ANNAMALAI UNIVERSITY

DEPARTMENT OF MECHANICAL ENGINEERING

2020- 2021

B.E(MECHANICAL ENGINEERING)
III-SEMESTER

MECP 308 - THERMAL LAB

INSTRUCTION MANUAL

NAME ____

BATCH____

BRANCH ____

Instructions to the students

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

The Mechanical Engineering Department endeavors to be recognized globally for outstanding education and research leading to well qualified engineers, who are innovative, entrepreneurial and successful in advanced fields of mechanical engineering to cater the ever changing industrial demands and social needs.

MISSION

The Mechanical Engineering program makes available a high quality, relevant engineering education. The Program dedicates itself to providing students with a set of skills, knowledge and attitudes that will permit its graduates to succeed and thrive as engineers and leaders. The Program strives to:

- Prepare the graduates to pursue life-long learning, serve the profession and meet intellectual, ethical and career challenges.
- Extend a vital, state-of-the-art infrastructure to the students and faculty with opportunities to create, interpret, apply and disseminate knowledge.
- Develop the student community with wider knowledge in the emerging fields of Mechanical Engineering.
- Provide set of skills, knowledge and attitude that will permit the graduates to succeed and thrive as engineers and leaders.
- Create a conducive and supportive environment for all round growth of the students, faculty & staff

PROGRAM EDUCATIONAL OBJECTIVES

1.	Prepare the graduates with a solid foundation in Engineering, Science and Technology for a successful career in Mechanical Engineering.
2.	Train the students to solve problems in Mechanical Engineering and related areas by engineering analysis, computation and experimentation, including understanding basic mathematical and scientific principles.
3.	Inculcate students with professional and ethical attitude, effective communication skills, team work skills and multidisciplinary approach
4.	Provide opportunity to the students to expand their horizon beyond mechanical engineering
5.	Develop the students to adapt to the rapidly changing environment in the areas of mechanical engineering and scale new heights in their profession through lifelong learning

(Thermal Lab)

1. Be regular and be punctual to classes
2. Come in proper uniform stipulated
3. Ensure safety to your body organs and laboratory equipment

   – SAFETY FIRST DUTY NEXT
4. Read in advance the contents of the instruction manual pertaining to the experiment due and come prepared. Understand the related basic principles.
5. Maintain separate observation and record note books for each laboratory portion of the course wherever justified.
6. Though you work in a batch to conduct experiment, equip yourself to do independently. This will benefit you at the time of tests and university examinations.
7. Independently do the calculations and sketching. If there is difficulty, consult your batch mate, classmate, teacher(s) and Laboratory in –Charge.

   Do not attempt to simply copy down from others. You may fulfill the formalities but you stand to loose learning and understanding
8. Obtain the signature of teacher (s) in the laboratory observation note book and record note book then and there during class hours (within a week subsequent to experimentation).This will relieve the teacher (s) from giving reminder.
9. Help to maintain neatness in the laboratory.

Students are advised to retain the bonafide record notebook till they successfully complete the laboratory course.

CONTENTS

SI NO	DATE	NAME OF EXPERIMENT	SIGNATURE

ANNAMALAI UNIVERSITY

DEPARTMENT OF MECHANICAL ENGINEERING
THERMAL LAB

STUDY AND VALVE TIMING ON FOUR STROKE IC ENGINES*

Aim:-

To determine the valve timings/settings of a *four stroke IC engine* and to draw the valve timing diagram.

Valve timing Diagram:-

Valve timing diagram is the graphical form of representing the timings (instants) in terms of the corresponding crank positions at which the inlet and exhaust valves open and close. The crank positions and the sequences are described with reference to the nearest dead center.

Purpose:-

At the time of every overhauling and repairing, the engine parts are dismantled and reassembled. After such reassembling, the valve timings are to be verified with the manufacturers recommendations, i.e, the original settings, and adjusted using the valve tappet if required. The valve timings are also to be periodically verified with original settings because of the wear and tear of the elements of the valve mechanism.

Procedure:-

Identification of valves:-

The engine cylinder head cover is removed to facilitate the observation of valves, valve mechanisms and their workings in case of multi cylinder engine. Incase of single cylinder engine the rocker arm box cover is removed. The engine crank shaft is manually turned in the correct direction (clockwise from the cranking end) and the functioning of valves is noted. Both inlet and exhaust valves will be in simultaneous operation at a particular period. This period represents the overlapping between two cycles (the suction process of later cycle overlapping with the exhaust process of the current cycle.) The valve which closes during this period is the exhaust valve while that opens is the inlet valve.

Rotating member for markings:-

A circular member (flywheel /pulley/brake drum) mounted on the crankshaft is used for making the markings related to the various events (*IVO,IVC,EVO & EVC*) with reference to the nearest dead center IDC/ODC for horizontal engine or TDC/BDC for vertical engine. The circumference of the circular member used will be useful in determining the various crank angles.

A pointer or an indicator fixed on the engine frame serves as the reference against which all the markings are made on the rim of the circular member.

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* General Instructions and procedure

Dead Centers:-

When the engine runs, the piston reciprocates between two extremities of the stroke. These extreme positions are called as dead centers, the velocity of reciprocation being zero at these instants. The crank positions corresponding to the dead center positions of the piston are termed TDC/ *BDC* or IDC */ODC* positions.

The crank is turned manually and the marking is made on the rim of the circular member when the piston is at a definite position (piston bottom coincides with the bottom of the cylinder) during its downward journey. On further rotation of the crank, the piston moves down, reaches the BDC position and reverses its direction to move up. During the upward journey the piston will reach the same definite position at which a marking was done earlier on the rim of the circular member. Now another marking is done on the rim of the circular member. Mid point of the two markings (on the shorter arc length) is the *BDC* marking on the rim. *TDC* marking is made diametrically opposite to the *BDC* marking.

At the commencement of valve just moving away from its seat due to the actuation by cam through push rod, the valve is said to have opened. When the valve has completed the movement against its seat by spring action, it is said to have closed.

When the crank is turned, the instant at which a piece of paper inserted in-between the valve stem and tappet/rocker arm is just gripped is the valve opening. *IVO* and *EVO* markings are made on the circular member corresponding to the openings of the inlet and exhaust valves.

Similarly the instant at which the paper just looses the grip in between the valve stem and tappet/rocker arm is the valve closing. *IVC* and *EVC* markings are made on the circular member.

The distances of the *IVO,IVC,EVO & EVC* markings on the circular member, from the nearest dead center are measured.[Fuel injection timing can also be noted by noting down the starting and ending of fuel injection through nozzle(i.e., fuel injector)]

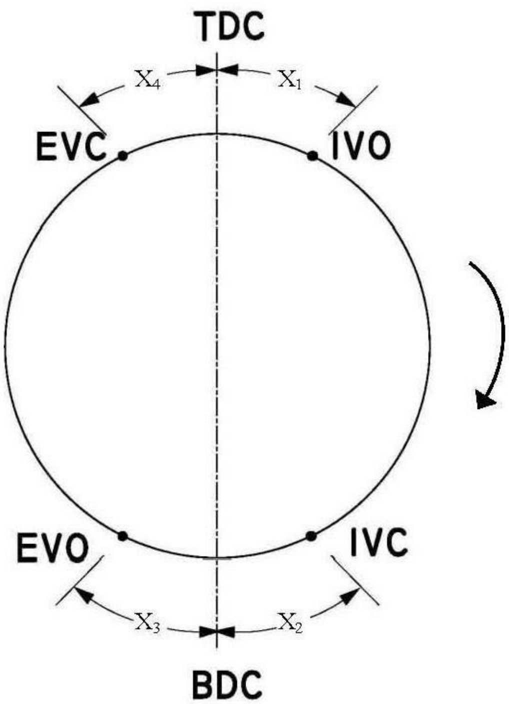
The observed diagram is drawn using the dimension details of markings on the circular member and the direction of rotation of the flywheel. The circle, drawn of any convenient radius, represents the circular member (flywheel/pulley/brake drum).

Inferring from the observed diagram, the events, their sequences and timings in relation to the nearest dead center are tabulated as shown. The arc lengths are expressed as crank angles in the last column of the table.

The valve timing diagram is drawn using the details (event, sequence and crank angle) in the table.

Model

OBSERVED DIAGRAM



Observation tabulation:-

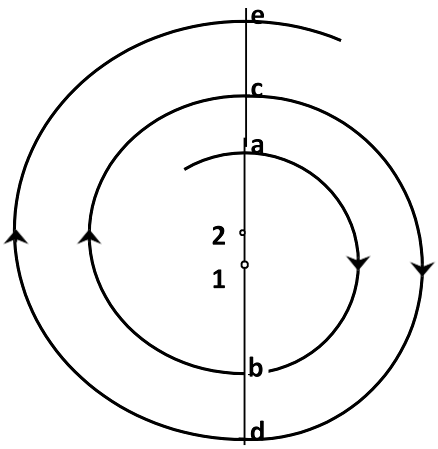
Circumference of flywheel =.............cm.

Sl. No.	Events	Sequence of Operation	Distance from the nearest dead center '**x**' in cms	Crank angle 'θ' in degrees
1	IVO			
2	IVC			
3	EVO			
4	EVC			

$$\text{Crank angle } \theta = \frac{X \times 360}{Circumference \text{ of } the flywheel/\ brake\ drum/pulley}$$

Procedure for drawing V.T.D.

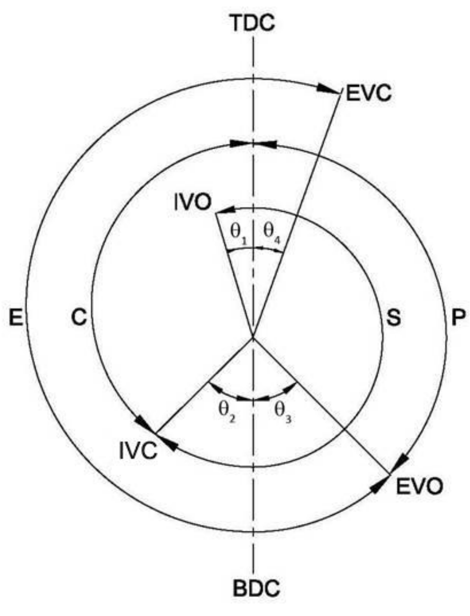
Draw a vertical line to represent the line of stroke. Mark a point 1 on it. Draw a semi-circle of any convenient radius taking point 1 as center to its RHS of the vertical line from 'a' to 'b'. Then mark another point 2 little above the point 1 on the vertical line (say 5 to 10 mm). Then draw another semi-circle from 'b' to 'c' taking 2 as center on the LHS of the vertical line. Similarly draw semi-circles from 'c' to 'd' on the RHS taking 1 as center and from 'd' to 'e' on the LHS taking 2 as center. Then extend the arcs to the desired length from 'a' as well as from 'e'.



Then locate all the events on the circular arcs as per the tabulation. Join these points with the center of the circle (Take point 1 as center) by radial lines. This radial line represents the crank positions corresponding to the events.

Model

VALVE TIMING DIAGRAM



S – Suction
C – Compression
P – Power
E – Exhaust

Result:

The angle through which the inlet valve remains open :

The angle through which the Exhaust valve remains open :

The angle of overlap :

Note: In the place of $\theta_1, \theta_2, \theta_3$ & θ_4 *, the actual values of the crank angles are to be substituted*

Expt. No : Date:

A. STUDY AND VALVE TIMING ON CHEVROLET ENGINE

Aim:-

To study and determine the valve timings/settings on Chevrolet engine and to draw the valve timing diagram.

Requirements:-

- Measuring tape
- A circular member attached to crank shaft
- A reference point

Specifications:-

Type :

Fuel used :

Power :

Speed :

Bore :

Stroke :

Type of Cooling :

OBSERVED DIAGRAM

Observation tabulation:-

Circumference of flywheel = cm.

Sl. No.	Events	Sequence of Operation	Distance from the nearest dead centre '**x**' in cms	Crank angle 'θ' in degrees
1	IVO			
2	IVC			
3	EVO			
4	EVC			

SPECIMEN CALCULATIONS:

$$\theta_1 \quad \frac{X_1 x\ 360}{\text{Circumference of the flywheel / pulley / brake drum}}$$

$$\theta_2 \quad \frac{X_2 x\ 360}{\text{Circumference of the flywheel / pulley / brake drum}}$$

$$\theta_3 \quad \frac{X_3 x\ 360}{\text{Circumference of the flywheel / pulley / brake drum}}$$

$$\theta_4 \quad \frac{X_4 x\ 360}{\text{Circumference of the flywheel / pulley / brake drum}}$$

VALVE TIMING DIAGRAM

RESULT:

The experiment was conducted and the Valve Timing Diagram for the Chevrolet engine was drawn. From the valve timing diagram the following values are obtained

Crank angle for which the Inlet valve remains open(θ_1+180+ θ_2) =
Crank angle for which the Exhaust valve remains open(θ_3+180+ θ_4) =
Angle of over lap (θ_1+ θ_4) =

Expt. No :   Date:

b) STUDY OF SI ENGINE FUEL SYSTEM (CARBURETORS)

Aim: To study the working principle, components and their function of a simple carburetor.

Definition:

Carburation is the process of measuring, mixing and supplying of air and fuel to a spark ignition engine. The mixture supply must be accordance of engine speed and load requirements. This process of carburation is accomplished in a device called as Carburetor

Mixture requirement:

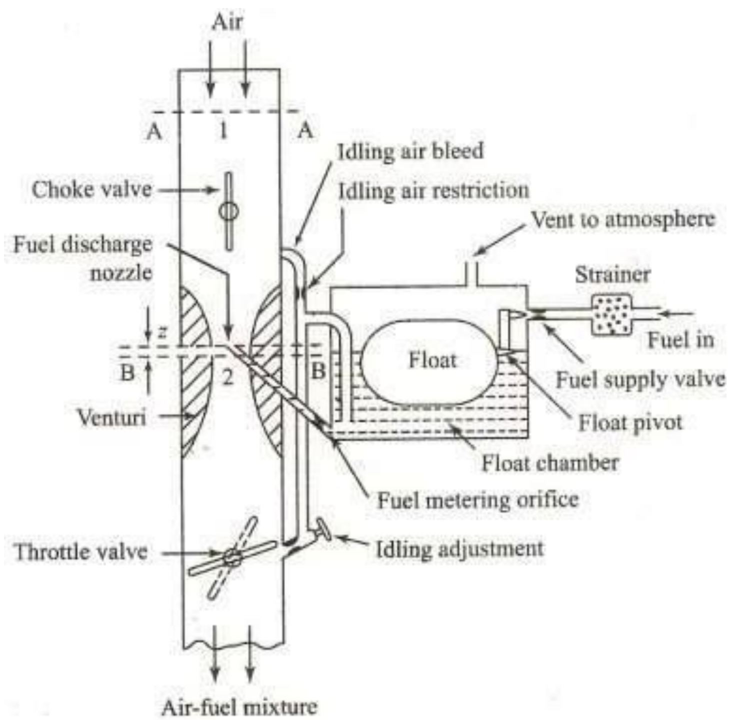
The air fuel ratio is the ratio of the weight of the air and the weight of the fuel supplied to an engine cylinder during suction stroke.

- Theoretically for complete combustion of 1kg of fuel (petrol) about 14.5 kg of air is required. Thus the air fuel ratio is 14.5:1 is known as theoretical or stoichiometric or chemically corrected air fuel ratio.
- If the air fuel ratio supplied to an engine is greater than the theoretical air fuel ratio, then the mixture is said to be as “lean mixture”.
- If the air fuel ratio supplied to an engine is less than the theoretical air fuel ratio, thenthe mixture is said to be as “rich mixture”.
- For cold starting and idling condition the rich mixture is required.
- Continuous driving in high way lean mixture is required.

Principle:

A carburetor has been the most common device used as to control the fuel flow into the intake manifold and distribute the fuel across the air stream. In a carburetor the air flows through the converging-diverging nozzle called a venturi. The pressure difference between the carburetor inlet and the throat of the nozzle (which depends on the air flow rate) is used to meter the appropriate fuel flow for that air flow. The air enters the air stream through the fuel discharge tube or ports in the carburetor body and its atomized and convected by the air stream past as the throttle plate and in to the intake manifold. Fuel evaporation starts within the carburetor continues in the manifold as fuel droplets move with the air flow and as the liquid fuel flows over the throttle and along the manifold walls. A modern carburetor which meters the appropriate fuel flow in to the air stream over the complete engines operating range is a highly developed and complex device. There are many types of carburetors; they share the basic concepts which we will now examine.

The Simple Carburetor



- The air enters the intake section of the carburetor (1) which removes the suspended dust particles.
- The air then flows in to the carburetor venturi (a converging-diverging nozzle) (2) where air velocity increases and the pressure decreases.
- The fuel level is maintained at a constant height in the float chamber (3) which is connected via an air duct (4) to the carburetor intake section (1).
- The fuel flows through the main jet (5) as a result of the pressure difference between the float chamber and the venturi throat where the air stream atomizes the liquid fuel.
- The fuel-air mixture flows through the diverging section of the venturi where the flow decelerates and some pressure recovery occurs.
- The flow then passes the throttle valve (7) and enters the intake manifold.

Limitation of simple carburetor:

The limitation of the elementary carburetor can be summarized as follows:

1. At low loads the mixture become leaner; the engine requires the mixture to be enriched low loads.
2. At intermediate loads, the mixture equivalence ratio increases slightly as the air flow increases. The engine requires an almost constant equivalence ratio.
3. As the air flow approaches the maximum wide-open throttle value, the equivalence ratio remains essentially constant.

Expt. No : Date:

A) STUDY AND VALVE TIMING ON FIELD MARSHAL 8 HP ENGINE

Aim:-

To study and determine the valve timings/settings on Field Marshal 8 HP engine and to draw the valve timing diagram.

Requirements:-

- Measuring tape
- A circular member attached to crank shaft
- A reference point

Specifications:-

Type	:
Fuel used	:
Power	:
Speed	:
Bore	:
Stroke	:
Type of Cooling	:

OBSERVED DIAGRAM

Observation tabulation:-

Circumference of flywheel = cm.

Sl. No.	Events	Sequence of Operation	Distance from the nearest dead centre '**x**' in cms	Crank angle '**θ**' in degrees
1	IVO			
2	IVC			
3	EVO			
4	EVC			

SPECIMEN CALCULATIONS:

$$\theta_1 \quad \frac{X_1 x\ 360}{\text{Circumference of the flywheel / pulley / brake drum}}$$

$$\theta_2 \quad \frac{X_2 x\ 360}{\text{Circumference of the flywheel / pulley / brake drum}}$$

$$\theta_3 \quad \frac{X_3 x\ 360}{\text{Circumference of the flywheel / pulley / brake drum}}$$

$$\theta_4 \quad \frac{X_4 x\ 360}{\text{Circumference of the flywheel / pulley / brake drum}}$$

VALVE TIMING DIAGRAM

RESULT:

The experiment was conducted and the Valve Timing Diagram for Field Marshal 8 HP engine was drawn. From the valve timing diagram the following values are obtained

Crank angle for which the Inlet Valve remains open(θ_1+180+ θ_2) =

Crank angle for which the Exhaust valve remains open(θ_3+180+ θ_4) =

Angle of over lap (θ_1+ θ_4) =

Expt. No : Date:

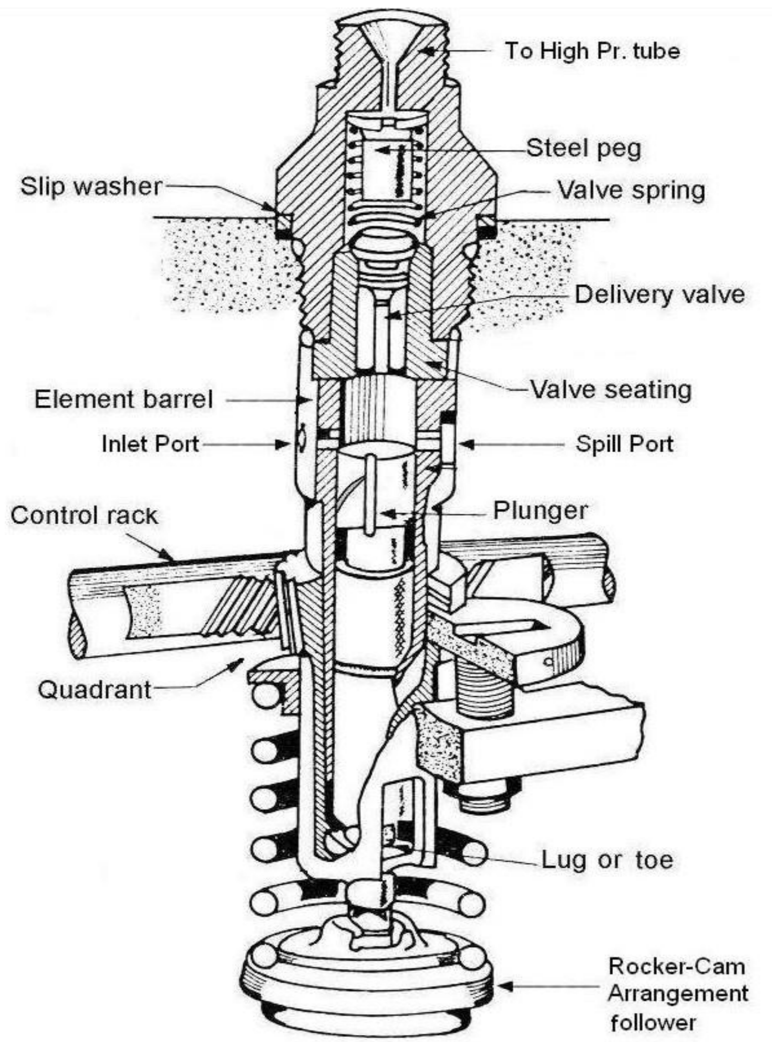
b) STUDY OF DIESEL INJECTION PUMP & DIESEL INJECTOR

Aim : To study the working principle, components and their function of a Jerk type fuel injection pump and a spring loaded Diesel injector or Atomiser.

JERK TYPE FUEL INJECTION PUMP

Functions : The main functions of the fuel injection pump is as follows…

i. To pump the fuel with high pressure (160 - 200) bar to the Injection unit.
ii. To regulate the speed of engine by supplying metered quantity of fuel
iii. To deliver the fuel at the right time of engine cycle (i.e. for combustion)



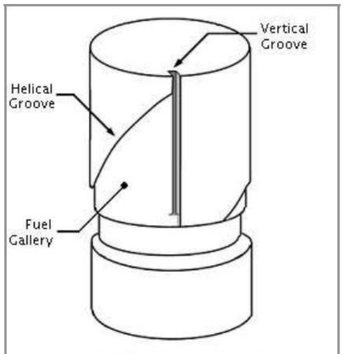
FUEL INJECTION PUMP
(Sectional View)

Consisting with the arrangement of

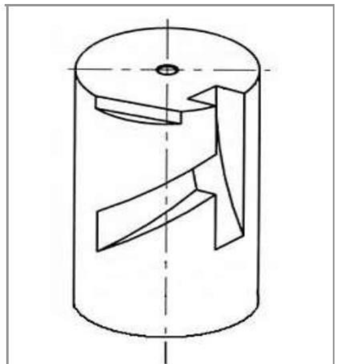
i. a plunger-barrel to pump fuel
ii. a rack & pinion to vary the speed
iii. a spring loaded delivery valve to supply fuel to injector
iv. a rocker-cam to mechanically actuate the plunger

Working :

- The pump is mechanically driven by camshaft through an exclusive cam (eccentric) arrangement and pumps by the reciprocating action of plunger. The plunger has helical groove adjoining with a vertical groove in its periphery, which forms a gallery to occupy the fuel.
- When the plunger is in its bottom most position both inlet & spill ports are open and the fuel enters through the inlet port filling the space above the plunger and also the gallery through the vertical groove.
- Sequentially the plunger actuated by the cam moves upwards and closes the ports.
- So the trapped fuel is "Pressurised" and pumped through the delivery valve.
- After pumping the pressure drops and the delivery valve spring retains, which pushes down the plunger to its initial (bottom) position.
- This creates the space for the fuel to enter once again through the inlet port.

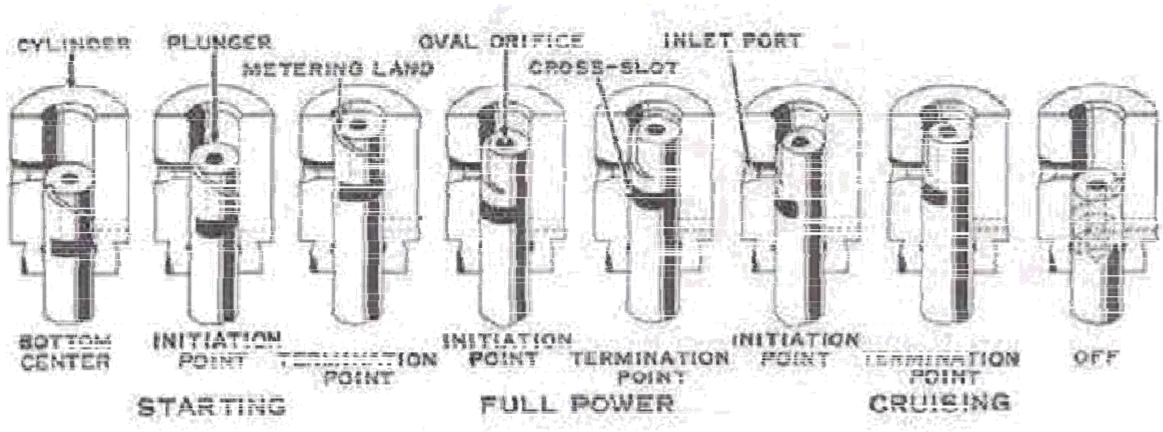


PLUNGER (Conventional)


PLUNGER (Modern)

Varying the Speed :

- The Speed of the engine is regulated by varying the groove position of plunger against inlet & spill ports by adjusting the control rod, which is connected to the accelerator through governor mechanism.
- The Pumping pressure remains high till the sides of the plunger is closing the ports by the helical periphery during its stroke.
- Once the helix opens the spill port, (i.e. coincides with the spill port as illustrated) fuelin the gallery passes out through it.



- So more the helical height, the pressure will be more and proportionally more quantity will be pumped, this is termed in the fig. as *"Effective Stroke"*.

- Similarly if the vertical groove of plunger coincides with the inlet port, then throughout the stroke there will be no closing of (inlet) port and hence no pressure and no fuel will be injected, (i.e.) the fuel enters the gallery and directly passes out through spill port, this is termed as *"zero delivery"*.

- *"Idling"* is the condition in which the fuel supply is minimum enough to keep the engine running and there will be no power transmission, this is attained by closing the inlet port by a minimum possible (helical) groove height. (i.e.) in this pressure (effective stroke distance) will be minimum so the quantity pumped also will be minimum.
- Similarly the in - between speed limits are set by positioning the helical height respectively against the inlet port by rotating the plunger using the control rod.

FUEL INJECTOR

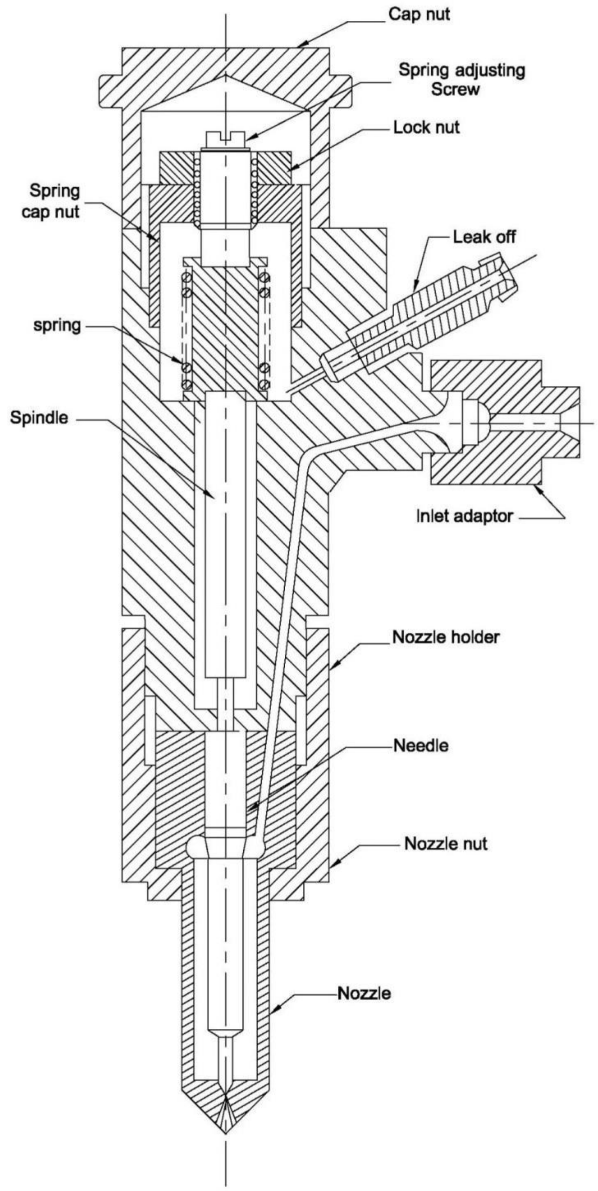
Fuel injector is also termed as Injection nozzle or Atomizer or fuel valve. This is a valve through which fuel is injected with high pressure in to the combustion chamber as a fine spray. The main functions of the fuel Injector is as follows…

i. Atomization – Breaking of fuel into fine droplets.
ii. Injection – Spraying the fuel with high pressure
iii. Controlling – Metering both injection timing and quantity of fuel
iv. Distribution – Properly directed injection in to the combustion chamber for better mixing

Construction :

- Fuel injector is mainly consisting of a nozzle, with a needle valve which is pressed in its seat by a compression spring through a needle valve.

- For the passage of fuel and its leak off, Annular grooves are provided in its body and the injector is supplied with fuel from fuel injection pump through a high pressure tube.



Fuel Injector

Working :

- The fuel with high pressure enters the nozzle through the drillings (annular grooves) in the injector body and surrounds the space around the conical or stepped face of the needle valve.
- When the needle valve is raised from its seat against the spring pressure by the high pressure of fuel acting on the conical face the fuel injection takes place through the nozzle.
- Once after injection, the pressure falls below the spring pressure and the needle valve closes.
- This action tends to setup an oscillation of the valve during each injection and consequently breaks the fuel in to fine droplets as well as injecting it with high pressure.

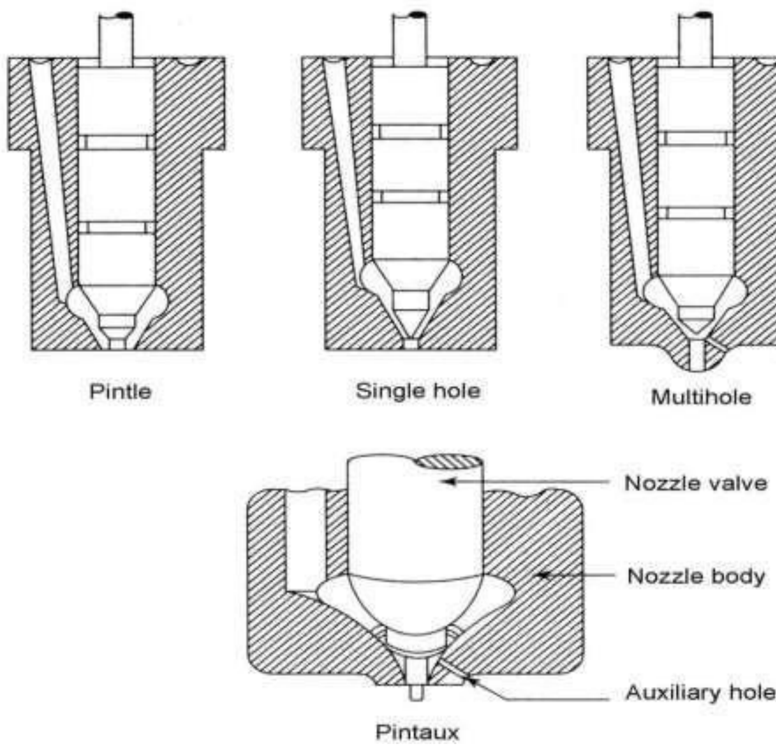
- Fuel leakage through the needle valve stem and spindle (during lift off) acts as lubrication and is drained back to the fuel filter through leak off line.

Screw adjustment of compression spring tension varies the pressure as well as the timing of injection. The normal injection pressure varies from 160 - 200 bar and number of injections (oscillations) varies depends upon the speed of engine.

Nozzle :

This is the main part of injector through which the fuel is sprayed in to the combustion chamber. The major function of a nozzle is to break the fuel in to fine particle droplets (Atomization) and to inject it in to the desired areas of combustion chamber (distribution) ensuring better mixing.

Types of Nozzles :



i) Single hole Nozzle :

- Has a single hole bored in the tip of nozzle either co-axially or conically as illustrated above
- The spray cone angle is 60° with hole dia 0.2m upwards and used for low pressure injection (8 -10 MPa**).**
- Mainly adapted in slow speed engines having speed less than 1000 rpm
- The main advantage of this nozzle is good mixing with air at low velocities.

ii) Multi hole Nozzle :

- Having holes from 4 to 18 bored around the injection tip as illustrated above
- Mainly used for high pressure (18 MPa) and adapted in high speed, high power engines.
- The main advantage of this nozzle is good fuel distribution with low pressure air motion in the chamber.

iii) Pintle Nozzle :

- Having a pin formation as an extension of stem closes the nozzle opening.
- The spray angle of hollow cone is 60° or more
- Widely used in engines with auxiliary combustion chambers. (i.e, Air cell, Swirl, Pre-combustion chambers)
- The main advantage of this nozzle is, avoids weak injection, dribbling and carbon deposition in nozzle tip.

iv) Pintaux Nozzle :

- Having an auxiliary hole in addition to Pintle type for pilot injection. (i.e,) First a small amount of fuel injected in to the chamber through this hole.
- Only for slow speed running of engine this auxiliary hole is used since the main hole pin lifts only at higher engine speeds.
- The main advantage of this nozzle is pilot injection, which provides easy starting under cold conditions.

STUDY AND PORT TIMING ON TWO STROKE IC ENGINES *

Aim :

To determine the port timings of Two stroke IC engines ¯and to draw the port timing diagram.

Ports:

The ports in a two stroke engine are small openings in the cylinder walls diametrically opposite to each other. The piston reciprocating inside the cylinder uncovers (opens) and covers (closes) the ports, thus performing the function of valves in 4 - stroke engines. The exhaust port lies slightly above the inlet (transfer) port. Hence during the ascending of the piston in a vertical engine, the closing of exhaust port precedes the closing of transfer port. Similarly in the descending of the piston, the exhaust port is uncovered first and then the inlet (transfer) port. The above said facts help in identifying the inlet and exhaust ports.

Procedure:

Dead centers:

On removal of the cylinder head, the piston top can be visualised. Rotation of the flywheel makes the piston reciprocate. Make a mark on the flywheel against the fixed pointer corresponding to a specific position of the piston in its upward stroke. On further rotation of the flywheel piston reaches the TDC position (maximum height) and reverses its direction of motion down wards. The position at which a mark was made earlier during upward stroke will be reached again during the downward stroke. Now make a mark on the flywheel. The mid point of the markings is the TDC point on the flywheel. As the direct location of TDC point requires visual judgment and is difficult, the procedure mentioned is suggested. The BDC point is marked in the flywheel diametrically opposite to TDC point. A port is said to open when the piston just starts uncovering it. It is said to close only when piston has totally covered it

After marking the dead center positions on the flywheel, markings are made corresponding to the opening and closing of the inlet and exhaust ports.

* General Instructions and procedure

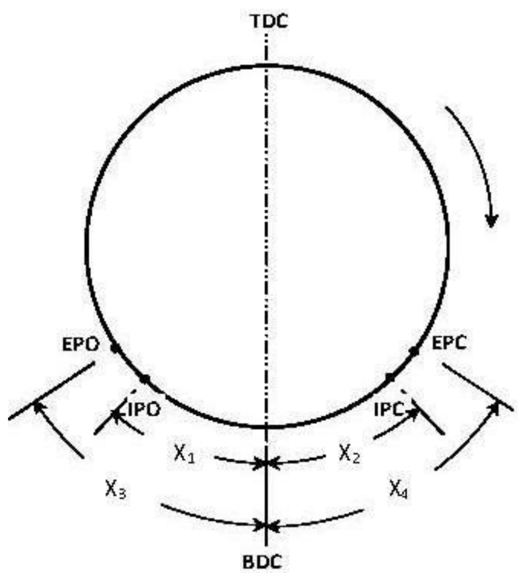
Observed diagram:

A circle of any convenient radius is drawn to represent the flywheel. The markings made on the flywheel are also shown in the circle and the distance of them from the nearest dead center are marked. When the sense of rotation of the flywheel is added, the observed diagram becomes complete.

The details of the observed diagram ie. the crank positions (angle and sequence) in relation to the nearest dead center, corresponding to the opening and closing of the inlet and exhaust valves are tabulated. The respective crank angles are calculated from the arc lengths in observed diagram.

Model

OBSERVED DIAGRAM



Observation tabulation:-

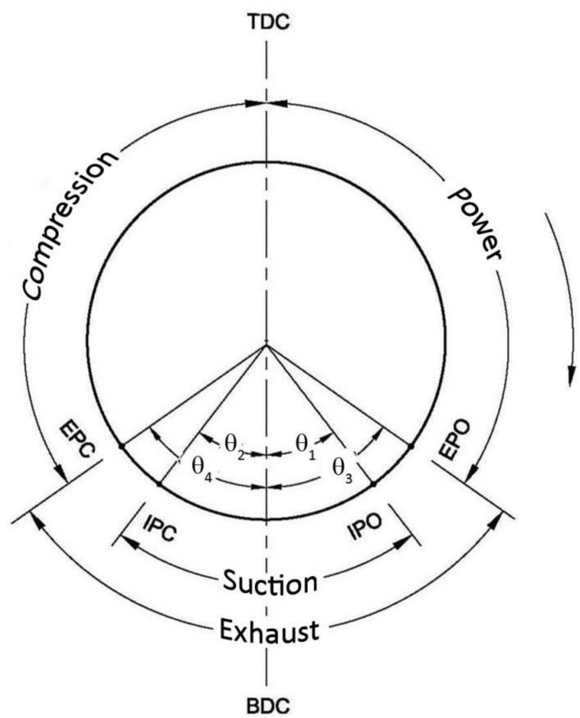
Circumference of flywheel =..............cm.

Sl. No.	Events	Sequence of Operation	Distance from the nearest dead centre X in cms	Crank angle θ in degrees
1	IPO			
2	IPC			
3	EPO			
4	EPC			

$$\text{Crank angle } \theta = \frac{x \times 360}{\text{Circumference of the flywheel/pulley/brake drum}}$$

Port Timing Diagram:

The port timing diagram is drawn using the inferences from the table. The crank angles, the sequences in relation to the nearest dead center position of the crank and the required direction of travel of the observer along the circular diagram are furnished in the port timing diagram.



Result:

The angel through which the inlet port remains open :

The angle through which the Exhaust port remains open :

Expt. No : Date:

A) STUDY AND PORT TIMING ON PETTER 5 HP ENGINE

Aim :

To study and determine the port timings of Petter 5 HP engine and to draw the port timing diagram.

Requirements:-

- Measuring tape
- A circular member attached to crank shaft
- A reference point

Specifications:-

Type	:
Fuel used	:
Power	:
Speed	:
Bore	:
Stroke	:
Type of Cooling	:

OBSERVED DIAGRAM

Observation tabulation:-

Circumference of flywheel =.............cm.

Sl. No.	Events	Sequence of Operation	Distance from the nearest dead centre X in cms	Crank angle θ in degrees
1	IPO			
2	IPC			
3	EPO			
4	EPC			

$$\text{Crank angle } \theta_1 = \frac{X_1 \times 360}{\text{Circumference of the flywheel/pulley/brake drum}}$$

$$\text{Crank angle } \theta_2 = \frac{X_2 \times 360}{\text{Circumference of the flywheel/pulley/brake drum}}$$

$$\text{Crank angle } \theta_3 = \frac{X_3 \times 360}{\text{Circumference of the flywheel/pulley/brake drum}}$$

$$\text{Crank angle } \theta_4 = \frac{X_4 \times 360}{\text{Circumference of the flywheel/pulley/brake drum}}$$

PORT TIMING DIAGRAM

RESULT:

The experiment was conducted and the Port Timing Diagram for the Petter 5 HP engine was drawn

Crank angle for which Inlet port remains open ($\theta_1+\theta_2$) :

Crank angle for which the Exhaust port remains open ($\theta_3+\theta_4$) :

Expt. No : Date:

B) DISMANTLING AND ASSEMBLING OF KIRLOSKAR AV I ENGINE

Aim:

To understand the constructional details, part function and system working of a single cylinder diesel engine through dismantling and assembling.

Specifications:

Type

No. of strokes per cycle

Type of cooling

Fuel used

Speed

Power

Bore

Stroke

Tools Required:

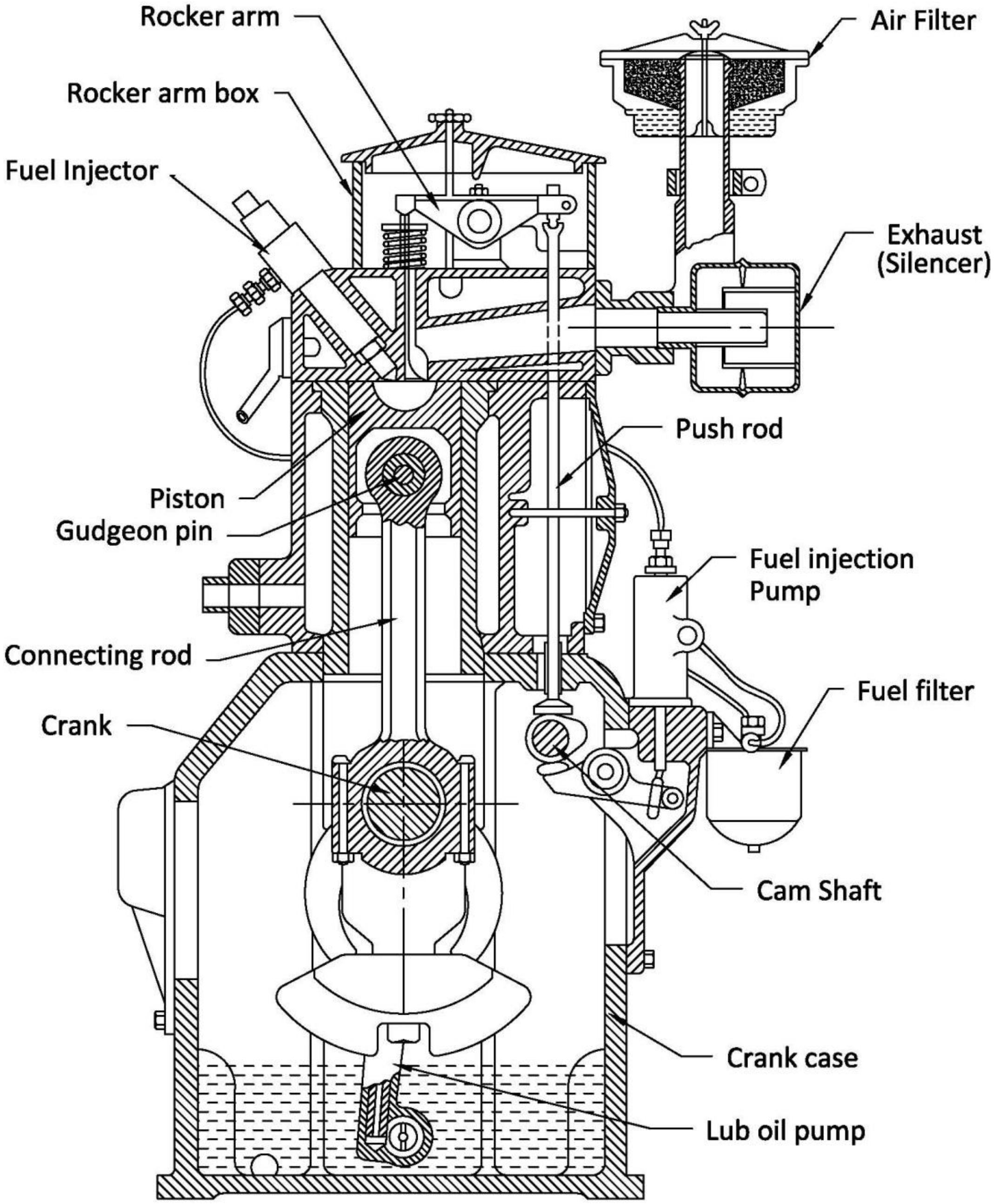
Procedure:

Using the correct tools, dismantle the engine from the top end (remove only vital parts) and reassemble the engine in the reverse order (i.e. from the bottom end).

While assembling the engine, identify all the vital parts.

Expectations from the learners:

- Dismantling and assembling of the I.C engine components using correct tools.
- Listing of any 10 (ten) important components of the engine along with their functions and materials used.
- Drawing of the sectional elevation of the engine with its parts.
- Step by step procedure for dismantling and re - assembling.



SECTIONAL VIEW OF A DIESEL ENGINE

KIRLOSKAR AV-I ENGINE PARTS LIST

1. Rocker box / cover door (MS sheet)
2. Rocker box with rocker arm
3. Decompression lever
4. Cylinder head (alloy iron)
5. Injector /Nozzle
6. Inlet and outlet valves
7. Valve spring
8. Air filter (oil stained filter)
9. Exhaust silencer pipe
10. Cylinder head gasket
11. Cylinder block
12. Cylinder (Alloy iron)
13. Fuel tank
14. Piston (Aluminum alloy)
15. Piston ring (cast iron)
16. Gudgeon pin
17. Push rod cover
18. Push rod
19. Tappet
20. Crankcase
21. Fuel pump bracket
22. Fuel injection pump
23. Fuel control lever
24. Cam shaft (medium steel)
25. Crank shaft (medium steel)
26. Fuel filter
27. Fly wheel
28. Timing gears
29. Gear cover (mild steel)
30. Connecting rod (medium carbon steel)
31. Lubricating oil pump
32. Lubricating oil filter casing
33. Dip stick (oil level indicator)

Expt. No : Date:

A) STUDY AND VALVE TIMING ON DODGE ENGINE

Aim:-

To study and determine the valve timings/settings on Dodge engine and to draw the valve timing diagram.

Requirements:-

- Measuring tape
- A circular member attached to crank shaft
- A reference point

Specifications:-

Type	:
Fuel used	:
Power	:
Speed	:
Bore	:
Stroke	:
Type of Cooling	:

OBSERVED DIAGRAM

Observation tabulation:-

Circumference of flywheel = cm.

Sl. No.	Events	Sequence of Operation	Distance from the nearest dead centre '**x**' in cms	Crank angle 'θ' in degrees
1	IVO			
2	IVC			
3	EVO			
4	EVC			

SPECIMEN CALCULATIONS:

$$\theta_1 \quad \frac{X_1 x\ 360}{\text{Circumference of the flywheel / pulley / brake drum}}$$

$$\theta_2 \quad \frac{X_2 x\ 360}{\text{Circumference of the flywheel / pulley / brake drum}}$$

$$\theta_3 \quad \frac{X_3 x\ 360}{\text{Circumference of the flywheel / pulley / brake drum}}$$

$$\theta_4 \quad \frac{X_4 x\ 360}{\text{Circumference of the flywheel / pulley / brake drum}}$$

VALVE TIMING DIAGRAM

RESULT:

The experiment was conducted and the Valve Timing Diagram for the Dodge engine was drawn. From the valve timing diagram the following values are obtained

Crank angle for which the Inlet Valve remains open(θ_1+180+ θ_2) =

Crank angle for which the Exhaust valve remains open(θ_3+180+ θ_4) =

Angle of over lap (θ_1+ θ_4) =

Expt. No : Date:

B) STUDY OF ENGINE COOLING SYSTEM

NEED FOR A COOLING SYSTEM

The temperature of a working fluid in a reciprocating IC engine varies from the ambient temperature to about 3000 K during each cycle. The maximum temperature during combustion is approximately equal to the melting point of platinum and the temperature of the exhaust gases is more than the melting point of aluminium. If there were no external cooling of the cylinder, the cylinder walls would assume an average temperature of the gases to which they are exposed, which may be as high as 1500 K in the region of exhaust valves. And, no known material is capable of sustaining continuously such high temperatures. Therefore, if an engine is not cooled properly, it will reach a temperature which will seriously harm the functioning of certain parts because - distortion, cracking and melting would take place at such high temperatures. The high temperature inside the system can also cause the lubricant to be burned up leading to ceasing of piston and bearings, warping of valves etc. And, the fresh charge entering the engine would get heated leading to detonation, reduction in volumetric efficiency and the engine output.

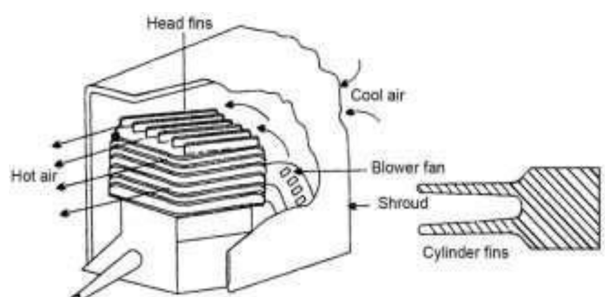
Types of Cooling System

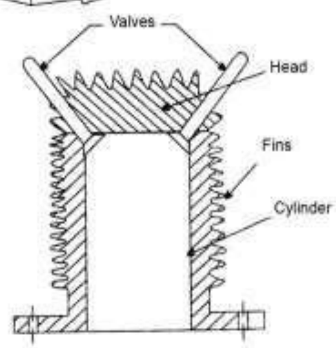
A cooling system means dissipation of the undesirable heat energy to the surrounding air. There are two types of cooling system being used in IC engines:

(a) Direct or air-cooling system - heat energy from the engine is directly transferred to the surrounding air,
(b) Indirect or water-cooling system - heat energy from the engine is transferred to the surrounding air with the help of water which circulates through the engine parts.

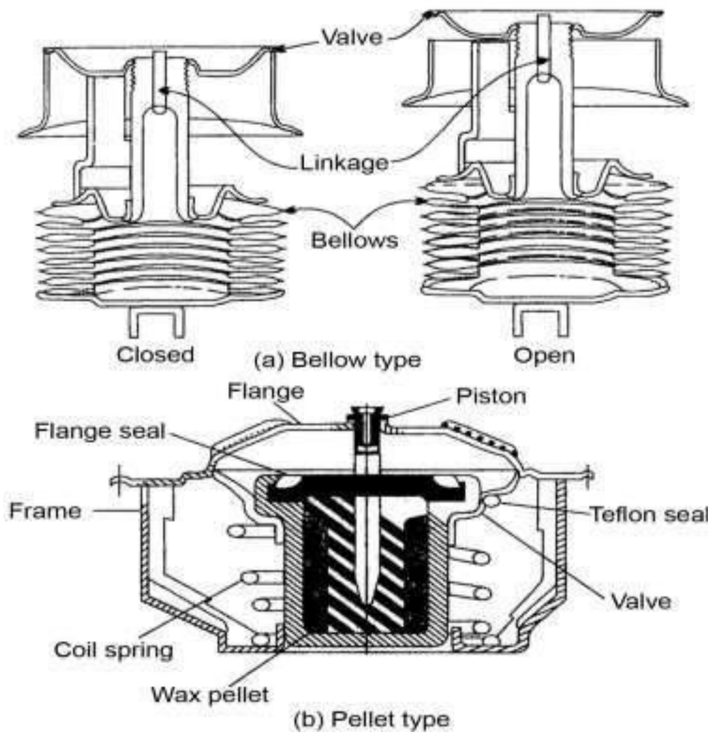
Air-Cooling System

This system is being extensively used for engines in scooters, motorcycles, cars (Volkswagen-a German car) combat tanks, small aeroplanes and stationary generator sets. The dissipation of heat energy IS by convection and radiation. Since the flow of heat energy is directly proportional to the area exposed to the surroundings, outer surfaces of the engine cylinders and their head are provided with extended Surface called 'fins'. The cooling surface area of the system is increased by increasing the number of fins, as shown in figure. This increase in area is essential because the air is a poor conductor of heat energy and the heat transfer coefficient from





metal to air is much lower than metal to water. The fins are usually tapered to increase the rate of heat transfer.
Motorcycle engines are open to the atmosphere. The forward motion of the motorcycles give a good velocity to air flowing over the engine and an effective cooling is achieved. The engines of other vehicles (like scooters, cars etc) are usually covered and as such a centrifugal or axial flow fan, driven by the engine crankshaft, directs cooling air to flow over the cylinder and cylinder head. In multi-cylinder engines, air enters a duct provided in the system to cool each cylinder and is exhausted through openings at the rear of the engine.



Thermostats for air cooling of engines.

The rate of engine cooling is controlled by a bellows type thermostat shown in figure, mounted in the lower part of each engine. Bellows are filled with volatile liquid under reduced pressure. When the bellows is heated, the liquid vaporizes and expands. The movement of the bellows operates a linkage to open the valve. When the unit is cooled, the vapour condenses, reducing the pressure and the bellows collapse to close the valve. Fig. (b) illustrates a Pellet type thermostat. It is a sealed unit in wax pellet which expands on heating and contracts on cooling. It is connected by a piston and flange to a valve, so that the expansion of the pellet opens the valve. A coil spring closes the valve when the pellet contracts.

The advantages of the air-cooling system are:

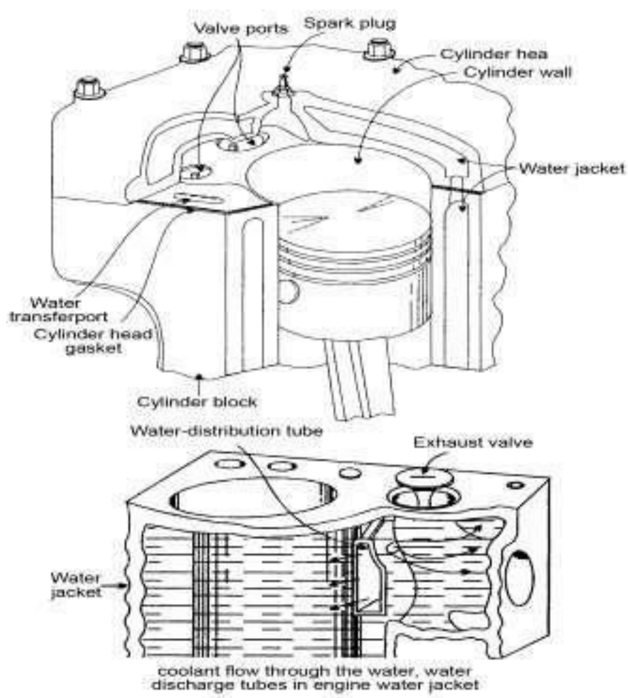
1. Cooling system design is simple and cheaper.
2. Components like radiators, pumps etc. required in liquid cooling systems are absent. Therefore, operating cost and maintenance is reduced.
3. Suitable for cold climates. Absence of water and coolant disallows freezing.
4. Occupy less space.

The limitations of air-cooling systems are:

1. Can be used in small size engines cooling in multi-cylinder engine is not uniform, engines are subjected to high working temperatures.
2. Engines using air-cooling have lower compression ratio, hence are lower output engines.
3. Mechanical noise cannot be suitably reduced.

WATER-COOLING SYSTEM

In this system, water or coolant is circulated through water jackets around each of the combustion chambers, cylinders, valves, seats and stems. Water is flowing through the systems under the action of a centrifugal water pump driven by v-belt from a pulley mounted on the engine crankshaft. Water after flowing through the passages in the cylinder block and the cylinder head, enters the radiator and is cooled by air flowing over the radiator tubes and fins. The air flow is created by a fan and by the forward motion of the vehicle. It is the common practice to mount the fan and the pump on the same shaft driven by the crankshaft. The water cooled after flowing through the radiator, flows back to the water pump for its recirculation.



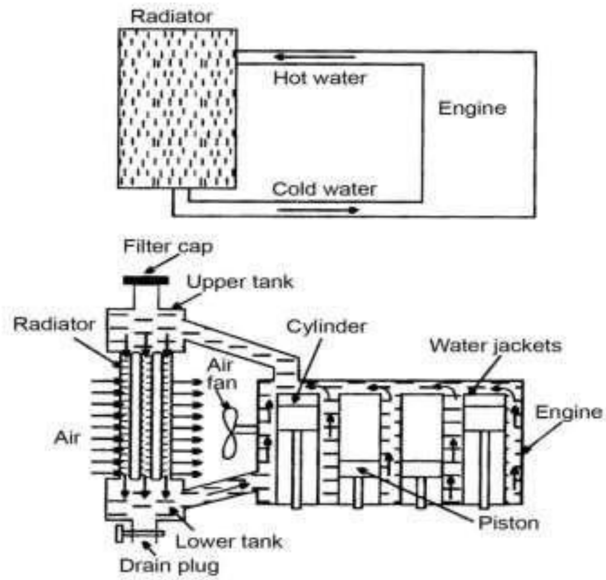
The water passages in the cylinder block and head, valve ports and seats and other hot part is shown in figure. Heat energy flows by conduction through the metal walls to the water in the passages and is connected away by the circulating water. The tubes through which the water flows, are long, flat and thin walled and have a number of small openings that direct the water against the exhaust valves. The tube fits in the water jacket and can be removed from the front end of the block. Water cooling systems is usually carried out by any of the following methods:

1. Thermo-Syphon System (natural circulation)
2. Pump or forced circulation system.

Thermo-Syphon system

The basic principles and operation of thermo-syphon system can be explained' with the help of sketch shown in figure. It is a natural phenomenon that when a fluid particle comes in contact with a hot surface, its density decreases with increase in temperature and the fluid Particles have a tendency to move up. Their place is occupied by heavier (colder) particles and when they come in contact with the hot surface, they also move up. This way a motion is created and the fluid particles carry heat energy from the hot surface to other places.

As shown in figure the radiator and the water passages are filled up with water before the engine is started. When the engine is running, the water particles come in contact with hot cylinder walls and they move up and enter the upper tank of the radiator. Air drawn by the fan from the surroundings flows over the radiator tubes and cools water flowing down through the radiator tubes. Cold water again comes in contact of the cylinder walls and the process repeats.



Although, this device is simple and cheap, the operation is automatic and requires very little maintenance. The disadvantages are:

1. Rate of circulation is very slow and large quantities of water will be required.
2. System can be employed only on small engines because cooling water may not reach all places where appropriate cooling is required.
3. Not suitable for cold climatic conditions.

Forced Circulation System

The rate of heat transfer can be increased substantially if the fluid particles, coming in contact with a hot surface, are set in motion by external methods (forced circulation). This principle is utilized in forced cooling system adopted by a large number of vehicles (cars, buses, trucks, diesel locomotives etc). The main components of this system are (i) radiator

(ii) fan (iii) water pump and (iv) thermostat. The working principle can be explained with a block diagram shown in figure.

The water pump is provided between the lower tank of the radiator and water inlet to the engine block and cylinder head. The water pump receives power from the engine camshaft. The pump forces water to flow through the passage provided inside the cylinder block and head. Hot water comes out of the engine block and will go to the radiator through the thermostat (a control valve).

All modem cooling systems incorporate a thermostatic device which does not permit water to come out of the engine block for circulation through the radiator for cooling until its temperature has reached a value suitable for efficient engine operation. The location and functioning of these thermostatic devices vary with different designs but the principle of operations is the same.

The advantages of the water cooling system are many and can be listed as:

(a) The system can circulate water to all areas where cooling is required.

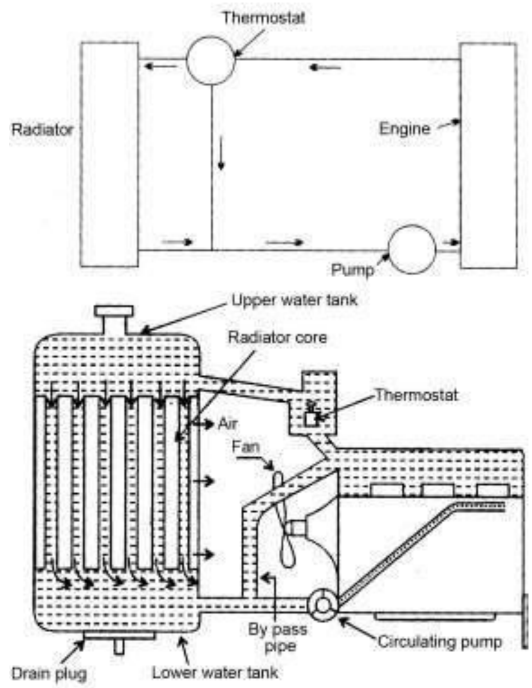
(b) The rate of water circulation is quite fast.

(c) The temperature of the system can be automatically controlled and a small quantity of water will be required.

(d) Engines with high specific output will not pose any problem with water cooling.

(e) The size of the cooling jackets can be reduced and the structure can be made compact.

(f) The engine can be installed anywhere in the vehicle.



Principles of forced circulation system.

The disadvantages of the system are:

(a) The use of radiator and pump increases the weight of the engine.

(b) The maintenance is costly.

(c) The system requires more energy for its operation and

(d) The engine performance becomes more sensitive to climatic conditions.

(e) The system is complicated and expensive.

ADVANCED COOLING CONCEPTS

The conventional cooling systems have two main disadvantages:

1. A large volume of coolant is required and it can lead to a slow engine warm up and the fuel consumption will be higher for a short journey.
2. The cooling system is likely to overcool parts of the engine especially the cylinder liner at part loads.

Expt. No : Date:

STUDY OF ENGINE LUBRICATION SYSTEM

INTRODUCTION:

The internal combustion engine consists of many moving parts that rub against each other. Friction exists between the points. The supply of lubricating oil between the moving parts is called lubrication.

Purpose of Lubrication:

1. To reduce friction between the moving parts
2. To reduce the wear of moving parts
3. To act as seal and prevent leakage between the parts such as pistons, rings, and cylinders
4. To keep down the temperature of the moving parts and thus prevent seizure
5. To carry away the much of heat generated by friction
6. To wash away the acidic accumulation and the abrasive metal worm from the friction surfaces.

Types of lubricants

Lubricants are classified in three phases-liquid, semi-solid and solid. Liquid (fuel oils) are used in engine lubricating system such as transmission and rear axle systems. Semi-solid oils like grease are used in chassis lubrication. Solid lubricants like graphite and mica, mixed with oil are used to lubricate springs.

Properties of lubricants

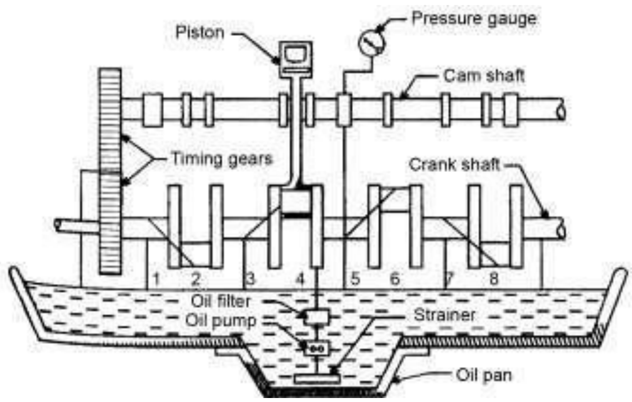
1. A suitable viscosity, preferably constant with temperature.
2. Oiliness- to ensure adherence to the bearings and for less friction and wear.
3. High film strength-to prevent metal-to-metal contact when under heavy load.
4. Anti-corrosive properties to prevent corrosion of any part of the engine.
5. Low pour point- the lubricant should flow at low temperature to the oil pump.
6. Cleansing ability- to clean the parts internally from dirt, metal particles and by-products of combustion.
7. Non-foaming characteristics- to enable the oil to dispersed air (oxygen) that would encourage oxidation.
8. Safety- non-toxic and not inflammable or explosive.

ENGINE LUBRICATING SYSTEMS

Engine lubrication system means lubrication of main engine parts like main bearings, connecting rod bearings, wrist pins, camshaft bearings and cams, cylinder walls, valves and timing drive. Equipments like starter, generator, water pump and distributor are separately lubricated. The engine lubrication system circulates oil from a common sump or reservoir at the bottom of the crank case and may be called Wet sump lubrication. This can be classified as

(i) Full pressure system
(ii) Splash system and
(iii) Modified splash system.

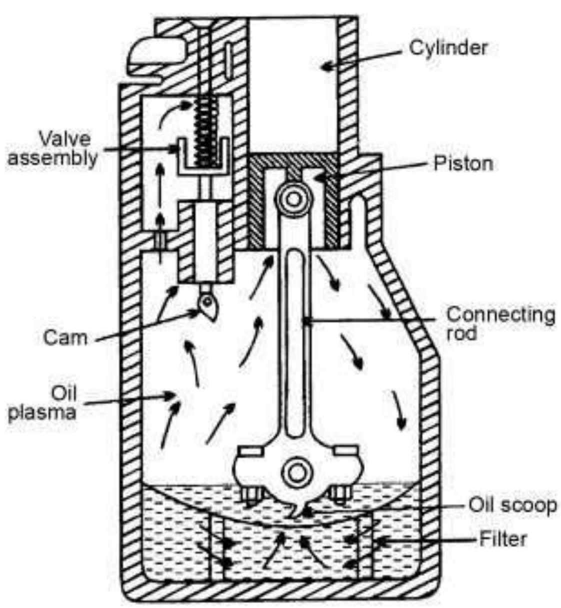
Full pressure system:



Oil is forced through different parts under pressure by a geared pump to most of the various rotating and reciprocating parts. Oil enters the connecting rod bearings and crankshaft through drilled passages. A nozzle is sometimes placed on the upper end of the connecting rod to spray oil, as a coolant, on the underside of the piston crown (as in diesel engine). Overhead valve engines have an oil line leading to a hollow rod which supports the rocker anus. Oil can then flow through the rocker arms, to valve stems and tappets and down to the valve guides. This system is best suited for large engines.

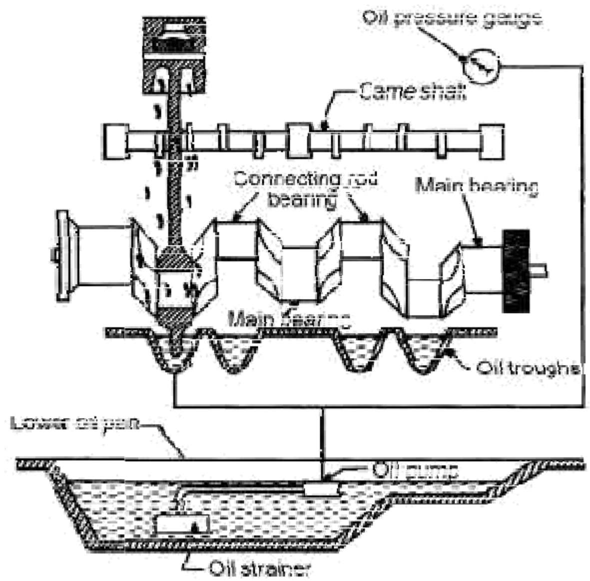
Splash system:

Small engines usually have a splash system, shown in figure. The level of oil is maintained at a particular level in the sump. The connecting rod is supplied with dippers on the end and they splash the oil on the various parts as they travel through oil troughs at the bottom of the stroke. A pump is usually employed to carry the oil to the troughs. Excess oil supplied falls back into the sump under the action of gravity.



Modified splash system is a combination of the full pressure and splash system. The main and crankshaft bearings are lubricated on the principles of full pressure system and the connecting rod bearings are lubricated by means of dippers as shown in Figure.

Since it is not possible even with the finest gauge to filter all the minute particles of grit and abraded metal which cause wear of bearings, it is essential to have in the oil circuit adequate filters of large total area for the removal of all dangerous abrasive materials. Therefore, two filters in the circuit one before the pump and the other after the pump are provided. The gear pump produces the required pressure in the system and is driven by the camshaft. An oil pressure gauge is provided to indicate satisfactory oil supply.



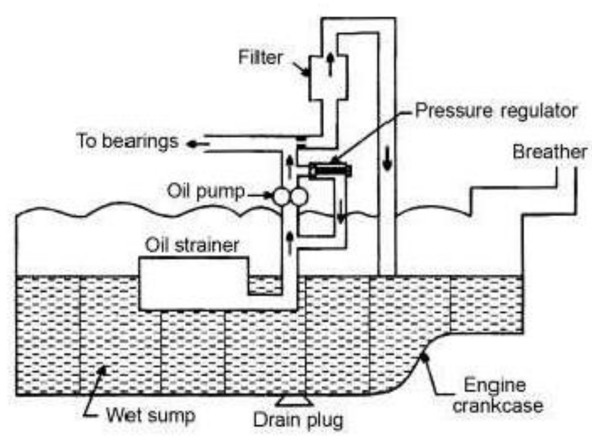
Splash system for a four cylinder engine.

Mist Lubrication System- In most of the two-stroke engines, the charge enters the crankcase through reed valve while the piston is describing the inward stroke (moving towards TDC) and is compressed in the crankcase when the piston describes the expansion stroke. Thus, two-stroke engines are not suitable for crankcase lubrication.

Wet sump lubrication system

The full pressure or forced system of lubrication can be either Wet sump or the dry sump system. In the wet sump system only one pump which draws its oil from the bulk supply contained in the sump formed in the lower half of the crank case.

Therefore 2 to 3 percent lubricating oil (a fuel/oil ratio of 40 to 50:1 is the optimum for good performance) is mixed with the fuel (gasoline) in fuel tank. When the mixture passes through the carburetor, the gasoline, being more volatile, vapourizes and mixes with air. The oil which is less volatile enters the crankcase as a mist and goes to the cylinder for lubrication. The oil impinging on the crankcase walls lubricates the main and connecting rod bearings. Some oil enters the engine cylinder with the vapourized fuel and lubricates the piston, piston rings and cylinder.



Expt. No : Date:

A) STUDY AND VALVE TIMING ON JET ENGINE

Aim:-

To study and determine the valve timings/settings on Jet engine and to draw the valve timing diagram.

Requirements:-

- ✓ Measuring tape
- ✓ A circular member attached to crank shaft
- ✓ A reference point

Specifications:-

Type :

Fuel used :

Power :

Speed :

Bore :

Stroke :

Type of Cooling :

OBSERVED DIAGRAM

Observation tabulation:-

Circumference of flywheel = cm.

Sl. No.	Events	Sequence of Operation	Distance from the nearest dead centre '**x**' in cms	Crank angle 'θ' in degrees
1	IVO			
2	IVC			
3	EVO			
4	EVC			

SPECIMEN CALCULATIONS:

$$\theta_1 \quad \frac{X_1 x\ 360}{\text{Circumference of the flywheel / pulley / brake drum}}$$

$$\theta_2 \quad \frac{X_2 x\ 360}{\text{Circumference of the flywheel / pulley / brake drum}}$$

$$\theta_3 \quad \frac{X_3 x\ 360}{\text{Circumference of the flywheel / pulley / brake drum}}$$

$$\theta_4 \quad \frac{X_4 x\ 360}{\text{Circumference of the flywheel / pulley / brake drum}}$$

VALVE TIMING DIAGRAM

RESULT:

The experiment was conducted and the Valve Timing Diagram for the Jet engine was drawn. From the valve timing diagram the following values are obtained

Crank angle for which the Inlet Valve remains open (θ_1+180+ θ_2) =

Crank angle for which the Exhaust valve remains open (θ_3+180+ θ_4) =

Angle of over lap (θ_1+ θ_4) =

Expt. No : Date:

B) STUDY OF RECIPROCATING AIR COMPRESSOR

Aim:

To study the working principle, components and their function of an Air compressor

Air Compressors are classified into:

1. Positive displacement compressor
    a) Reciprocating air compressor
    b) Rotary air compressors.

Classification of Reciprocating Air Compressor:

(i) Single acting compressor,
(ii) Double acting compressor,
(iii)Single stage compressor,
(iv)Multi stage compressor

2. Dynamic compressor
    a) Centrifugal air compressor
    b) Axial air compressor

Single acting reciprocating compressor: In single acting compressor the air is compressed in the cylinder on one side of the piston only.

Double acting compressor: In double acting compressor the air is compressed on both sides of the piston.

Single stage compressor: In single stage compressor, the air is compressed in a single cylinder.

Multi stage compressor: In multistage compressor, the air is compressed in two or more cylinders. Multi stage compression is done to achieve high pressure ratio. In a compressor when compression ratio exceeds 5, generally multistage compression is adopted. The following arrangements are generally in practice for reciprocating compressors.

No. of stages	Delivery press
One	up to 5 bars
Two	5 to 35 bar
Three	35 to 85 bar
Four	above 85 bars

According to pressure range the compressors are also classified as:

Fans : Pressure ratio is 1 to 1.1
Blowers : Pressure ratio is 1.1 to 4.0
Compressors : Pressure ratio is above 4

Some Important parts and its functions:

Low pressure cylinder: Air is compressed from atmospheric pressure to intermediate pressure in L.P. Cylinder.

High Pressure Cylinder: Air is compressed from intermediate pressure to delivery pressure in H.P Cylinder.

Inter Cooler: Air is cooled in between the two compression stages at constant pressure.

After Cooler: Air is cooled after the compression is over to accommodate more air in the receiver tank.

Air Filter: It filters dust particles from the air. Otherwise the dust particles will adhere the inner surface of the cylinder and thereby increases the friction between the cylinder and piston. Due to this more power loss, wear and tear will be taking place.

Orifice Meter: It is used to measure the actual flow of air for compression by measuring pressure difference across the orifice using manometer.

Air Stabilising Tank: During suction stroke, the air from atmosphere is sent into the LP cylinder. During compression, air is sent to HP cylinder through inter cooler. The flow of air in the pipe line from atmosphere to the LP cylinder is not uniform (i.e. intermittent) due to the suction of the air taking place in the alternative strokes. To measure the flow rate of air, the flow must be uniform across the orifice. Otherwise the manometer reading will fluctuate. Hence an air stabilising tank is introduced between orifice meter and LP cylinder. This stabilises the flow of air between the air filter and stabilising tank. While connecting the pipe line and the stabilising tank, see, that these are connected in diametrically opposite. However, air stabilising tank, is fitted only in the experimental air compressors to measure the flow rate of air.

Safety Valves: It releases the air when the pressure of air exceeds the desired limit.

Pressure Cut off Switch: It is a device used to disconnect the electrical circuit, when the pressure of air in the receiver tank reaches the desired pressure. This disconnects the circuit of no volt coil in the Star-Delta Starter; thereby it switches off the motor.

Prime mover and Dynamometer: The prime mover used for the compressor is a trunnion type electrical motor. This motor itself is acting as dynamometer to measure the input power of the compressor.

Work done on P-V diagram of compressor:

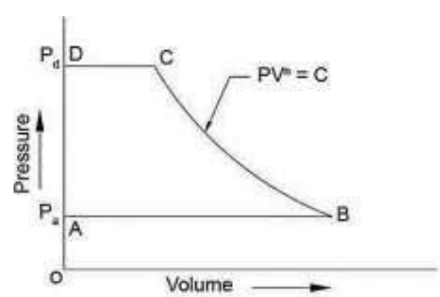


Fig.2 P-V diagram for Single stage air compressor.

The P-V diagram of a single stage reciprocating air compressor with zero clearance is shown in Fig.2 The air is sucked in from the atmosphere during the suction stroke AB at pressure P_a(i.e. at atmospheric pressure). At the end of suction stroke the air is compressed polytropically, during the part of its return stroke (process BC). During compression stroke the pressure and temperature of air increases and volume decreases. This happens until the pressure P_d (delivery pressure) in the cylinder is sufficient to force open the delivery valve at C after which no more compression takes place. The delivery occurs during the remainder of the return stroke CD. The work done on the air per stage is area ABCDA. In the case of air compressors, the inlet and outlet valves are operated by pressure difference only. Not by any external means.

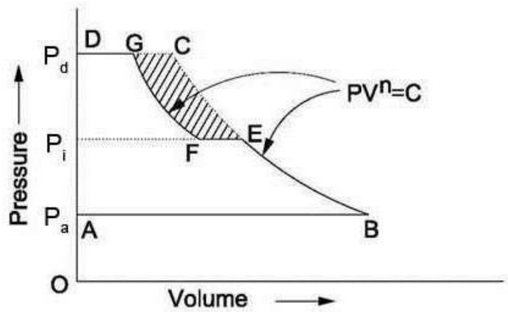


Fig.3 P-V diagram for two stage air compressor with inter cooling.

The air is sucked in LP cylinder during the suction stroke at intake pressure P_a and Temperature T_a. After compression in the first stage from B to E it is delivered to the intercooler, at a constant pressure P_i. The air is cooled in an intercooler, at a constant pressure P_i before passing it to second stage. The process of intercooling is represented by the line EF. The air from the intercooler is then directed to the second stage of compression FG to the delivery pressure P_d. Then the air delivered to the receiver tank at constant pressure P_d. This process is represented by GD in the P-V diagram. The shaded area CEFGC shows the amount of work saved due to two stage compression with intercooling per cycle.

The advantages with multistage compression are:

(i) Some work is saved.
(ii) Uniform torque is obtained with the result, that a smaller size flywheel is needed.
(iii) Volumetric efficiency is increased.
(iv) Light cylinders are required.
(v) The maximum working temperature is reduced thereby more effective lubrication is possible.

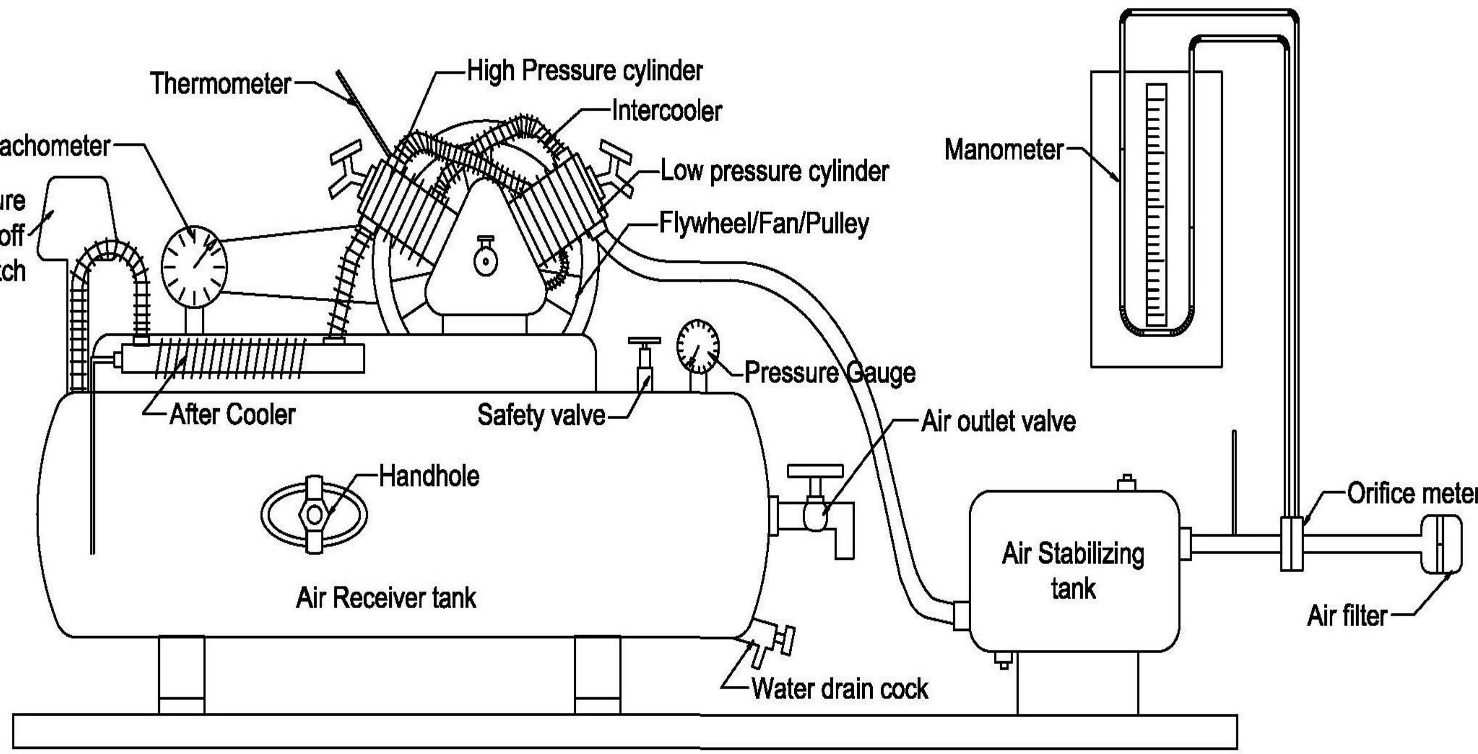


Fig. 4. The Schematic diagram of air compressor

Expt. No : Date:

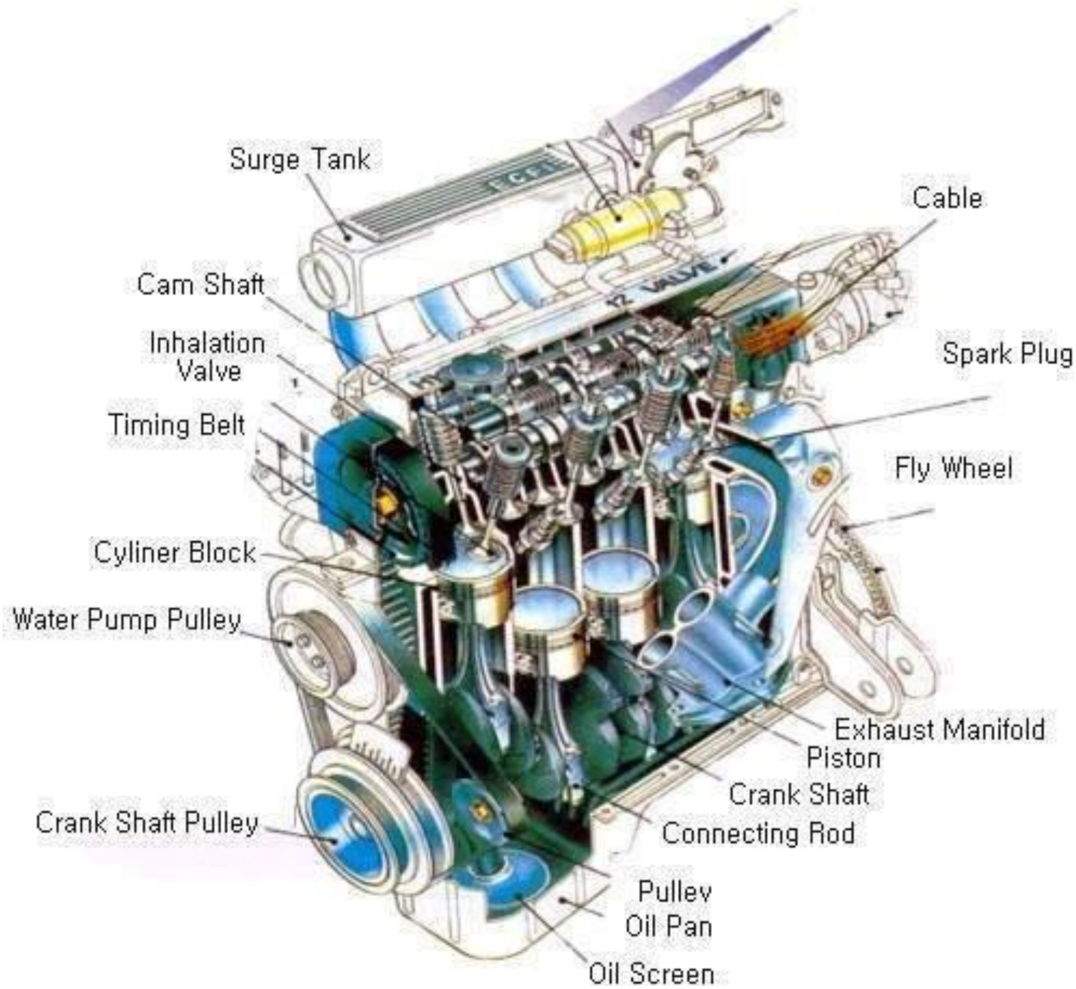
STUDY OF DISMANTLED FORD FIESTA PETROL ENGINE

AIM

To understand the constructional details, part function and system working of a multi cylinder petrol engine.

Specification

TYPE	: FOUR CYLINDER 16 VALVE VERTICAL WATER COOLED 4 – STROKE MPFI –PETROL ENGINE
BORE	: 79 mm
STROKE	: 76.5 m
MAX.POWER	: 121.36 bhp @ 6500 rpm
MAX. TORQUE	: 150Nm @ 4500 rpm
CAPACITY	: 1497 cc
COMPRESSION RATIO	: 11:1
FIRING ORDER	: 1---3---4---2.



A cross section of an water cooled IC engine with its working parts is as shown.

Constructional Details of IC Engines

Parts in the petrol engine

a) In Cylinder head

1. Double over head cam Mechanism (DOHC)
2. Inlet and exhaust valves.
3. Multi Point Fuel Injection system (MPFI)
4. Exhaust Gas Recirculation (EGR) unit
5. Inlet and Exhaust manifold.
6. Combustion Chamber

b) In Cylinder block

1. Piston
2. Piston rings
3. Connecting rod

4. Gudgeon pin
5. Electronic control unit (ECU)
6. Water pump
7. Turbo charger

c) In crank case

1. Crank shaft
2. Cooling oil pump
3. Oil sump

d) Power transmission system

1. Fly wheel
2. Clutch and gear box mechanism
3. Timing gear arrangement

Cylinder head

In an internal combustion engine, the cylinder head sits above the cylinders on top of the cylinder block is generally made by aluminum alloy or grey cast iron. It closes in the top of the cylinder, forming the combustion chamber. This joint is sealed by a head gasket. In most engines, the head also provides space for the passages that feed air and fuel to the cylinder, and that allow the exhaust to escape. The head can also be a place to mount the valves, spark plugs, and multi point fuel injection systems.

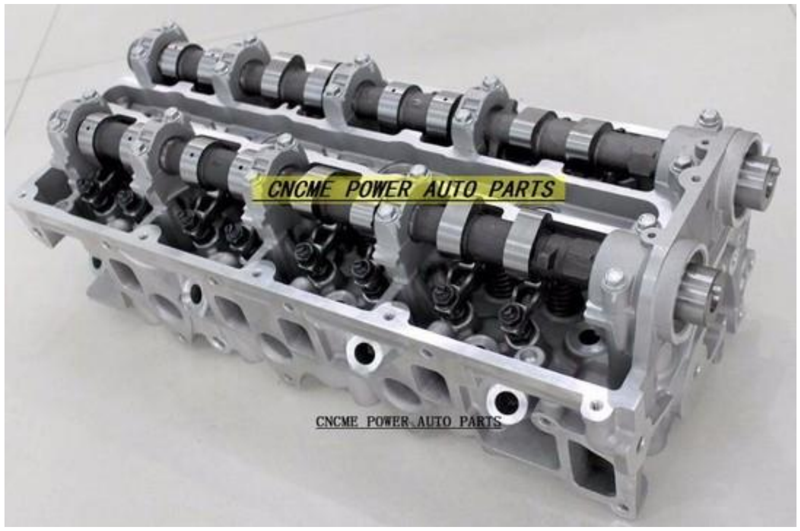
Double Over Head Cam Mechanism (DOHC)

Over head Cam (OHC)

The main advantage of an OHC design is that valves are operated almost directly by the camshaft, which makes it easier to maintain precise timing at higher rpms. It's also possible to install three or four valves per cylinder.

DOHC

(DOHC) valve train layout is characterized by two camshafts located within the cylinder head, one operating the intake valves and the other one operating the exhaust valves.

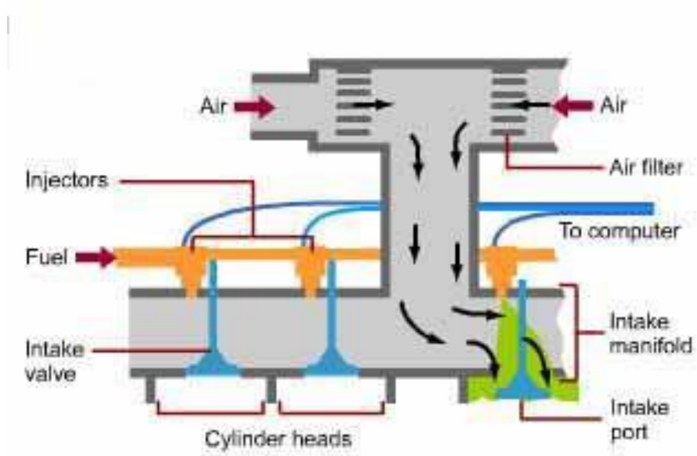


Inlet and Exhaust valves

Inlet and exhaust valves are used to control the regulate charge coming to engine for burning and exhaust gases going out from the cylinder respectively. They are provided either on cylinder head or on cylinder walls. They are commonly mushroom shaped poppet type.

Multi point fuel injection system(MPFI)

The **MPFI** is a system or method of injecting fuel into internal combustion engine through multi ports situated on intake valve of each cylinder. It delivers an exact quantity of fuel in each cylinder at the right time.



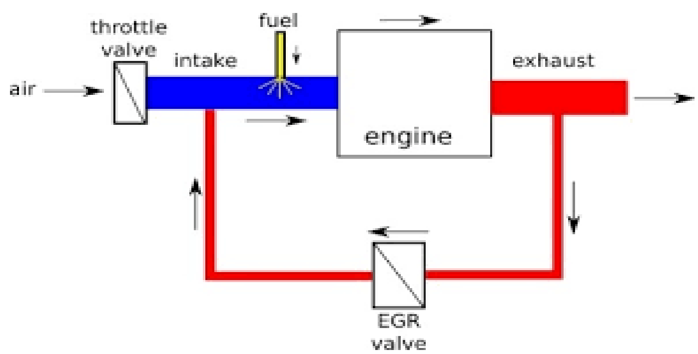
- When you step on the gas pedal, the throttle valve opens up more, letting in more air. The engine control unit (ECU, the computer that controls all of the electronic components on your engine) "sees" the throttle valve open (with the help of Mass airflow sensor) and increases the fuel rate in anticipation of more air entering the engine.
- It is important to increase the fuel rate as soon as the throttle valve opens; otherwise, when the gas pedal is first pressed, there may be a hesitation as some air reaches the cylinders without enough fuel in it.

Sensors monitor the mass of air entering the engine, as well as the amount of oxygen in the exhaust. The ECU uses this information to fine-tune the fuel delivery so that the air-to-fuel ratio is just right.

CRDi (common rail direct injection) and **MPFI** (multi point fuel injection) both are fuel injection system used to inject fuel, in diesel engines inside cylinder and in petrol engines into the manifold where fuel is atomized, respectively.

Exhaust Gas Recirculation (EGR)

In internal combustion engines, exhaust gas recirculation (**EGR**) is a nitrogen oxide (NO_x) emissions reduction technique used in petrol/gasoline and diesel engines. **EGR** works by recirculating a portion of an engine's exhaust gas back to the engine cylinders.



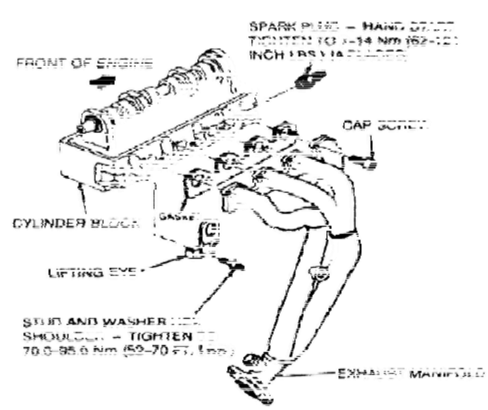
Inlet and Exhaust manifold

Inlet manifold :

Intake manifold is the pipe which brings air or air-fuel mixture into the combustion chamber for combustion. It is connected to intake valves.

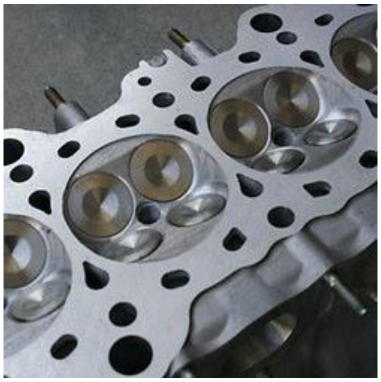
Exhaust manifold :

Exhaust manifold is a pipe with takes out exhaust gases from the combustion chamber after combustion. It is connected to exhaust valves.



Combustion chamber

An enclosed space in which combustion takes place, such as the space above the piston in the cylinder head of an internal-combustion engine or the chambers in a gas turbine or rocket engine in which fuel and oxidant burn the chamber in a reciprocating engine between the cylinder head and the piston, in which combustion occurs.



Cylinder Block

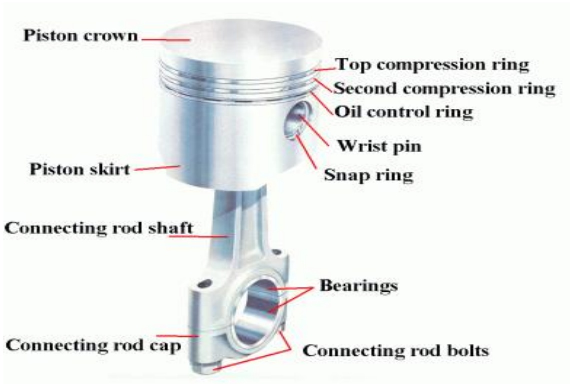
Cylinder

As the name suggests the cylinder is cylindrical in shape. This the actual place where fuel burning happens and piston reciprocates. A cylinder is machined with a very high surface finish. It is case hardened, to obtain a hard scratch free surface.

The cylinders of a multi-cylinder engine are cast as a whole and it is called *cylinder block*. The cylinder block is the main supporting structure of an engine.

Cylinder block is mounted with cylinder head at top and crankcase at the bottom. Both cylinder head and crankcase are attached to the cylinder block with the help of nuts and bolts.

Piston



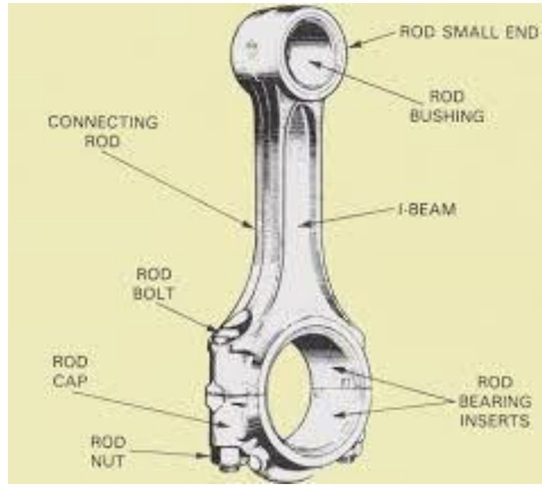
A piston is a cylindrical component, which fits inside the cylinder and forms a movable boundary. The piston moves smoothly inside cylinder, with the help of proper lubrication. A piston makes almost airtight contact with the cylinder walls, with the help of piston rings. Piston is the first link in transmitting the gas force into crankshaft.

Piston rings

Piston rings are fitted in piston to provide leak free contact between piston and cylinder wall. However, they permit a small amount of lubricant pass through to provide lubrication for smooth running. They are designed to bear high temperature and thrust.

Connecting rod

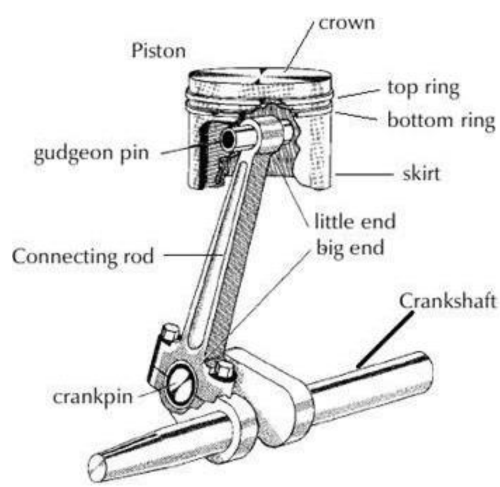
A connecting rod transfers reciprocatory motion from piston head to crank shaft, where it gets converted into rotary motion. Connecting rod has two ends small end and big end. Small end is connected to piston head with the help of gudgeon pin and big end is connected with crankshaft with the help of crank-pin.



Connecting rods are commonly made from cast aluminum alloy and are designed to withstand dynamic stresses from combustion and piston movement.

Gudgeon pin

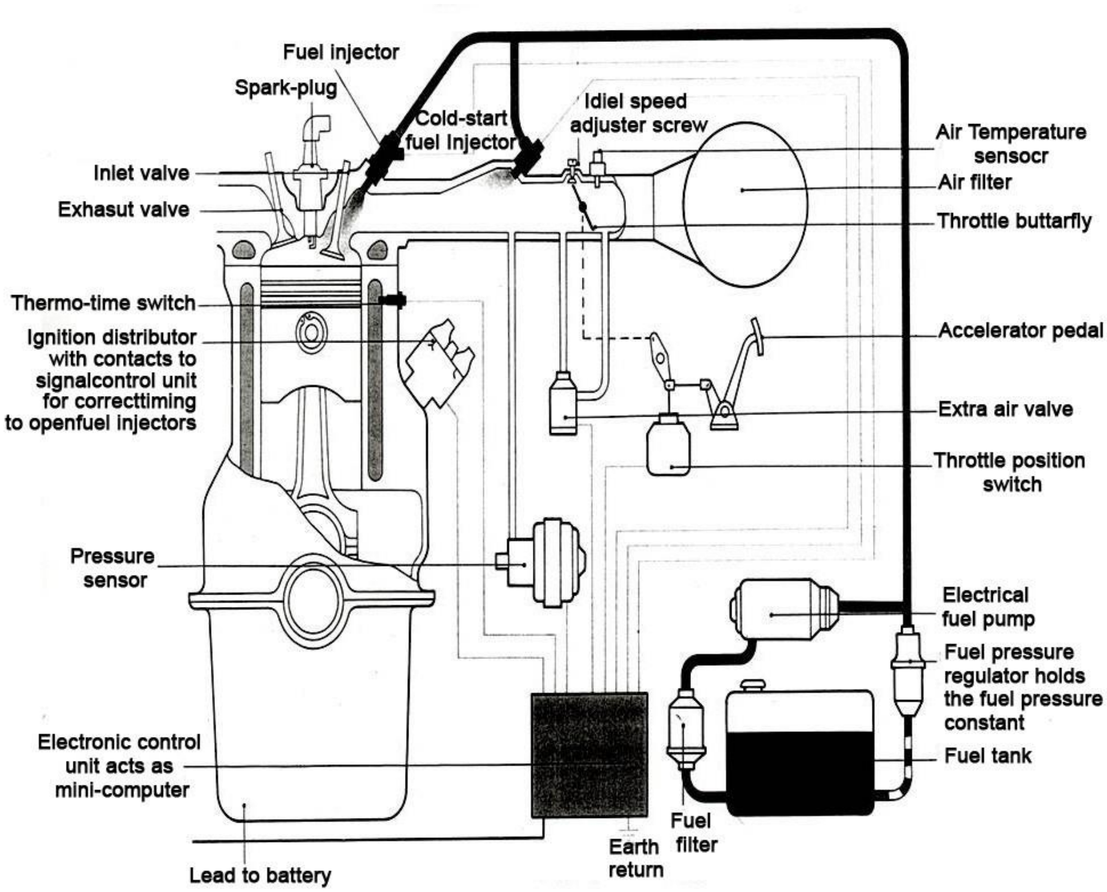
It is a pin which connects small end of connecting rod to the piston.



Electronic control unit (ECU)

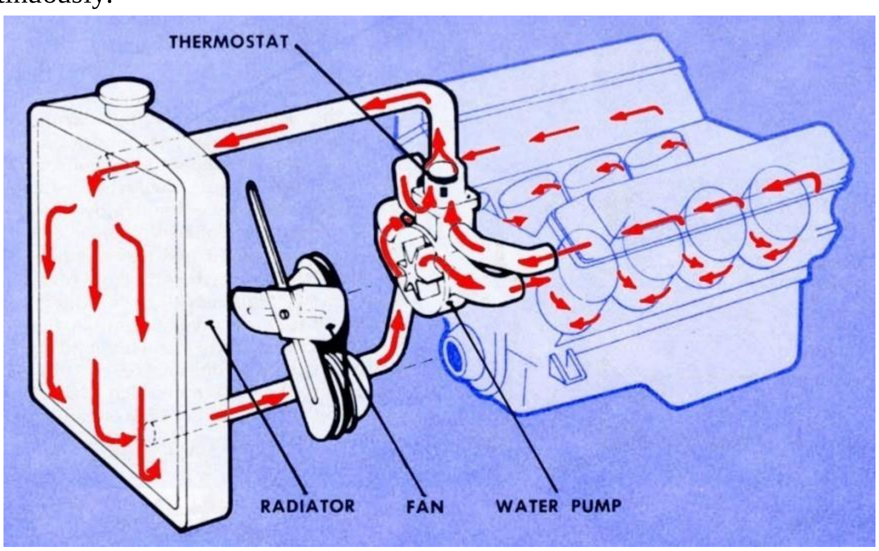
The electronic control unit (ECU) used in today's cars and trucks is used to control the engine and other components' functions. An ECU is a computer with internal pre-programmed and programmable computer chips that is not much different from a home computer or laptop. The vehicle's engine computer ECU is used to operate the engine by using input sensors and output components to control all engine functions.

The ECU needs inputs from vehicle sensors like the sensor and camshaft sensors to compute the information using a program that has been stored in the ECU on a programmable memory chip. The ECU program will use the inputted sensor information to compute the needed output like the amount of fuel injected and when to spark the coil in order to start the engine.



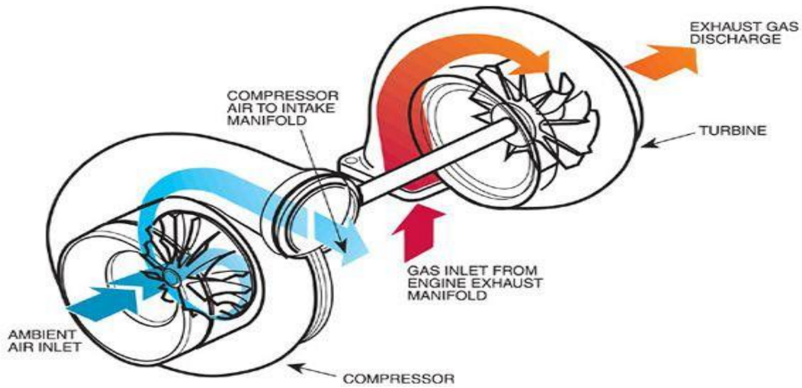
Water pump

The water pump is a simple centrifugal pump driven by a belt connected to the crankshaft of the engine. The pump circulates fluid whenever the engine is running. The water pump uses centrifugal force to send fluid to the outside while it spins, causing fluid to be drawn from the center continuously.



Turbo charger

The turbocharger us uses the exhaust gas to drive a turbine. This spins an air compressor that pushes extra air (and oxygen) into the cylinders, allowing them to burn more fuel each second.



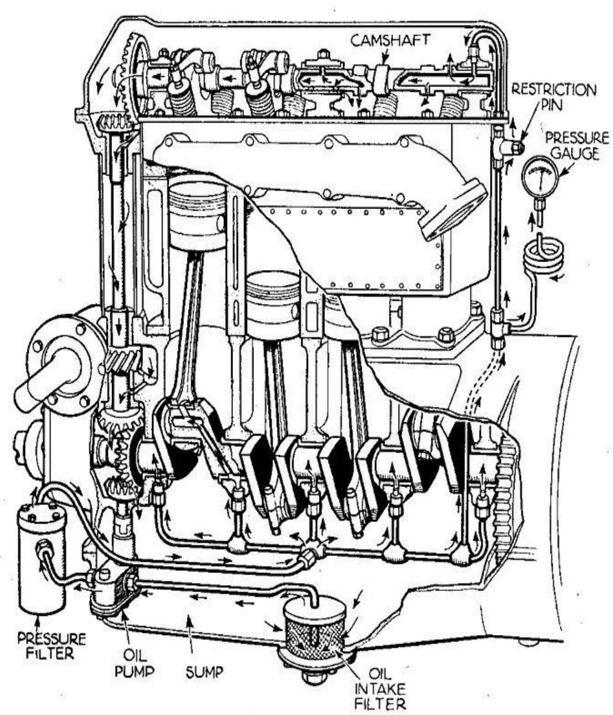
Crank case

Crank shaft

A Crankshaft converts reciprocating motion of the piston to rotary motion with the help of connecting rod. Crankshaft has provisions for static and dynamic balancing.

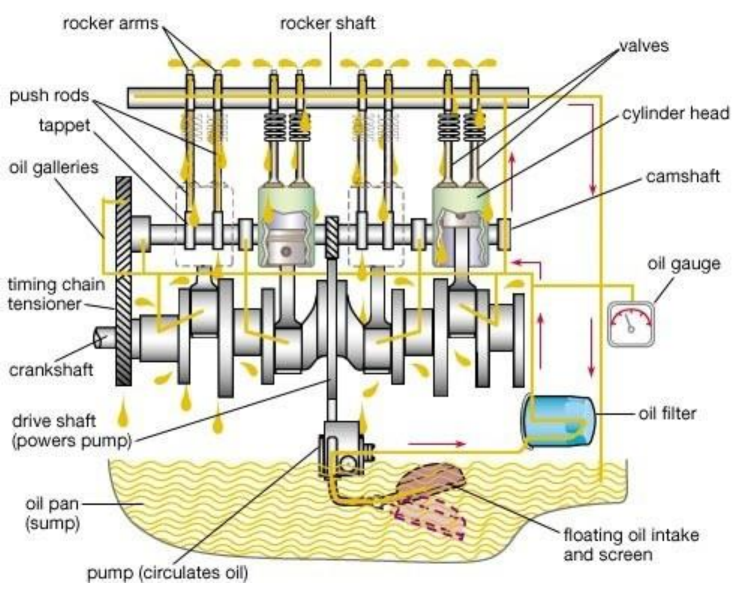
Cooling oil pump

The *oil pump* in an internal combustion engine circulates engine oil under pressure to the rotating bearings, the sliding pistons and the camshaft of the engine. This lubricates the bearings, allows the use of higher-capacity fluid bearings and also assists in *cooling* the engine.



Oil sump

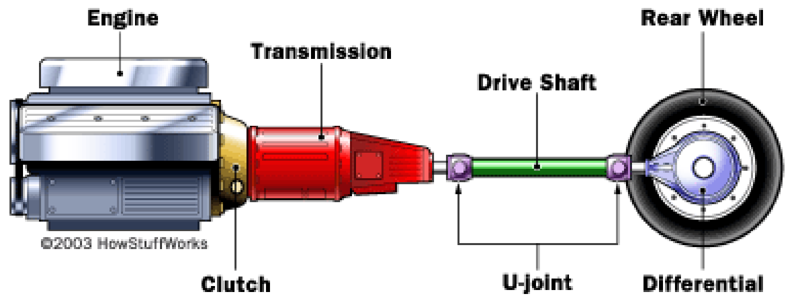
Sump oil is just another name for engine oil/lub oil. It's called so because it is stored in sump which is an oil pan the bottom part of engine. Oil's main purpose is to lubricate all the parts of the engine.



Power transmission system

Need of power transmission

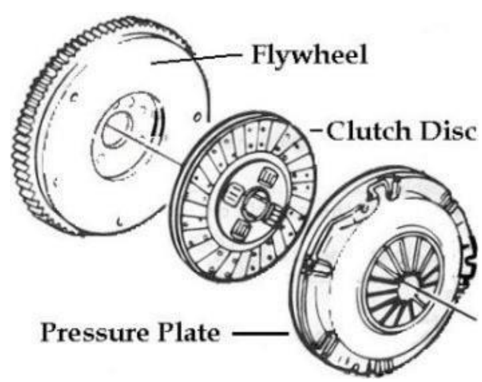
The mechanism that transmits the power developed by the engine of automobile to the engine to the driving wheels(rear wheels) is called the transmission and the system is called transmission it is used to system. Transmit engine torque to the driving wheels to drive the vehicle on the road.



Fly wheel

A flywheel is a rotating mechanical device that is used to store rotational energy. Flywheels have an inertia called the moment of inertia and thus resist changes in rotational speed. The amount of energy stored in a flywheel is proportional to the square of its rotational speed.

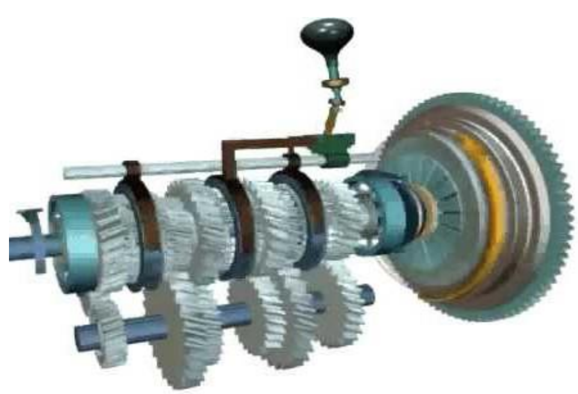
Clutch and gear box mechanism



Clutch

A *clutch* is a mechanical device which engages and disengages power transmission especially. The *clutch* is located between the engine and the *gearbox*, as disengaging it is usually required to change *gear*.

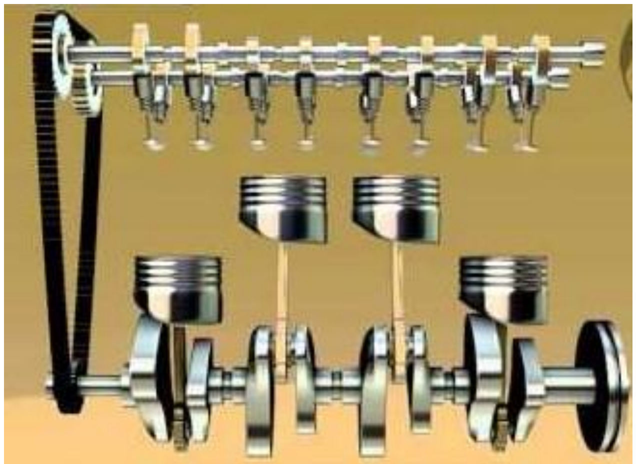
Gear box assembly



The *gear box* is the second element of the power train in an automobile. It is used to change the speed and torque of vehicle according to variety of road and load condition. A *gear box* changes the engine speed into torque when climbing hills and when the vehicle required.

Timing gear arrangement

The *timing gear* is connected by chain, *gears*, or a belt to the crankshaft at one end and the camshaft on the other. The crankshaft drives the camshaft and the *gear* train controls valve *timing* in an internal-combustion engine



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Expt. No. :
Date :

DETERMINATION OF FLASH POINT AND FIRE POINT OF A LIQUID FUEL

Aim: To determine the flash and fire point temperatures of the given kerosene fuel sample using Pensky Martens Apparatus.

Definition:

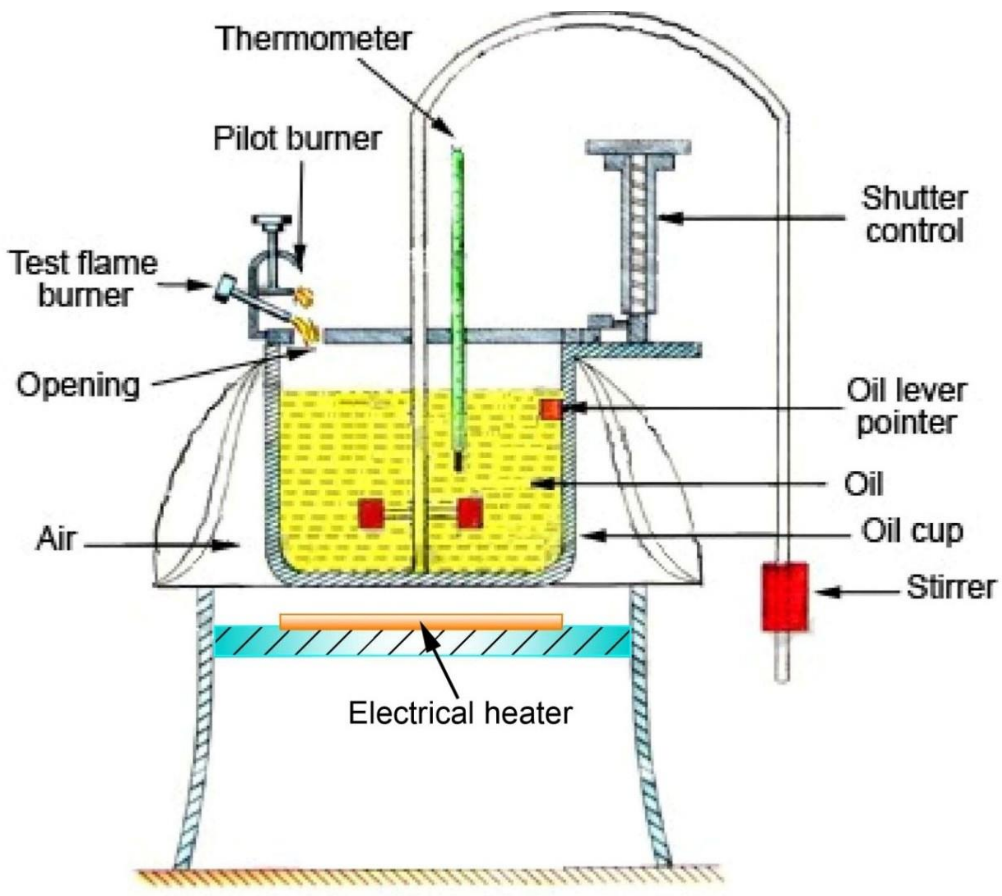
Flashpoint

The lowest temperature at which a product gives just sufficient vapour to form an inflammable mixture with air under the conditions of a standard test is called flashpoint.

Fire point

The temperature of a liquid fuel that gives of enough vapour to support continuous combustion is called fire point.

Apparatus required: Thermometer, Stirrer, Pensky-Martens closed tester



Standard Pensky-Martens closed tester

Description of apparatus:

The cup has a flange which rests on the brass top and the lower parts of the cup is within the Air Bath or Heating Vessel. The top plate is screwed on the Air Bath through brass spacers, so that an air gap is produced between the cup and the Air Bath by which the transmission of heat to the cup is entirely by heated air. The heat is supplied by an electric heater which is kept below the Air Bath and the regulation of the heat is carried out by a Energy regulator. The function of the Air Bath and the Top Plate is to prevent external air draughts from interfering with the heating.

The cover proper of the lid is made of brass plate and has a tubular fitment which enables it to sit on the cup. It has three holes A, B & C in the peripheral region and also one circular hole which carries a split tube for taking brass collar of a thermometer, and one central hole admits stirrer rod.

The peripheral hole "A" is larger and the flame exposure to the oil under test is given through it. The flame is produced by a burning gas jet of a gas reservoir fitted closer to hole A. The gas is supplied from gas mains. The shutter is a brass disc fitted concentrically on the cover plate. It has two peripheral holes matching the hole B & A of the cover plate. The shutter can be rotated by the spring loaded handle G which is mounted on the cover plate. Initially the shutter keeps all the holes A, B &C closed properly. Initially the shutter keeps all the holes A, B & C closed but by slight rotation all the three holes get exposed. A lever arrangement fitted to the shutter tilts the gas Chamber in such a way that the gas jet with the flame enters the hole momentarily.

The gas chamber has another ancillary jet called the Pilot flame F which is shown in figure. This enables the main gas jet to be relighted if extinguished during the test. The pilot flame burns continuously and is away from any of the holes of the cover plate.

Procedure:

1. Clean and dry the cup and fill it with the given fuel sample (kerosene or diesel) to the indicated level.

2. The lid is closed and thermometer of correct range is inserted in the opening into the sample and the cup is placed in correct position.

3. The sample is heated with the help of an electric heater at a constant rate using the regulator.

4. The sample is uniformly heated with the help of stirring mechanism which rotates at 1-2 rev/sec.

5. When the sample is expected to reach the flashpoint temperature, apply the test flame for every 1^{o}C rise.

6. Do not stir the sample when the test flame is being applied.

7. The test flame should be continued at regular intervals until the flash is observed, with peak flickering sound. The temperature should be noted when the peak flickering sound occurs, which is the flashpoint temperature of the given sample.

8. The fire point is found by continuing the experiment. If the fuel burn continuously for more than 5 seconds, then that temperature is taken as the fire point temperature of the given sample.

9. Repeat the test twice or thrice with fresh fuel sample and observe the results.

Observation:

Sl. No.	Oil Temperature in ^{o}C	Remarks
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		

Result:

The flash and fire point temperature of the given kerosene sample were determined using PENSKY MARTENS APPARATUS.

1. The flash point temperature of the given kerosene fuel sample is_______ ^{o}C

2. The fire point temperature of the given kerosene fuel sample is________ ^{o}C

Expt No. :

Date :

DETERMINATION OF MOISTURE CONTENT OF FUEL

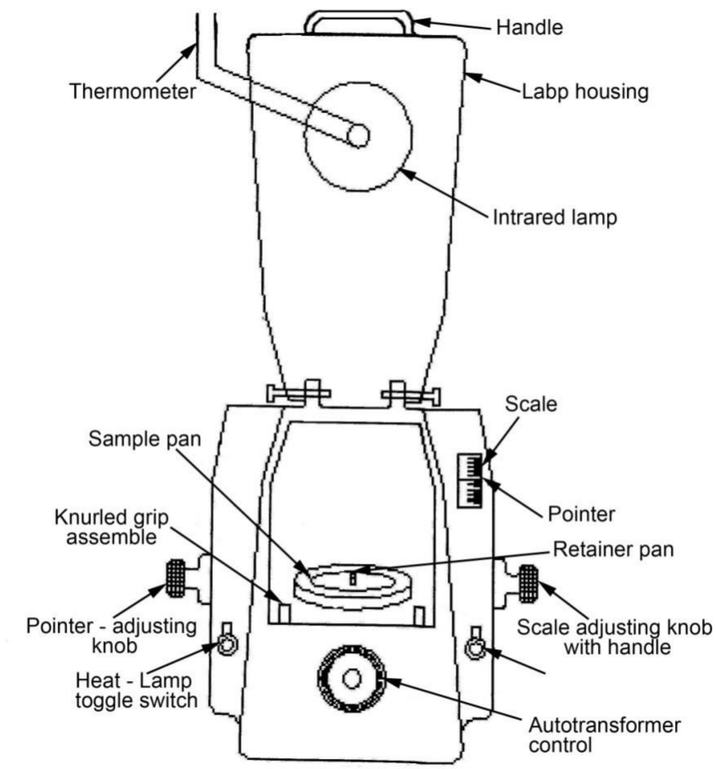
Aim:

To determine the moisture percentage of the given saw dust / rice husk using infrared moisture balance.

Principle:

The moisture content of the given sample fuel (saw dust / rice husk) does not change its chemical structure while losing moisture under exposure of infrared radiation. Solid fuel drying and weighing are carried out simultaneously. The percentage of moisture in fuel will be measured directly using the following procedure.

Apparatus Required:



Infrared Moisture Balance

1. Sample pan
2. Electronic balance

Procedure:

1. Turn the scale lamp" ON "by means of toggle switch.

2. By turning the scale adjusting knob rotate the scale until the 100%mark coincides with the index.

3. Move the pointer to the index by turning the pointer adjusting knob in a direction opposite to that in which the pointer must move to coincide with index.

4. Rotate the scale until the 0% mark coincides with the index. The pointer is now above the index.

5. Raise the lamp housing and carefully distribute the test materials on the sample pan until the pointer return to the index, approximately 10 grams of the material corresponds to 100 divisions of the scale.

6. Lower the lamp housing and turn "ON" the infrared lamp by means of the toggle switch(b)

7. Adjust the lamp autotransformer control to the proper setting for the given sample being tested.

8. To attain complete drying, wait till the oscillatory pointer stops & read the final moisture content of the given sample and then switch off the infrared lamp.
9. Repeat the trial 2 or 3 times and record the moisture content of the given sample.

Note: Discoloration on smoking of the sample, caused by excessive heat indicates the release of volatile matter other than moisture and the sample yields errors in results.

Observation:

Sl. No.	Initial weight of the sample (w_1) gm	Final weight of the sample (w_2) gm	Loss in weight w = (w_1-w_2) (w) gm	% of moisture (Direct reading)	% of moisture (calculation)
1.					
2.					
3.					

Calculation:

$$\text{\% Percentage of moisture} = \frac{\text{Loss in weight (w)}}{\text{Initial weight of the sample } (w_1)} \times 100$$

Where Loss in weight (w) = {Initial weight of the sample (w_1) – final weight of the Sample (w_2)}

Result:

The moisture content of the given saw dust / rice husk was determined using infrared moisture balance.

The moisture content of the given sample by

1. Direct method:__________________%
2. Calculation method:______________%

Expt No. :
Date :

DETERMINATION OF KINEMATIC VISCOSITY OF LUBRICATING OIL USING REDWOOD VISCOMETER

Aim:

To determine the kinematic viscosity of given lubricating oil at different temperature using redwood viscometer.

Definition:-

Viscosity

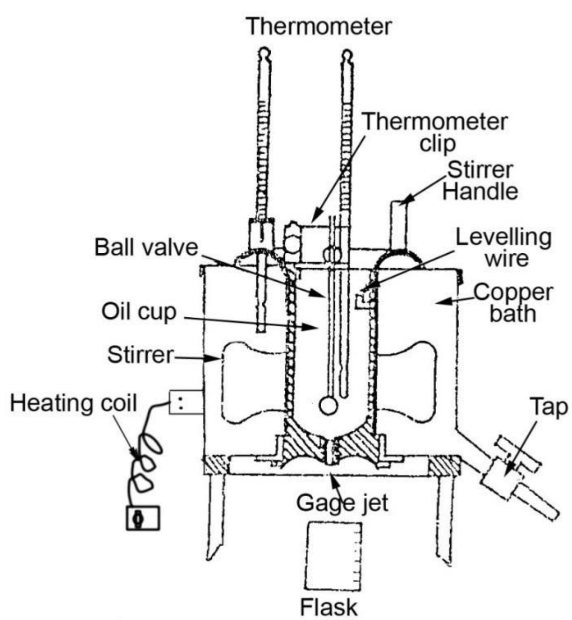
Viscosity is defined as the internal resistance offered by the fluid to the movement of one layer of fluid over an adjacent layer. It is due to the cohesion between the molecules of the fluid. The fluid which obeys the Newton law of viscosity is called as Newtonian fluid.

Kinematic viscosity

Kinematic viscosity is defined as absolute viscosity divided by density at a given temperature.

Apparatus required:

1. Thermometer (0-100^{o}C)
2. Stop watch
3. 50ml standard flask
4. Given sample oil.



Redwood viscometer

Description of apparatus:

The redwood viscometer consists of vertical cylindrical oil cup with an orifice in the centre of its base. The orifice can be closed/opened by a ball valve. A hook pointing upward serves as a guide mark for filling the oil. The cylindrical cup is surrounded by the water bath. The water bath maintains the temperature of the oil to be tested at constant temperature. The oil is heated by heating the water bath by means of an immersed electric heater in the water bath, the provision is made for stirring the water, to maintain the uniform temperature in the water bath, and to place the thermometer to record the temperature of oil and water bath.

Observation:

Room temperature $\mathbf{T_R}$ = __________ °C

Sl. No.	**Temperature of oil °C**	**Time taken to fill 50ml sec (t)**	**Kinematic viscosity cm^2/sec**
1.			
2.			
3.			
4.			

Calculation:

Kinematic Viscosity (γ) =**A**t-**B**/t in cm^2/sec

A = 0.245 cm^2/sec^2

B = 65 cm^2

t=Time taken to fill 50 ml of oil in sec

Procedure:

1. Clean the cylindrical oil cup and ensure the orifice tube is free from dirt.
2. Close the orifice with ball valve.
3. Place the 50ml flask below the opening of the orifice.
4. Fill the oil in the cylindrical oil cup up to the mark in the cup
5. Fill the water in water bath.
6. Insert the thermometers in their respective places to measure the oil and water bath temperatures.

7. Heat the oil by heating the water bath, stirr the water bath to maintain uniform temperature.

8. At particular temperature lift the ball valve and collect the oil in the flask and note down the time taken in seconds for collecting 50 ml of oil. A stop watch is used to measure the time. This time is called redwood seconds.

9. Increase the temperature and repeat the procedure and note down the redwood seconds.

Graph: The following graph has to be drawn.

1. Temperature Vs Redwood seconds
2. Temperature Vs Kinematic Viscosity

Result:

The Kinematic Viscosity of given lubricating oil at different temperatures were determined.

Expt No. :
Date :

DETERMINATION OF CLOUD POINT AND POUR POINT OF A LIQUID FUEL

Aim:-

To determine the cloud point and pour point of coconut oil.

Definition:-

Cloud point:

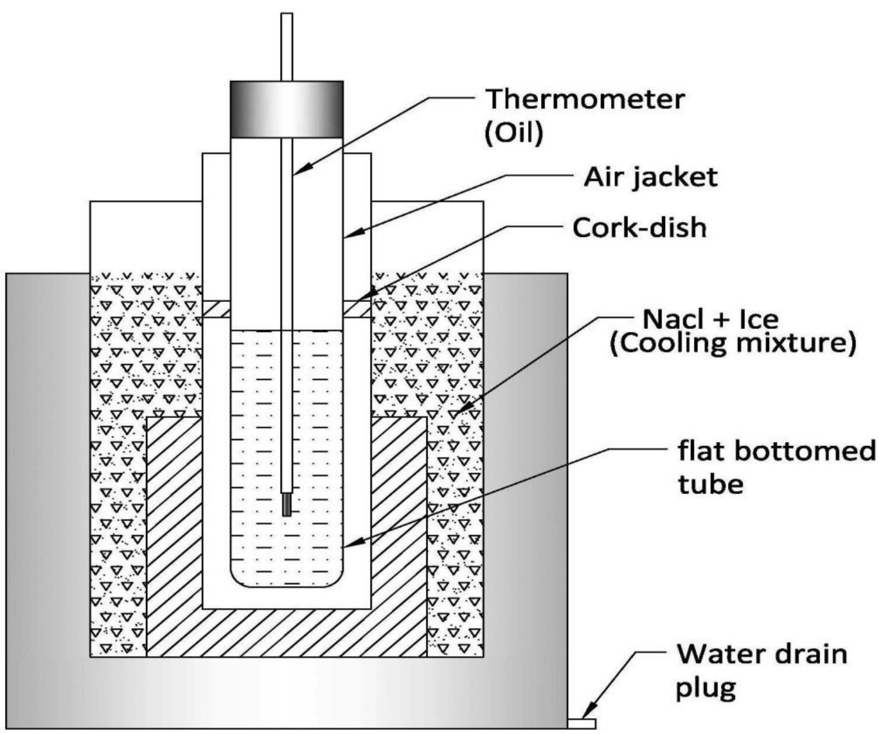
When an oil is cooled slowly, the temperature at which it becomes cloudy or hazy in appearance is called its cloud point.

Pour point:

While the temperature at which the oil ceases to flow or pour, is called it pour point.

Apparatus Required:-

1. Cloud and Pour Point apparatus, 2.Thermometer



Cloud and Pour Point apparatus

Procedure:-

1. Apparatus consists of flat bottomed tube enclosed in a air Jacket. Fill the coconut oil to the marked level in the test jar.
2. Test Jar is surrounded by a freezing mixture (Ice + Nacl)
3. Introduce a thermometer into the oil.
4. As the cooling time increases, temperature falls continuously.
5. With every 2° degree fall in temperature of oil test Jar is examined.
6. The temperature at which cloudiness is noticed is recorded as cloud point.
7. Continue the cooling.
8. The temperature at which oil does not flow in the test Jar even when kept horizontal for few seconds is regarded as pour point

Observation:

Sl. No.	Oil Temperature in °C	Remarks
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

Result:

The cloud point and pour point of the given coconut oil has been determined

1. The cloud point temperature of the given coconut oil sample is______°C

2. The pour point temperature of the given coconut oil sample is_______°C