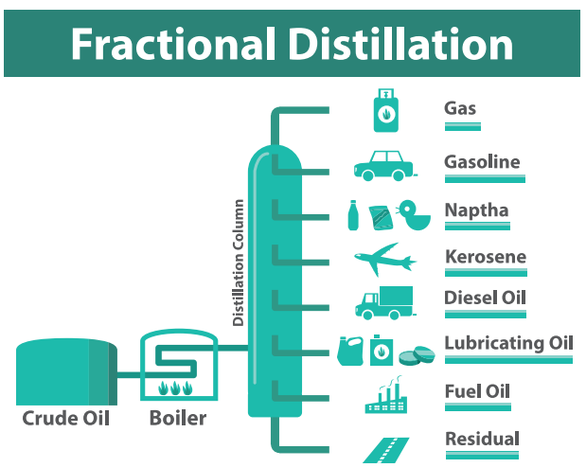


Figure 3.4 Fractional Distillation Process.

3.4 DISTILLATION CURVE

From the above curve, it is understood that the most volatile parts of the gasoline evaporate at lower temperature. This petrol vapor is mixes with air and makes the engine to start easy at cold condition. As the working temperature increases, the less volatile parts evaporate and mixes with air. Based on the distillation graph, the required additives during summer and winter season, can be added with fuel to ensure smooth operation of engine. Fig 3.4, 3.4(a) shows Distillation Curve and Fractional Distillation Process.

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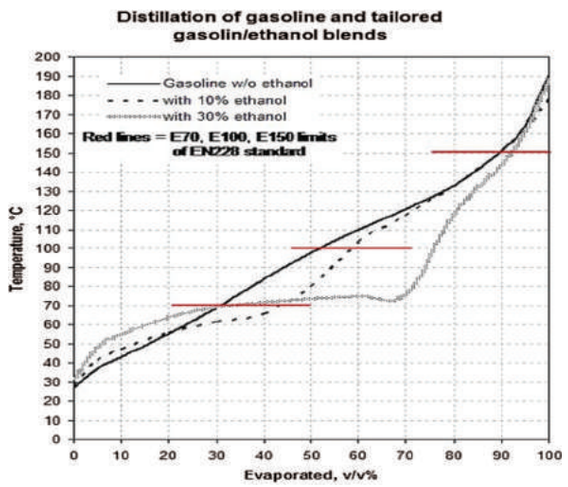

Figure 3.4(a) Distillation Curve-(% of Evaporation Vs Temperature °C)

Student Activity

1. Students should visit the nearby petrol bunks to study the usage and applications of gaseous and liquid fuels and should submit a report on it.
2. Students should visit the nearby petrol bunk and should note down the change in cost of petrol, diesel and coolant oil per litre respectively for seven days from the start of the task and should submit a report on it.
3. Students should learn the importance of octane and cetane number.

Glossary

Colorific Value	-	வெப்பமதிப்பு
Cryogenic	-	கடுங் குளிர்வியல்
Flash Point	-	வெடிப்பு நிலை
Fire Point	-	எரிநிலை
Viscosity	-	பிசுபிசுப்புத்தன்மை
Moisture	-	ஈரப்பதம்
Sediment	-	வீழ்படிவு
Crude Oil	-	கச்சா எண்ணெய்
Unleaded Petrol	-	ஈயம் கலக்கப் படாத பெட்ரோல்
Distillation Curve Diagram	-	வடிகட்டி பிரித்தல் நிலையின் வளைவு வரைபடம்

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SAMPLE QUESTIONS

Choose the correct answer:

1. Why the Solid fuels are not used in Automobile Engines?
   a) Scarcity of Fuel
   b) Higher fuel cost
   c) Low heat energy and more ash and smoke

2. What type of liquid fuel used in Automobile Engines?
   a) Mineral Oil
   b) Vegetable Oil
   c) Animal Oil

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3. The quality of which fuel is known by Octane number.
   a) Petrol
   b) Diesel
   c) LPG

4. The quality of which fuel is known by Cetane number
   a) Petrol
   b) Diesel
   c) LPG

5. Which is the another name of Gasoline
   a) Petrol
   b) Diesel
   c) LPG

Answer the following questions:

1. Define Fuels.
2. Write any five properties of Petrol.
3. Define Octane Number.
4. Write any five properties of Diesel.
5. Define Cetane Number.
6. What is meant by LPG?
7. What are the properties of LPG?
8. What is meant by CNG? Mention the advantages of CNG.
9. What are the two different types of Heat Engines?
10. Define Clearance Volume.
11. Define Swept Volume.
12. What is Volumetric Efficiency?
13. What is Heat Efficiency?

Unit 4 History of Automobiles

Contents

TLGIQ6

Learning Objectives

- To learn about the self-propelled vehicle with stage by stage improvement from past to present.

4.0 INTRODUCTION

4.1 HISTORY OF AUTOMOBILE

In the early days, the man began his journey by walking. Then he used animals like horse, elephant, camel, donkey for his journey. Wheels are the most ancient discovery for human kind. With the help of wheel, the mankind designed horse carriage, bullock cart for transportation of people and goods. As time has gone on, they have devised increasingly more effective and efficient methods of travel. The automobile made a dramatic change in the way people travel.

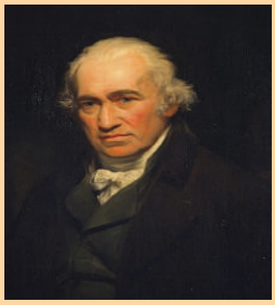
Leonardo da Vinci considered the idea of a self-propelled vehicle in the 15thcentury. In 1680, Sir Issac Newton discovered that if steam is sent out in the rear direction, the vehicle will move forward. In 1769, Nicolas-Joseph Cugnot of France was the constructor of the first true automobile. Cugnot's vehicle was a steam-powered tri cycle carrying four people, and run for 20 minutes at3.6 km per hour.

During the 18th century, James Watt invented the steam engine and it leads to many developments in road transportation. In 1801, Richard Trevithick of Great Britain invented a steam-powered road carriage. Following him, W.H. James invented the automobile running with different speed. Till then, the research was focused on the External combustion engine. In 1863, Jean-Joseph-Etienne Lenoir, a Belgian engineer invented the "horseless carriage" and it uses an internal combustion engine. This is the first commercially successful internal combustion engine. In 1867, Nikolaus August Otto, German engineer invented the four-stroke internal combustion engine. This engine is the first to efficiently burn fuel directly in a piston chamber.

Two-stroke internal combustion engine was invented by Sirclerk, a German scientist in 1880. In 1885, a German engineer, Karl Benz builds the first true automobile powered by a gasoline engine. It has three wheels and looked similar to a carriage. In 1886, Gottlieb Wilhelm Daimler and Wilhelm Maybach invent the first four-wheeled, four-stroke engine in Germany. It is known as the "Cannstatt-Daimler."

In 1892, Rudolf Diesel was a German thermal engineer, invented the internal-combustion engine that runs on diesel. In 1894, Benherd developed an automobile by placing the engine in the front part of the chassis.

Horsepower



James Watt

The term was adopted in the late 18th century by Scottish engineer James Watt to compare the output of steam engines with the power of draft horses.

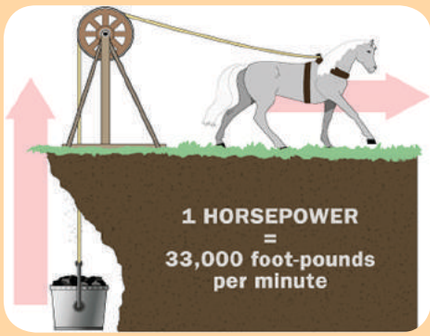
It was later expanded to include the output power of other types of piston engines, as well as turbines, electric motors and other machinery. When the steam engine began to do the work of horses in the mines during the early 1800s, the mine owners began to ask how many horses an engine would replace.

Watt measured the capability of a big horse to pull a load and found it could pull a weight of 150-pounds while walking at 2.5 miles per hour.

This works out to 33,000 foot-pounds per minute or 550 foot-pounds per second.

It was later expanded to include the output power of other types of piston engines, as well as turbines, electric motors and other machinery.

The definition of the unit varied among geographical regions. Most countries now use the SI unit watt for measurement of power.



In 1900, a steering wheel is designed to replace the steering tiller and the vehicle was used for road transportation. In 1906, the first automobile was produced and sold. In 1908, henry ford manufactured 20000 cars. A lot of research and development had been made from 1910. In 1920, spark plug engine, water cooled engines are introduced.

Later, many vehicle manufacturers start begins to manufacture and sell their vehicle on the market. Many models based on the utility and usage has been introduced. Some of them include two-wheeler, three wheelers, passenger cars, luxury cars, buses, trucks etc.

4.2 ENGINE

The engine is the power plant of an automobile. A device which is used to convert one form of energy into mechanical energy is called an Engine. The heat energy produced by burning of the fuel is converted into mechanical power, then it is called a Heat Engine.

Heat engines are classified into two types.

1. External Combustion Engine
2. Internal Combustion Engine

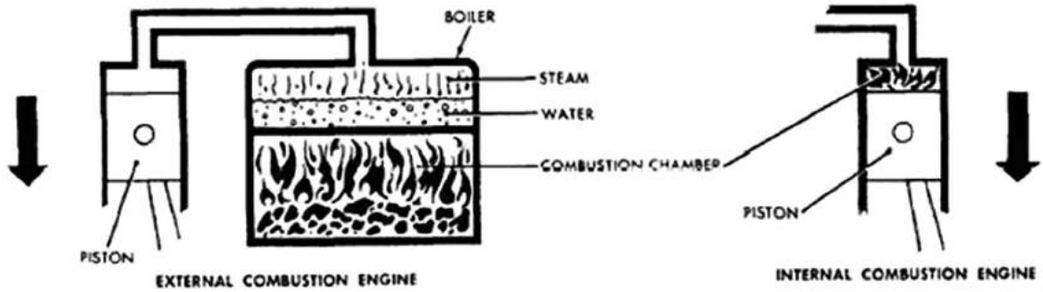


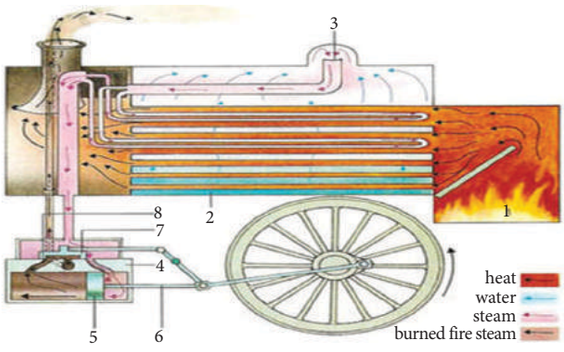
Figure 4.2

4.2.1 External Combustion Engine

An external combustion engine is a heat engine where a working fluid, is heated by combustion in an external source like Boiler. The fluid then, by expanding and acting on the mechanism of the engine, produces motion and usable work.

In external combustion engines, the combustion process takes place outside the mechanical engine system. External Combustion Engines are used in the following.

Ancient Marine Engine



Ancient Road Roller Engine

Steam Locomotive

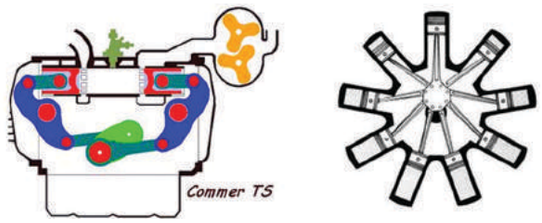


Figure 4.2.1

4.2.2 INTERNAL COMBUSTION ENGINE

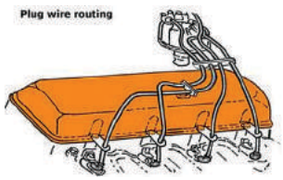
An internal combustion engine (ICE) is a heat engine where the combustion of a fuel and air occurs inside the engine combustion chamber that is an integral part of an engine.

4.2.3 Classification of Internal Combustion Engine

Internal Combustion Engines are classified in many different ways as follows

1. According to the Cycle of Operation
   a) Otto Cycle
   b) Diesel Cycle
2. According to the No. of Stroke
   a) Two stroke engine
   b) Four stroke engine

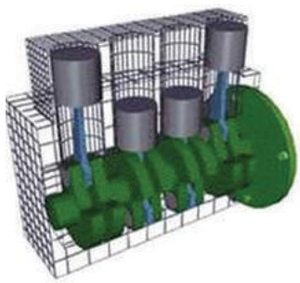
3. According to the Fuel used
   a) Petrol or Gasoline Engine
   b) Diesel Engine
   c) Gas Engine



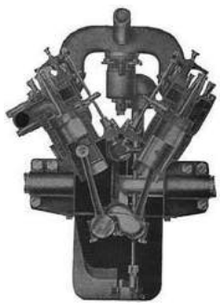
4. According to the Combustion System
   a) Spark ignition system
   b) Compression ignition system

5. According to the No. of cylinder
   a) Single cylinder engine
   b) Multi-cylinder engine

6. According to the arrangement of Cylinder
   a) Inline engine
   b) V – type engine
   c) Opposed cylinder engine
   d) Radial engine



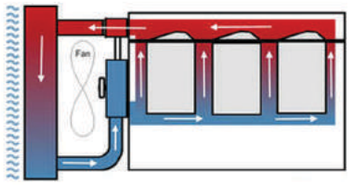
Inline Engine



V – Type Engine

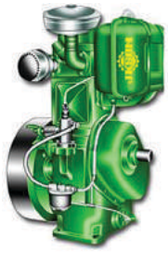
7. According to the construction of Valve
   a) L – head engine
   b) T – head engine
   c) I – head engine
   d) F – head engine

8. According to the Cooling System
   a) Air cooled engine
   b) Water cooled engine



9. According to the Speed
   a) Low-speed engine
   b) Medium speed engine
   c) High-speed engine

10. According to the Usage
   a) Stationary engine
   b) Automotive engine
   c) Locomotive engine
   d) Marine engine
   e) Aircraft engine



Stationary Engine

Automotive Engine

Marine Engine

Locomotive Engine

Aircraft Engine

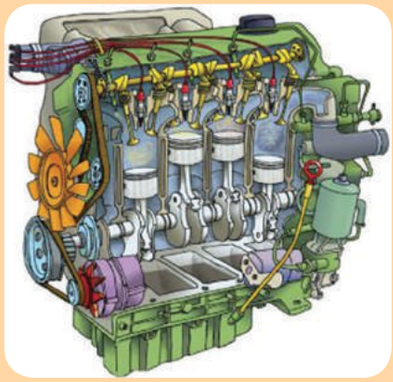
Internal compression engine

Nikolaus Otto

Nikolaus August Otto (14 June 1832, Holzhausenan der Haide, Nassau – 26 January 1891, Cologne) was a German engineer who successfully developed the compressed charge internal combustion engine which ran on petroleum gas and led to the modern internal combustion engine.

The VDI (Association of German Engineers) created DIN standard 1940 which says "Otto Engine: internal combustion engine in which the compressed fuel-air mixture is initiated by a timed spark ignition", which has been applied to all engines of this type since.

His main interest in school had been in science and technology but he graduated after three years as a business apprentice in a small merchandise company.



4.3 TECHNICAL SPECIFICATION OF THE ENGINE

1. Top Dead Centre (TDC) is the outermost point of forward travel of the piston in the cylinder.
2. Bottom Dead Centre (BDC) is the innermost point of backward travel of the piston in the cylinder.
3. Stroke Length is the distance between TDC and BDC travelled by the piston in the cylinder. It will be twice the crankshaft throw.
4. Crankshaft throw is the distance between the centre of the crankshaft main bearing to the centre of the crank pin. It will be half of the stroke length.
5. Cylinder bore is the inside diameter of the cylinder.
6. Clearance volume is the volume of the cylinder above the piston when the piston is at TDC.
7. Swept volume / Displaced volume is the volume displaced by the piston when piston moves from TDC to BDC
8. Total volume is the volume of the cylinder above the piston when the piston is at BDC.

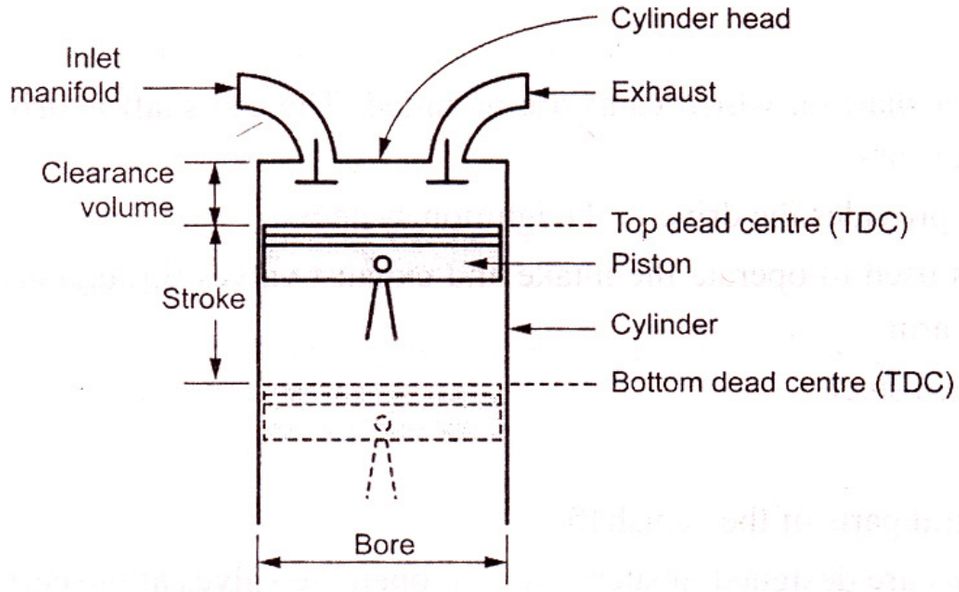


Figure 4.3 Technical Specification of the Engine

9. Compression ratio is the ratio of total volume of the cylinder to clearance volume.
10. Indicated power is defined as the power developed by combustion of fuel inside the engine cylinder.

$$IP = \frac{P_m LAN}{60 \times 1000}$$

I.P. = Indicated Power, kW

P_m = Mean Effective Pressure, N/m^2

L = Stroke Length, m

A = Cross section area of Piston, m^2

N = Crankshaft RPM (for 2 Stroke engine N, for 4 Stroke engine N/2)

11. Brake power is the actual work output of an engine or the actual work available at the crankshaft. It can be measured with the help of brake dynamometer.

$$B.P = \frac{2\pi NT}{60 \times 1000}$$

B.P. = Brake Power, kW

N = Crankshaft RPM

T = Torque or Resisting torque in the dynamometer, Nm and

12. Frictional power: Engine brake power is always less than Indicated power, due to frictional losses at the working surfaces like bearings, piston rings and valves. The power loss due to friction is called as frictional power.
13. Friction power, F.P. = Indicated power, I.P. – Brake power, B.P.

Efficiency: The ratio of power output and power input to the engine is called as Efficiency. It is calculated by Volumetric Efficiency, Thermal Efficiency and Mechanical Efficiency.

Volumetric Efficiency is defined as the ratio of the actual volume of air inducted during the intake stroke to the theoretical volume of a cylinder.

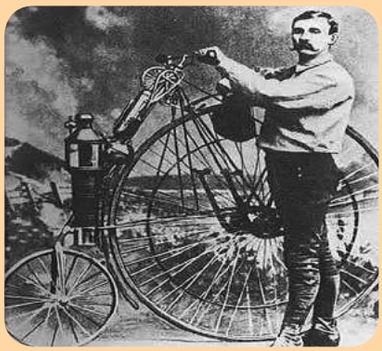
Thermal Efficiency is the ratio of the useful work obtained to the heat supplied to the engine.

Mechanical Efficiency is defined as the ratio of flywheel output to the useful work obtained from the engine.

Who made the first motor cycle?

First motor cycle was designed and built by the German inventors Gottlieb Daimler and Wilhelm Maybach in 1885.

It was designed as a testbed for their new engine, rather than a true prototype vehicle.



14. Brake Mean Effective Pressure (BMEP) is the mean (average) pressure on the piston uniformly acting during the power stroke, which would produce the same measured (brake) power output.

15. Specific fuel consumption (SFC) is defined as the total fuel consumption per hour per kW power developed. SFC is the rate of fuel consumption per kWh. It allows comparing engines of different sizes to see which is the most fuel efficient. It helps to determine which engine uses the least amount of fuel while producing high power. When Indicated power (IP) is used to calculate SFC, then it is known as Indicated Specific fuel consumption (ISFC) and when Brake power (BP) is used to calculate SFC, then it is known as Brake Specific fuel consumption (BSFC).

4.4 ROYAL AUTOMOTIVE CLUB

RATING

RAC Rating was introduced by the Royal Automobile Club in England. The tax horsepower or taxable horsepower was an early system by which taxation rates for automobiles were calculated. Taxable horsepower is a calculated figure based on the engine's bore size, number of cylinders but does not reflect on developed horsepower.

D = the diameter of the cylinder in inches [1" = 25.4mm], and

n = the number of cylinders

4.5 SOCIETY OF AUTOMOTIVE ENGINEERS RATING

Society of Automotive Engineers Rating is based on net power developed on the engine. Net power is the power developed by the engine by removing engine belt-driven accessories, air cleaner, emission controls, exhaust system, and other power-consuming accessories.

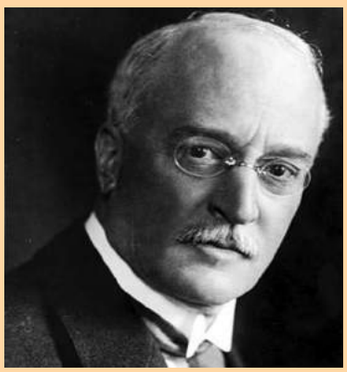
Student Activity

1. Students should prepare the list of most widely used cars by the public.
2. Students should prepare an album containing the cars used in India and other foreign countries.
3. Students should visit the nearby workshops to learn the functioning of Internal and External combustion engines

DO YOU KNOW?

Diesel engine

Rudolf Christian Karl Diesel (German: 18 March 1858 – 29 September 1913) was a German inventor and mechanical engineer, famous for the invention of the diesel engine, and for his mysterious death. Diesel was the subject of the 1942 film Diesel



Rudolf Diesel

Diesel was born in Paris, France in 1858 the second of three children of Elise and Theodor Diesel.

His parents were Bavarian immigrants living in Paris. Theodor Diesel, a bookbinder by trade, left his home town of Augsburg, Bavaria, in 1848.

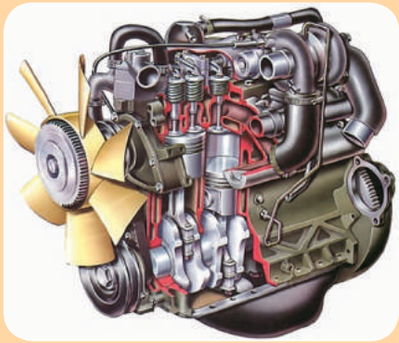


Figure 4.5

He met his wife, a daughter of a Nuremberg merchant, in Paris in 1855 and became a leather goods manufacturer there.

Glossary

Transportation	-	போக்குவரத்து
Dramatic	-	நடைமுறை மாற்றம்
Discovered	-	கண்டுபிடிப்பு
Commercially	-	வணிகரீதியாக
Combustion	-	எரியூட்டுதல்
Efficiently	-	திறமையான
Manufactured	-	தயாரித்தல்
Luxury	-	சொகுசான

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TLLS3H

SAMPLE QUESTIONS

Choose the correct answer:

1. In which year Nikolos otto invented four stroke internal combustion engine?
   a) 1863 b) 1866
   c) 1880
2. In which year Rudalf Diesel invented diesel engine?
   a) 1886 b) 1892
   c) 1894
3. Crank throw is
   a) The distance between TDC & BDC
   b) half of the stroke length
   c) Double time of the stroke length
4. Which type of steam engine is used in locomotive?
   a) Internal combustion engine
   b) External combustion engine
   c) opposite cylinder engine
5. Stroke is
   a) Distance between TDC & BDC
   b) Equal to crank throw
   c) Half of the crank throw

Answer the following questions:

1. What is meant by Automobile?
2. In which year and by whom the Automobile Vehicle is invented?
3. Describe the History of Automobile.
4. Based on the Fuels how the Automobile Vehicle is classified? Mention the Names.
5. State three examples of External Combustion Engine.
6. What is Internal Combustion Engine?
7. How do you classify the Internal Combustion Engine?
8. What is Stroke?
9. Write short notes on TDC & BDC.
10. Define Compression Ratio.

Unit 5 Engine

Contents

TLQERT

Learning Objectives

- To learn about Internal and External combustion engines.
- To learn about the engine parts, manufacturing procedure and the material used.
- To learn about the thermal energy produced in two stroke and four stroke engines.

5.0 INTRODUCTION

Thiruvalluar quotes "When water fails, functions of nature cease". In modern world "When automobile fails, functions of world cease". The mobility of the people and world will ceases when there is no automobile. Thus Automobile plays a vital role in transportation of people and goods from one place to another, even in between the continents.

The driving force required to drive the vehicle is provided by the Engine. Engine is considered to be the heart of an automobile. Based on Law of conservation of Energy, i.e., Energy can be transformed from one form to another form, engine is used to convert heat energy obtained by burning of fuel into mechanical energy and therefore they are called as Heat Engines.

5.1 PETROL ENGINE

In petrol engines, the heat energy is obtained by burning the petrol with air and this heat energy is converted into mechanical energy. Since petrol is also called as gasoline, this engine is also called as Gasoline engines.

The liquid state of petrol fuel is converted into vapour and it is mixed with atmospheric air. This air-fuel mixture is inducted into the engine, and it is burnt with the spark introduced by the spart plug. Hence, this engine is also called as spark ignition engine. This engine was invented by Nichloas Otto, German scientist in 1876. The engine is working based on otto cycle which is constant volume cycle. To burn a fuel, four operations is required namely, intake of fuel air mixture, compression of fuel air mixture, burning of furl air mixture and sent out the burnt air fuel mixture from the engine. Each operation is completed in each stroke of the piston and four stroke is required to complete a cycle. Hence it is called as four stroke engine.

5.2 DIESEL ENGINE

In diesel engines, the heat energy is obtained by burning the diesel with air and this heat energy is converted into mechanical energy. In 1897, Rudolph diesel invented the Diesel engine and hence the engine was called by his name "Diesel engine". This engine is working based on constant pressure cycle. In diesel engine, the air alone is intaken during suction stroke and it is compressed during the compression stroke. At the end of the compression stroke, diesel fuel is injected at high pressure which automoise the diesel fuel. The temperature of the compressed air is sufficient enough to start the combustion. Since air alone is compressed at high pressure, it will liberate more energy than petrol engine. Hence this engine is used on trucks, buses and heavy vehicles.

Since the cost of the diesel fuel is less and high energy is available, this engine is widely used for transportation, though the maintenance cost is more.

5.3 PARTS OF AN IC ENGINE

1. Cylinder Block
2. Cylinder Liner
3. Cylinder Head
4. Crank Case
5. Oil Sump
6. Gasket
7. Piston
8. Connecting rod
9. Crank Shaft
10. Timing Gear, Timing Chain
11. Vibration damper
12. Cam shaft
13. Valve and Valve mechanism
14. Inlet Manifold and Outlet Manifold
15. Flywheel
16. Silencer

Other components like oil pump, fuel pump, carburetor, distributor, water pump, air filter, oil filter etc are also attached to the engine. The major components of IC Engine is shown in Fig 5.3.

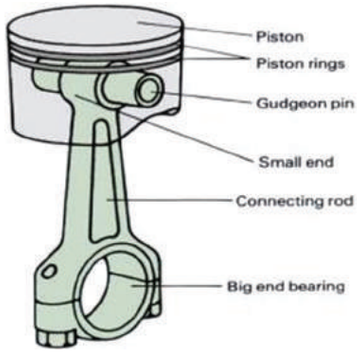
The Material of the major components are shown in Table 5.1.

Cylinder Block

Cylinder Head

Crank Case

Silencer



Piston Assembly

Cam Shaft

All Types of Valves

Vibration Damper

Manifold

Flywheel

Figure 5.3 Major Components of IC Engine

Table 5.1 Major Parts of an IC Engine and Its Material

Part	Material
Cylinder Block	Grey cast iron or Aluminum alloy
Cylinder Liner	Steel alloy containing Nickel, Manganese, Chromium, Silicon
Cylinder Head	Grey cast iron or Aluminum alloy
Crank Case	Grey cast iron or Aluminum alloy
Oil Sump	Pressed steel
Gasket	Alloy Steel containing copper, asbestos
Piston	Aluminum alloy
Piston Pin	Special steel
Piston Ring	Cast iron
Connecting Rod	Forged Alloy steel
Crank Shaft	Heat treated alloy steel
Vibration Damper	Aluminum alloy or wrought iron
Timing Gear, Timing Chain	Special alloy steel
Cam Shaft	Heat treated alloy steel
Main Bearing	Steel containing phosphor cronze, lead, bronze, tin, antimony and aluminum
Valve	Alloy steel containing silicon, chromium, nickel
Manifold	Cast iron or Aluminum
Flywheel	Pressed steel / cast iron
Silencer	Cast iron or hardened steel

5.3.1 Cylinder Block

The cylinder block is the main supporting structure for the various components. Cylinder block will have one or more cylinders. For multicylinder engine, the cylinders are cast as a single unit, called cylinder block. The cylinder block inner surface is machined and finished accurately for the piston to reciprocate up and down. The cylinder head is mounted on the top of the cylinder block. Cylinder head gasket is placed between the cylinder block and cylinder head. The cylinder head and cylinder block are provided with water jackets or with cooling fins. The crankshaft is mounted on bottom of the cylinder block with the help of bearings. The bottom portion of the cylinder block is called crankcase. A sump for lubricating oil is fastened to the bottom of the crankcase.

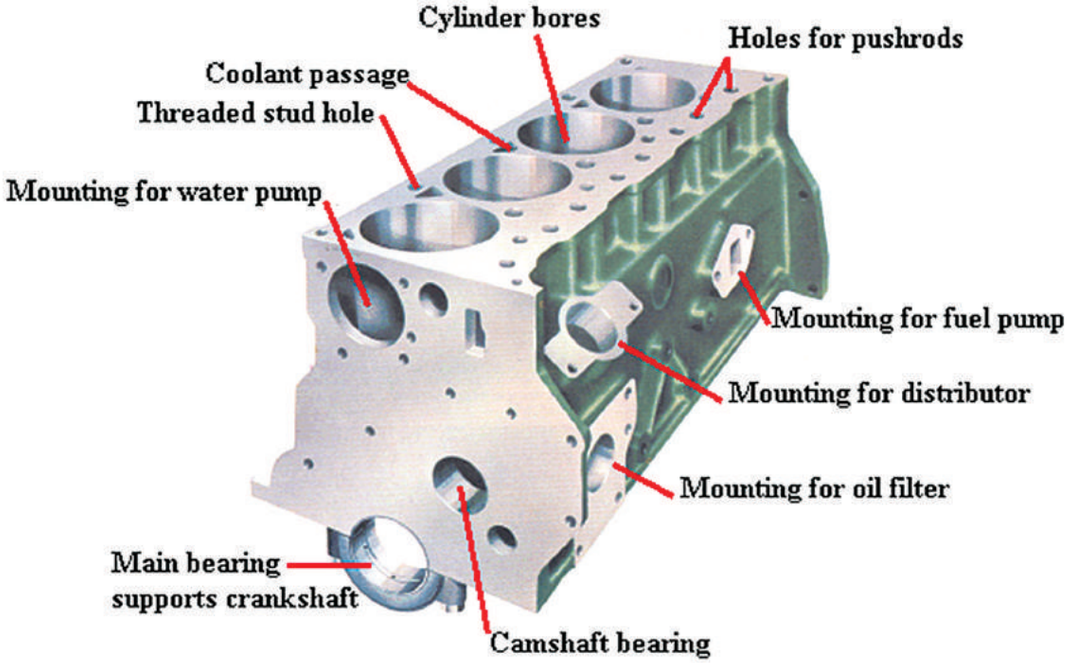
Cylinder blocks are two types

1. **Split block:** Crank case and cylinder block are manufactured as a separate unit and
2. **Mono block:** Crank case and cylinder block are manufactured as a single unit

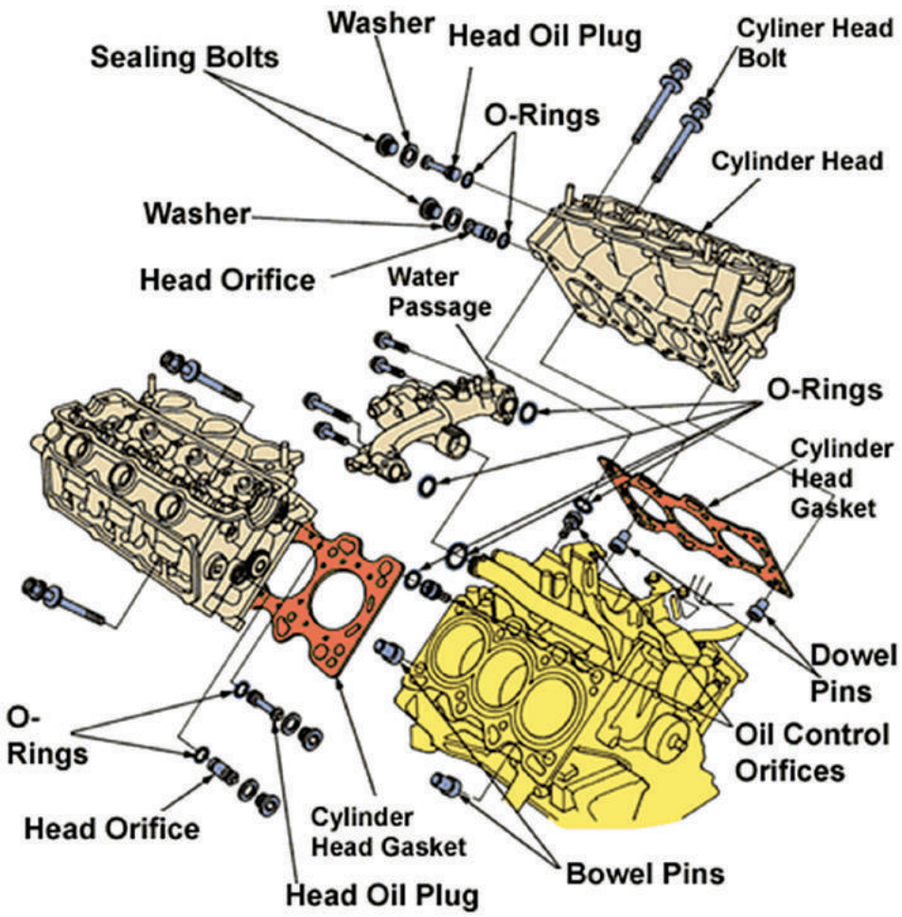
The mono block and split block are shown in Fig 5.3.1.

5.3.2 Cylinder Liner

The cylinder will wear with use, and therefore there may be reduction in



Mono Block



Split Block

Figure 5.3.1 Mono Block and Split Block

performance as well as maintenance cost is increased. In such cases, the use of a sleeve or liner can restore proper clearances to an engine. Due to prolonged use, the liner will wear and it can be replaced at lower cost. Cylinder liners are of two types namely dry liner and wet liner.

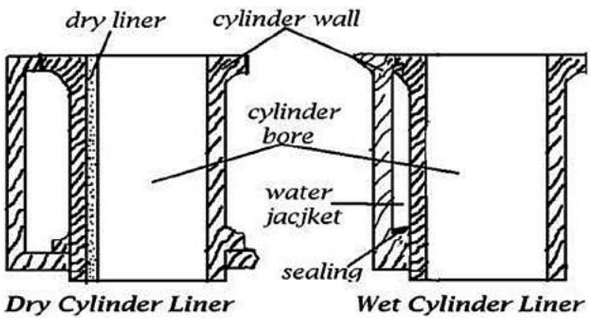


Figure 5.3.2 Dry and Wet Liner

(a) Dry liner

The outer diameter of liner and inner diameter of the cylinder wall are manufactured to fit perfectly. Liners are assembled with the help of hydraulic press or by cooling the liner. The dry type liner is not in direct contact with the coolant hence the name "Dry". The cylinder liner is surrounded by the cylinder body. The cylinder body is contacted by the cooling water so as to achieve heat dissipation. Liner thickness would be 1.5 mm to 3.0 mm. Flanges and seals are at top surface of cylinder.

Figure 5.3.2(a) Dry Liner

Wet liners may have a cooling water space between the engine block and liner, or they may have integral cooling passages. Liners with integral cooling passages are sometimes referred to as water-jacket liners.

(b) Wet liner

The inner surface of wet liner are perfectly machined and honed. The outer surface is not machined. They are referred to as "wet liners" because their outer sides come in direct contact with the engine's coolant. The thickness of the liner will be 3.0mm to 6.0 mm. It is sealed by a metallic sealing ring from top and a rubber sealing ring at the bottom. A wet liner cylinder block features cylinder walls that are entirely removable, which fit into the block by means of special gaskets.

Figure 5.3.2(b) Wet Liner

5.3.3 Cylinder head

In an engine, the cylinder head assembled above the cylinders on top of the cylinder block with the help of studs. It closes in the top of the cylinder, forming the combustion chamber. This joint is sealed by a head gasket. The head also provides passage for intake of air and fuel and exhaust of burnt gases, water cooling passage. The head can also be a place to mount the valves, spark

plugs, and fuel injectors. In case of overhead valve engine, then oil passage for pushrod and rocker arm are also available. Cylinder heads are classified as

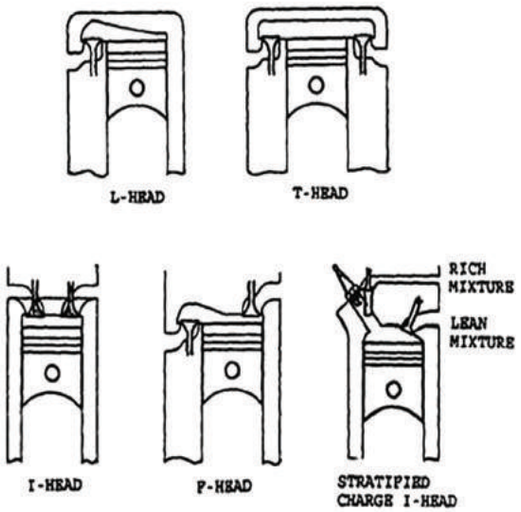


Figure 5.3.3 Types of Cylinder Head

L – Head Engine

I – Head engine

F – Head engine

T – Head engine and are shown in Fig 5.3.3.

5.3.4 Crank case

The crank shaft and cam shaft are placed on the crank case. It is formed as the portion of the cylinder block below the cylinder bore and the oil sump at the bottom. Crank case and the cylinder block are made as a single unit. The oil sump is connected with the crank case by the studs. The Crank case with Crank shaft is shown in Fig 5.3.4

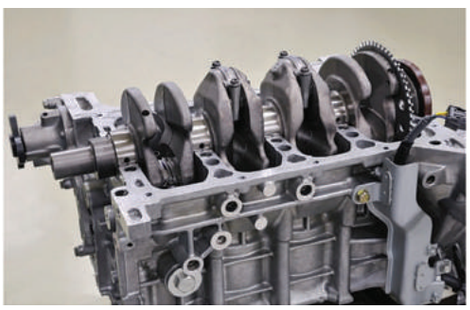


Figure 5.3.4 Crank Case with Crank Shaft

5.3.5 Oil sump

The oil sump is attached below the crank case. It is used to store the lubricating oil which is used for lubricating purpose. To drain or replace the used lubricating oil a drain arrangement is fitted.

Figure 5.3.5 Oil Sump

5.3.6 Gasket

When connecting two metal parts directly, there musty be air tight connection between the parts or otherwise if there is a gap, it allows the gas or the liquid to leak. To arrest the leakage of gas or oil, the gasket is being used. It makes the two metal components air tight and close. Gaskets are placed in the cylinder block, cylinder head crankcase and oil pump and in oil sump. For placing the inlet and outlet manifolds on the cylinder head gaskets are being used.

Figure 5.3.6 Gasket

5.3.7 Piston

The piston is the most important component of the engine. It is kept inside the

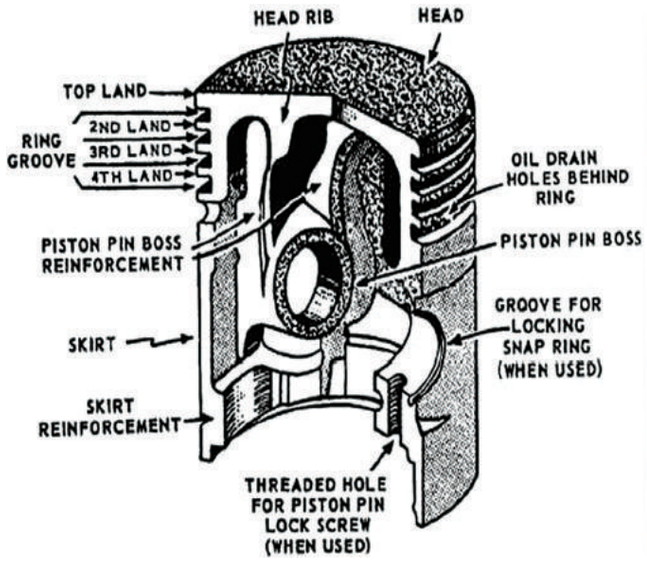


Fig 5.3.7 Parts of Piston

cylinder liner and allowed to move up and down. It is used to suck the air fuel mixture inside the cylinder and transmits the engine power to the connecting rod which is obtained during the power stroke. It is used to convert the heat energy into mechanical energy. The first piston was made of iron. As the usage of iron was heavy, it observed more energy that was produced by the engine. To avoid this power loss the less weight, easily machinable and less price metal alloys such as aluminium alloy are being used nowadays. The piston is shown in Fig 5.3.7.

To make a good piston the following qualities should be maintained while manufacturing.

1. The weight should be less
2. Cost should be low
3. The piston should be easily machinable
4. It should with stand very high temperatures
5. It should have the capacity to transfer more heat quickly.
6. It should not expand easily due to high temperature.

5.3.7.1 Methods to avoid expanding

As the engine is being operated continuously at very high temperatures the piston gets over heated than the engine cylinder. Because the engine cylinder block is continuously cooled by using the cooling water. As the Piston gets more heat than the engine cylinder the piston gets expanded. If the piston expands, the movement of the piston become difficult for it and will stop which affects the engine in producing the power. To avoid this piston expansion the following provisions are adopted on the piston

a. Horizontal slot
b. Heat Dam
c. Vertical slot
d. T slot
e. Oblique slot
f. Solid slot

a) Horizontal slot

The horizontal Slot is being made on the top of the piston, Just below the oil ring at the skirt portion of the piston so that the heat

coming from the piston head during power stroke is observed by the slot. By this way the piston is protected from expansion and allowed to operate the engine safely.

Figure 5.3.7.1(a) Horizontal Slot

b) Heat Dam:

It is like how we store water in ponds and use it when needed. Similar to that to save the heat generated inside the engine combustion chamber and use it effectively small pits in concave shape are made on the piston head which are used to save heat. Hence the heat transfered from the crown to the skirt is being reduced and the expansion of piston is being avoided

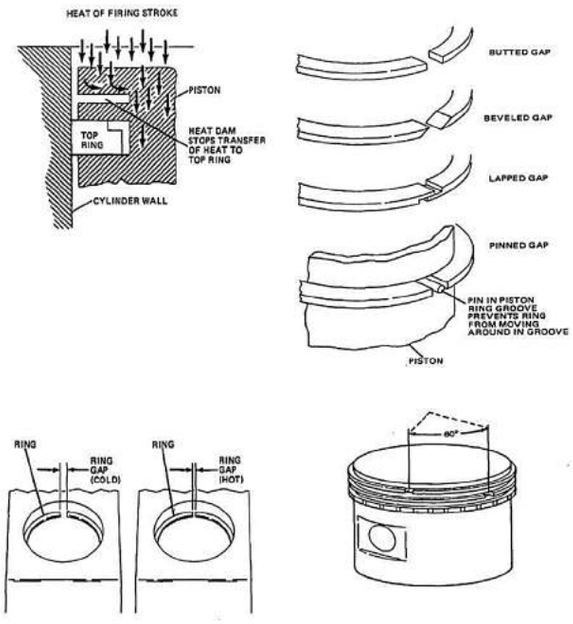


Figure 5.3.7.1(b) Heat Dam

c) Vertical Slot:

This type of slots is used in preventing the piston's expansion due to heat particularly at the outer periphery. The slots are made in selected places where the expansion is predicted to be more in such a way that it should tolerate the expansion of the piston.

Figure 5.3.7.1(c) Vertical Slot

d) T slot:

Similar to the vertical slot piston the T-slot helps the Piston to avoid expansion in the diameter wise as well as in the lengthwise and helps engine to function properly.

Figure 5.3.7.1(d) T-Slot

e) Oblique Slot:

In this type the slots are made on the piston's oil ring slots to control the temperature of the piston. The slots are made slightly in slanting manner such that it reaches the skirt. In this type the heat produced in the engine is blocked in such a way that it should not reach the skirt. The heat is transferred in sideways and also in the lengthwise so that the piston is saved from the high temperature produced inside the engine combustion chamber.

Figure 5.3.7.1(e) Oblique Slot

f) Solid Slot:

Similar to oblique slots, in solid type, small holes are made on the slots of the oil ring. These holes restrict the heat from the head to enter into the skirt. Hence the piston works safely.

Figure 5.3.7.1(f) Solid Slot

5.3.7.2 Functions of piston

In the engine at the combustion chamber the power obtained during power stroke cannot be sent directly to the crankshaft. The component used to transfer the power (gas pressure) from the combustion chamber to the crankshaft through the connecting rod is the piston.

The functions of the piston are listed below.

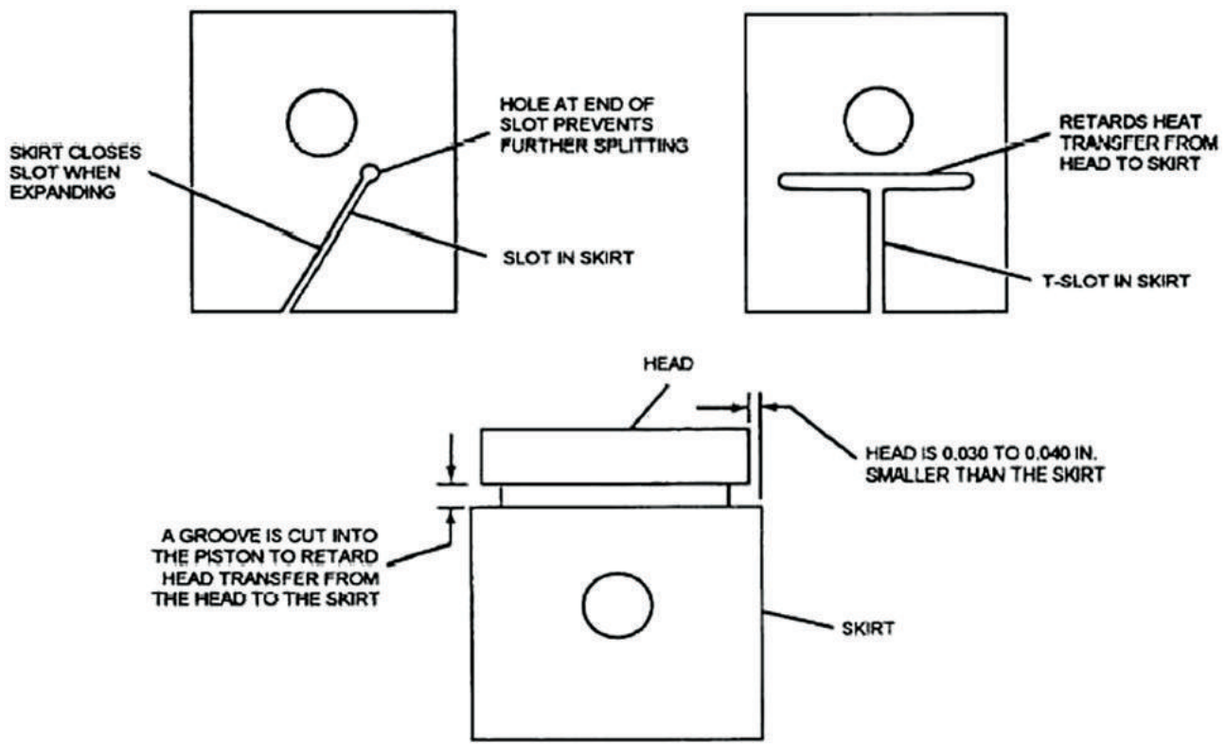


Figure 5.3.7.1 Schematic Diagrams of Various Slot

1. To transfer the power from the combustion chamber to the crank shaft through the connecting rod.
2. To transmit the heat produced from the power to the combustion chamber walls
3. To acts as seal inside the cylinder to withstand high pressure and protects the crankcase in avoiding high pressure to pass to the crank case
4. It acts as a guide to connecting rod
5. It acts as a component for supporting the piston ring
6. It is used to suck the air or air fuel mixture and also used to compress them
7. It is used to expel the hot gases to the atmosphere during the exhaust stroke.

5.3.7.3 Types of piston

Piston is used to transmit power from engine combustion chamber to the crankshaft. Pistons are classified according to their heads hased on the type of engine and its performance. They are classified as follows,

a. Flat head piston
b. Domed head piston
c. Concave (bowl) head piston

a) Flat head piston

In this type, the piston head is in flat shape. This shape helps in removing combusted products after the power stroke. The design of these pistons is very easy. However, the efficiency of the engines using this type of pistons is less.

Figure 5.3.7.3(a) Flat Piston

b) Domed head piston

In this type, the piston head is of cap like structure. ie., more volume is added to the piston head. This structure helps in smooth compression stroke and also results in proper mixing. Compression ratio is higher for using these types of piston. However the manufacturing process is difficult.

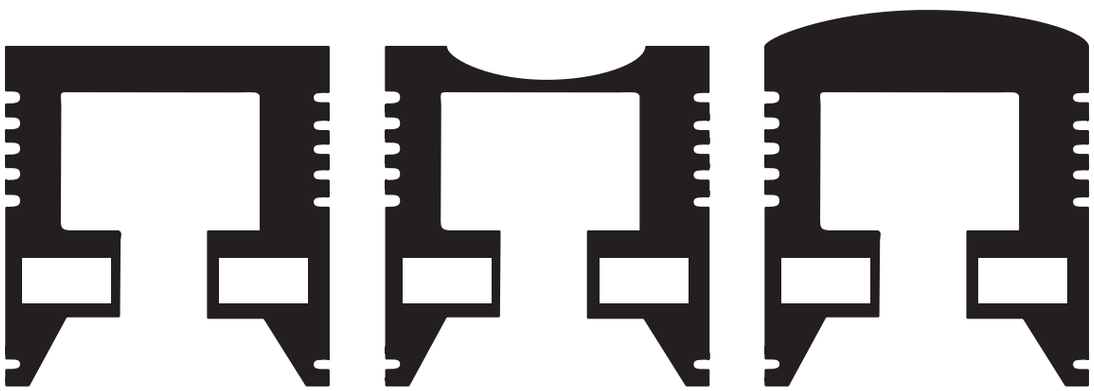


Figure 5.3.7.3 Types of Piston Head

Figure 5.3.7.3(b) Dome Piston

c) Concave head piston

In this type, the piston head is of concave in structure. Due to this, high pressure is produced inside the combustion chamber. These types of piston are used in high compression diesel engines. Concave like structure helps in increasing air turbulence which leads to proper mixing and results in good combustion.

Figure 5.3.7.3(c) Concave head Piston

5.3.7.4 Piston arrangement

The upward and downward motion of cylindrical object inside the cylinder is called piston. Piston consists of heat dam, land, skirt, piston pin boss, rings, grooves. Heat dam is a thin groove cut on the piston head between the top ring groove and the top of the piston. There are slots for compression and oil rings. Below these slots, holes are made for piston pin or piston boss. Slots are present on the

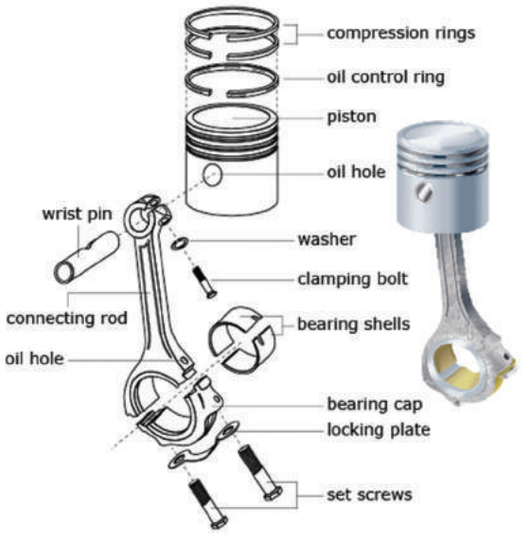


Figure 5.3.7.4 Piston Arrangement

piston skirt. Cylinder liner present inside the cylinder acts as sliding surface for piston.

a) Piston Pin

A piston pin is a hollow shaft that connects the small end of the connecting rod to the piston. It is made up of special alloy steel to prevent wear and tear.

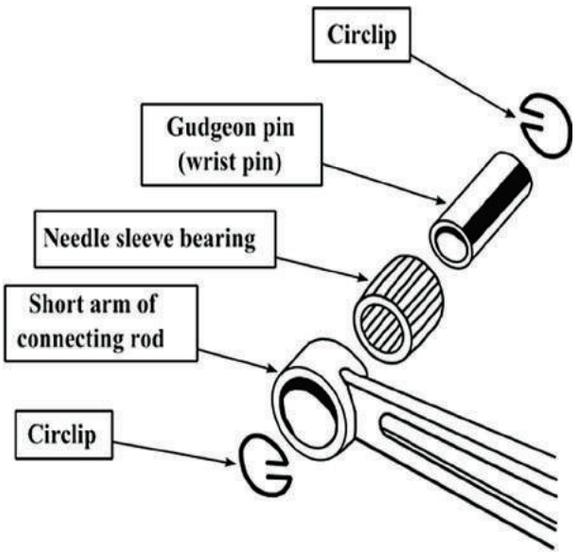


Figure 5.3.7.4(a) Piston Pin

b) Piston Rings

Depending upon the horse power of the engine, one or more piston rings is used. It provides a tight seal between the piston and the cylinder wall thus preventing leakage of combustion gases. The performance of the engine is reduced, if the piston rings are worn out and it can be replaced. Piston rings are classified as

i) Compression ring

ii) Oil scrapper ring

Compression ring

The compression ring seals the combustion chamber from any leakage during the combustion process. When the air-fuel mixture is ignited, pressure from combustion gases is applied to the piston head, forcing the piston toward the crankshaft. The pressurized gases travel through the gap between the cylinder wall and the piston and into the piston ring groove. Combustion gas pressure forces the piston ring against the cylinder wall to form a seal. It also transfers heat from the piston to the cylinder wall. No. of compression ring is depending upon the compression ratio of the engine. Higher the compression ratio more the number of piston rings. Compression rings are made up of Cast Iron.

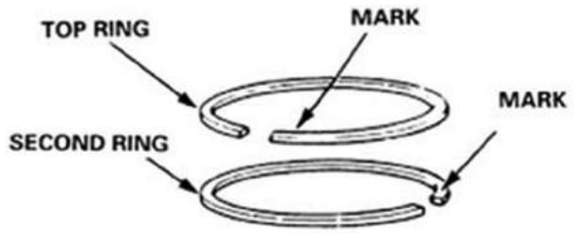


Figure 5.3.7.4(b)(i) Compression Rings

Oil scrapper ring

The bottom most ring is called as oil scrapper ring. The lubricating oils are sprinkled on the cylinder wall and inner side of the piston through the connecting rod oil passage. This ring is used to scrape excess lubricating oil from the cylinder walls, thus prevents the lubricating oil from getting into the combustion chamber of the cylinder Oil scrapper rings are made up of cast iron.

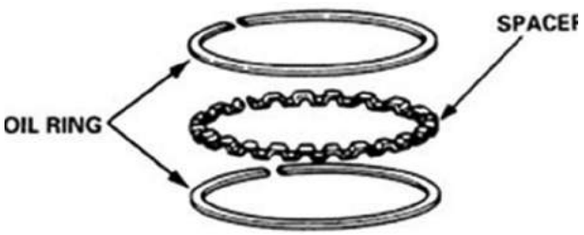
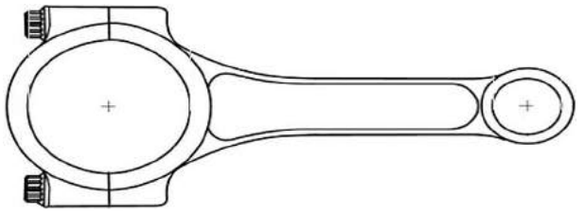


Figure 5.3.7.4(b)(ii) Oil Scrapper Ring

5.3.8 Connecting Rod

It interconnects the piston and the crankshaft and transmits the gas forces from the piston to the crankshaft. The two ends of the connecting rod are called as small end and the big end. Small end is connected to the piston by gudgeon pin and the big end is connected to the crankshaft by crank pin. Connecting rod is made up of Forged steel.



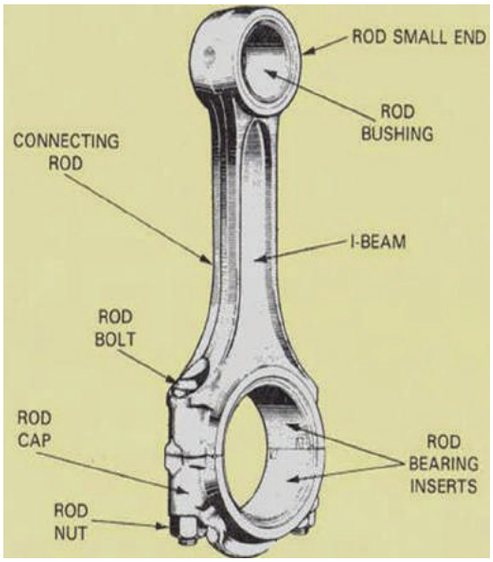


Figure 5.3.8 Connecting Rod

5.3.8.1 Piston, connecting rod and their connection procedures

The engine piston and connecting rod assembly is the most essential arrangement for operating any engine. For connecting the piston and connecting rod piston pin is used. Piston pin is connected with piston and connecting rod based on the three types as indicated below.

a. Fixed Type

B. Semi Floating Type

C. Full Floating Type

The above connecting procedures vary depends upon the torque and power produced from the engine. Piston pin connecting procedures shown in Figure 5.3.8.1.

5.3.8.1(a) *Fixed type:*

In this type the piston and connecting rod are connected with the piston pin by the fixed set of screw inside the piston pin boss for avoiding release of piston pin from its connection. For this purpose, the small end of connecting rod is positioned on centre of the piston pin for attaining the reciprocating motion.

5.3.8.1(b) Semi floating type:

In semi floating type of connection there is a split shaped arrangement in the small end of the connecting rod and it looks like a clamp. This clamp shaped portion is kept with the help of a bolt and nut to avoid removal of piston pin from it. There is a groove at the centre of the piston pin which prevents the pin to not to come out from the clamp. The two ends of the pin are connected

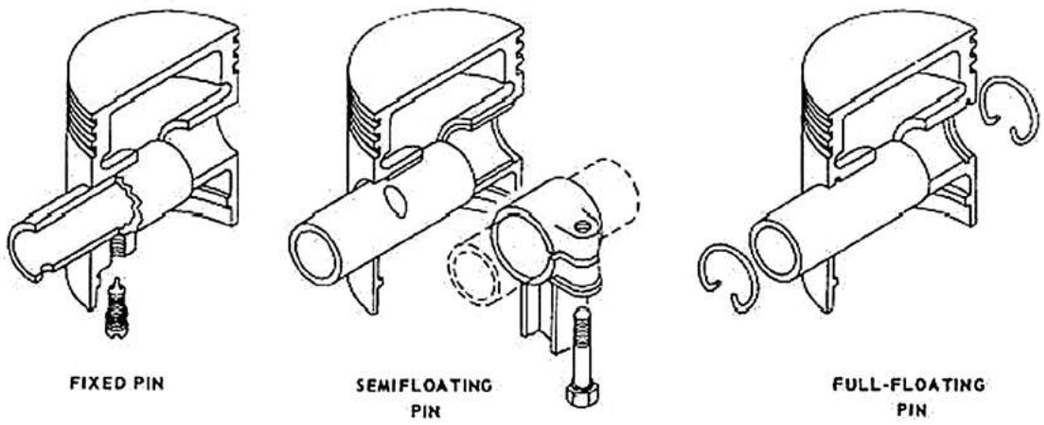


Fig 5.3.8.1 Piston Pin Fixing Method

with the help of the piston pin boss bearing and arrange to be movable within the pin.

5.3.8.1(c) Full floating type:

In this type the connection method of piston pin is designed in a simple way with no much difficulty. During the engine operation for avoiding damage on cylinder wall by the rubbing of piston pin, two circlips were attached with the piston pin boss. In this type, the piston pin is connected at the small end of the connecting rod and piston pin boss and allowed to float (move) easily with in the boss. Hence it is called as full floating type.

5.3.9 Crank Shaft

It converts the reciprocating motion of the piston into useful rotary motion of the output shaft. The crankshaft is enclosed in a crankcase and it is made up of Cast steel.

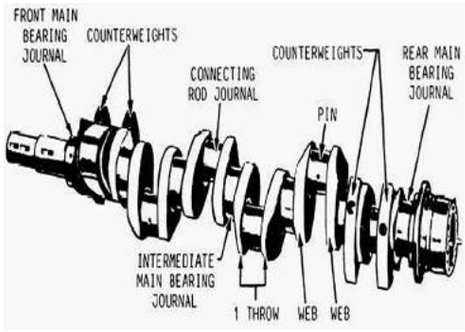


Figure 5.3.9(a) Crank Shaft

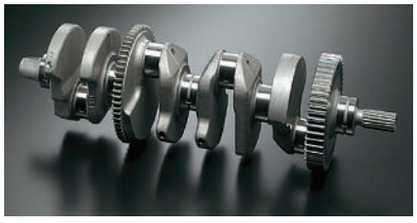


Figure 5.3.9(b) Crank Shaft

5.3.10 Vibration Damper

The power impulses of an engine result in torsional vibration in the crankshaft. If this torsional vibration were not reduced, the crankshaft might break. To avoid this, a vibration damper is mounted on the front of the crankshaft and it controls this vibration. Also a pulley is attached to the vibration damper to drive the fan.

Figure 5.3.10(a) Vibration Damper

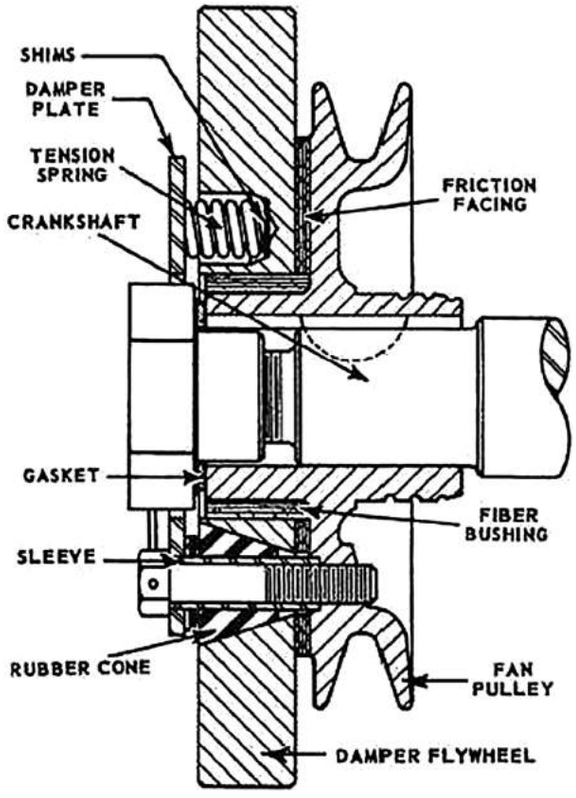
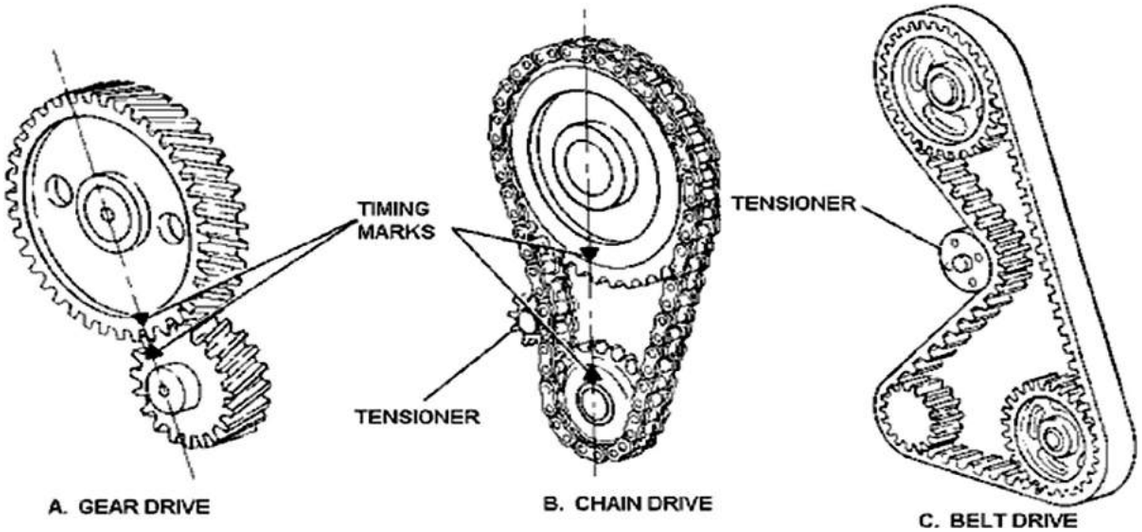
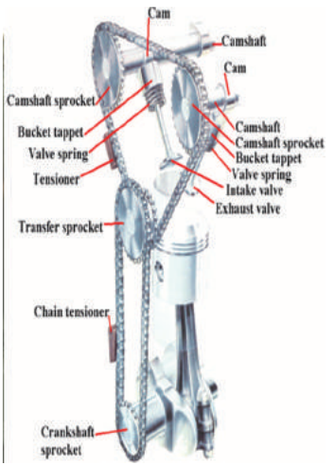


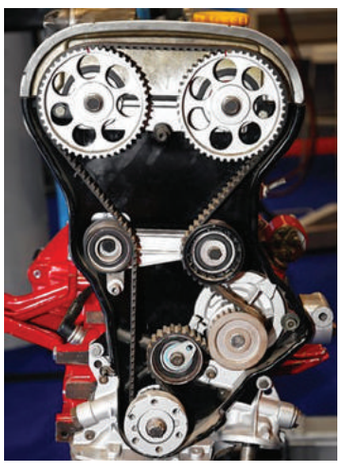
Figure 5.3.10(b) Schematic of Vibration Damper

5.3.11 Timing Gear

Timing gear is used to synchroinse the crankshaft and camshaft. The number of







A. Gear Drive **B. Chain Drive** **C. Belt Drive**

Fig 5.3.11(a, b, c) Timing Gear with Various Drive

teeth in camshaft is always twice the number of teeth in crankshaft. Hence, camshaft will always rotate at half the speed of the crankshaft. Timing mark will be marked in the timing gear. This corresponds to first cylinder TDC position. The marks are properly aligned at the time of engine assembly during manufacturing. This will operate the valve at proper time. If the distance between the crankshaft and camshaft is more, then they are connected by timing chain or by timing belt. Timing Gear with Various Drive shown in Figure 5.3.11(a, b, c)

5.3.12 Cam shaft

For obtaining power from the engine, the processes such as valve opening and closing, supplying the air fuel mixture at the appropriate timings and producing spark in the spark plug in order to ignite the air fuel mixture should be done correctly. For performing this type of operation a component called as cam shaft is used., The cams in the cam shaft are designed in such a way to rotate for opening and closing the valves by the cam shaft according to the valve timing and firing order of the engine. In addition to this, eccentric arrangement in the

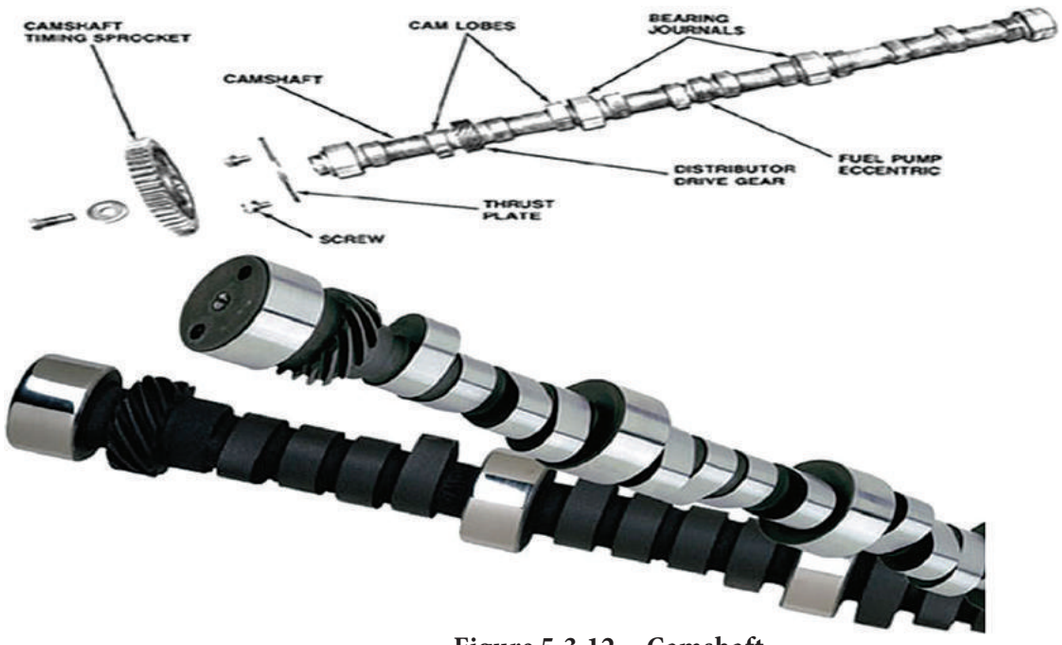


Figure 5.3.12 Camshaft

cam shaft performs the function of actuating the petrol pump and also the skew gear arrangement which is required for operating the oil pump. The timing gear is fitted at the edge of the cam shaft. This gear arrangement is placed in the cylinder block. This gear is made up of special steel for avoiding wear and tear. Cam shaft is actuated by this timing gear with the help of crank shaft. Cam shaft rotates always at half the speed of crank shaft rotation.

5.3.13 Valve

In the engines (generally in four stroke engines) valves are used for supplying enough air fuel mixture into the combustion chamber for combustion and for expelling the burned gases to the exhaust by opening and closing of ports in the engine. There are two valves namely intake and exhaust valves present in the engines. These valves are made up of nickel, chromium alloy steel or silicon chromium alloy steel. The head of the intake valve is generally larger in size than the exhaust valve. These valves are made up of the process called drop forging. In the present days, exhaust valves are produced by austenitic steel. Generally poppet valves are used in present engines.

5.3.13.1 Methods of operating the valves:

In the engine, operating mechanism of the valve varies with the position of the valve arrangements. Valves are placed on the cylinder head in such a way that the valve is moved downwards to open the ports. In another system, valve is placed at the cylinder head in such a way to move upwards to open the ports. Valve mechanisms are generally classified into,

a. Over head poppet valve mechanism
b. Straight poppet valve mechanism

a) Over head poppet valve mechanism:

Construction

This consists of two moving parts, namely push rod and rocker arm. Cam in the can shaft is always in touch with the tappet. One end of the push rod is in contact with tappet and other end with the rocker arm. The other end of

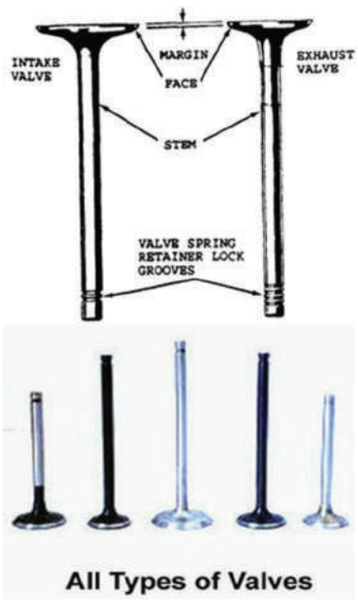


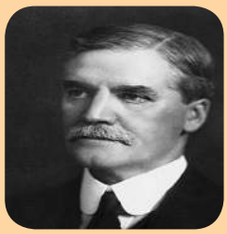
Figure 5.3.13(a) Valves

the rocker arm is made in contact with the valve stem. Rocker arm on the rocker shaft is placed in such a way that it could easily moved up and down. Valves are placed in the valve guides on the cylinder head. Valves are seated properly with the help of valve spring and spring lock.

Operation

When the engine runs, the crank shaft rotates. As the crank shaft is connected with the cam shaft with the help of the timing gear and chain arrangement the cam shaft rotates now. As the cam shaft rotates, the cam present on the cam shaft also rotates. Once the cam rotates, the tappet (placed on the cam) starts to move up and down depends on the rotation of the cam. Due to this action, the push rod which is in contact with the tappet starts to move up and down. This movement of the push rod lifts one end of the rocker arm upwards. As the rocker arm is fitted with rocker shaft, the other end of the rocker arm moves down towards valve stem due to the lift of the arm end at the push rod side. Due to this valve moves downwards and opens the port. By repeating the cam shaft rotation, tappet, push rod and rocker arm, both inlet and exhaust valves open and close for inducting the charge and expelling the hot gases.

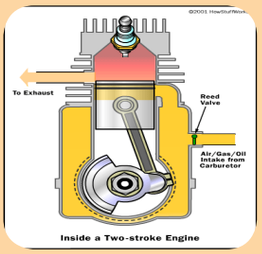
TWO STROKE ENGINE



Sir Dugald Clerk:

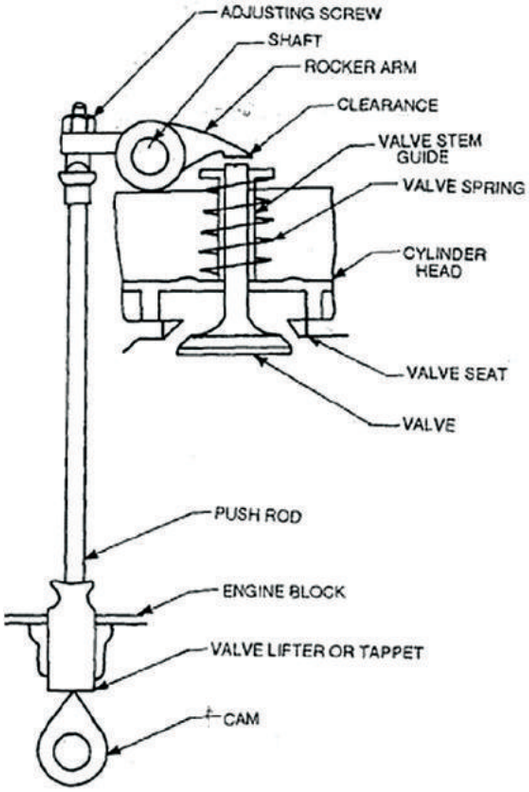
Sir Dugald C lerk (1854, Glasgow – 1932, Ewhurst, S urrey) was a Scottish engineer who designed the world' s first successful two-stroke engine in 1878 and patented it in England in 1881.

He was a graduate of Anderson's University in Glasgow (now the University of S trathclyde), and Yorkshire College, Leeds (now the University of Leeds). He formed the intellectual property firm with George Croydon Marks, called Marks & C lerk. He was knighted on 24 August 1917.

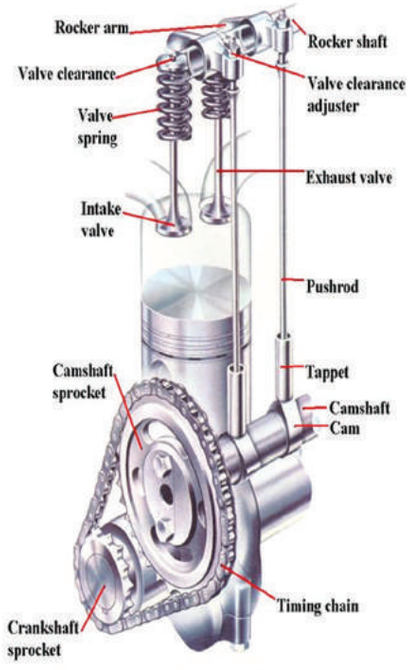


Dugald C lerk was born in Glasgow on 31 March 1854, the son of Donald Clerk a machinist and his wife, Martha Symington. He was privately tutored thenapprenticed to the firm of Messrs H O Robinson & Co in Glasgow.

From 1871 to 1876 he went to Anderson College in Glasgow studying engineering then to the Yorkshire College of Science in Leeds. In the First World War he was Director of Engineering Research for the Admiralty.



(a)



(b)

Figure 5.3.13(b) Over head Poppet Valve Mechanism

b) Straight Poppet Valve Mechanism:

Construction

In this mechanism, all the components of the over head valve except push rod, rocker arm were used. Cam on cam shaft touches tappet. Tappet directly touches valve stem. The valve is fitted with the help of valve spring and the spring lock.

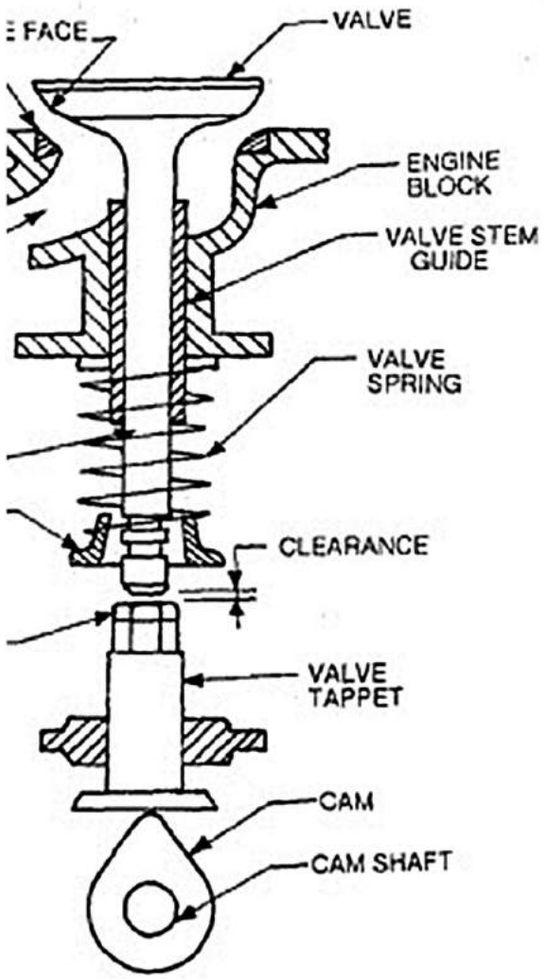


Figure 5.3.13(c) Straight Poppet Valve Mechanism

Operation

When the engine is started the flywheel rotates and the crank shaft starts to rotate. As the crank shaft and cam shaft are connected

by the timing gear and chain the cam shaft rotates. By the rotation of cam shaft the tappet started to move upwards. As the tappet is directly in contact with the valve stem when the tappet moves upwards the valve stem due to the lift of the tappet moves upwards and opens the port. By repeating the cam shaft rotation and tappet movement both inlet and exhaust valves open and close for inducting the charge and expelling the hot gases.

5.3.14 *Manifold*

Manifolds are the passages through which the air or air fuel mixture enters into the combustion chamber and exhaust gases from the combustion chamber are expelled out. The manifold are of two types they are,

a) Inlet Manifold

b) Exhaust Manifold

a) Inlet Manifold

Inlet manifold is used to pass the air from the filter of the diesel engine or air fuel mixture from carburetor of the petrol engine to the combustion chambers of all the cylinders. This intake manifold is generally made of cast iron. This is fitted at the top of the cylinder head.

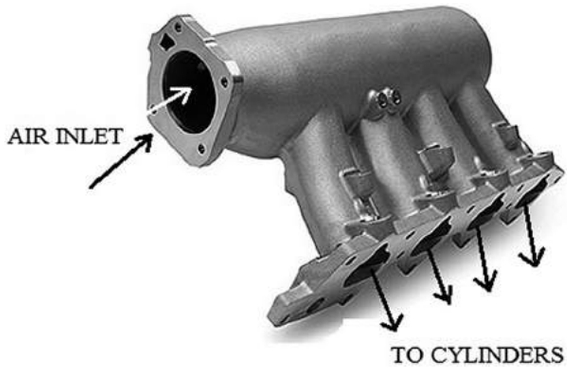


Figure 5.3.14(a) Inlet Manifold

b) Exhaust Manifold

This exhaust manifold is used to transmit the exhaust gases from the cylinder to the silencer. This is fitted between the cylinder head and silencer. This is made of cast iron.

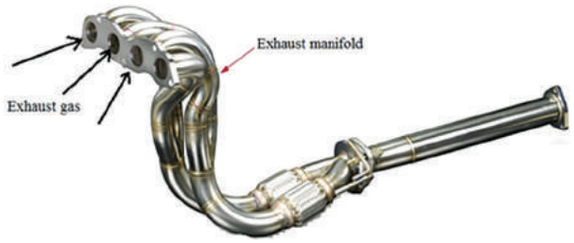
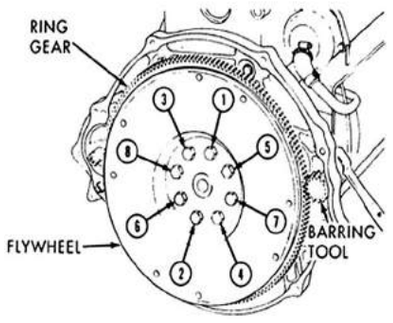


Figure 5.3.14(b) Exhaust Manifold

5.3.15 *Flywheel*

This is the important component of the engine. This arrangement is used for storing the energy and releasing the energy. It is used to rotate the crankshaft continuously from the initial condition due to its inertia. This is fitted at the end of the crankshaft. It



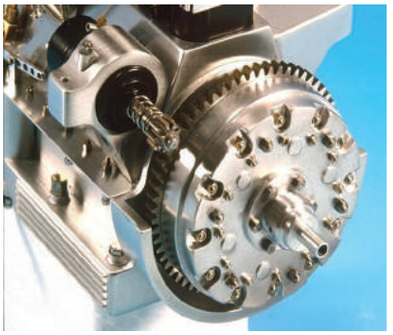


Figure 5.3.15 Flywheel

stores the power during expansion stroke and releases the energy during other strokes. It helps crank shaft to rotate continuously. The flywheel of any engine is generally made of cast iron or brass steel. Ring gear is situated at the periphery of the flywheel. This ring gear is in mesh with the pinion gear of the start motor which is used to start the engine.

5.3.16 Silencer

After the power stroke of the engine the exhaust gases get expanded and expelled through the exhaust manifold. During the exhaust process when the gases are passed through exhaust manifold, due to pressure differential huge noise is produced. This leads to noise pollution. In order to reduce the noise pollution and to operate the engine in smooth condition silencer is used. Silencer acts as resistant for noise and converts the sound energy into heat. Fibre glass is generally used as the insulation material inside the silencer. Chambered, turbo, straight flow are the types of silencer used in automobile.

Figure 5.3.16 Silencer

5.4 FOUR STROKE PETROL ENGINE

Engine running with petrol as a fuel is called as petrol engine. If a power stroke is obtained once in every four stroke of piston (TDC to BDC / BDC to TDC), then the engine is said to be four stroke petrol engine.

Construction

The figure shows the construction of a single cylinder petrol engine. In this the reciprocating motion of a cylinder is converted into rotary motion of crankshaft with the help of connecting rod. One end of connecting rod is connected to piston and another end it is connected to crankshaft. In crankshaft, flywheel is attached at one end and vibration damper, fan belt pulley is attached at the other end. Intake valve, exhaust valve, spark plug is mounted above the top of the cylinder. The fresh air fuel mixture is inducted through intake valve and the burnt gases are sent out through exhaust valve. The opening and closing of valve are made by camshaft. The camshaft and crankshaft are connected by means of timing gear. The four stroke petrol engine is shown in Figure 5.4.

In any internal combustion engine, the following definite sequence of events called strokes namely

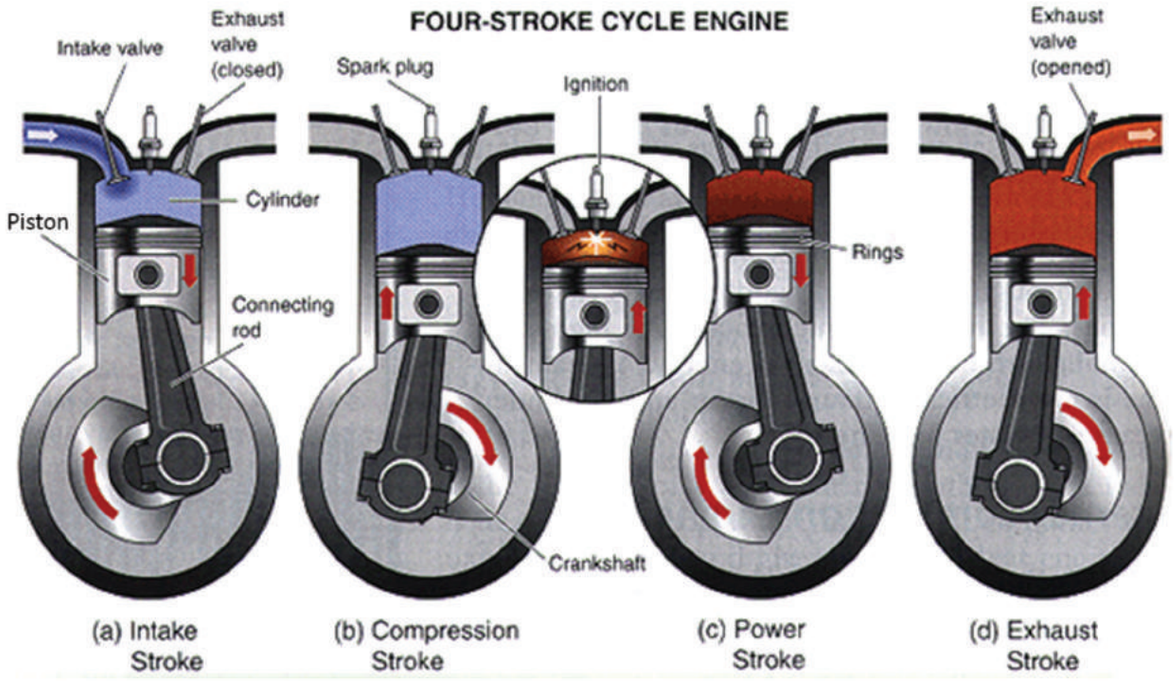


Figure 5.4 Working of Four Stroke Petrol Engine

a. Suction Stroke,

B. Compression Stroke,

C. Power Stroke And

D. Exhaust Stroke

The above four strokes will form a cycle. If the cycle of operations is completed in four strokes of the piston or two revolutions of the crankshaft or one revolution of the camshaft, then it is called as a four-stroke engine.

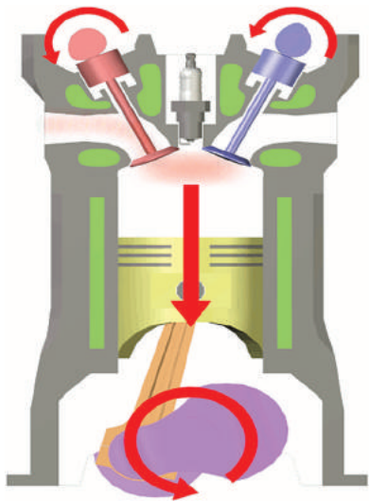


Figure 5.4(a)

a) Suction Stroke

During the suction stroke, the piston moves downward from Top Dead Centre to Bottom Dead Centre. The intake valve is open and exhaust valve is closed. This downward movement of the piston produces a partial void, or vacuum, in the cylinder, and air – fuel mixture rushes into the cylinder through the opened intake valve.

b) Compression Stroke

The charge taken into the cylinder during the suction stroke is compressed by the return stroke of the piston. The piston travels from bottom dead centre to top dead centre. During compression stroke both inlet and exhaust valves are in closed position.

The mixture which fills the entire cylinder volume is now compressed into the clearance volume. At the end of the compression stroke the mixture is ignited with the help of a spark plug located on the cylinder head.

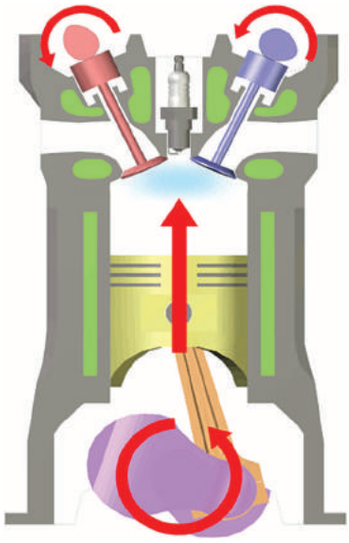


Figure 5.4(b)

c) Power Stroke

Rapid combustion of the fuel releases heat and there is an increases in the temperature inside the combustion chamber. The increased temperature of the gases also produces an increased pressure in the combustion chamber. The high pressure of the gases acting on the face of the piston causes the piston to move from TDC to BDC. This reciprocating motion is converted into the rotary motion of crankshaft through connecting rod. During power stroke, both inlet and exhaust valves are in closed condition. As the piston travels downward, there will be drop in combustion pressure and temperature as the volume increases. At the end of power stroke, exhaust stroke will be started.

d) Exhaust Stroke

At the end of power stroke, exhaust stroke will be started. During this stroke, the exhaust vavle will be open and the inlet value will be closed. When the piston from BDC to TDC, the burnt air fuel mixture is sent out through exhaust valve.

At the end of exhaust stroke, the intake stroke of the next cycle starts and this keep the engine in running condition.

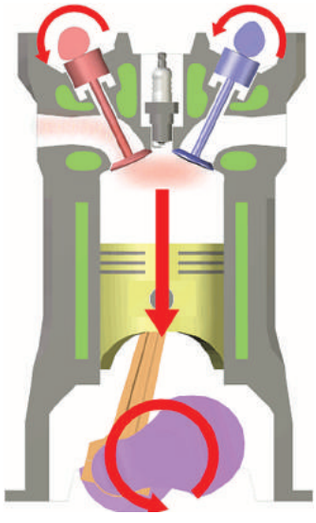


Figure 5.4(c)

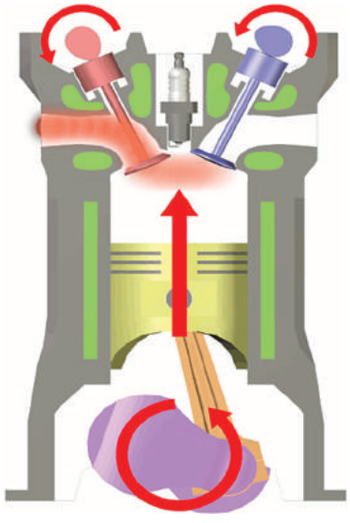


Figure 5.4(d)

Scavenging

At the end of exhaust stroke the exhaust valve is open and at the start of intake stroke, the inlet valve is kept open. At this time, fresh air – fuel mixture for the next cycle will pushes out the exhaust gases of the previous cycle. Thus, Scavenging is the process of removal of exhaust gases by blowing in fresh air.

Valve Over Lap

At the end of exhaust stroke the exhaust valve is open and at the start of intake stroke, the inlet valve is kept open. The time duration in which both the valves are kept open is called as valve overlap.

Advantages

- ❒ Fuel economy
- ❒ Lubrication oil Consumption is less
- ❒ Can be used in different vehicle
- ❒ Thermal Efficiency is high
- ❒ Volumetric Efficiency is high
- ❒ Low wear and tear

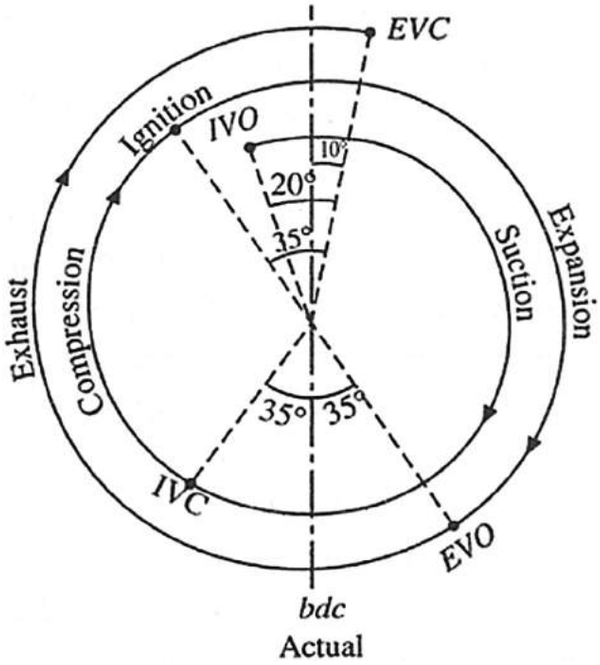
Disadvantages

- ❒ Number of parts are more
- ❒ Mechanical Efficiency is low
- ❒ Maintenance cost is more
- ❒ Complicated design
- ❒ More space is required

e) Valve Timing Diagram For A Four Stroke Petrol Engine

In a four stroke engine, an engine cycle to produce power is done on every two revolution of crankshaft. Theoretically it may be assumed that the valves open and close and the spark (or injection of fuel)occurs at the engine dead centres. However, in actual operation, the valves do not operate at dead centre positions but operate some degree on either side of the dead centres. The opening occurs earlier and the exhaust continues even at later crank angles. The ignition is also timed to occur in advance of the completion of compression stroke.

The timings of this sequence of events can be shown graphically in terms of crank angles from dead centre position. This diagram is known as valve timing diagram. It is shown in figure 5.4(e).



TDC = Top dead centre, BDC = Bottom dead centre, IVO = Inlet valve opens IVC = Inlet valve closes, EVO = Exhaust valve opens, EVC = Exhaust valve closes

Figure 5.4(e) Valve Timing Diagram For Four Stroke Petrol Engine

Intake valve timing:

The inlet valve will be open 10° to 30° before TDC (i.e during exhaust stroke), remain open during suction stroke and closes at 30° to 40° after BDC (i.e. during compression stroke). This gives the inlet valve a total opening of 220° of crankshaft rotation. This will ensure the full induction of fresh charge in cylinder during suction stroke.

After the inlet valve closed in the compression stroke, the air fuel mixture is compressed by the piston. This will increase the pressure and temperature in the cylinder.

With both intake and exhaust valve are in closed condition, the spark will be introduced by the ignition system through spark plug at 20° to 40° before TDC. These will initialise the combustion and the air fuel mixture will be burned in the combustion chamber. Thus the chemical energy of the fuel is converted into heat energy.

Exhaust valve timing:

The exhaust valve opens at 30° to 60° before the completion of power stroke. Due to this, the gases have an outlet for expansion, which removes the greater part of the burnt gases. The valves remain open during open during the exhaust stroke and it is closed at 20° after TDC, during the intake stroke of the next cycle.

Scavenaging

The inlet valve will be open 10° to 30° before TDC and at the same time the exhaust valve is already in the open condition. This will make the fresh charge to push out the burnt out gases from the cylinder. Scavenging will be made till 20°After TDC.

Valve over Lap

The portion of the operating cycle in which, when the piston is passing TDC (top dead centre) on the exhaust stroke, both the intake and exhaust valves are open. It is usually expressed in degrees of crankshaft rotation. Valve overlap is necessary for the efficient flow of gases in and out of the combustion chamber.

5.5 TWO STROKE PETROL ENGINE

The two stroke cycle engine completes one power stroke in one revolution of a crankshaft.

Construction

Inside the engine, the small end of the connecting rod is connected to the piston with the help of piston pin. The big end of the connecting rod is connected to the crankpin of the crankshaft. When the crankshaft rotates, the piston will reciprocate on the cylinder and vice versa. There is no inlet and exhaust valves as in case of four-stroke engine but consists of the inlet port (IP), an exhaust port (EP) and transfer port (TP). The fresh charge enters into the crankcase through inlet port. Transfer port is used to transfer the compressed charge from crankcase to the cylinder. Exhaust port is used to transfer the burnt gases out of the engine. The movement of the piston will open and closes the ports. A spark plug will be placed in the engine head.

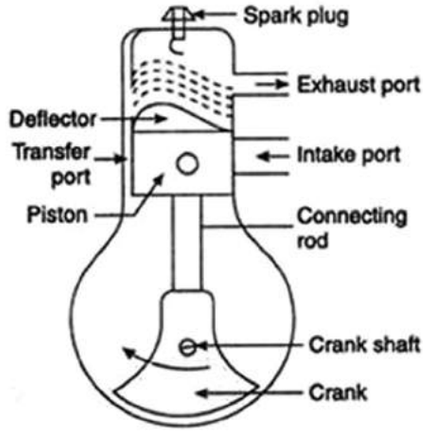


Figure 5.5(a) Two Stroke Petrol Engine

Working principle

In two stroke engine, all the four events namely suction, compression, power and exhaust cannot be distinctly identified. For each revolution of crankshaft or for every two stroke of piston, a working / power stroke is obtained. Hence the cycle of operation can be explained with two stroke of piston movement namely Upward stroke and Downward stroke.

Upward Stroke

During upward stroke, the piston moves from BDC to TDC. It expels the burnt gases to the atmosphere through the exhaust port. It closes the transfer port and then the exhaust port. Then it compresses the already inducted charge (air-fuel mixture) in the combustion chamber of the cylinder. At the end of the upward stroke, the ignition of the fresh charge is takes place by the spark plug.

Further, the upward movement of the piston a partial vacuum is created in the crankcase and this allows the entry of the fresh charge into the crankcase through uncovered inlet port. The exhaust port and the inlet port remains covered when the piston at the TDC.

Downward stroke:

As soon as the combustion of the fresh charge takes place, a large amount of the hot

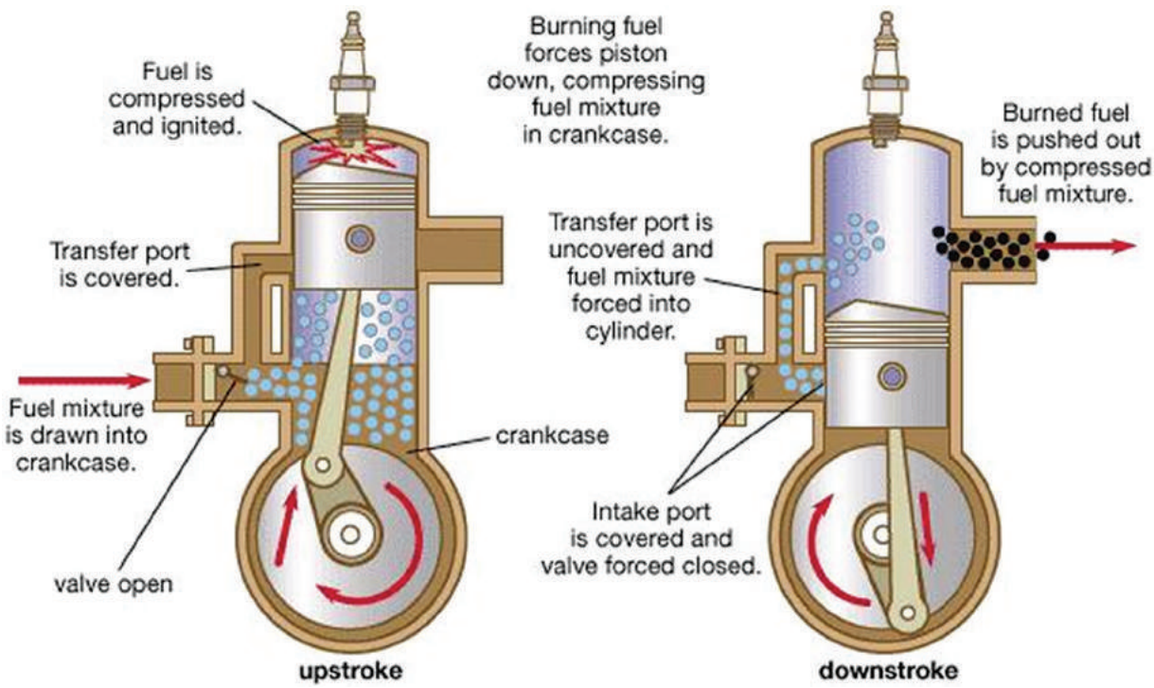


Figure 5.5(b) Upword and Downword Stroke of Two Stroke Petrol Engine

gases is produced and this exerts a very high pressure force on the top of the piston. Due to this high pressure force, the piston moves downward and rotates the crankshaft and does useful work.

During this stroke the inlet port is covered by the piston and the new charge is compressed in the crankcase due to the downward movement of piston.

Further downward movement of the piston uncovers first the exhaust and the exhaust starts through the exhaust port.

Further downward movement of the piston uncovers port the transfer port and the charge through it is forced into the cylinder.

The charge strikes the deflector on the piston crown, rises to the top of the cylinder and pushes out most of the exhaust gases.

The piston is now at BDC position. The cylinder is completely filled with the fresh charge but it is somewhat diluted with the exhaust gases.

Finally the cycle event is then repeated and the power stroke is obtained for the every single revolution of the crankshaft.

Reason for less power in two stroke engine

- The fresh air fuel charge is mixed with exhaust gas and sent out before combustion
- The charge is diluted by the burnt gases due to incomplete scavenging.
- Combustion is improper as lubrication oil is mixed with fresh charge
- Volumetric efficiency of the engine is low.

Advantages:

- Smoother in operation
- It is simpler in construction and mechanism.

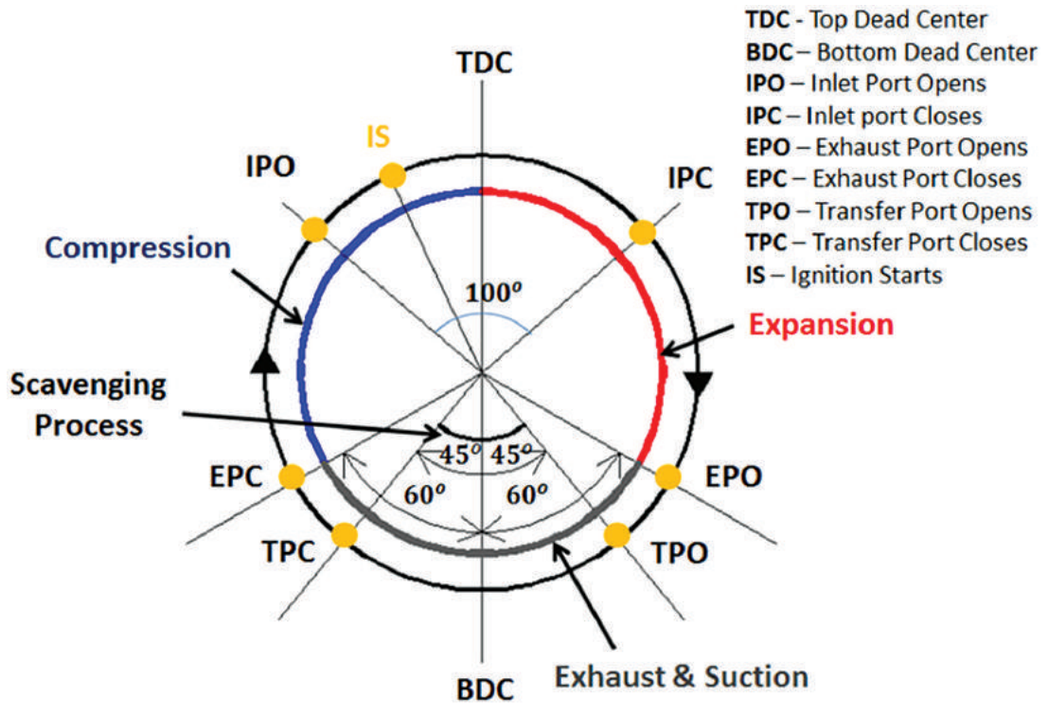


Figure 5.5(c) Port Timing diagram of Two Stroke Petrol Engine

- ❒ Power developed by the two stroke engine is twice that developed by the four stroke engine for the same engine speed and volume.
- ❒ Cost of the engine is less since less no. of parts
- ❒ Less maintenance since fewer spare parts due to its simple design
- ❒ Low manufacturing cost
- ❒ It has high mechanical efficiency.
- ❒ A two stroke engine is more compact, light and requires less space

Disadvantages:

- ❒ It has high fuel consumption
- ❒ It does more consumption of the lubricating oil.
- ❒ Not suitable for heavy vehicles
- ❒ There is a greater wear and tear of moving parts.
- ❒ Thermal efficiency is less than four stroke engine.
- ❒ The charge is diluted by the burnt gases due to incomplete scavenging.
- ❒ It produces greater noise.

5.6 COMPARISON OF TWO STROKE AND FOUR STROKE ENGINE

The two stroke and four stroke engine are compared and their differences are given below (Table 5.6).

Table 5.6 Differnce Between Two Stroke and Four Stroke Engine

S.no	Two Stroke Engine	Four Stroke Engine
1.	It has one revolution of crankshaft within one power stroke.	It has two revolution of crankshaft between one power strokes.
2.	2 strokes are required to complete a cycle.	4 strokes are required to complete a cycle.
3.	It requires lighter flywheel because it generates more balanced force due to one revolution for one power stroke.	It requires heavy flywheel because it generates unbalance force due to two revolutions for one power stroke.
4.	One non-power stroke in a cycle	Three non-power stroke in a cycle
5.	Engines are lighter	Engines are heavier
6.	Engine construction is simple.	The Engine construction is a bit complicated
7.	Ports are used for inlet and outlet of air fuel mixture	Valves are used for inlet and outlet of air fuel mixture
8.	Ports are opened and closed by piston movements	Valves are operated by separate valve operating mechanism.
9.	Less no. of moving parts	More no. of moving parts
10.	Volumetric efficiency is less	Volumetric efficiency is more
11.	Thermal efficiency is less	Thermal efficiency is more
12.	Two stroke engines are less efficient and generate more smoke.	Four stroke engines are more efficient and generate less smoke.

S.no	Two Stroke Engine	Four Stroke Engine
13.	These engines are easy to manufacture.	These engines are comparatively hard to manufacture.
14.	More wear and tear occurs	Less wear and tear occurs.
15.	A part of air fresh air fuel mixture mixes with the exhaust gas, hence less power.	Burnt out gases is not mixed with fresh charge, hence more power.
16.	Fuel consumption is more.	Fuel consumption is less
17.	High power-to-weight ratio	Less power-to-weight ratio
18.	More noise	Less noise
19.	Air cooled engine.	Air / water cooled engine.
20.	Works based on Clerk cycle.	Works based on otto / diesel cycle
21.	Easy lubrication due to lubrication oil mix with the fuel.	Complex lubrication mechanism
22.	Consumption of lubrication oil is more because some oil burns with fuel.	Consumption of lubrication oil is less
23.	Less weight	More weight
24.	Used in scooter, mopeds, auto rickwsaw.	Used in motor cycles, autoricksaw, car, bus, lorry, trucks, tractors etc.

5.7 FOUR STROKE DIESEL ENGINE

The engine which uses diesel as a fuel is called as diesel engine. The compression ratio for diesel engine is higher and it will be ranging from 16 : 1 to 20 : 1. The compression ratio for a petrol engine is 10:1. During suction stroke, the air alone is inducted. The fuel is pressured and distributed to various cylinders through the fuel injection pump. Diesel injector will be located in cylinder head for injecting the diesel fuel at high pressure. There is no spark plug. All the remaining parts are similar to petrol engine.

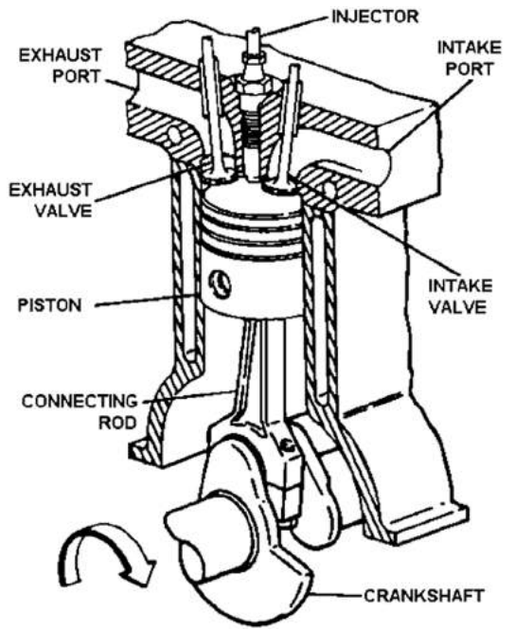


Figure 5.7(a) Four Stroke Diesel Engine

Construction

The construction of a single cylinder diesel engine is shown in above figure. The reciprocating motion of a piston is converted into rotary motion of a crankshaft through connecting rod. The piston and the crankshaft are connected by means of a connecting rod. The flywheel is attached to the one end of the

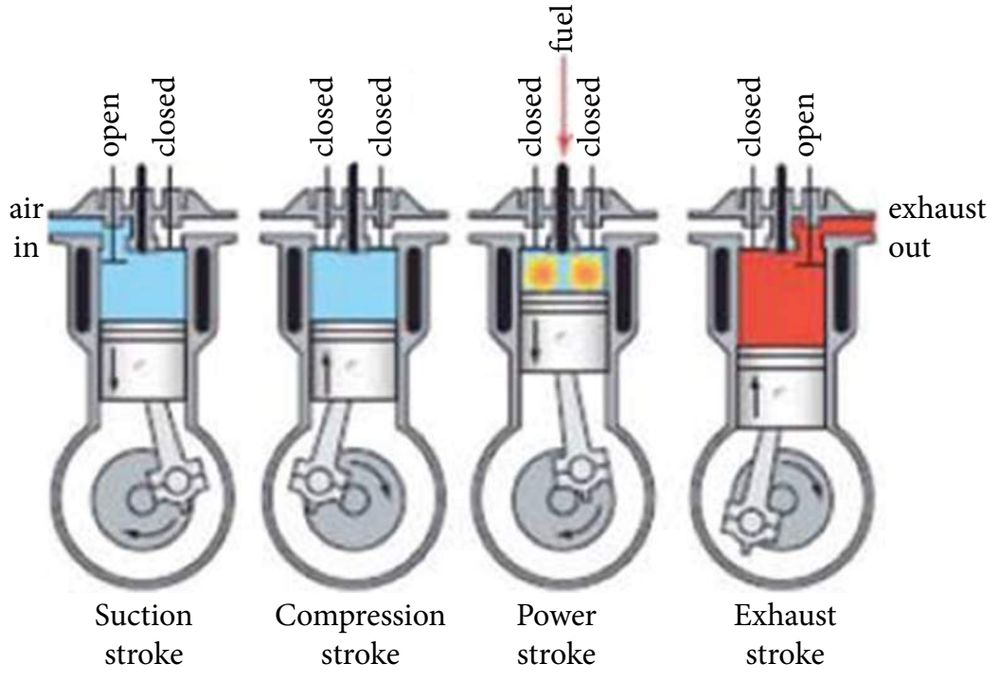


Figure 5.7(b) Working of Four Stroke Diesel Engine

crankshaft and on another side a pulley is attached to it. Inlet valve, exhaust valve and fuel injector are located on the engine head. The inlet valve will allow the air inside the cylinder, the fuel injector will inject the fuel and the exhaust valve will sent the burnt gases to the atmosphere. The valves are operated by the camshaft. The camshaft is driven by crankshaft through timing gear.

The following sequence of events will occur continuously for the engine operation. The figure shows the sequence of events

- ❒ Air alone induced inside the cylinder
- ❒ Air alone compressed
- ❒ Finely automised diesel fuel is injected onto the compressed air followed by combustion
- ❒ Burnt gases are let out from the cylinder.

The above sequence of operation forms a cycle and for each operation, a piston stroke is required. Thus for four operation, four strokes are required and hence it is called as four stroke engine. The four strokes are namely called

i. Suction Stroke
Ii. Compression Stroke
Iii. Power Stroke
Iv. Exhaust Stroke

i) Suction Stroke

In this stroke, the piston moves down from the top dead centre towards the bottom dead centre. The inlet valve opens and the air is drawn into the cylinder due to the vacuum created inside the cylinder. To fill the vacuum, the air is entered inside the cylinder. The inlet valve closes at the end of the stroke and the exhaust valve remains closed during this stroke.

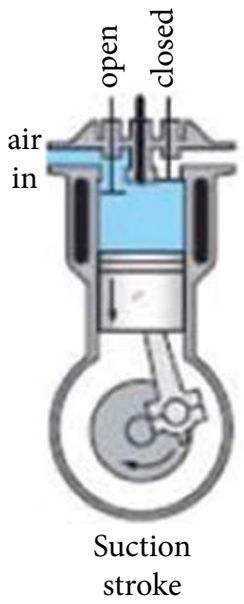


Figure 5.7.1(a) Suction Stroke

ii) Compression Stroke

In this stroke, the piston moves up from bottom dead centre to top dead centre. During this stroke, both inlet and exhaust valves are closed. The air drawn into the cylinder during suction stroke is entrapped inside the cylinder and compressed due to upward movement of the piston. The fuel is injected at the end of the compression stroke by the injector and the fuel ignites.

Figure 5.7.1(b) Compression Stroke

iii) Power Stroke

The hot gases which are produced due to ignition of fuel during compression stroke and compressed air now expand adiabatically, in the cylinder pushing the piston down towards the BDC. This downward movement of the piston is converted into rotary motion of the crankshaft and hence work is done. During expansion, the pressure and the temperature reduce. In this stroke, both inlet and exhaust valve remain closed.

Figure 5.7.1(c) Power Stroke

iv) Exhaust Stroke

At the end of the power stroke, exhaust stroke will start. In this stroke, the piston again moves upward. The exhaust valve opens, while inlet valve is closed. A greater part of the burnt fuel gases escapes due to their own expansion. The upward movement of the piston pushes the remaining gases out through the open exhaust valve. At the end of an exhaust stroke, the exhaust valve closes and the cycle is thus completed and suction stroke of next cycle is started.

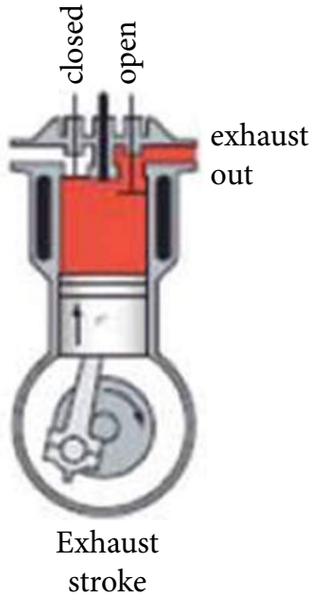


Figure 5.7.1(d) Exhaust Stroke

Scavenging

During the end of exhaust stroke and start of the suction stroke, the inlet valve and exhaust valve will be kept open condition. This will make the fresh charge to push out the burnt out gases from the cylinder and this phenomenon is called as scavenging.

Valve over Lap

The portion of the operating cycle in which both the intake and exhaust valves are kept open is called as valve overlap. It is usually expressed in degrees of crankshaft rotation. Valve overlap is necessary for the efficient flow of gases in and out of the combustion chamber.

Advantages

- ❒ Operating cost is less
- ❒ Lubrication oil consumption is less
- ❒ Can be used in all types of vehicle
- ❒ Thermal Efficiency is high
- ❒ Volumetric Efficiency is high
- ❒ Wear and tear is less

Disadvantages

- ❒ No. of moving parts is more
- ❒ Mechanical Efficiency is low
- ❒ Maintenance cost is more
- ❒ Complicated design
- ❒ More space is required

e) Valve timing diagram of four stroke diesel engine

The valve timing diagram for a four stroke cycle diesel engine is shown in Figure 5.7 (a) below:

In a four stroke diesel engine, an engine cycle to produce power is done on every two revolution of crankshaft. It may be assumed that the valves open and close and injection of fuel occurs at the engine dead centres. However, in actual operation, the valves do not operate at dead centre positions but operate some degree on either side of the dead centres. The opening occurs earlier and the exhaust continues even at later crank angles. The fuel injection is also timed to occur in advance of the completion of compression stroke. The diagram which shows the position of crank of four stroke engine at the beginning and at the end of suction, compression, expansion and exhaust of the engine are called as valve timing diagram. This diagram is known as valve timing diagram.

Inlet valve opening and closing:

In an actual engine, the inlet valve begins to open 10° to 25°before the piston reaches the TDC during the exhaust stroke. This is necessary to ensure that the valve will be fully open when the piston reaches the

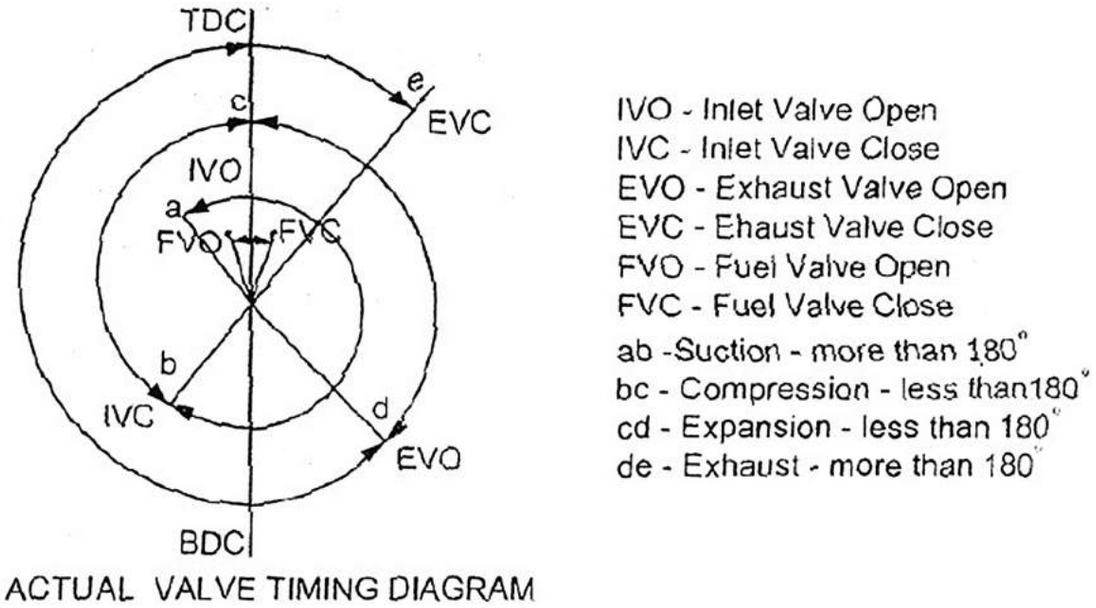


Fig 5.7(a) Valve Timing Diagram of Four Stroke Diesel Engine

TDC. If the inlet valve is allowed to close at BDC, the cylinder would receive less amount of air than its capacity. To avoid this, the inlet valve is kept open for 25°to 45°after the BDC, during the compression stroke. This will ensure the full induction of fresh charge in cylinder during suction stroke.

After the inlet valve closed in the compression stroke, the air is compressed by the upward motion of the piston. This will increase the pressure and temperature inside the cylinder.

With both intake and exhaust valve are in closed condition, the fuel injector will inject the diesel fuel at high pressure at 5° to 10° before TDC. The temperature of the compressed air at the end of compression stroke is sufficient enough to initialise the finely automised diesel fuel for combustion. The air fuel mixture will be burned in the combustion chamber. Thus the chemical energy of the fuel is converted into heat energy. Based on the speed of the engine, the fuel is injected even 25° before TDC.

Exhaust valve timing:

The exhaust valve opens at 30° to 60° before the completion of power stroke. Due to this, the gases have an outlet for expansion, which removes the greater part of the burnt gases. The valves remain open during open during the exhaust stroke and it is closed at 20° after TDC, during the intake stroke of the next cycle.

Scavenging

The inlet valve will be open 10° to 30° before TDC during exhaust stroke and at the same time the exhaust valve is already in the open condition. This will make the fresh charge to push out the burnt out gases from the cylinder. Scavenging will be made till 20° after TDC.

Valve over lap

The portion of the operating cycle in which, when the piston is passing TDC (top dead centre) on the exhaust stroke, both the intake and exhaust valves are open. It is usually expressed in degrees of crankshaft rotation. Valve overlap is necessary for the efficient flow of gases in and out of the combustion chamber. It is will vary with respect to size and configuration of engine.

5.8 TWO STROKE DIESEL ENGINE

When the cycle of operation of engine completes in one revolution of the crankshaft or two stroke of the piston and one power stroke is obtained in each revolution of a crankshaft, then the engine is called as two stroke engine.

Construction

Inside the engine, the small end of the connecting rod is connected to the piston with the help of piston pin. The big end of the connecting rod is connected to the crankpin of the crankshaft. When the crankshaft rotates, the piston will reciprocate on the cylinder and vice versa. There is no inlet and exhaust valves as in case of four-stroke engine but consists of the inlet port (IP), an exhaust port (EP) and transfer port (TP). The fresh charge enters into the crankcase through inlet port. Transfer port is used to transfer the compressed charge from crankcase to the cylinder. Exhaust port is used to transfer the burnt gases out of the engine. The movement of the piston will open and closes the ports. A fuel injector is placed in the engine head.

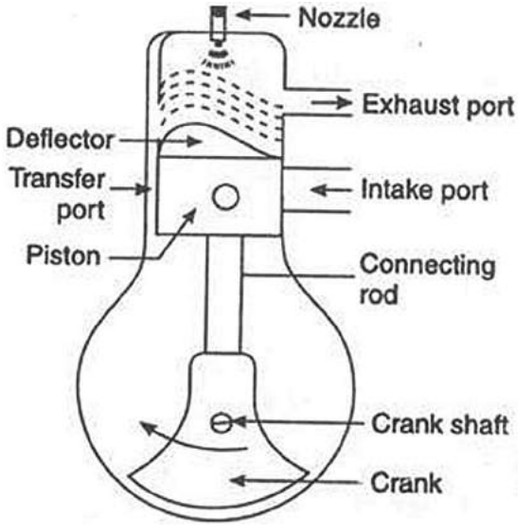


Figure 5.8(a) Two Stroke Diesel Engine

Working principle

In two stroke engine, all the four events namely suction, compression, power and exhaust cannot be distinctly identified. For each revolution of crankshaft or for every two stroke of piston, a working / power stroke is obtained. Hence the cycle of operation can be explained with two stroke of piston movement namely Upward stroke and Downward stroke.

Upward Stroke

During upward stroke, the piston moves from BDC to TDC. It expels the burnt gases to the atmosphere through the exhaust port. It closes the transfer port and then the exhaust port. Then it compresses the already inducted charge (air-fuel mixture) in the combustion chamber of the cylinder. At the end of the upward stroke, the diesel fuel is injected at high pressure through fuel injection nozzle and this will automise the fuel. The temperature of the compressed air is sufficient enough to ignite the diesel and combustion is take place.

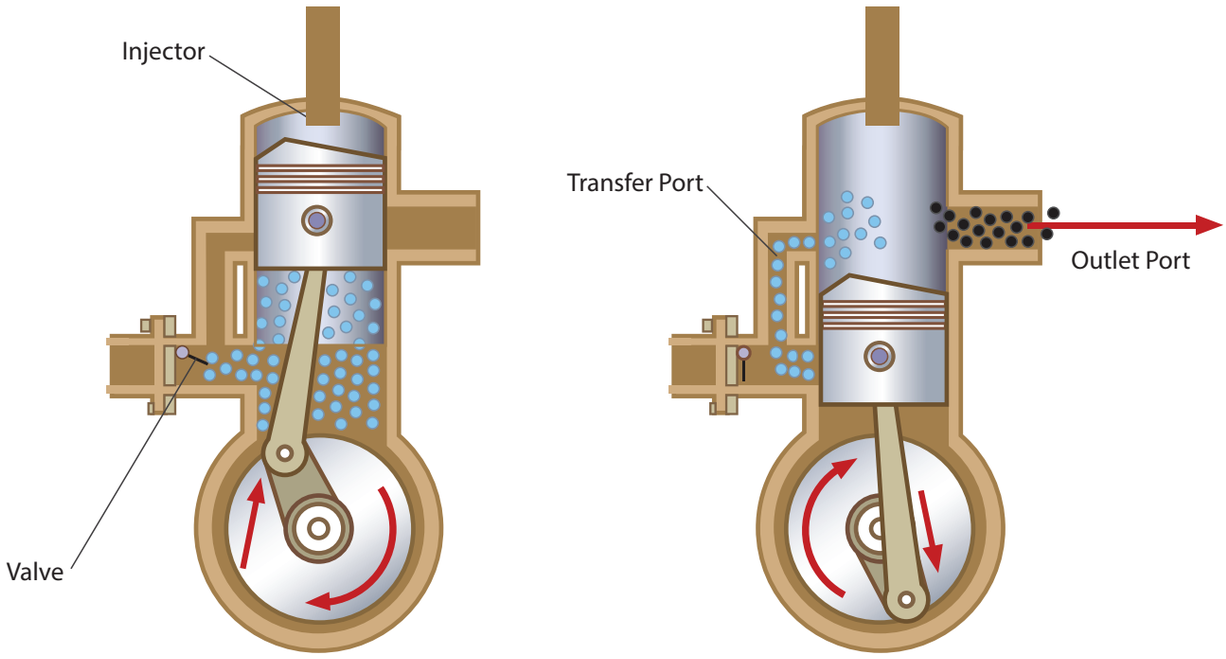


Fig 5.8(b) Upward and Downward Stroke of Two Stroke Diesel Engine

Further, the upward movement of the piston a partial vacuum is created in the crankcase and this allows the entry of the fresh charge into the crankcase through uncovered inlet port. The exhaust port and the inlet port remains covered when the piston at the TDC.

Downward stroke:

As soon as the combustion of the fresh charge takes place, a large amount of the hot gases is produced and this exerts a very high pressure force on the top of the piston. Due to this high pressure force, the piston moves downward and rotates the crankshaft and does useful work.

During this stroke the inlet port is covered by the piston and the new charge is compressed in the crankcase due to the downward movement of piston.

Further downward movement of the piston uncovers first the exhaust and the exhaust starts through the exhaust port.

Further downward movement of the piston uncovers port the transfer port and the fresh air is forced into the cylinder.

The fresh air strikes the deflector on the piston crown, rises to the top of the cylinder and pushes out most of the exhaust gases.

The piston is now at BDC position. The cylinder is completely filled with the fresh charge but it is somewhat diluted with the exhaust gases.

Finally the cycle event is then repeated and the power stroke is obtained for the every single revolution of the crankshaft.

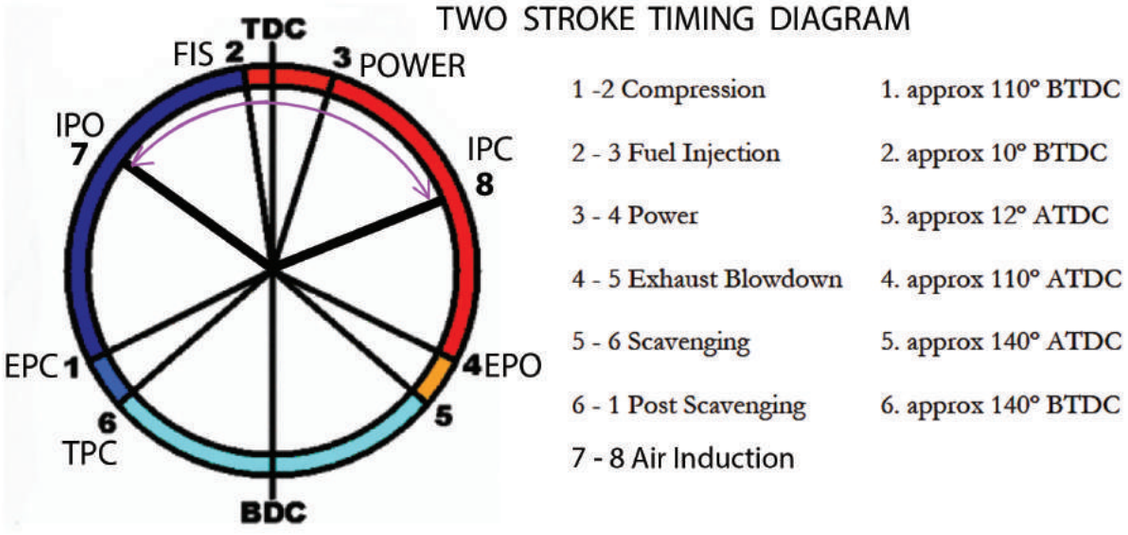


Fig 5.8(c) Port Timing Diagram of Two Stroke Diesel Engine

Student Activity

1. Students should visit the nearby workshops to study the types of petrol and diesel engines, and also to study the purpose of piston, connecting rod, crank shaft, camshaft, timing gear and flywheel.
2. Students should visit the nearby engine service centre and should prepare a sketch of engine block, crank case, cylinder head and gasket.

Glossary

Converted	-	மாற்றம்
Compressed	-	அழுத்துதல்
Combustion	-	எரியூட்டுதல்
Prolonged	-	நீடித்த
Surrounded	-	சுற்றுப்புறம்
Liner	-	உரை
Combustion Chamber	-	எரியும்அறை
Lubrication	-	உயவிடுதல்
Top Dead Centre	-	மேல்நிலை
Bottom Dead Centre	-	கீழ்நிலை

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SAMPLE QUESTIONS

Choose the correct answer:

1. Which material is used for manufacturing cylinder block?
   a) Gray cast iron or aluminum alloy
   b) Cast iron or steel
   c) Brass or steel
2. Which liner has directly contact with cooling water?
   a) Dry liner
   b) Wet liner
   c) None
3. Conecting rod is used to
   a) to connect crank shaft and cylinder head
   b) to connect crank shaft and piston
   c) to connect crank shaft and cylinder block
4. Which type of piston pin is mostly used now a days?
   a) semi floating type
   b) full floating type
   c) fixed type

5. Order of the strokes for getting power.
   a) Exhaust,suction, power, compression
   b) Suction, exhaust power, compression
   c) suction, compression power, exhaust
6. Which is used to open the valve in Engine?
   a) Crank shaft.
   b) Cam shaft
   c) Fly wheel
7. Which liner is does not contact with cooling water?
   a) Dry liner
   b) Wet liner
   c) None
8. Where is vibration Damber located?
   a) In front of the Crank shaft.
   b) Back side of the crank shaft
   c) In front of the Cam shaft.
9. Which indicates cycle of operation engine?
   a) Exhaust, suction, power, compression
   b) Suction, exhaust power, compression
   c) suction, compression power, exhaust
10. Which is used to prevent leakage between cylinder and cylinder head?
    a) Gasket
    b) Oil seal
    c) Dust cover

TLZATG

Answer the following questions:

1. Who is invented Petrol Engine?
2. Who is invented Diesel Engine?
3. Write any 10 important parts of I.C. Engine.
4. What are the two types of cylinder liners?
5. What is the purpose of Gasket?
6. State any five method to control the expansion of the piston due to over heat.
7. Name the types of Piston.
8. What is meant by Vibration Damper?
9. In how many ways Piston and connecting rod are connected? Mention the names.
10. Draw a neat sketch of Over head Puppet Valve mechanism and explain the same.
11. Draw a neat sketch of Straight Puppet mechanism and explain the same.
12. Draw a neat of Four Stroke Petrol Engine and explain the working principle.

Unit 6

Intake, Exhaust System and Combustion Chamber

Contents

TM5J77

Learning Objectives

- To learn about the engine emissions along with its impact on humans and environment.
- To learn about the engine firing procedure.

6.0 INTRODUCTION

In the earth, all the living organisms, animals and human beings are living with the help of oxygen present in nature (or) atmosphere. For producing power and food they use energy obtained from burning the fuel. Human beings use different fuels to get their heat energy according to their needs. In the same way they use heat energy obtained from burning the fuel for operating their automobiles. Human beings use different approaches for burning the fuels to produce energy or power. For attaining such strategies, they using separate systems for transferring fuel from the fuel tank in to combustion chamber. The system used to perform this function is called as the intake system. The exhaust gases produced from the combustion of fuel inside the combustion chamber are sent out of the engine by another system called as the exhaust system.

6.1 EFFECTS OF POLLUTANTS

The exhaust emissions released from the engine combustion chamber are toxic to the human beings and highly pollute the environment. Hence it is advisable to produce less emission from the engines. It can be achieved by burning the fuels completely in the engine combustion chamber. By controlling the pollutants from the automotive engines, the environment can be maintained as clean and all the human beings, animals and all the plants can live peacefully without any diseases. The following are the important pollutant emissions coming out from the internal combustion engines.

1. Carbon Monoxide
2. Nitric Oxide
3. Hydro Carbon
4. Smoke
5. Particulate (solid, liquid pollution)
6. Sulfur Dioxide and etc.,

The following picture and table present the effects of the above pollutants on human beings

In order to reduce the formation of the above hazardous pollutants the fuel must be burnt completely inside the

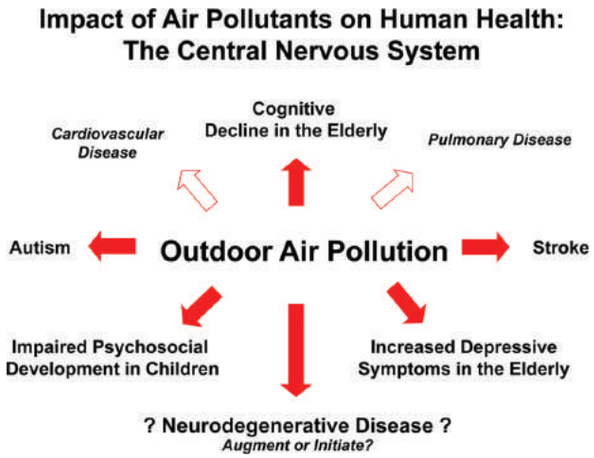

Figure 6.1

Table 6.1 Effects of pollutants

Pollutants	Effects
1. Carbon monoxide	Reduces the oxidation in the blood. It affects the nerves, the heart and the eyes.
2. Nitric oxide	Affects human's cells and blood flow.
3. Hydro carbon	It affects the human eyes.
4. smoke	It affects the human eyes.
5. Particulate matter (solid, liquid pollution)	It leads to cancer, bronchitis and allergy like diseases by inhaling.
6. Sulfur dioxide	It affects human beings and plants.

engine itself in the vehicle. The way of supplying the fuel and air inside the engine combustion chamber plays an important role in achieving complete combustion. The system used for supplying appropriate air and fuel at the appropriate timing inside the combustion chamber of the engine is called as the "intake system". The important components of the engine intake system are

1. Fuel Tank
2. Fuel Filter (Petrol & Diesel)
3. Air Filter
4. Fuel Pump (Petrol and Diesel)
5. Feeding Pump
6. Inlet Manifold
7. Carburettor
8. Injector
9. Nozzle
10. Combustion chamber.

6.2. FUEL TANK

The fuel tank is used to store the fuel needed to produce output energy in the vehicle. It is made of Galvanized Iron by pressing process. This fuel tank varies depending on the cubic capacity of the vehicle. Similarly, the location of this tank in the vehicle will vary depends on the type of vehicle. A separate tank will be generally mounted on the top of the vehicle chassis frame according to the fuel filling system. The fuel tank is shown in Figure 6.2.

Figure 6.2 Fuel Tank

6.3. FUEL FILTER

There is a possibility of having fuel contaminated with dust particles while filling the fuel or during storage. If the contaminated fuel is supplied to the chamber, it leads to incomplete combustion

Figure 6.3 Fuel filter

Figure 6.4 Air filter

and creates problem in reciprocating movement of the piston up and down. The incomplete combustion causes formation of pollutants in the exhaust. Hence fuel filter is used in path way of the fuel supply line to avoid the above said problems. It removes the dust particles and sends the purified fuel to the fuel injector and to the combustion chamber. Figure 6.3 shows the Fuel Filter

6.4. AIR FILTER

In any diesel or petrol engine for achieving combustion of the fuel sufficient amount of oxygen or pure air is required. Hence before sending the atmospheric air into the carburettor in petrol engines or directly into the combustion chamber in diesel engines, the air must be purified. In automobiles there are number of designs in air filters based on the engine used. If it is a gasoline engine air filter is mounted at the carburettor inlet, where as the filter is fitted at the intake manifold in diesel engine. There are different types air filters used in vehicles. Figure 6.4 shows the Air Filter. They are

1. Dry Type Air Cleaner (filter)
2. Oil bath type Air Cleaner (filter)
3. Oil coated air filter (Oil wetted type air cleaner)

Air filters applications (Uses of Air cleaner)

Though there are many usages of the air filters in many different applications, the important usages of the air filter in automobile are,

1. To send clean air without dust and contaminates to the carburettor.
2. To avoid mal-functioning of the engine and prevent damages of the engine parts due to incomplete combustion
3. To reduce the pressure difference occurs in the intake manifold and lowers the noise level. Figure 6.4 shows the Air Filter

6.4.1 Dry Type Air Cleaner

In this type of air filters, the cover, filtering part and bottle housing are coupled with each other. When the air is inducted to the filter through the filter cover, the dust particles and contaminations in the air are removed. Then purified air passes

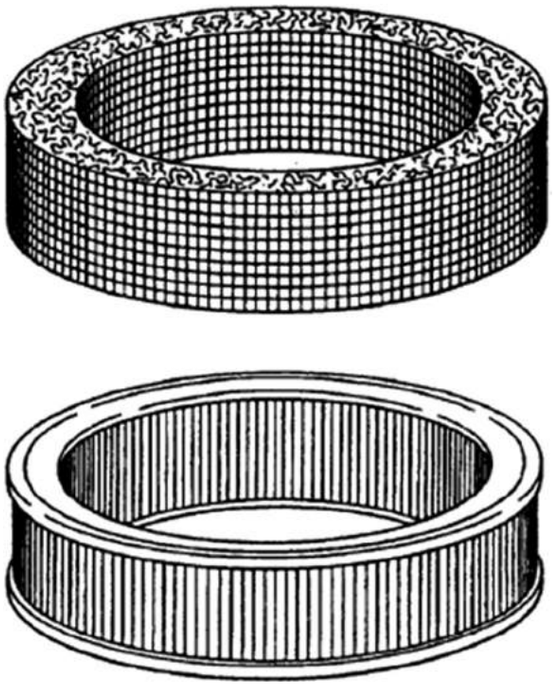

Figure 6.4.1 Dry Type Air Cleaner

to the upper section of the carburettor through the filter outlet in the intake air path and enters into the carburettor. In this type of filters, a number of folded paper elements are used as a filter. Figure 6.4.1 shows the Dry Type Air Cleaner.

6.4.2 Oil Bath Type Air Cleaner

In oil bath type, the air filter is filled with oil in the container such as a tank. This type of filter is made up of copper metal and looks like a spider net in ring shape. It is enclosed in the middle of the tank filled with oil and the upper cover kept in closed position. Due to the reciprocating downward movement of piston the air is sucked in to the engine through the intake manifold where the air filter is fixed. The air is initially passed through the oil present in the filter tank, where surface of the oil absorbs larger size dust particles in it. After that the smaller size dust particles in the air are removed

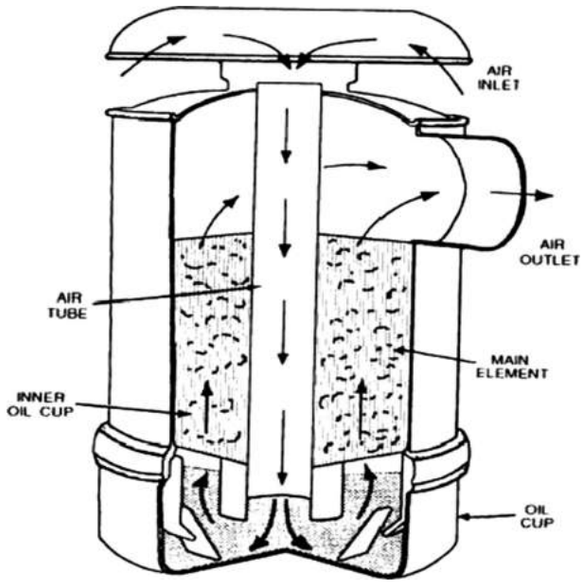

Figure 6.4.2 Oil Bath Type Air Cleaner

by the filter. The filtration components and oil container are fitted separately in this type of filters. Figure 6.4.2 shows the Oil Bath Type Air Cleaner.

6.4.3 Oil Wetted Type Air Cleaner

In this type of filter, the filter is not dipped in the oil in the tank. Instead, the surface of the filter will be coated with oil. The air passing through the filter initially touches the oil on the filter and removes larger size dust particles and impurities. After that the air is passed into the net shaped filter and the air gets purified again and the cleaned air is sent to the engine. Generally, in automobiles after running for 8000 kilometers the filter is

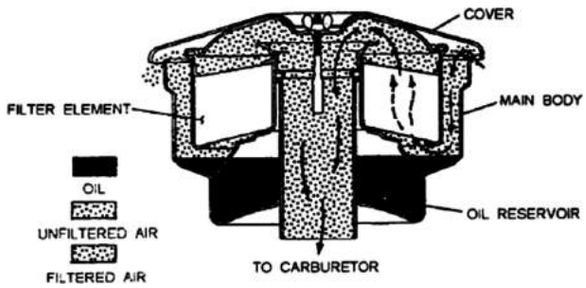

Figure 6.4.3 Oil Wetted Type Air Cleaner

cleaned with petrol or paraffin and can be reused. Figure 6.4.3 shows the Oil Wetted Type Air Cleaner.

6.5. FUEL PUMP

The required amount of fuel (for producing power) pumped from the fuel tank to the combustion chamber is transferred by the device called fuel pump.

It is classified according to the fuel used as,

1. Fuel Pump (Petrol Engine)
2. Fuel diesel pump (diesel engine)

6.5.1 Petrol Fuel Pumps

A fuel pump is used to transfer the fuel from the fuel tank through the filter with appropriate pressure to the float chamber of the carburettor in gasoline engines to drive the vehicle. Petrol Fuel pumps are classified in two types as

1. A.C. Mechanical Fuel Pump
2. S.U. Electric Fuel Pump

Fig 6.5.1(a) A.C. Mechanical Fuel Pump

Fig 6.5.1(b) S.U. Electric Fuel Pump

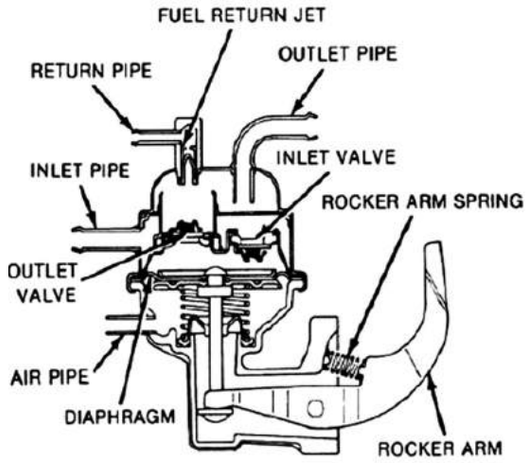

Figure 6.5.1 (a) Schematic of A.C. Mechanical Fuel Pump.

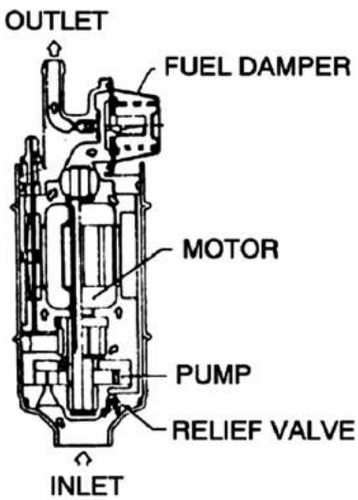

Figure 6.5.1 (b) S.U. Electrical Fuel Pump.

6.5.2 Diesel Fuel Injection Pump

Unlike in petrol engines, in diesel engines diesel stored in the fuel tank is sucked by the Diesel fuel injection pump. The fuel from the fuel tank is passed through the fuel filter and feed to the fuel injection pump. The fuel injection pump develops high pressure and the pressurized fuel is sent to the fuel injector and sprayed into the engine's combustion chamber. This fuel injection pump is classified into two types. They are,

a) Inline Pump

b) Distributer Pump

6.6 FEED PUMP

Feed pump is another pump arrangement located between the diesel fuel tank and the filter in the diesel **Fuel Injection Pump** (FIP) block. The drive for the fuel feed pump is given from the camshaft of the fuel injection pump by cam or eccentric. The fuel feed pump is designed to operate manually by hand for purging the air in the fuel line when air bubbles are present. This fuel feed pump is classified into two types based on the delivery of fuel continuously or intermittent while the fuel injection pump is running. They are

1. Single acting pump
2. Double acting pump

6.6.1 Single Acting Pump

Construction

This type of pump is mounted on the body of the fuel injection pump. This single acting pump is driven by the cam or eccentric of the fuel injection pump's cam shaft. The components such as roller tapper, pressure spindle and plunger are in contact with each other and placed inside the pump body. For emergency purpose, hand priming device is used to increase the pressure of fuel. Figure 6.6.1 shows the Single Acting Pump.

Working Principle

When the engine is started the drive is received from the engine's crank shaft and given to the FIP cam shaft through timing gears. Now the cam shaft of the FIP rotates and while rotating the roller tappet the feed pump is actuated by the cam or eccentric in the cam shaft. Hence the plunger is actuated by the action of the roller tappet. Pressure spindle is now actuated by the plunger. Therefore, the fuel in the pressure chamber is pressurized and sent to the FIP. At the same time the high-pressure fuel developed in the FIP is sent to the nozzle (injector) by the FIP. The quantity of fuel delivered is equal to swept volume or equal to stroke length. The delivery passage is closed by the pressure spindle with the spring force. This is the way how the single acting pump works.

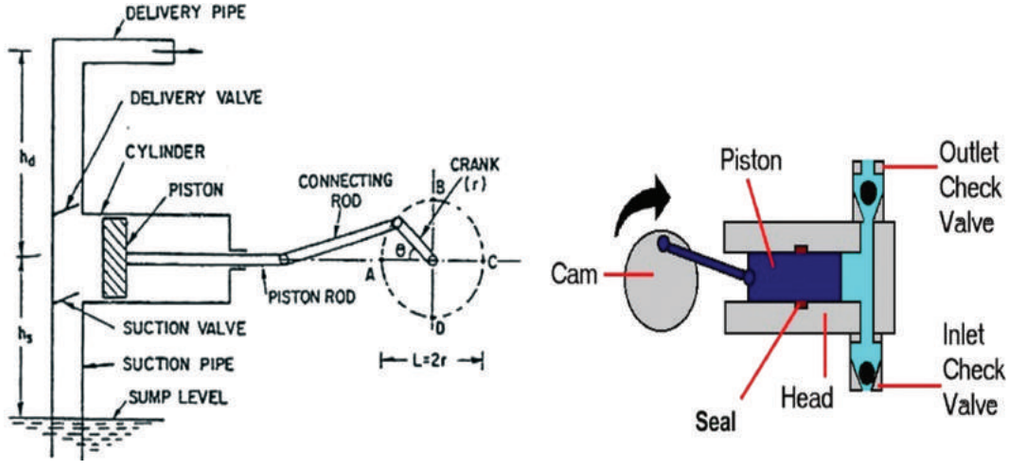

Figure 6.6.1 Single Acting Pump

6.6.2 Double Acting Pump

Construction

This type of pump is similar to the single acting pump in its construction. However, it differs from the single acting pump that the plunger in the pump is operated in such a way to achieve the suction and delivery of fuel at the same time. Figure 6.6.2 shows the Double Acting Pump.

Working Principle

When the drive is received from the engine cam shaft, the cam shaft of the FIP starts rotating and actuates the roller tappet of the fuel pump. Hence the plunger moves downward and presses the pressure spring. Now the pressure valve and suction valve are opened at the same time. And the fuel suction and delivery are achieved at the same time. For each and every rotation of FIP camshaft, the pressurized fuel delivery and suction process are done simultaneously. Since the two actions are done at the same time, this pump is called as the double acting pump.

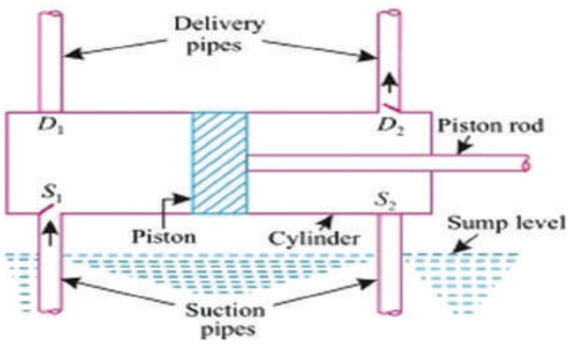

Figure 6.6.2 Double Acting Pump

6.7 Inlet Manifold

Inlet manifold is a pipe which is made up of cast iron or aluminium metal. It is used to send the air fuel mixture from the carburettor to the engine inlet port in petrol engines and air to the combustion chamber in diesel engines. It is also a place to locate the carburettor in petrol engines. The governor or super charger can't be fitted here. In L-head engine the inlet manifold is situated at the adjacent of cylinder block, and in I- head engine it is situated at the adjacent of cylinder head. In V- shape engine it is situated between the two cylinders. Since the exhaust and coolant supply are placed close to the intake manifold there may be possibilities for the inlet manifold to get heated. Hence a thermostat valve with coolant circulation is provided in modern engines to avoid heating of the intake manifold. Therefore, by using the thermostat valve, the inlet manifold can be cooled. The engine is also heated easily by using the thermostat valve from low temperature. Therefore, engine can be started easily. The inlet manifold of the engine is classified into two types. They are

1. Dual intake manifold
2. Four-barrel intake manifold

Dual Intake Manifold

Four-Barrel Intake Manifold.

Figure 6.7 Dual and Four-Barrel Intake Manifold.

Figure 6.7 shows the Dual Intake Manifold and Four-barrel intake manifold

6.8 CARBURETTORS

Carburettor is a device which is used to atomize the petrol and mix it with the air in the proportion depending upon the speed and torque of the engine. This mixture enters into the engine via inlet manifold with the help of carburettor. The venture in the carburettor is used to mix the fuel with the air to the required proportion. After mixing the air fuel mixture is introduced into the engine cylinder. Figure 6.8 shows the Carburettors

The carburettor is classified into several categories. They are as follows,

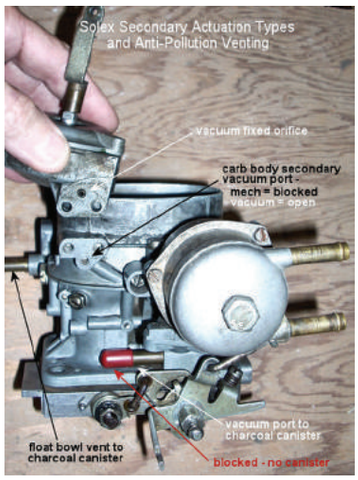

Figure 6.8 Carburattors

1. According to the float chamber
   a) Eccentric
   b) Concentric
2. According to the path of air flow
   a) Down Draft
   b) Side Draft

SPARK PLUG

Albert Champion

During the early 1900s, France was the dominant manufacturer of spark plugs.

Frenchman, Albert Champion was a bicycle and motorcycle racer who immigrated to the United States in 1889 to race. As a sideline, Champion manufactured and sold spark plugs to support himself.

In 1904, Champion moved to Flint, Michigan where he started the Champion Ignition Company for the manufacturing of spark plugs.

He later lost control of his company and in 1908 started the AC Spark Plug Company with backing from Buick Motor Co. AC presumably stood for Albert Champion.

His AC spark plugs were used in aviation, notably for the trans-Atlantic flights of Charles LIndbergh and Amelia Earhart. They also were used in the Apollo rocket stages.

c) Up Draft
d) Semi-Down Draft

3. According to the package
   a) Single Unit
   b) Double Unit
   c) Four-Barrel Unit.
4. According to the Types of Metering System
   a) Air-Bleed jet
   b) Metering Rod Type
5. According to the type of venturi
   a) Plain Venturi
   b) Double Venturi
   c) Vane Venturi
   d) Nozzle-Bar Venturi
   e) Triple Venturi
6. Also, it is classified based on the placement of the carburettor, they are
   a) Simple Carburettor
   b) S.U Carburettor
   c) Solex Carburettor
   d) Zenith Carburettor
   e) Cartor Carburettor

6.9 FUEL INJECTORS

Injector plays an important role in injecting the diesel into the cylinder of the diesel engine. It injects equal amount of the fuel to each cylinder as per the firing order. Injector is used to spray the diesel fuel into the cylinder in the form of very fine particles in the range of 20 to 100 micrometers. Due to this, the diesel fuel is completely mixed with the air. This leads to complete combustion. Figure 6.9 shows the Fuel Injector.

The diesel fuel injectors have the following components,

1. Nozzle body
2. Cap unit
3. Delivery unit

Nozzle body consists of nozzle valve; spindle, springs, adjusting nut are placed together. A passage is made on the injector to pass the high-pressure fuel to inject into the combustion chamber and the bypass unit

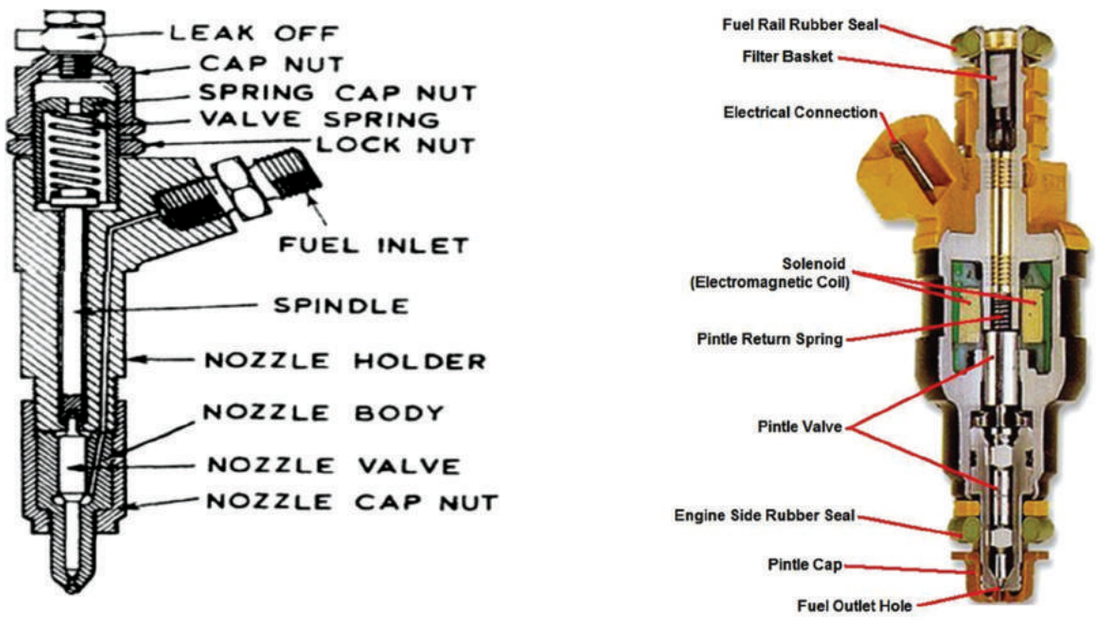

Figure 6.9 Fuel Injector

is used to let the fuel to go back to the fuel tank. Figure 6.9 shows the Fuel Injector.

Working Principle of Injectors

By the rotation of engine crankshaft, the camshaft rotates by using the timing gear connected with it. Hence the camshaft connected to the fuel injection pump also rotates and high pressure is developed in the fuel injection pump. The pressurized fuel the fuel tank is supplied to the fuel injector through the high-pressure fuel line. The diesel fuel entering the injector reaches the nozzle and starts to spray with the help of spring force acting inside the nozzle. Diesel fuel enters into the nozzle at very high pressure opens the nozzle valve by lifting against spring force acting inside the spindle. Hence the nozzle valve opens and high-pressure diesel fuel in the nozzle is injected into the chamber generally at the pressure of 200 bars in the form of very fine droplets. The droplets of the diesel fuel then vaporize and mix with the air inside the combustion chamber to attain proper mixture for burning. When the injection process is over the pressure getting reduced in the spring inside the nozzle, hence the spindle moves the nozzle valve downward. Hence the nozzle valve gets closed. In this way the diesel fuel injector works.

6.10 NOZZLE

Nozzle is the important component used for injecting the diesel at very high pressure at correct timing for the maximum power output of the engine. It is a part of injector which is placed at the cylinder head and has contact with combustion chamber in order to inject the fuel. It helps in injecting the fuel as per the requirements

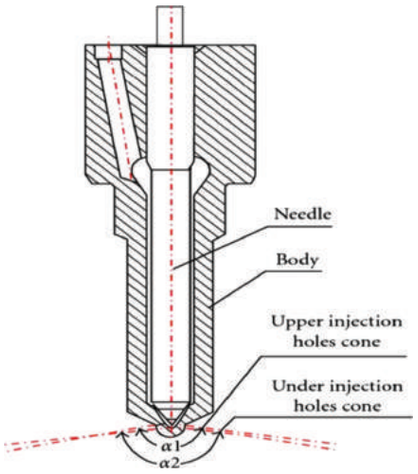

Figure 6.10 Nozzle

of the engine at different pressures and at constant temperature with accurate metering. Nozzle is designed to fit in to the nozzle valve and it can be assembled only by the authorized company. A hole for supplying fuel is available at the tip of nozzle valve. The diesel entering into the injector at high pressure is used for opening the valve and the returning action is taken by springs provided in the valve. Figure 6.10 shows the Nozzle.

There are different types of nozzles,

1. Single Hole Nozzle
2. Multi Hole Nozzle
3. Long Stem Nozzle

6.10.1 Single Hole Nozzle

It has a single hole at the tip for injecting a fuel. The nozzle has a cone shaped spindle which is used for opening and closing the nozzle hole. Figure 6.10.1 shows the Single Whole nozzle.

6.10.2 Multi Hole Nozzle

It has a multi holes for injecting the fuel depending upon the engine

Figure 6.10.1 Single Whole Nozzle

Figure 6.10.2 Multi Whole Nozzle

requirements. Figure 6.10.2 shows the Multi Whole nozzle.

6.10.3 Long Stem Nozzle

The long stem nozzle is mainly used for the direct injection into combustion chambers.

Small Stem Nozzles are commonly not used for these types (direct injection) of engines. Figure 6.10.3 shows the Long Stem Nozzle.

Some of the long stem nozzles are,

a. Pintle Nozzle
b. Pintaux Nozzle
c. Delay Nozzle

a) Pintle Nozzle:

This type of nozzle injects the fuel which is in the form of pencil's cone edge. It is mainly used in the swirl type of combustion chamber, air cell chamber

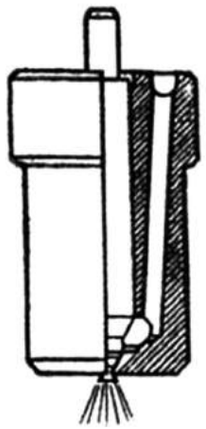

Figure 6.10.3(a) Pintle Nozzle

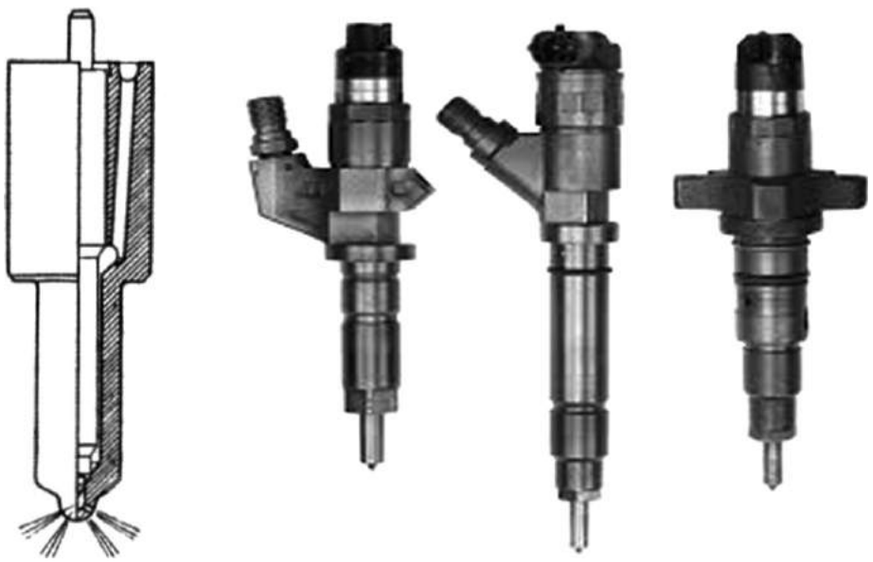

Figure 6.10.3 Long Stem Nozzle

and Pre-combustion chamber engines. Figure 6.10.3(a) shows the Pintle Nozzle.

b) Pintaux Nozzle:

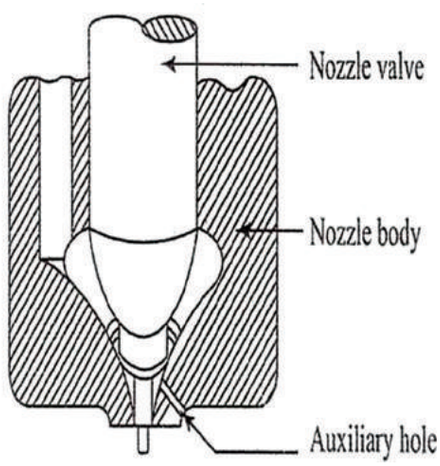

Figure 6.10.3(b) Pintaux Nozzle

This type of nozzle is advancement in the pintle nozzle type. This type of nozzle has the tip projected outside and has a hole in the centre for injecting the fuel. This type of nozzle can achieve combustion even in cold starting condition of engine. Figure 6.10.3(b) shows the Pintaux Nozzle

c) Delay Nozzle:

It is the further advancement in pintle type nozzle in which the fuel injection and the amount of fuel injected into the combustion chamber are controlled depending on engine speed. This type of nozzle is called as delay nozzle.

6.11 COMBUSTION CHAMBERS

The combustion chamber is the place where the air fuel mixture is burnt. It is the space covered by the cylinder head, cylinder wall and piston top. Above the piston there are inlet and exhaust valves and a spark plug present in the cylinder head. Depending on the position of the valves, spark plug and the combustion chamber the engines can be classified as

- L – Head engine
- I – Head engine
- F – Head engine
- T – Head engine
- Spherical shape

L – Head Engine

This type of engine is used for slow and high speed applications. In this type of engines the inlet and exhaust valves are placed in the cylinder block itself and the valves open the intake and exhaust ports by moving upward motion. The spark plug is fitted at the top of the engine cylinder head. Figure 6.11(a) shows the 'L' Head Engine.

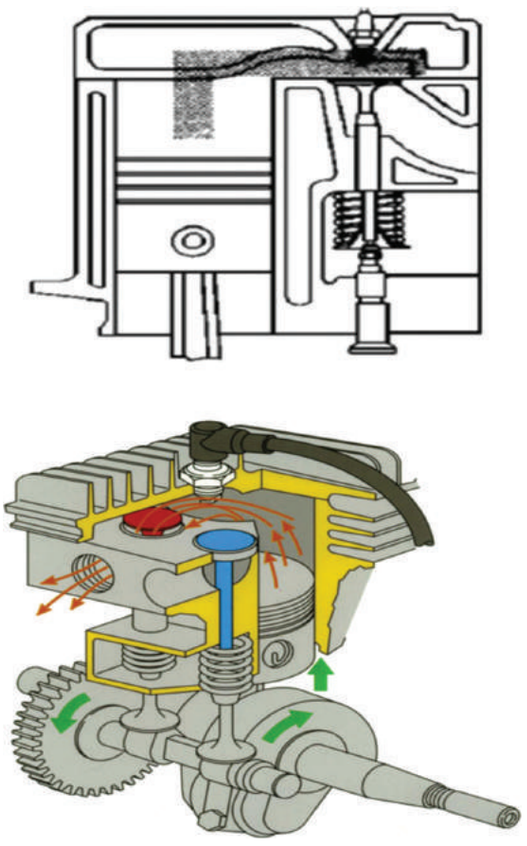

Figure 6.11(a) L – Head Engine

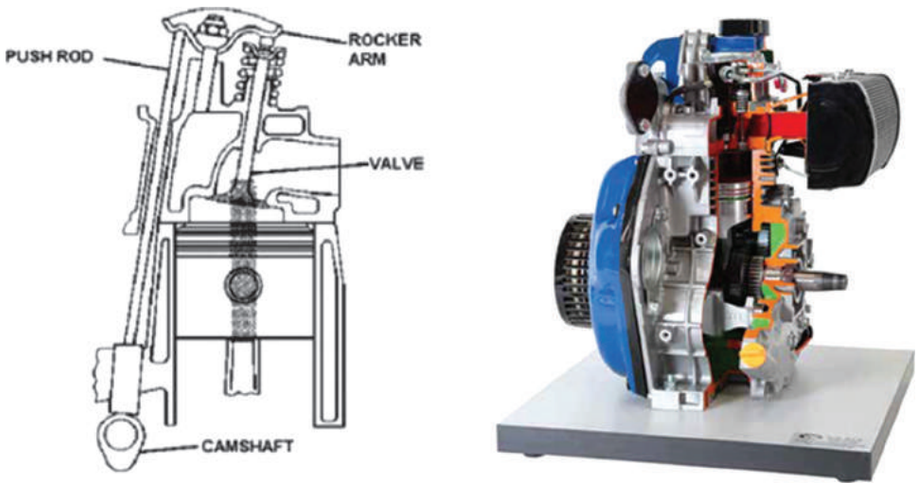

Figure 6.11(b): I– Head Engine

I– Head engine

This type of engine is used in high speed vehicle and racing vehicle. The inlet and exhaust valves replaced in the cylinder head and the spark plug is fitted at the side of cylinder head. Figure 6.11(b) shows the 'I' Head Engine.

F– Head engine

In this engine the combustion chamber is designed in stretched manner at the side way of the engine. The inlet valve is fitted on the upper side of cylinder head which moves in downward motion and exhaust valve is fitted in lower side of cylinder head which moves in upward direction and the spark plug is in the side of cylinder head. Figure 6.11(c) shows the 'F' Head Engine.

T– Head engine

It is designed in stretched manner in both lateral sides, the inlet and exhaust valves are fitted at the lower side of cylinder

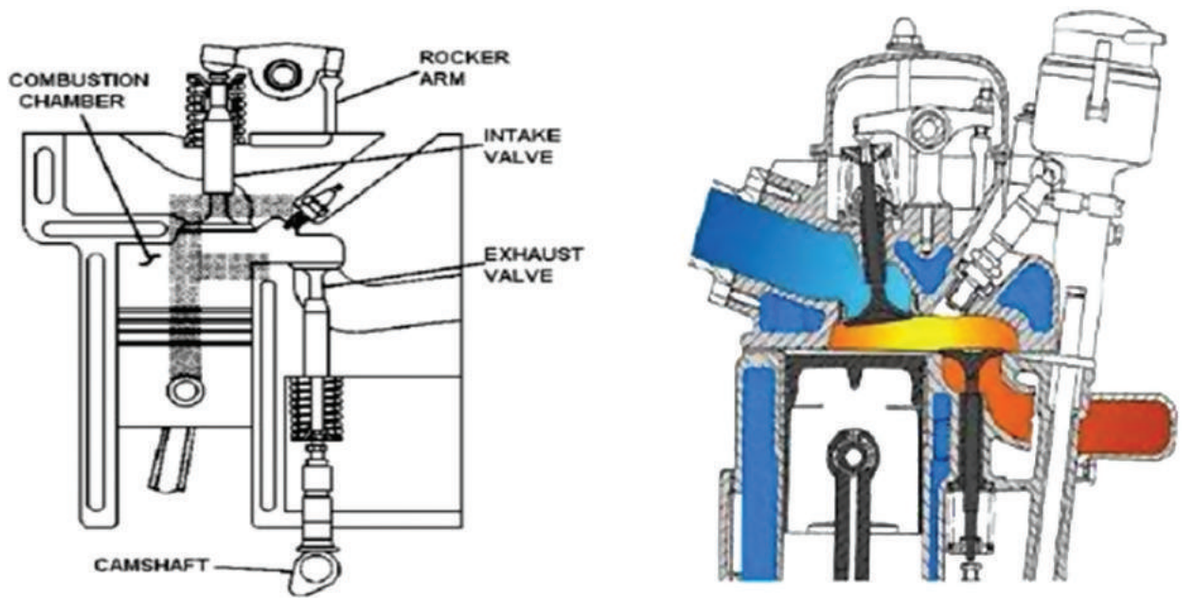

Figure 6.11(c): F – Head Engine

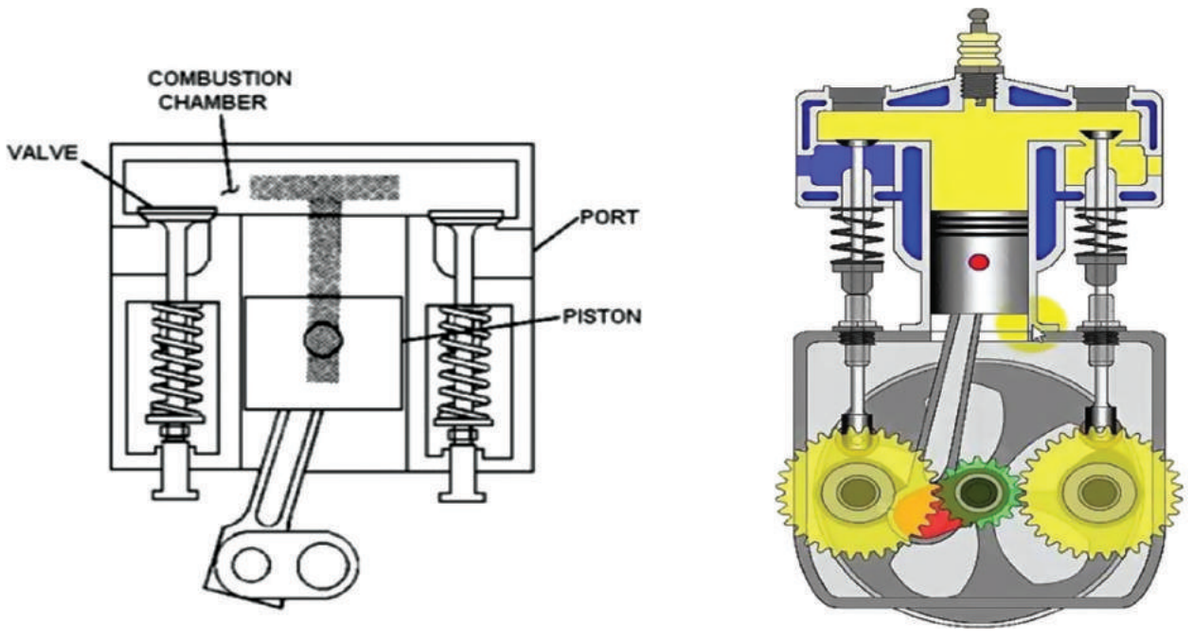

Figure 6.11(d): T – Head Engine

head in which the valves move in upward direction and the spark plug is fitted at the top of cylinder head. Figure 6.11(d) shows the 'T' Head Engine.

Spherical shape

In engine's combustion chamber, if the cylinder head or the piston top has internally or externally a spherical shape then the combustion chamber can be called as spherical combustion chamber. The inlet and exhaust valves are fitted at the opposite direction and the spark plug is fitted either centre or at lateral sides in such engines.

6.11.1 Types of combustion chambers of diesel engines

Due to high power output of diesel engines, the combustion chambers are designed in different types depending on the engines torque and speed requirements. The diesel engine combustion chambers are mainly of the following,

a. Open Combustion chamber
b. Pre-Combustion chamber
c. Swirl Combustion chamber
d. Squish Combustion chamber
e. Air cell and energy cell

(a) Open Combustion chamber

This type of combustion is mainly used in slow and high-speed engines. The piston head is designed in such a way to have a (semi spherical) bowl shape and the injector of the engine is mounted on the cylinder head. Figure 6.11.1(a) shows the Open Combustion Chamber.

(b) Pre-Combustion chamber

It is mainly used in high speed engines. It consists of two chambers such as auxiliary (or pre) combustion chamber and other called as the main combustion chamber. The auxiliary combustion chamber is small and is used for igniting the small amount of the air fuel mixture.

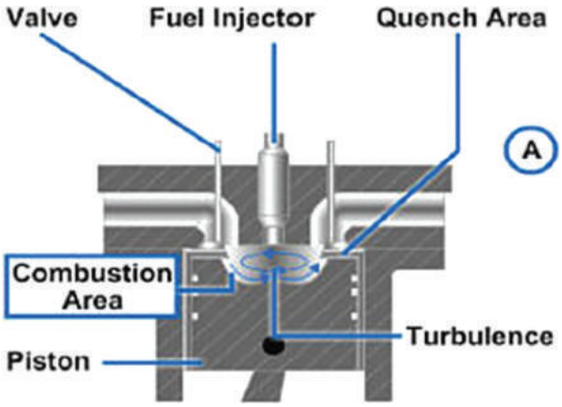

Figure 6.11.1(a) Open Combustion Chamber

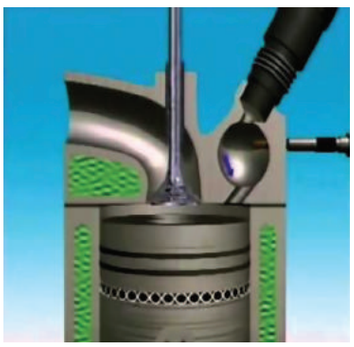

Figure 6.11.1(b) Pre-Combustion Chamber

The mixture first starts ignited in the auxiliary chamber and the combustion flame travels towards the main combustion chamber for the burning the rest of the air fuel mixture. Normally Glow plug is used to initiate combustion of the mixture. The glow plug will be located at the auxiliary chamber. Figure 6.11.1(b) shows the Pre-Combustion Chamber.

(c) Swirl Combustion chamber

It is also known as the turbulent chamber. The air enters into the combustion chamber in swirl motion in which the fuel is injected on the swirl air motion, allowed to mix with the air and achieves

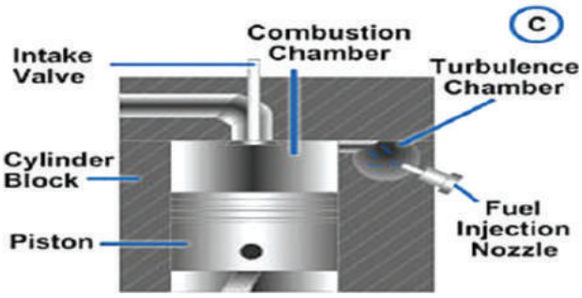

Figure 6.11.1(c) Swirl Combustion Chamber

combustion. Figure 6.11.1(c) shows the Swirl Combustion Chamber.

(d) Squish Combustion chamber

The piston head has the bowl shape in which the air motion is travelled from the side to centre of chamber. The radically inward movement of the air is called as squish. As the piston moves from BDC to TDC, the squish motion is created and the fuel is injected and ignited. Figure 6.11.1(d) shows the Squish Combustion Chamber.

(e) Air cell and energy cell

Air cell

The Air cell design has two (called as air cell and main) chambers in which they

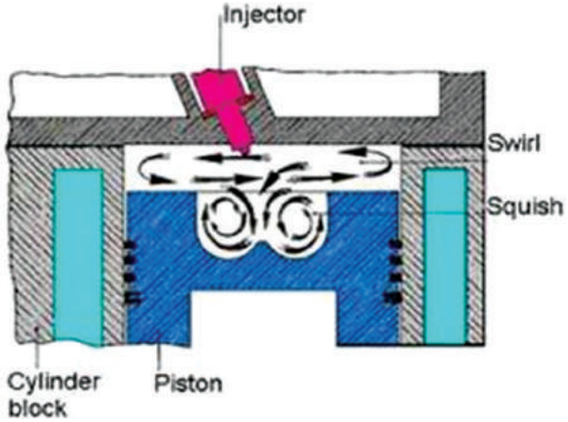

Figure 6.11.1(d) Squish Combustion chamber

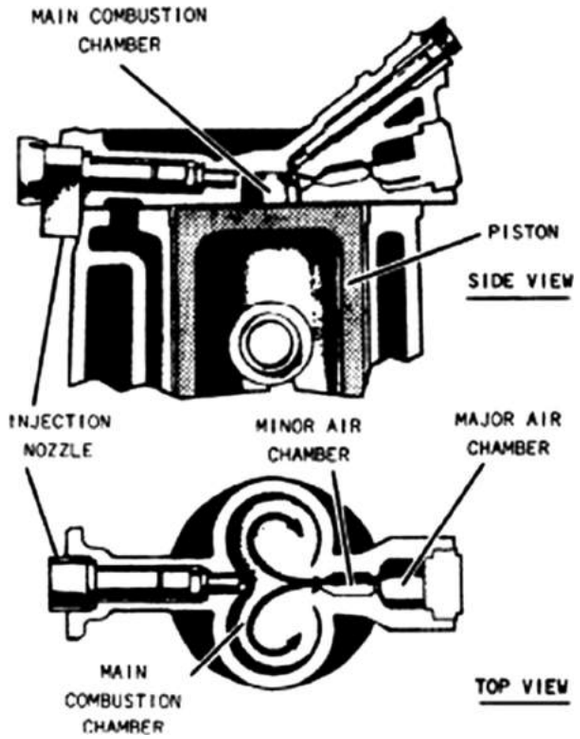

Figure 6.11.1(e) Air Cell and Energy Cell

are connected together by a narrow passage. Due to this arrangement the pressure of the inlet air increases in the air cell chamber and the pressurized air enters into the main chamber in which the fuel is injected and combustion is achieved. Figure 6.11.1(e) shows the Air Cell and Energy Cell.

Energy cell

It is also known as Lenovo combustion chamber. It combines the Air cell and Pre combustion chamber modes. In this type of chamber the energy cell is connected via the narrow passage with main chamber. When the engine runs, the pressure of the air in the energy cell is increased due to the narrow path and fuel is also injected in the similar way as pre chamber. The combustion at the energy cell is continued in the main chamber where the main combustion takes place. By this way the energy is utilized by injecting fuel in the energy cell. Due to piston movement from TDC to BDC and depending on pressure difference between the chambers the mixture is combusted completely.

6.12 EXHAUST SYSTEM

In an engine the products of combustion (pollutants) formed during the combustion process must be taken out of the engine. This system is called as the exhaust system. This system includes exhaust port, exhaust manifold, exhaust pipe, muffler and a catalytic converter.

6.12.1 Exhaust manifold

Exhaust manifold is a part of the exhaust system that is used for removing unwanted gases such as carbon monoxide, carbon dioxide, smoke, unburned hydrocarbon etc., which are formed during the combustion process. Through the exhaust port of the engine the exhaust products are passed to the exhaust manifold. The unwanted gases coming out from the all cylinders in the engine are collected in the exhaust manifold and sent to the exhaust pipe called as tail pipe. This is the main purpose of the exhaust manifold present in the engine. Exhaust manifold is generally made up of cast iron. Figure 6.12.1 shows the Exhaust Manifold.

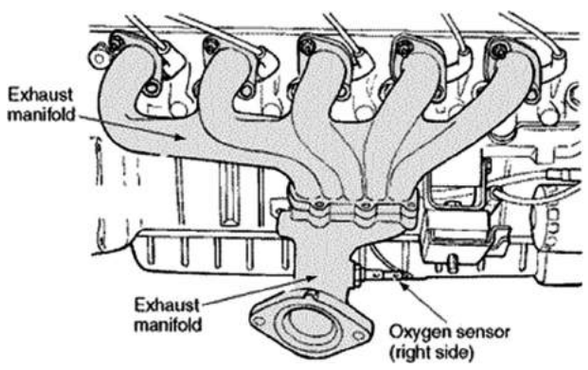

Figure 6.12.1 Exhaust Manifold

6.12.2 Exhaust Pipe

Exhaust pipe is the one which connects exhaust manifold and muffler. It is around 5cm in radius and 1cm in thickness generally. The exhaust pipe arrests the vibrations to the muffler which is coming from the engine.

6.12.3 Exhaust Mufflers

The exhaust mufflers are used to send heat, gas and sound without any destruction. To do these the mufflers have to perform the following operations.

1. Reduce the temperature of exhaust gas
2. Reduce the speed of the exhaust gas
3. Reduce the sound of the exhaust gas
4. Reduce the strength hot and unburned gas

Different types of mufflers are used to perform the above functions. They are of

a) Baffle type
b) Wave cancellation type
c) Resonance type
d) Absorber type
e) Combined absorber and resonance type

6.12.3(a) Baffle type

This type of mufflers will be in cylindrical shape. This will be divided into many rooms. Hence the exhaust gas speed gets reduced and the energy also gets reduced. Fig 6.12.3(a) shows the baffle type muffler.

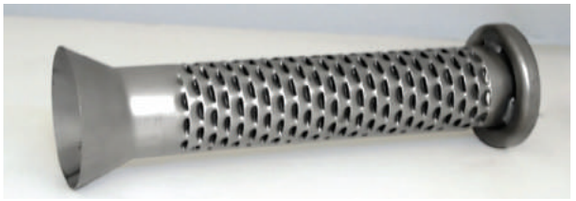

Figure 6.12.3(a) Baffle Type Muffler

6.12.3(b) Wave cancellation type

In this type the burnt gases are separated and again combined and expelled out to the atmosphere. In this type the speed of the gas can be reduced but the sound can't be reduced completely. Fig 6.12.3(b) shows the wave cancellation type.

6.12.3(c) Resonance type

In this type of mufflers the serially arranged resonators absorb the sound of the out coming gases. So that the sound as well as heat gets reduced. Fig 6.12.3(c) shows the resonance type.

6.12.3(d) Absorber type

In this type the exhaust pipe is surrounded by special type of materials which could absorb the sound. When the exhaust enters into this muffler the absorber material absorbs the sound. Fig 6.12.3(d) shows the absorber type.

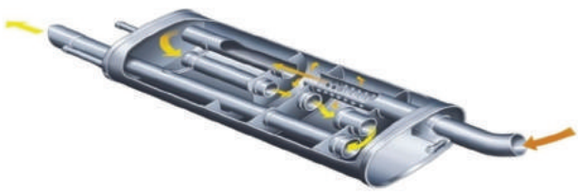

Figure 6.12.3(b) Wave Cancellation Type Muffler

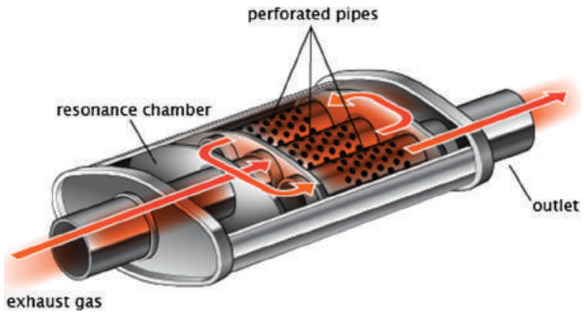

Figure 6.12.3(c) Resonance Type Muffler

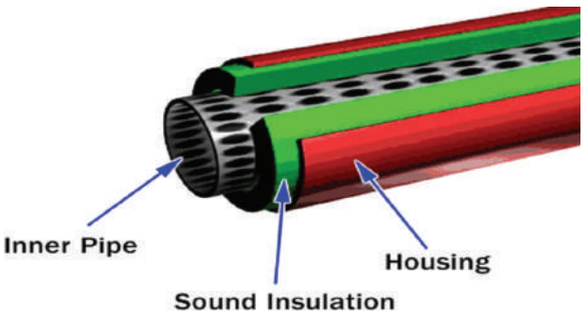

Figure 6.12.3(d) Absorber Type

6.12.3(e) Combined absorber & resonance type

In the combined type mufflers in addition to the absorber material resonators are also fixed on the exhaust path. In this type of mufflers both heat and vibrations are absorbed. Fig 6.12.3(e) shows the Combined absorber & resonance type.

6.13 CATALYTIC CONVERTORS

The exhaust gases coming out from the exhaust manifold are highly toxic to human beings and plants. The catalytic convertor fitted with the exhaust pipe could reduce the harmful emissions such as unburned hydrocarbon, nitrogen oxides and carbon monoxide emissions. In catalytic

TH96V4

Combined resonance and absorber type muffler: 1. Inlet; 2. Noise absorbant; 3. Access port; 4. Outlet; 5. Resonant

Figure 6.12.3(e) Combined Resonence and Absorber Type

convertors platinum, palladium and rhodium chemicals are used as catalysts which are coated in the form of honey comb like structures and being used in vehicles. A secondary passage is also made to supply oxygen into the convertor. When the toxic gases (such as hydrocarbon and carbon monoxide) are passed into the catalytic convertors, they are converted into water and carbon dioxide. Three way catalytic convertors reduce the nitrogen oxides also by the way of reduction action to nitrogen and oxygen. Fig 6.13 shows the catalytic convertor.

6.14 ENGINE TUNE-UP PROCEDURE

Checking the engine components and adjusting the components for better engine's performance is called as engine tuning. Tuning the engine for better performance increases the life of the engine. The flow chart shown in Figure 6.14 presents the engine tuning procedure on various components of the engine.

To improve the engine's performance (efficiency) the following components must be maintained in good condition.

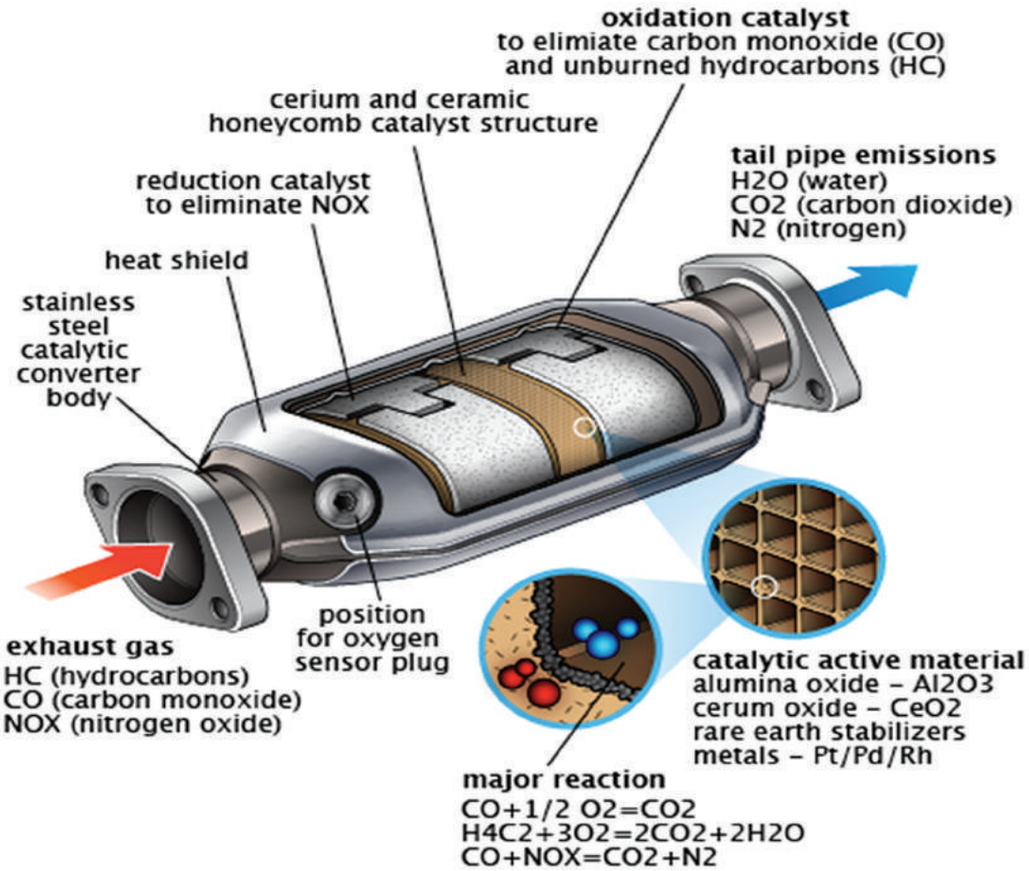

Figure 6.13 Catalytic Convertors

(1) Air inlet and exhaust system

- The Air filter should be cleaned
- The air inlet manifold should be cleaned
- Pre cleaner should be cleaned
- The crank case ventilation should be checked
- Exhaust system and muffler should be tested

(2) Engine testing

- The intake manifold of the system should be tested.
- Should check the air bubbles on the radiator.
- In the cylinder head gasket leakage should be tested
- Cylinder head bolts should be tightened well
- Have to check the valve clearance
- Have to check pressure of all the cylinder

(3) Ignition system testing

- The Spark plug should be cleaned
- Connection to the ignition coil should be tested
- Distributor cap and rotor should be checked
- The Condenser should be tested
- Ignition timing should be adjusted correctly

(4) Fuel system testing

- The leak (or) block in the fuel line should be tested