

ENGINE: - Engine is a device which converts one form of energy in to another form.

HEAT ENGINE: - Converts heat energy in to mechanical energy. Heat energy is obtained from combustion of fuel. Chemical energy in fuel is converted in to heat.

INTERNAL COMBUSTION ENGINE: - Those heat engines in which fuel is burnt inside the engine cylinder is called internal combustion engine. EX :- Diesel engine, Petrol engine, Gas engine.

EXTERNAL COMBUSTION ENGINE: - Those heat engines in which fuel is burnt out side the engine cylinder is called external combustion engine. EX: - Steam engine, Steam turbine.

CLASSIFICATION OF I.C. ENGINES: - Engines may be classified as given below:-

1. On the basis of fuel used:- (i) Petrol Engine (ii) Diesel Engine (iii) Gaseous Engines.	4. On the basis of Method of ignition of fuel: (i) Spark ignition engine (ii) Compression ignition engines.
2. On the basis of no. of strokes per working cycle:- (i) 2- Stroke Engines. (ii) 4- Stroke Engines	5. On the basis of method of cooling: (i) Air Cooled engine (ii) Water cooled engine.
3. On the basis of working Cycle:- (i) Otto- Cycle Engines. (ii) Diesel cycle Engines (iii) Dual cycle Engine.	6. On the basis of no. of cylinders:- (i) Single cylinder engine (ii) Multi-cylinder engine.

MAIN SYSTEMS OF AN I.C ENGINE: - Followings are the main systems of an I.C engine:-

1. Air supply system.
2. Fuel supply system.
3. Lubricating system.
4. Cooling system.

m:- In this system we shall study about requirement of air, Air cleaner, drawbacks of choking of air cleaner, Turbocharger, After cooler and importance of after cooling etc.

2. Fuel Supply System:- In this system we shall study about functions of the system, classification, fuel injection pumps, injectors, Mico-Bosch and Cummins P.T. fuel supply system, cetane no., knocking of fuel etc.

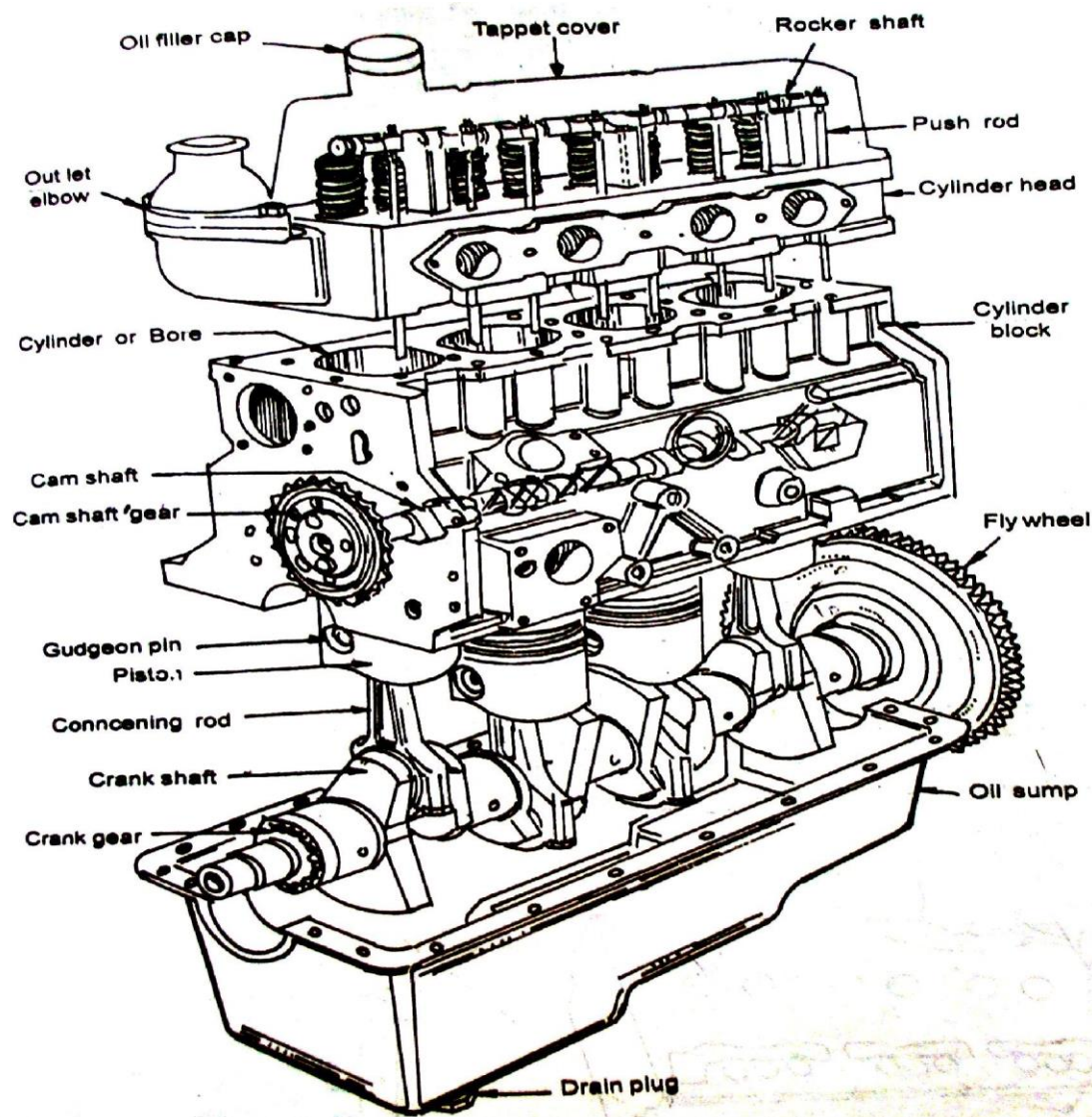
3. Lubricating System:- In this system we shall study about properties of lubricating oil, oil additives, viscosity rating, lubricating circuit, components of lubrication system, Blow by, reasons of low lubricating oil pressure and high oil consumption etc.

4. Cooling System:- In this system we shall study about different methods of cooling, Drawbacks of overcooling and reasons of over heating etc.

Sub-discipline:- INTERNAL COMBUSTION ENGINE (Lessons: IX Sessions: 22)

Lesson-II: Constructional Details of Engine Session-2: Cylinder, Cylinder head, Piston and Piston Rings, Connecting rod & Crankshaft

Engine Construction



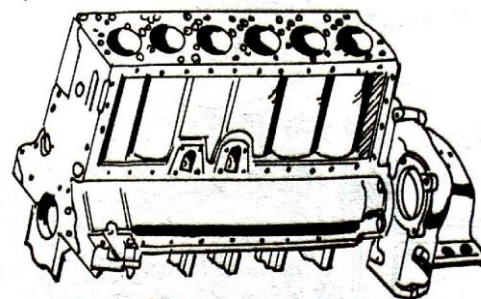
The main parts of the engine are as follows: -

- | | |
|---------------------------------|-------------------------------|
| 1. Cylinder block and crankcase | 8. Crankshaft |
| 2. Cylinder head | 9. Flywheel |
| 3. Oil pan /c sump | 10. Camshaft |
| 4. Piston | 11. Valve and valve mechanism |
| 5. Piston Rings | |

1. Cylinder Block and Crankcase

It forms the basic framework of the engine. Cylinder block houses the engine cylinders and crank case supports crankshaft and camshaft. Most engines have cylinder block and crankcase as a single casting. Some big engines have separate crankcase and cylinders are fitted (bolted) separately with the crankcase.

- There are inbuilt oil galleries for circulation of lubricating oil.
- Water-cooled engines have inbuilt passages for flow of cooling water. Air cooled engines have fins outside of the cylinders for cooling.
- Big engines have separate liners placed inside the cylinder bores, which are replaced when worn out. **Material: - Cast Iron**



2. Cylinder Head

The top of the cylinder block is covered by cylinder head. It has combustion chamber and holes for fitting injector and valves. There are inbuilt galleries for flow of lubricating oil. In water-cooled engines, there are also passages for flow of water.

In air-cooled engines, there are fins outside the head for cooling. The cylinder head is bolted to the top of the cylinder block with a gasket in between them.

Material: Cast Iron.

3. Oil pan / Sump

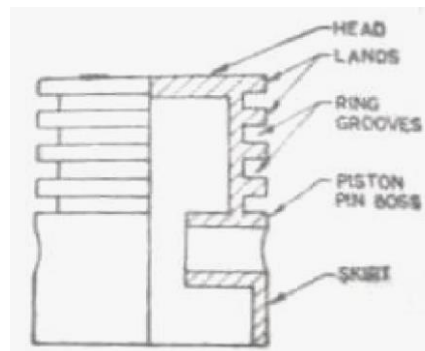
It is the lowest part of the engine. It stores oil for engine lubrication system. There is a drain plug at the bottom of the oil sump.

Material: - Steel sheet or Aluminum.

4. Piston

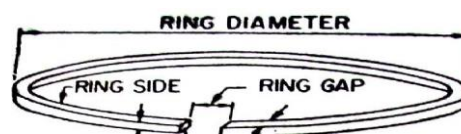
Piston transfers the power obtained from expansion of gases to the crankshaft via connecting rod. It is equipped with rings.

Material: - Aluminum Alloy



5. Piston Rings

Piston rings are fitted into the grooves of the piston. There are two types of piston rings-

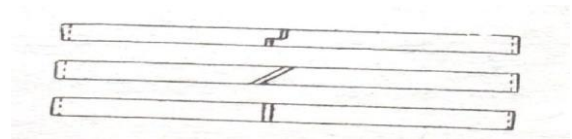


(b) Oil Control rings

Compression rings are used to maintain good seal between the piston and the cylinder wall. These rings seal the air as it is compressed and also the combustion pressure. Oil control rings scrape off excessive oil from the cylinder wall and return it to the oil sump. It also maintains an oil film on the cylinder wall.

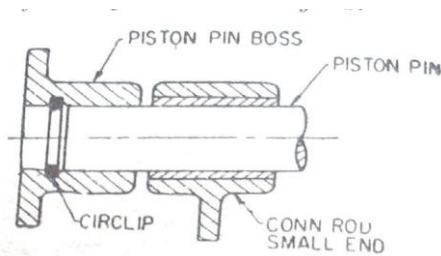
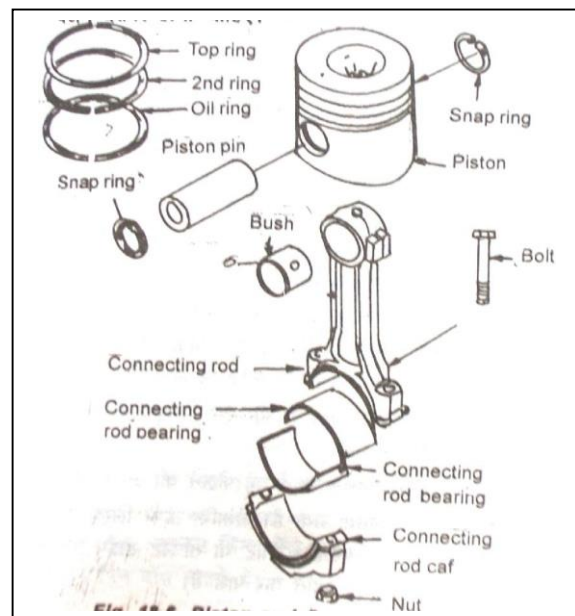
Minimum two compression rings and one oil control ring are fitted in 4-stroke engines. An oil control ring is fitted into the lower groove of the piston. Piston rings are split having lapped, angled or butt joints.

Material: - Cast iron alloy



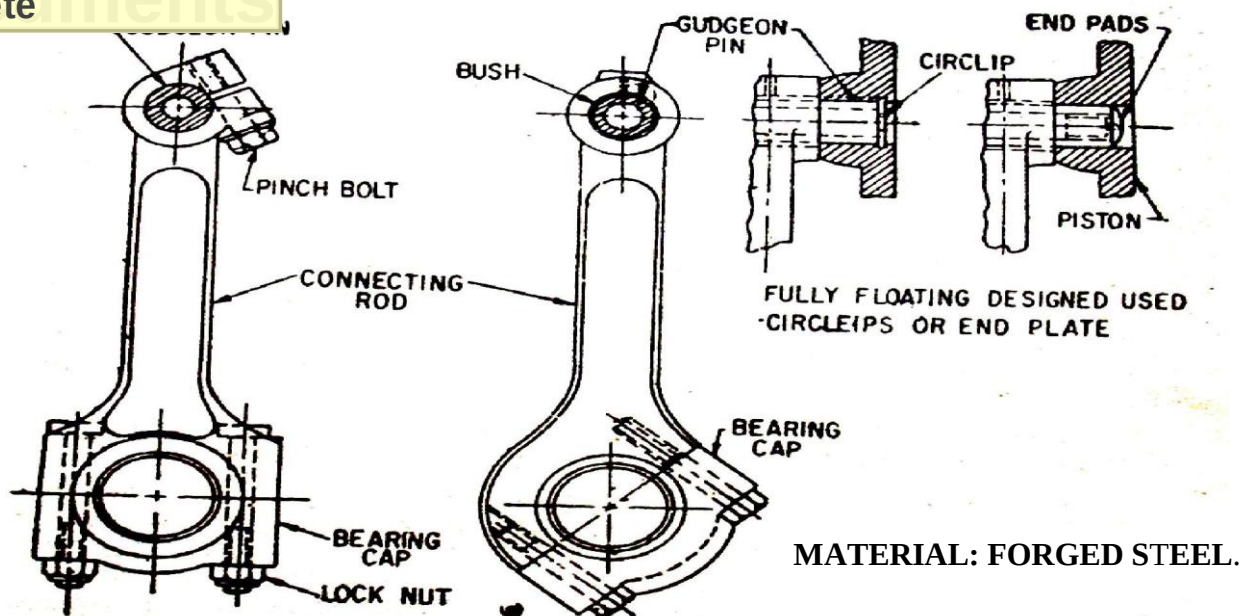
6. Piston Pin or Gudgeon Pin: It connects the piston and the small end of the connecting rod.

Material: Steel Alloy (Case hardened)



7. Connecting Rod

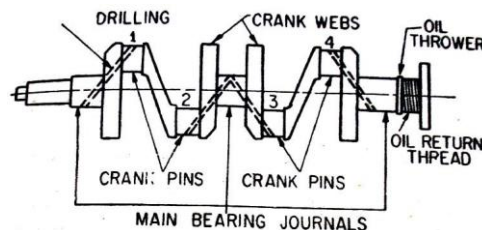
It joins the piston pin with the crank pin of the crankshaft. Small end of the connecting rod is connected to the piston pin and the big end to the crank pin. Connecting rod converts the linear motion of piston into rotary motion of the crankshaft.



8. Crankshaft

Crankshaft is the part on to which reciprocating motion of the piston is converted into rotary motion. A crankshaft consists of

- Crank Pins
- Webs
- Balancing Weight and
- Main Journal



Crankshaft has drilled oil galleries through which oil can flow from the main bearing to connecting rod (C.R) bearing. The rear end of the crankshaft carries flywheel and the front end carries a gear, vibration damper and fan belt pulley.

Material: - Steel Alloy

Sub-discipline:- INTERNAL COMBUSTION ENGINE (Lessons: IX Sessions: 22)

Lesson-II: Constructional Details of Engine Session-3: Flywheel, Camshaft and Sump, Inlet and Exhaust valve, Push rod, Rocker arm, Valve clearance, Valve operating mechanism

9. Flywheel

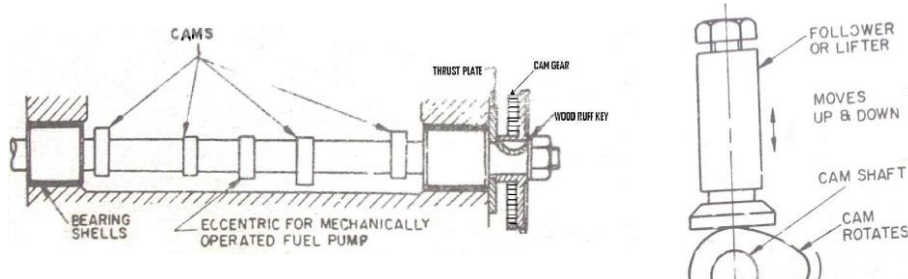
Flywheel is a heavy steel wheel attached to the rear end of crankshaft. During power stroke the engine tends to speed up and during other three strokes it tends to slow down. The Flywheel stores power during power stroke and releases during other three strokes to keep the engine running at the constant speed. It also controls the engine vibration.

Flywheel is also used as a part of clutch mechanism. Flywheel also has teeth to mesh with self-starter during starting.

10. Camshaft

Camshaft is a shaft on which cams are mounted. Cam is a device, which changes rotary motion of the camshaft into linear motion of the follower or lifter. A camshaft has a number of cams along the length. There are two cams for each cylinder, one to operate the inlet valve and the other to operate the exhaust valve.

In addition, the camshaft has an eccentric to operate the fuel feed pump and a gear to drive the oil pump.

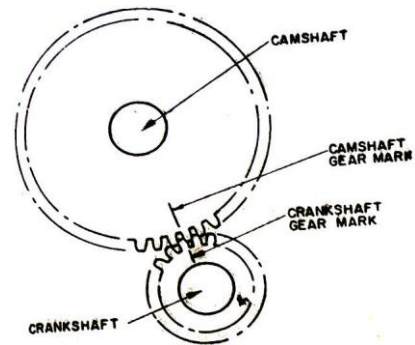


The crankshaft drives the camshaft. The camshaft gear has teeth twice of crankshaft gear teeth.

$$\begin{aligned}
 \text{Gear ratio} &= \frac{\text{Nos. of teeth on crankshaft gear.}}{\text{Nos. of teeth on camshaft gear}} \\
 &= \mathbf{1:2}
 \end{aligned}$$

Thus camshaft turns at half the speed of the crankshaft.

There should be a definite relationship between crankshaft and camshaft. There are marks on crankshaft gear and camshaft gear, which are matched during assembly to maintain the definite relationship between the two.



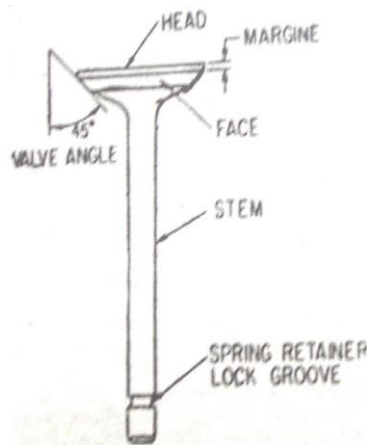
Note: - In Cummins Engines, there are three cams for each cylinder on camshaft. One cam operates inlet valve, second operates injector and third operates exhaust valve. Also there is no eccentric, because these engines have no fuel feed pump.

11. Valve and Valve Operating Mechanism

Valve: - Valve is a device to open and close a passage. There are two valves for each cylinder – an inlet valve and another exhaust valve. Air enters to the cylinder through the **inlet valve** and the burnt gases escape through the **exhaust valve**. When closed, the valve must seal the combustion space tightly.

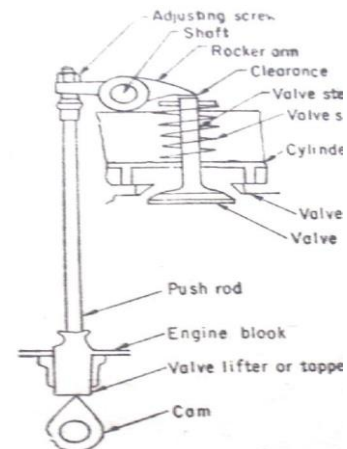
Inlet valve is subjected to less heat and is made of **nickel chromium alloy steel**. Exhaust valve is subjected to severe heat and is made of **silicon chromium alloy steel**. Silchrome steel has very high resistance to heat.

The angular face is ground on the valve head to make an angle of 45° or 30° to match the angle of valve seat in the cylinder head.



Valve Operating Mechanism:

Cams mounted on a camshaft operate valves. The crankshaft drives the camshaft. As the cam rotates it lifts the valve tappet, which actuates the push rod. The **push rod** rotates the **rocker arm** about a shaft called rocker arm shaft. The rocker arm pushes down the valve to open the passage.



Valve - Tappet Clearance: A slight clearance is kept between the valve stem and rocker arm called valve tappet clearance. This clearance allows for expansion of the valve stem as the engine becomes heated. If sufficient clearance is not given, the valve will not seat properly, when the engine becomes heated, which will cause power loss. The exhaust valve has more clearance than the inlet valve due to more heating. Valve-tappet clearance is adjusted by means of an adjusting screw on the rocker arm.

12. Accessories: These are the parts, which are used for better working of the engine.

Air cleaner: It is used to allow clean air entrance into cylinders for fuel combustion.

Oil filter: It screens impurities from the lubricating oil so that only clean oil will circulate throughout the engine.

Fuel filter: It screens impurities from fuel *i.e.* HSD so that clean fuel will flow through fuel pump and will go for combustion inside the cylinder.

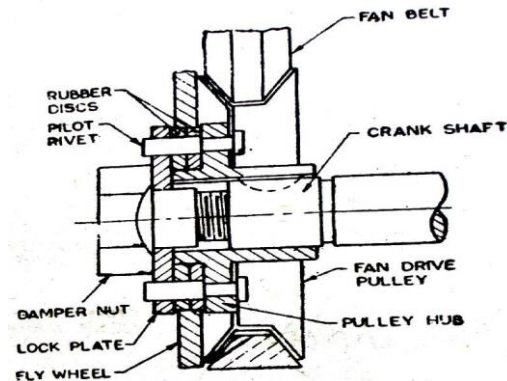
Oil pump: It is used to supply pressurized oil into the lubricating circuit for engine lubrication.

13. Other Parts

Fuel pump: It supplies pressurized fuel to the fuel circuit.

Injector: It is fitted into the cylinder to supply fuel in atomized and vaporized form.

Vibration damper: While engine is running, winding and unwinding effect comes on crankshaft during power stroke. This winding – unwinding effect develops torsional vibration due to which crankshaft may break. To damp down (control) this torsional vibration, vibration damper is used.



It is simply a small flywheel. It is mounted at the front end of the crank shaft.

Sub-discipline:- INTERNAL COMBUSTION ENGINE (Lessons: IX Sessions: 22) Lesson-II: Constructional Details of Engine. **Session-4: Demonstration of Engine components in I.C. Engine Model Room**

1. To identify, Locate fitment position in engine and realize working of

- | | |
|--------------------|-------------------------------|
| a. Cylinder, | m. Rocker arm, |
| b. Cylinder head, | n. Valve, |
| c. Sump, | o. Valve operating mechanism, |
| d. Piston, | p. Injector, |
| e. Piston rings, | q. Air cleaner, |
| f. Connecting rod, | r. Oil filter, |

2. a) To locate the valve clearance position.
b) To realize why valve clearance is generally more on exhaust valve?
3. To count Nos. of teeth on crankshaft gear & camshaft gear and to verify speed ratio.

By observation,

T_1 = Nos. of teeth on crankshaft gear.

T_2 = Nos. of teeth on camshaft gear.

Suppose,

N_1 = Speed of crankshaft gear

N_2 = Speed of camshaft gear

Speed ratio = N_1 / N_2

We know that $N_1 / N_2 = T_2 / T_1$

Speed ratio = T_2 / T_1

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4. To count nos. of teeth on crankshaft gear & P.T. pump gear (or Mico-Bosch fuel injection pump gear) and to verify speed ratio.

(Proceed same as Sr. no. 3.)

Sub-discipline:- INTERNAL COMBUSTION ENGINE (Lessons: IX Sessions: 22)
Lesson-III: Basic Terminology and Working Principle of I.C. Engine. Session-5: T.D.C., B.D.C., Swept volume, Clearance volume, Compression ratio, Stroke length, Cylinder bore, Firing orders, Working Principle of 4-stroke Diesel Engine

Basic Terminology:

Top Dead Centre (TDC): The upper most extreme point beyond which piston can not go in upward directions.

Bottom Dead Centre (BDC): The bottom most extreme point beyond which piston can not go in downward direction.

Stroke: The complete movement of piston in one direction, i.e. either from TDC to BDC or from BDC to TDC is known as stroke.

Stroke Length (L): Distance between TDC & BDC.

Bore (d): The diameter of engine cylinder. It is measured in mm or inches.

Clearance Volume (V_c): The volume of cylinder above TDC.

Swept Volume or stroke Volume or Displacement Volume (V_s): The volume of cylinder between TDC and BDC is called swept volume.

Compression Ratio: It is the ratio between the volume of air inside the engine cylinder when piston is at BDC (V_s + V_c) and the volume after compression when piston is at TDC (V_c)

$$\text{Or, C.R (r)} = \frac{V_c + V_s}{V_c}$$

$$V_s = \text{Swept volume} = \frac{\pi}{4} d^2 L \text{ (Volume between TDC \& BDC)}$$

V_c = Clearance volume. (Volume inside the cylinder when piston is at TDC)

d = Bore

L = Stroke Length

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V_c

V_s

TDC

Swept Volume

BDC

FIRING ORDER: - The sequence in which the power impulses occur in an engine is called the firing order. The firing order is selected as a part of the engine design to obtain the best engine performance.

Firing order of 6 cylinders NT 743C, NTA 855, KTA1150 Cummins Engines and HA 694 Kirloskar Engine, ALU 680 Ashok Layland Engine is: 1 - 5 - 3 - 6 - 2 - 4

Firing order of 12 cylinders MWM-TBD-232 V12, MWM-TBD-234 V12 engine is:
A1 - B2 - A5 - B4 - A3 - B1 - A6 - B5 - A2 - B3 - A4 - B6

Firing order of 12 cylinders BF12L 513C Dutez engine is:
1 - 8 - 5 - 10 - 3 - 7 - 6 - 11 - 2 - 9 - 4 - 12

WORKING PRINCIPLE OF 4-STROKE DIESEL ENGINES:

In our track machines, 4 stroke diesel engines are used. In 4 stroke diesel engine one working cycle completes in 4 strokes of piston or 2 revolutions of crank shaft. Working Principle of 4 stroke diesel engine can be explained as follows:-

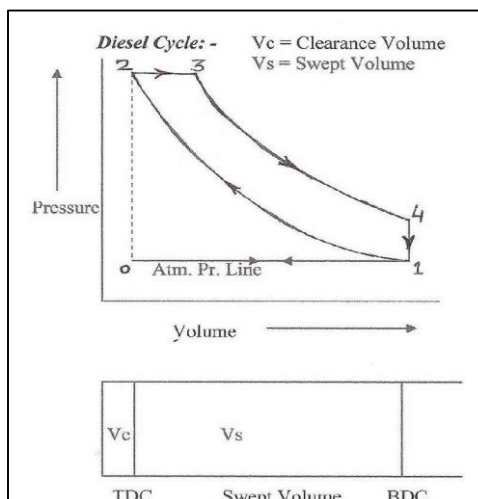
Suction Stroke: - In suction stroke, suction or inlet valve opens. Piston moves from TDC to BDC and vacuum is created inside the engine cylinder. In this process, fresh air will enter inside the engine cylinder at atmospheric pressure. At the end of suction stroke inlet valve is closed.

Compression Stroke: - In this stroke both valves remain closed. Piston moves from BDC to TDC compressing the air. Compression of air takes place according to adiabatic process, $PV^\gamma = \text{constant}$. In this process pressure and temperature will increase gradually up to 28 bars and 550°C respectively. At the end of compression stroke, fuel is injected through injector in the combustion chamber.

Power Stroke: - The self ignition temperature of diesel is 440°C. The diesel in the combustion chamber burns and burning gases expand. The burning gases push down the piston from TDC to BDC. Thus power is delivered at the crank shaft.

Exhaust Stroke: - Exhaust valve opens. Burnt gases go out by self pressure through the exhaust valve. Piston moves from BDC to TDC and pushes out the remaining gases. At the end of the stroke, exhaust valve gets closed.

Thus one working cycle gets completed in 4-strokes of piston or two revolutions of crank shaft or one revolution of camshaft.



From Graph: Suction Stroke:

At point 0 → Inlet valve opens.

Process 0-1 → Piston moves from TDC to BDC. Due to piston movement, vacuum is created inside the engine cylinder. Due to this vacuum, fresh air enters inside the engine cylinder. Theoretically it is assumed that atmospheric air enters at constant pressure.

At Point 1 → Inlet valve closes.

Compression Stroke:

Process 1-2 → Piston moves BDC to TDC. Adiabatic compression of air according to law $PV^\gamma = C$, takes place.

Power Stroke:

- At Point 2 → Injection of fuel starts. Fuel injection pr. = 180 bar. Self ignition temperature of diesel is 440°C, so it starts burning.
- Point 2-3 → It is known as “Heat addition process at constant pressure”. Fuel is injected in the cylinder. Piston moves from TDC towards BDC.
- Point 3 → Fuel cut off point.
- Process 3-4 → Adiabatic expansion of flue gases takes place. Piston moves to the BDC due to the force exerted by the expanding flue gases.

Exhaust Stroke:

- At point 4 → Exhaust valve opens.
- Process 4- 1 → Exhaust gases go out (Heat rejection at constant volume). Pressure drops inside the engine cylinder up to atmospheric pressure.
- Process 1- 0 → Piston moves from BDC to TDC. Exhaust of flue gases takes place at atmospheric pressure.
- At Point 0 → Exhaust valve closes.

Sub-discipline:- INTERNAL COMBUSTION ENGINE (Lessons: IX Sessions: 22)

Lesson-IV: Air Supply system of Diesel Engine. Session-6: Requirement of Air, Types of Air cleaner, Cleaning and checking of Dry type Air cleaner. Draw backs of choking of Air Cleaner.

REQUIREMENT OF AIR:

For Combustion of diesel inside the engine cylinders sufficient quantity of air should be available. For complete combustion of one liter HSD, 12,500 to 14000 liter fresh air at NTP is required. Only 22 – 23% O₂ is available in atmospheric air which is used for burning of fuel. If less air is available then burning of fuel will be incomplete and instead of CO₂, CO will form. To supply air of proper quality (dry, cool, clean & fresh) in sufficient quantity inside the engine cylinders is the function of air supply system.

Main components of the Air Supply System are as follows:

1. Air Cleaner
2. Hump Hose
3. Vacuum Indicator
4. Turbo Charger
5. After Cooler
6. Inlet Manifold
7. Exhaust Manifold
8. Silencer (Muffler)

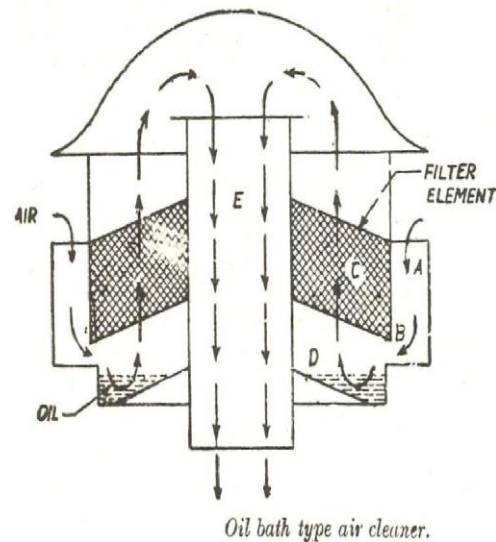
AIR CLEANER:

Air contains dust and dirt. If the air is not filtered before its entrance into the engine cylinders, the dust and dirt particles will seriously damage the engine. These dust and dirt will mix with the lubricating oil and form abrasive pastes, which will quickly wear the piston, rings, cylinder wall, bearings, valve guides and other relatively moving parts. This wear will cause high lubricating oil consumption, increased blow by and reduce engine components life. The purpose of air cleaner is to remove these harm full dust and dirt particles from the air. It not only cleans the air but also muffles the noise resulting from air entrance to the inlet manifold and valve ports. It also arrests the flame in case the engine back fires.

AIR CLEANER: Two types of Air Cleaner

1. Oil bath type air cleaner
2. Dry (paper) type air cleaner

Oil Bath Type Air Cleaner: It is a heavy duty air cleaner. It consists of a wire-mesh filter element saturated with oil. At the bottom, there is an oil pan. the operation of air cleaning is carried out in two stages. In the first stage, the air strikes on the oil surface and then lift upward reverses into the filter element. The dust particles penetrate into the oil surface and get absorbed by it. In the second stage the partially cleaned air passes through the wire-mesh filter element, in which the remaining dust particles are retained.



This type of air cleaner is cleaned periodically. The wire-mesh filter is removed, cleaned in petrol and dried by air. Oil in the pan is also replaced.

Dry Type Air Cleaner:

It consists of a specially pleated paper element over which a fine mesh screen is provided for strengthening. By placing the pleated element, a large filtering surface is provided and yet restriction to air flow is minimal. The element is enclosed in a silencing chamber.

The element should be cleaned periodically. With a dry type air cleaner, a filter restriction indicator (Vacuum Indicator) is often found mounted into the clean air side of the system. When an air cleaner is not choked, it looks transparent and if becomes choked then it will give red indication.

Pre-cleaner:

Pre-cleaner is fitted on the air cleaner to arrest the thick dust and soil particles. On the engine which work in very unsafe atmosphere (dusty atmosphere), Pre cleaners are essentially required. Pre-cleaner has screen which arrests the thick soil and straw. After filtering through the screen, the air enters in the pre-cleaner body and revolves by strips fitted on the angle. Due to revolving, thick dust and soil separates and settles down at the bottom. A glass bowl is fitted at the bottom of the pre-cleaner. The bowl is cleaned periodically after filling by dust.

CLEANING OF DRY TYPE AIR CLEANER:

1. Only outer element is cleaned and never clean inner element.
2. Air should be applied from inside to outside and not in reverse direction.
3. Pressure of air should be 3.5 bar to 4.5 bar.
4. Nozzle dia should not be less than 0.8mm
5. Nozzle should not come in touch with paper element. It should remain approx. 1" away.
6. Tapping of air cleaner on the rigid surface is not allowed.

CHECKING OF DRY TYPE AIR CLEANER:

1. Bring the air cleaner in dark room.
2. Glow a bulb of 100W inside the air cleaner.
3. Light rays should not come out through the side of air cleaner. It should work like a lamp shade; otherwise it is damage to be rejected.

DRAW-BACKS OF CHOKING OF AIR CLEANER

are used to clean the air. If air cleaner is choked then following problems will arise:

1. Incomplete combustion of fuel

Fuel will not burn properly and instead of carbon-dioxide, carbon-monoxide will form and engine will give black smoke.

2. Dilution of Lubricating Oil:

As the fuel will not burn properly it will accumulate on piston. This accumulated fuel will leak through the piston rings and cylinder liner into the oil sump and mix with the lubricating oil causing dilution of it.

3. Increase Wear and Tear

Due to dilution of lubricating oil improper lubrication will take place and wear and tear of different engine parts increases.

4. Chocking of injector Holes

Due to un-burnt fuel and hence more carbon particles, injector holes may choke. Due to which the fuel cannot be injected in proper pattern.

5. Chocking of Silencer

Due to more carbon particles in exhaust, silencer also may choke.

Sub-discipline:- INTERNAL COMBUSTION ENGINE (Lessons: IX Sessions: 22) Lesson-IV: Air Supply system of Diesel Engine. Session-7: Supercharging, Turbocharger and After cooler, Importance of After cooling, Demonstration in I. C. engine model room

SUPER CHARGING: The process of supplying air to the engine cylinder above atmospheric pressure is called super charging. In a naturally aspirated engine, the piston-cylinder draws air equal to its stroke volume. The pressure inside the cylinder is less than the atmospheric pressure during the suction stroke. But in a supercharged engine, the air is forced into the cylinder at a pressure higher than atmospheric (at least 6 PSI).

TURBOCHARGER: Turbo charger is a device which is used to supply air inside the engine cylinders at more than atmospheric pressure. It is connected between air cleaner and inlet manifold. It is driven by the exhaust gases of the engine.

Construction and Working of Turbocharger: A turbo charger consists of a turbo wheel (turbine) and a centrifugal blower impeller (compressor wheel), separately enclosed in casings but mounted and rotating on a common shaft. It is mechanically independent of the engine except that its turbine is connected with exhaust manifold and the impeller with the after cooler or inlet manifold. The turbine portion should be made of heat resistance material.

The turbocharger is fitted between the air intake and exhaust system. Exhaust gases pass from the engine exhaust manifold to the turbine and rotates the wheel. The rotating motion of turbine is transferred through a common shaft to a compressor wheel. The compressor wheel then sucks air from the air cleaner and pushes it into the intake manifold under pressure. The actual pressure is measured in inches of mercury (Hg) and is dependant upon the engine, turbo design and power requirements.

Care: Turbo charger rotates by the exhaust gases at rpm of 1,25,000 to 1,40,000 approx. Bearing design and precise balancing of the whole rotating assembly are, therefore, of the greatest importance in ensuring a long useful life for the unit.

Turbo-compressor performance is sensitive to the presence of dirt and other harmful deposits. Special attention should be paid to air filtration when a turbocharger is fitted. Deposits should never be allowed to build up on the compressor as they would cause unbalance, and in most designs provision is made for cleaning the compressor without dismantling the turbocharger.

with the turbocharger is that the engine should not be stopped at full rpm. Before stopping, it should be run 3 to 5 minutes at idle rpm. If we do not do so, the lubricating oil supply to the turbocharger shaft bearings stops with the engine stop, but the turbocharger shafts keep on rotating for a considerable time at high rpm. Thus due to no lubrication, its bearings become red hot and the unit may get damaged. Also oil seal may get damaged due to overheating which will result in oil leakage to the impeller side.

Advantageous features of the turbocharger are:

1. By supplying more air more fuel can be injected for combustion inside the combustion chamber and therefore more power is obtained.
2. Better control over the air/fuel ratio at all engine speeds reduces the degree of smoke emission.
3. Having more air at lower speeds enables better fuel combustion and gives lower torque speeds.
4. A pressurized air manifold helps reduce combustion noise.
5. Turbocharger speed is controlled by the exhaust system and atmospheric back pressure. Engine working at high altitudes would normally suffer from lack of oxygen due to less air density. As the atmospheric pressure is less at altitude the back pressure in the exhaust system is less and the resistance to turbine shaft rotation is less. This results in the turbocharger shaft rotating at a faster speed forcing more air into the combustion chamber and thereby compensating for the lack of oxygen.

AFTER COOLER (INTERCOOLER): After cooler is a device, which is used to cool the air coming out from turbocharger before entering into the engine cylinders. After cooler are of two types:

- (i) Air to Air type – Used in Deutz Engine (BCM machine) model BF 12L 513C.
- (ii) Air to water type – Used in MWM & Cummins engines.

IMPORTANCE OF AFTER COOLING: In turbocharged engine, air coming from the turbocharger gets heated due to which its density decreases. Due to increase in temperature the density of air will decrease which is not desirable. In we cool the air in after cooler before it enters in to the engine cylinder, the density will increase. For limited vol. inside the engine cylinder, we can supply more air inside due to which more fuel will burn and we get more power. In this way output of the engine will increase.

INLET MANIFOLD: The inlet manifold is used to carry air into the engine cylinders through inlet valves. It is made of Al or C.I and its inside surfaces are smooth, so that there should not be obstruction to the passing air. It is bolted with cylinder head with a gasket at each joint to prevent air leakage.

EXHAUST MANIFOLD: It is similar to inlet manifold. It is made of C.I. It is fitted with cylinder head with asbestos gasket in between them. It collects the exhaust gases from the cylinder and sends to the silencer (muffler).

SILENCER (MUFFLER): Muffler is used

1. To reduce the noise of exhaust gases.
2. To reduce the temperature of the exhaust gases.
3. To trap the unburnt gases and burning gases.
4. To arrest spark.

Mufflers maintain some back pressure in the exhaust gases. This is necessary for the engine. At the start of suction stroke, Exhaust valves are open along with inlet valve for some time. If inlet gases have no restriction then they will enter rapidly and cool the exhaust valve very fast. Due to this rapid cooling exhaust valve may get bent. So this pressure is required to prevent the exhaust valve from rapid cooling.

Right Flow: In this silencer exhaust gases come out through the holes of a pipe and re-enter into the holes of another pipe and then go out.

Reverse Flow Type: In this type of silencer there are three or four segments connected by pipes with each other. These pipes are not in a line. Exhaust gases move forward and reverse inside the silencer.

Flexible Pipe: Exhaust manifold is connected with the engine and vibrates with it. Exhaust silencer is hanging with the chassis. A flexible pipe is fitted in between muffler and exhaust manifold to prevent the vibrations from reaching to the muffler.

Rain Cap: The engine in which exhaust pipe is fitted vertically; the rain drops may enter the cylinder head and combustion chamber through the pipe. If it is not prevented it will rust the valves and piston rings. In such engines rain cap is fitted over the exhaust pipe. If rain cap is damaged then exhaust pipe should be covered by a jar while the machine is stable.

DEMONSTRATION IN I. C. ENGINE MODEL ROOM

1. To demonstrate the air system components: Dry type air filter, Wet type air filter, Turbocharger, Inlet manifold, Aftercooler, Exhaust manifold, Silencer (Muffler) etc.
2. To explain the working of turbocharger and its components.
3. To sketch the block diagram of air flow circuit.

Sub-discipline:- INTERNAL COMBUSTION ENGINE (Lessons: IX Sessions: 22)

Lesson-V: Fuel Supply system of Diesel Engine. Session-8: Functions and classification of Fuel supply system, Mico-Bosch fuel supply system, Block diagram, Fuel Injection Pumps, Injectors and Filters.

FUNCTIONS OF FUEL SUPPLY SYSTEM

1. Storing of fuel.
2. Filtering the fuel
3. Delivering the fuel to pump
4. Injecting fuel into engine cylinder
5. Regulating the engine speed.

CLASSIFICATION OF FUEL SUPPLY SYSTEM

1. Air Injection System: In this system liquid fuel is injected with compressed air. This system is less reliable, less efficient and requires an air compressor. Due to this reason the system has become obsolete.

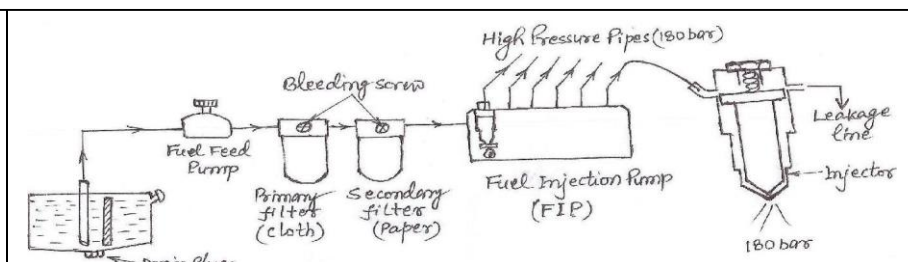
2. Solid Injection System: In this system only the liquid fuel is injected and there is no need of compressed air. There are two types of solid injection system in use:

- a) Individual pump system (Mico-Bosch fuel supply system)
- b) Common rail fuel injection system (Cummins P.T. fuel supply system)

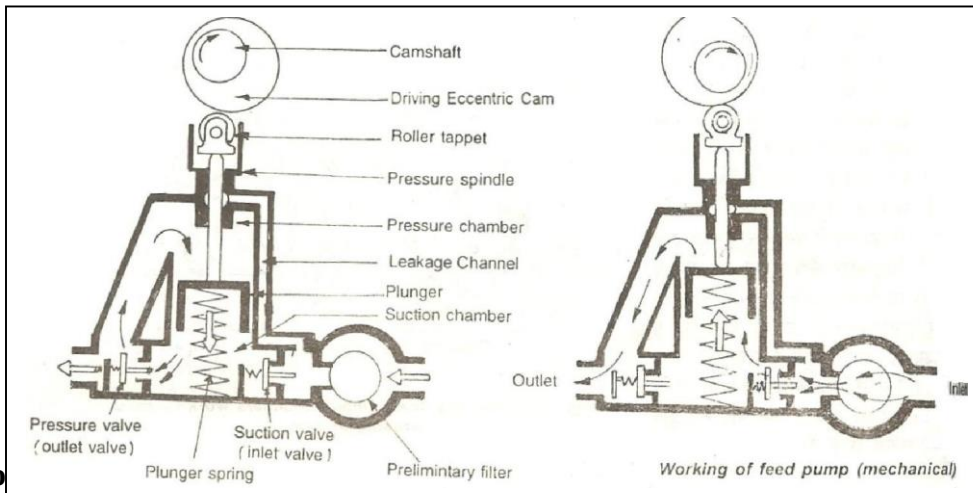
a) Individual Pump System (Mico-Bosch fuel supply system)

Working Principle: In this system fuel is drawn from the tank by a fuel feed pump and send to the fuel injection pump through fuel filters. The fuel injection pump (FIP) will pressurize the fuel individually for each cylinder and send to the corresponding injectors through high pressure pipes. The high pressure fuel goes to the injector at the time of injection. The injector injects fuel at approx. 180 bar to the engine cylinder in atomized and vaporized form. Extra fuel is returned by the fuel injection pump to the diesel tank. Also a leakage line from the injector goes to the diesel tank. The system contains following components:

1. Diesel Tank
2. Fuel feed pump
3. Fuel filter
4. FIP
5. Injector
6. Leakage Line



Fuel Feed Pump: Plunger type fuel feed pump is used in Mico-Bosch fuel system.



When the plunger lifts due to spring force a vacuum is created in the suction chamber and diesel is sucked, simultaneously the diesel is forced out from the pressure chamber. When the tappet presses the plunger due to eccentric movement, the fuel is forced to the pressure chamber. In this way diesel is sucked from the tank and send to injection pump. If the tank level is lower than the engine level, this pump is used to suck the diesel from the tank and send to the fuel injection pump.

Fuel Filter: In Mico-Bosch fuel system mainly two filters are used.

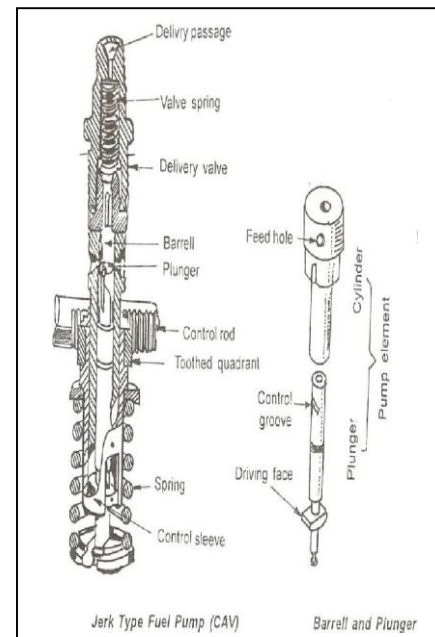
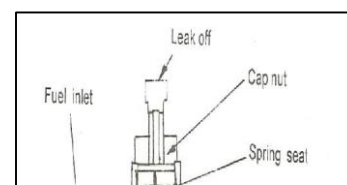
- Primary filter and
- Secondary filter

Primary filter is made up of felt or cloth and the secondary filter is made up of paper. In many cases a pre-filter is also used. This is made of bronze mesh.

Fuel Injection Pump:

This is used in Mico-Bosch fuel system to build up a high pressure in fuel for injection. FIP also meters the correct quantity of fuel according to varying load and speed requirements and delivers it at the correct time to the engine cylinder. Injection sequence is produced in FIP. There are individual plungers driven by cams of a camshaft in the FIP. The plunger reciprocates in the barrel. The plunger has a rectangular vertical groove and helical groove. The delivery valve is lifted off its seat under the pressure of the fuel against the spring. The fuel from the delivery valve goes to injector.

When the plunger is at the bottom of its stroke the supply port and spill port are uncovered, the fuel from fuel feed pump after filtration is forced into the barrel. Now the plunger is pushed up by the cam movement and both the ports are closed. On further movement of plunger, the fuel above it is compressed which lifts the delivery valve and fuel goes to the injector. The plunger raises up still further and at a particular moment, the helical groove connects the fuel on the upper part of the plunger to the spill port. Consequently the fuel goes out and there is a sudden pressure drop due to which the delivery valve falls back on its seat under the spring force.



Thus pressure in the delivery pipe drops and discharge from

Injector:

The fuel injector is used to inject a small volume fuel in a fine spray to the combustion chamber. It consists of needle valve which is pressed on its seat in the nozzle by a spindle or plunger. The pressurized fuel enters in the injector body from the high pressure pipe. The fuel passes through drillings to a point just about the nozzle seat. The needle valve is lifted from its seat by pressure of the fuel and the injection takes place. When the injection pressure falls below the spring pressure the valve gets closed. This action sets of an oscillation in the valve which consequently breaks fuel into small particles. Fuel leakage through the needle valve stem enters the upper part of the injector and is returned to the pump suction side or fuel tank. Fuel leakage provides lubrication for the valve stem.

Sub-discipline:- INTERNAL COMBUSTION ENGINE (Lessons: IX Sessions: 22)

Lesson-V: Fuel Supply system of Diesel Engine. Session-9: Cummins PT Fuel supply system, Difference between Mico Bosch and Cummins PT Fuel supply system, Air lock.

b) Common rail fuel injection system (Cummins P.T. fuel supply system)

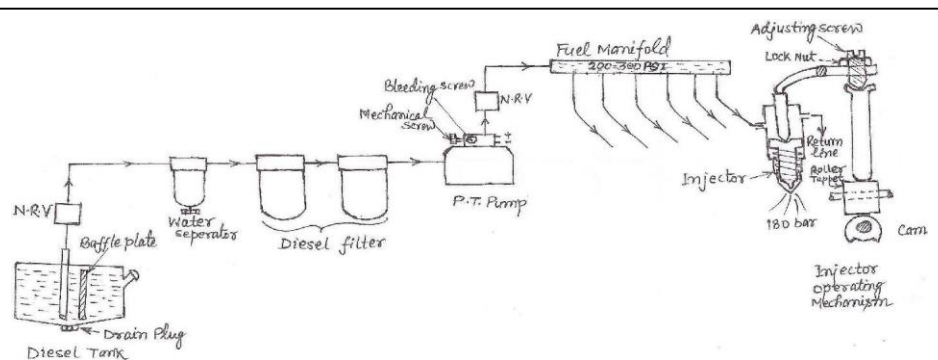
Operating Principle:

This system was designed by Cummins engineers for Cummins diesels. The identifying letter P.T. is abbreviation for 'Pressure-Time'. The operation is based on the principle that amount of fuel injected depends upon pressure of fuel and time available for the filling diesel into injector cup.

The PT pump is driven by cam shaft gear at crank shaft speed. The 'PT' pump draws fuel from the diesel tank through water separator and fuel filter. The PT pump delivers fuel to the fuel manifold through shutdown valve at a pressure of 200 – 300 PSI. From fuel manifold, fuel goes to the injector and returns to the tank. The injector plunger is actuated by cam mechanism at the time of injection. Travel of plunger opens path for the diesel to the injector cup for a few degree rotation of cam shaft. Fuel pressure and the length of time the metering orifice is exposed to the fuel inlet, determines the quantity of fuel which fills in the injector cup. Then the cam mechanism pushes down the injector, resulting in injection at the pressure of approximately 180 bar.

The Cummins PT Fuel system consists of following components.

1. Diesel Tank
2. Water separator
3. Fuel Filters
4. P.T. Pump
5. Fuel Manifold
6. Injector
7. Return Line



P.T. Pump:

el pump is used. It is called a governor control pump because, governor assembly controls pressure regulation and engine RPM. Fuel flow through the P.T pump is as under:

The gear pump transfers fuel from the fuel tank through the filter screen into the pressure regulator plunger cavity. The fuel further divides into two directions:

- a) By one path the fuel acts on the *pressure regulator by pass plunger* and returns to the gear pump suction.
- b) In the second path the fuel flows through throttle, where it can proceed through two paths
 - i) Idle fuel path and
 - ii) Manual controlled path

At idle speed, the manual controlled fuel path is closed and the fuel flows through the idle fuel path from the idle port in the governor. At intermediate speed and full speed fuel passes through both the paths. The PT pump governor exercises final control over engine speed. The fuel coming through throttle flows through the open shutdown valve to the fuel manifold.

Injector: The PT Injector performs to important functions:

- i) It meters the right quantity of fuel into the injector cup.
 - ii) It injects the metered amount of fuel through the spray holes in the combustion chamber.
- There are two types of Cummins injector. The flanged injectors are used in engines equipped with fuel manifold. The cylindrical injectors are used in engines, equipped with drilled fuel passages.

DIFFERENCE BETWEEN MICO-BOSCH & CUMMINS P.T. FUEL SUPPLY SYSTEM:

	MICO BOSCH	CUMMINS
1	Separate reciprocating pump (plunger & barrel) are used for each engine (each) cylinders.	A low pressure gear pump is used for all engine cylinders.
2	Fuel injection pump will supply the fuel to the injector only at that particular time when cylinder is ready to receive the fuel.	Gear pump will continuously supply the fuel to the injectors.
3	As soon as injector receives the fuel, it injects the fuel to the engine cylinders.	Injectors receive the fuel continuously, but it is injected at that particular time, when cylinder is ready to receive fuel. For remaining time it is returned back to the tank.
4	Final Fuel injection pressure is built up in the fuel pump and injector only injects the fuel in the form of fine spray.	As injector receive the fuel at very low pressure (200 to 300 PSI) at which it is not possible to inject it into the engine cylinder. The pressure of fuel before injecting into the engine cylinder is increased up to final injection pressure (App. 180 bar) in the injectors. In this way injector increases the pressure & breaks the fuel in fine particles. After that fuel is injected. Hence the injectors of Cummins PT fuel supply system are also called unit injectors.
5	The opening & closing of injector takes place because of high pressure of fuel to be injected.	Opening & closing of injector takes place in the same fashion as that of valves (Inlet & outlet.)
6	No need to provide push rod & rocker arm for operation of injectors.	Push rod & rocker arm are provided for opening & closing of valves.

REMOVING AIR LOCK: If due to any reason air enters into the fuel system lines then it becomes impossible to start the engine. The air present in the fuel lines blocks the passage and the fuel can't be delivered to the engine cylinders. Air may enter into the engine cylinder due to

the tank, when the machine negotiates over a curve and the level of HSD oil falls below the opening of suction pipe in the tank. It may also enter due to loose connections or any small hole in the fuel lines in between the tank and fuel pump.

Also the air may enter into the fuel supply system while changing the filters. This air is to be removed for proper functioning of fuel supply system. For removing the air from the fuel supply system, following method is adopted:

In Mico-Bosch fuel supply system -

1. Loose vent-screw provided on the body of the fuel filters and fuel injection pump.
2. Do hand priming by fuel feed pump hand operated lever.
3. Priming will be done till oil free from air bubbles starts to come through the first vent screw in the fuel flow direction.
4. As soon as the fuel free from air bubbles starts coming out through the first vent screw in the fuel flow direction, tighten the vent screw.
5. Repeat the step 3 & 4 for the remaining vent screws facing the fuel flow direction in sequence.

In this way air is removed from the system.

In Cummins P. T. fuel supply system -

1. Loosen/ remove the bleeding screw provided on the shutdown valve.
2. Prime the engine by self starter to force out the entrapped air until the fuel free from air starts flowing through the bleeding screw.
3. As soon as the fuel free from air bubbles starts coming out through the bleeding screw, tighten the screw.
4. Sometimes if it is suspected that fuel filter has become empty, it is filled by H.S.D. by loosening and taking out the output pipe and simultaneously loosening the input pipe for air removal. Then P.T. pump suction line is filled by H.S.D. and connection is restored to normal. Now steps 1, 2 and 3 are done.
5. Sometimes in place of priming the engine, P.T. pump suction line after filling by H.S.D. is blown by mouth to force out the entrapped air.

In this way air is removed from the system

Sub-discipline:- INTERNAL COMBUSTION ENGINE (Lessons: IX Sessions: 22)

Lesson-VI: Fuel Supply system of Diesel Engine. Session-10: Demonstration in I.C. Engine Model Room.

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1. To demonstrate the components of Mico-Bosch fuel supply system.
 2. To draw the fuel flow circuit of Mico-Bosch fuel supply system.
 3. To demonstrate the components of Cummins PT fuel supply system.
 4. To draw the fuel flow circuit of Cummins PT fuel supply system.

Sub-discipline:- INTERNAL COMBUSTION ENGINE (Lessons: IX Sessions: 22)

Lesson-VII: Lubricating system of Diesel Engine. Session-11: Concept of lubrication and functions of Lubricating oil, Properties of Lubricant and Lubricating circuit.

CONCEPT OF LUBRICATION: Whenever two metallic surfaces move over each other, irregularities on the two surfaces interlock with each other due to which friction is produced. When metal surfaces are in direct contact to each other the friction produced in between them is called solid friction. When a film of lubricating oil is interposed between the two surfaces, the friction produced is called fluid friction. If the lubricants between the two surfaces do not cause complete separation, the friction produced is called boundary friction.

To supply lubricating oil between the moving parts is called lubrication and the system used is called lubrication system.

FUNCTIONS OF LUBRICATING OIL:-

1. To reduce friction between moving parts.
2. To reduce wear and tear of moving parts.
3. To provide cooling effect.
4. To provide cushioning effect. It absorbs shocks, between bearings and other moving parts.
5. To produce cleaning action, during its circulation.
6. To provide a sealing action. It helps the piston rings to maintain an effective sealing in the cylinder against high-pressure gases.

LUBRICATING OIL:-

- 1. Viscosity:** Viscosity means resistance of lubricating oil to flow. The viscosity of oil is specified as the time in seconds that it takes for a given amount of oil to flow by gravity through a standard size orifice at a given temperature. The viscosity of the oil varies inversely with temperature. The oil with minimum variation is preferred.
- 2. Flash Point:** The lowest temperature at which the lube oil will flash when a small flame is passed across its surface is called flash point. The flash point of the oil should be sufficient high to avoid flashing of oil vapors at temperatures occurring in common use.
- 3. Pour Point:** The minimum temperature at which the oil flow starts is called pour point. The oil cannot be used for lubrication below this temperature. So the pour point of the oil should be less than the lowest temperature encountered in the engine.
- 4. Corrosion Resistance:** Corrosion means destruction of a solid body by chemical action. The oil should not have any tendency to corrode engine parts.
- 5. Cleanliness:** Lubricating oil must be clean. It should not contain any dust/dirt particles so that the crankcase and oil lines are kept clean.
- 6. Physical Stability:** The lubricating oil must be stable physically at the lowest and highest temperatures prevailing in the engine.
- 7. Chemical Stability:** At high temperatures the oil should remain chemically stable. There should not be any tendency for oxide formation. The oil should not decompose to form carbon particles.
- 8. Adhesiveness:** The property due to which the oil particles stick with metal surfaces is called adhesiveness. Oil should have good adhesiveness.
- 9. Film Strength:** It is the property due to which the oil retains a film between two surfaces even at high speed and temperature. The film between moving parts should not break.

LUBE OIL ADDITIVES: -

Additives are mixed in the oil to impart those desired properties. These additives are as follows: -

- 1. Viscosity-index improver:** - To maintain a more uniform viscosity over the wide range of operating temperatures.
- 2. Pour point depressant:** - To reduce the pour point of the oil.
- 3. Oxidation inhibitors:** - To reduce oxidation of the oil caused by high temperatures.
- 4. Corrosion inhibitors:** - To inhibit corrosion due to the formation of acid at high temperatures.
- 5. Anti Rust:** - To prevent rust formation on internal parts during shutdown periods.
- 6. Antifoam:** - To control foaming and prevent air bubbles from entering the oil pump.
- 7. Detergent/Dispersants:** - To prevent the formation of deposits of Carbon, gum and dirt, detergent additives are used. Like ordinary hand soap, it loosens and detaches the deposits. The oil then carries the loosened material away. The larger particles drop to the bottom of the crankcase, but smaller particles tend to remain suspended in the oil. These impurities are flushed out when the oil is changed.

A dispersant is added to the oil to prevent the particles from clotting, and to keep them in finely divided state. Without dispersant, the small particles will tend to form large particles which might block the oil filter and passages.

- 8. Extreme pressure additives:** - Lubricating oil may be subjected to very high pressures in bearings and valve trains. To prevent the oil from squeezing out, extreme pressure additives are

react chemically with metal surfaces to form very strong, thin and slippery film. Thus they help the oil by providing protection during moments of extreme pressure.

Viscosity rating (SAE NUMBER) :

SAE stands for “Society of Automotive Engineers”. The oils which are used for winter have suffix ‘W’ (Ex.- SAE 15 W) and their viscosity test is made at 0° Fahrenheit (-18° Celsius). The oils without suffix ‘W’ (Ex. - SAE 40) are used for summer and their viscosity test is made at 210° Fahrenheit (99°C).

These day’s multigrade oils are available. These oils undergo minimum change in viscosity with temperature.

Example: SAE 15 W 40: This oil has the same viscosity as SAE 15W at 0°F and as SAE 40 at 210°F.

SAE No.	Viscosity at 0°F (Say bolt-seconds)	Viscosity at 210°F (Say bolt-seconds)
10 W	12"	-
20 W	48"	-
20	-	45" to 58"
30	-	58" to 70"

Oil grade	Temperature range
15 W 40	-10°C and above
20 W 40	0°C and above

Lesson-VII: Lubricating System of Diesel Engine **Session-12:** Different types of Lubricating systems, Oil pump, Relief Valve, Filters, Oil Cooler, Strainer, Oil Pressure Gauge, Oil Pressure Indicating light.

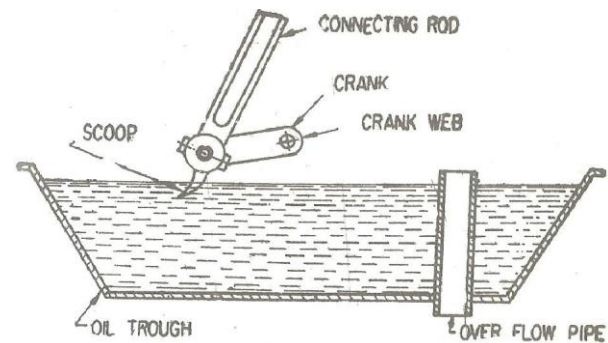
DIFFERENT TYPES OF LUBRICATING SYSTEMS:-

1. Petroil system
2. Splash system
3. Pressure system
4. Semi pressure system
5. Dry sump system

1. Petroil System: In this system lubricating oil is mixed into the petrol, while filling in the petrol tank. When the fuel goes into the crank chamber during the engine operation, the oil particles go deep in to the bearing surfaces and lubricate them. The cylinder wall, piston rings, piston pin and crankshaft are lubricated in the same way. This system is adapted in 2-stroke petrol engine.

2. Splash System:

In this system oil is stored in a sump. A scoop is made in the lowest part of the connecting rod. When the engine runs the scoop dips in the oil once in every revolution of crankshaft and causes the oil to splash on the cylinder walls. This action effects the lubrication of cylinder walls, piston rings,

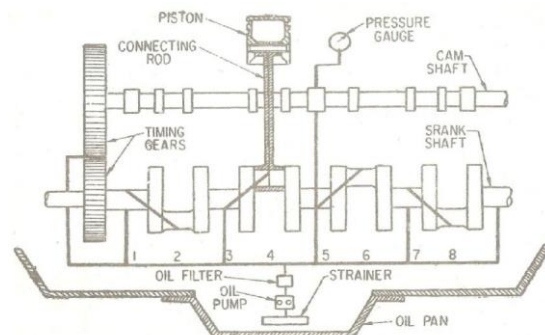


4. Semi Pressure System: It is the combination of splash system and pressure system. Some parts are lubricated by splash system and some parts are lubricated by pressure system.

5. Dry Sump System: In this system the oil is stored in a separate tank from where it is fed to the engine. This system is used in aircrafts because its engine position keeps on changing.

3. Pressure Lubricating System:

In this system engine parts are lubricated under pressure feed. Lube oil is stored in a sump. Oil pump draws oil through a strainer and delivers it to the main gallery through a filter at a pressure of $1.0 \text{ Kg/cm}^2 - 4.0 \text{ Kg/cm}^2$. The oil from the main gallery goes to the main bearings. After lubricating them, some of the oil falls back to the sump, some is splashed to lubricate cylinder walls and the remaining goes through a drilled hole to the crankpins. From crankpin it goes to the piston pin through a hole in the connecting rod web, where it lubricates the piston rings



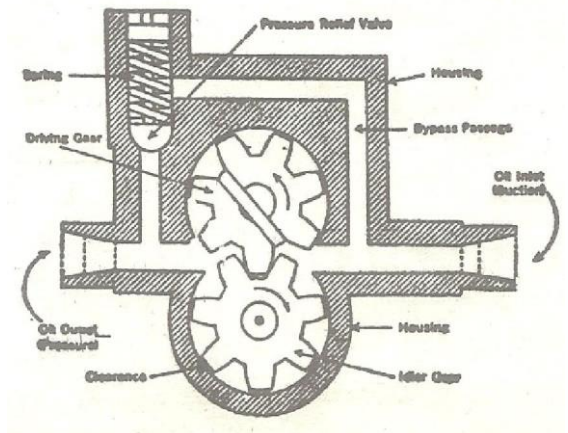
A separate oil line goes from the oil gallery for lubrication of camshaft and timing gears. The valve tappets are lubricated through a hole from the main gallery to the tappet guide surfaces. An oil pressure gauge at the panel indicates the oil pressure in the system.

LUBRICATING SYSTEM

- 1. Oil Sump:** Oil sump is the bottom most part of the crank chamber. It provides a covering for the crankshaft and stores oil in it. It contains a drain plug at its bottom to drain out the oil.
- 2. Strainer:** Oil strainer is simply a wire mesh screen. It is attached to the inlet of the oil pump. The strainer retains dirt or grit in the oil.
- 3. Oil Pump:** It supplies oil under pressure to the engine parts for lubrication. It is generally located out side the crankcase. Different types of the oil pumps used for engine lubrication are as follows: - 1. Gear pump 2. Plungers pump 3. Rotors pump 4. Vane pump.

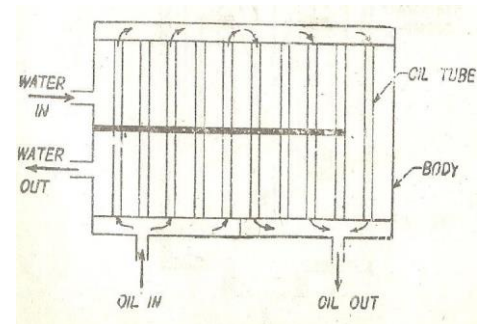
Gear Pump: It consists of two meshed spur gears enclosed in housing. There is very little clearance between the gear teeth and housing. One gear is drive gear getting power through its shaft from camshaft or crankshaft. The other gear is free to revolve on its own bearing. When the pump is in action, the oil enters between the gear teeth from the inlet side, carried around between the gears and pump housing and forced out through the outlet side.

This type of pump is used almost universally due to simplicity in construction. It can deliver oil at a pressure about $1.0 - 4.0 \text{ Kg/cm}^2$. A pressure **relief valve** is also provided in many oil pumps to relieve the excess pressure.



- 4. Oil Filter:** Oil filter is used to filter out the dirt/grit particles from the engine oil. There are two types of lube oil filters: i) Full flow type and ii) Super bypass type
- 5. Oil Cooler:** Oil cooler is provided to cool the lube oil in heavy-duty engines, where oil temperature becomes quite high. The viscosity of oil decreases with the temperature raise and oil film may break at high temperature.

The oil may be cooled either by cold water or by air stream. Water type oil cooler contains tubes in which oil circulates. The water circulates out side the tubes in the casing of the cooler. The heat of the oil is carried away by the circulating water. In air type cooler there are fins around the tubes to increase the cooling surface area. Air stream passes around the tubes and takes away the heat from the tubes and fins.



- 6. Oil Level Indicator:** The level of the oil in the sump is checked by a dipstick. Before starting the engine, oil level should be checked. The oil level should be between "H" and "L" mark of the dipstick.
- 7. Oil Pressure Gauge:** Oil pressure gauge indicates the oil pressure during engine operation. Normally one electrical type oil pressure gauge is fitted on the driving panel and another mechanical type oil pressure gauge is fitted near the engine at instrument panel.
- 8. Oil Pressure Indicating Light:** There is an oil pressure indicating light (Red LED/ Yellow LED) provided at the driving panel. This light glows when oil pressure becomes down from the minimum setting. It gives warning about decreased oil pressure.

Oil Pressure Rating: -1. At idle speed: - Min. 1.5 kg/cm^2 2. At rated speed: - Min 2.5 kg/cm^2 .

Lesson-VII: Lubricating System of Diesel Engine. Session-13: Blow by, Crank case ventilation, Reasons of Low lubricating oil pressure and high Oil consumption. Demonstration in I.C. Engine Model Room

BLOW BY: - The escaping of burnt gases (combustion products) from combustion chambers to the crank case chamber through cylinder walls is known as blow by.

CRANKCASE VENTILATION

The products of combustion contain mainly nitrogen, water and carbon dioxide. Sulphuric acid may also be present due to sulphur content in the fuel. The product of combustion may leak into the crankcase. The crankcase ventilation removes all these unwanted gases and sulphuric acid particles. It prevents the lubricating oil from being dilute and corrosion of crankcase metals due to acid formation.

REASONS FOR LOW LUBRICATING OIL PRESSURE

1. Less oil in the sump.
2. Loose connections in the oil lines.
3. Too weak relief valve spring.
4. Excessive clearance in the bearing due to which oil may leak rapidly from bearing ends.
5. Oil filter may be clogged.
6. Oil pump may be worn.
7. Faulty pressure gauge.

REASONS FOR HIGH LUBE OIL CONSUMPTION

1. Loose connections in oil filter lines.
2. Worn oil seal at front or rear main bearings.
3. Worn rear oil seal of camshaft.
4. Broken or improperly installed oil pan, valve cover and timing gear cover gaskets.
5. Cylinder and head distortion due to improper tightening of the cylinder head bolts.
6. Worn out oil control rings.
7. Out of round cylinders.
8. Loose bearings.
9. Excessive clearance in intake valve guides.
10. Excessive oil pressure.
11. Clogged oil breather.
12. High speed and high temperatures of engine, which reduces oil viscosity causing more oil flow. Hence more oil leaks and more oil burns.



PRECAUTIONS WHILE CHANGING LUBRICATING OIL

1. Oil should be drained when engine is hot. In hot condition, oil becomes thin and flows easily resulting in complete drain.
2. Drain plug should be kept open for sufficient time to ensure complete drain.
3. Lube oil filters and filter sealing rings also should be replaced with oil change.
4. Oil grade to be replaced should be same. If oil grade/brand is different, flushing of engine should be done with same new oil.
5. Before filling oil, drain plug should be tightened.
6. Oil level should be kept at 'H' mark of dipstick.
7. Filter-can should be filled with new oil.
8. After running of engine for few minutes, stop the engine and after 30 minutes, oil level should be checked and topped up.
9. Oil leakage should be checked and made fit.

- s provided in the lube oil system (MWM, Deutz engines), it should be cleaned.
11. Torn the filter paper and check for any metal particles.

DEMONSTRATION IN I.C. ENGINE MODEL ROOM

1. To Demonstrate lubricating system components such as
 1. Strainer
 2. Oil pump
 3. Relief valve
 4. Inline Lube Oil filters
 5. Super bypass filter
 6. Oil Cooler etc.
2. To demonstrate lube oil flow circuit.

Lesson-VIII: Cooling system of Diesel Engine. Session-14: Necessity of Cooling, Different methods of Engine cooling, Air Cooling system, Water Cooling system.

Necessity of Cooling:-

During combustion of air-fuel mixture, enormous amount of heat is produced and the temperature of burning gases may be reached up to 2500°C . The temperature is so high that it will cause: -

- a) Pre-ignition of the charge,
- b) Break the lubricating film between the moving parts,
- c) Weld the moving parts or
- d) Any mechanical breakage of the engine parts.

So this temperature must be reduced to 200°C - 250°C , at which the engine may work efficiently. However, too much reduction in temperature will lower thermal efficiency of the engine. Thus the purpose of the cooling system is to keep the engine at its most efficient operating temperature at all engine speeds and driving conditions.

The cooling system is so designed that it prevents cooling until the engine reaches to its normal operating temperature. When the engine warms up, the cooling system begins to function. It cools rapidly when the engine is too hot, and it cools slowly or not at all when the engine is cool or is warming up. Engines are designed to operate in a definite temperature range which will ensure correct clearances between parts, promote vaporization of the fuel, keep the oil at its best viscosity and prevent the condensation of harmful vapours.

DIFFERENT METHODS OF ENGINE COOLING:- The following methods are mainly employed for engine cooling: 1. Air cooling 2. Water cooling

AIR COOLING SYSTEM:- In this method, heat is dissipated directly to the air after being conducted through the cylinder walls. Fins and flanges on the outer surfaces of the cylinders and heads serve to increase the area exposed to the cooling air, and so raise the rate of cooling.

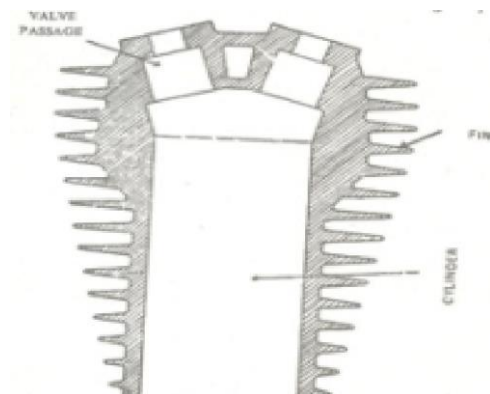
Advantages of air cooling:-

1. Lighter in weight due to absence of radiator, cooling jackets, and coolant.
2. No topping up the cooling system.
3. No leaks to guard against.
4. Antifreeze, corrosion resistance not required.
5. Engine warms up faster than the water-cooled engines.
6. Can be used in areas where there is scarcity of water.

Disadvantages: -

1. Less efficient cooling, because co-efficient of heat transfer for air is less than that of water.
2. Not easy to maintain even cooling all around the cylinder, distortion of the cylinder may take place.
3. More noisy operation.
4. It can be used only where the cylinders are exposed to air stream

Cooling fins: The fins are usually made of about the cylinder wall thickness at their roots, tapering down to about one-half the root thickness. The length of fins varies from one quarter to one third of the cylinder diameter. The distance between the two fins centers is about one-quarter to one third of their length. The total length of finned cylinder barrel is from 1 to 1.5 times the cylinder bore. Another experimental consideration is to allow 1,400 to 2400 cm^2 of cooling fins area per horse-power.



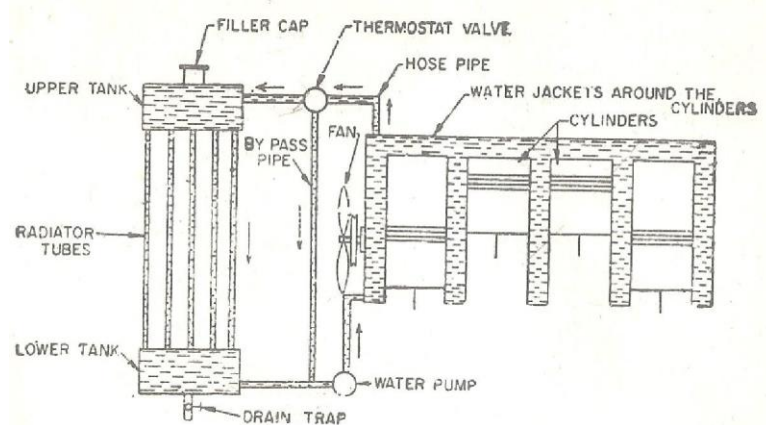
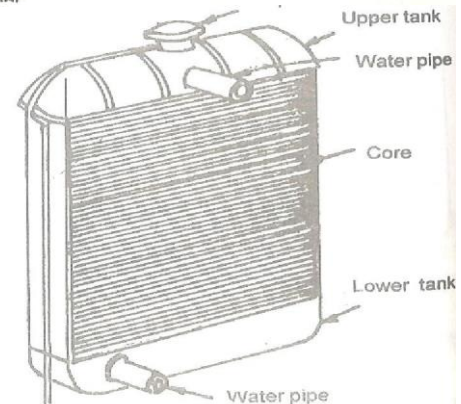
WATER COOLING SYSTEM: - In this method water is circulated through water jackets around each of the combustion chambers, cylinders, valve seat and valve stems. The circulating water, when passes through the engine jackets in the block and cylinder head, takes heat of the combustion. When it passes through the radiator, it is cooled by air drawn through the radiator by a fan and by air flow developed by the forward motion of the vehicle. After passing through the radiator, the water again goes in the engine jackets. The normal operating water temperature of the engine should be 71°C to 88°C, but the most suitable temperature is assumed to be 82°C for water cooled engines.

Components of the water cooling method: -

1. Radiator
2. Water Pump
3. Water Manifolds
4. Water jackets
5. Thermostat
6. Fan
7. Temperature gauge.

1. Radiator: -

Radiator is device to provide large amount of cooling surface to the large amount of air, so that the water circulating through it is cooled efficiently. It consists of an upper tank and a lower tank and between them a series of tubes. The upper tank is connected to the water outlets from the engine jacket by a hose pipe, and the lower tank is connected to the jacket inlet through the water pump. Water passes through the tubes. Fins are placed around the tubes to improve heat transfer. Air passes around the tubes, between the fins, absorbing heat from the water. If any tube is clogged the cooling effect of the tube is lost.



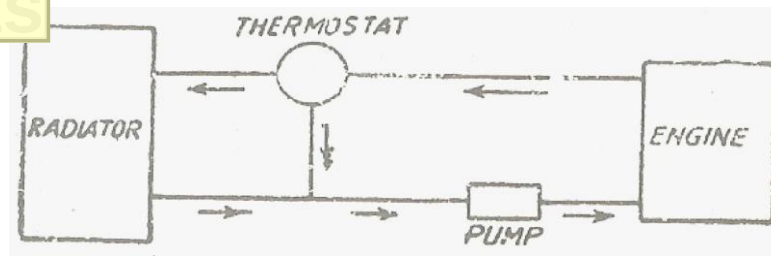
Radiator is usually made of copper and brass because of their high heat conductivity. The various sections of the radiator are almost completely joined together by soldering.

2. Water pump: - A pump is used to increase the velocity of the circulating water. An impeller type pump is fitted between the cylinder block and radiator. Pump is driven by the engine by a belt or gears. The impeller shaft is supported on one or more bearings. A seal prevents water from leaking out around the bearings.

3. Water Manifolds:

4. Water jackets: - Water jackets are cast into the cylinder blocks and heads. Jackets are the passages through which water circulates around the cylinders, valve ports and seats, combustion chambers and any other hot parts that require cooling.

5. Thermostat: - Thermostat valve is used to regulate the circulation of water in system to maintain the normal working temperature of the engine parts. The thermostat valve automatically works in the cooling system. When the engine is started from cold, the thermostat valve prevents the flow of water from engine to radiator, so that the engine readily reaches to its normal working temperature. Generally it starts opening and allowing water to the radiator at 74 degree centigrade and opens completely and allows whole water through the radiator at 85° centigrade.



Thermostat works on the principle- a heat unit operating a valve.

Wax- element thermostat: -

A copper cover is filled with wax and sealed. When temperature rises, the wax expands and operates the valve. When temperature reduces wax contracts and spring closes the valve.

6. Fan: - A fan is mounted behind the radiator. It is either fitted on the water pump shaft or separately driven by belts or hydraulic motors. The fan draws air through the radiator for cooling.

7. Temperature Gauge: - A temperature gauge is mounted on the instrument panel. There are two types of temperature indicators:-

1. Mechanical type.
2. Electrical type.

Closed system: - The circulation of water is closed in the system under pressure. The boiling point of the water is raised by keeping it under pressure. A relief valve is provided in radiator filler cap to prevent excessive pressure causing leaks. A vacuum valve is also provided in the cap to admit air when the pressure in the system falls below that of the atmosphere due to the condensation of steam vapours on cooling.

The relief valve is generally set to open at pressure of 0.55 to 1.10 kg/cm². A 1.10 kg/cm² valve would provide a boiling point of about 125 degree Celsius. By raising the boiling point of the coolant, the cooling capacity of the system is raised.

Corrosion inhibitor: - A corrosion inhibitor should be used in the cooling system to prevent the formation of rust and scale. Nalcool-2000 is used in MWM (Greaves) engines and coolant additive concentrate (CAC) is used in Cummins engines as a corrosion inhibitor. The water and corrosion inhibitor ratio by volume is 30:1 for Nalcool-2000 and 15:1 for Coolant additive concentrate. Also premixed coolant is available for top-up in Cummins engines.

As much as possible distilled water should be used for cooling. Clean tap-water also may be used. But water from rivers, canals etc, which are mostly dirty, should not be used.

Draining cooling system: - A drain plug is provided at the bottom of the radiator and also a drain plug is provided on the right side of the cylinder block. Remove the radiator cap to break any vacuum that may have developed.

Note: - If the coolant is lost from the system and the engine becomes overheated, do not refill the system immediately. Allow the engine to cool or refill slowly while the engine is running, otherwise there is danger of cracking the cylinder block and head.

Lesson-VIII: Cooling system of Diesel Engine. Session-15: Drawbacks of over cooling and reasons for over heating, Demonstration in I.C. Engine Model Room.

DRAW BACKS OH OVER COOLING:-

1. Thermal efficiency is decreased because more heat losses through the cylinder walls.
2. Combustion efficiency is decreased due to poor vaporization of fuel which results in loss of power and black smoke.
3. Mechanical efficiency is decreased because viscosity of lub. Oil increases and hence more piston friction is encountered.
4. Engine runs noisy due to excess clearance between moving parts.
5. Lube oil is diluted because incomplete burnt fuel escapes through the cylinder walls to the sump.
6. Sludge develops in sump.

Though more cooling improves volumetric efficiency, but the overall efficiency is decreased.

SUMMARY OF COOLING SYSTEM TROUBLES:

Troubles	Possible causes
1. external leakage	a) Loose hose clips. b) Defective rubber hose. c) Damaged radiator seams. d) Loose core plugs. e) Damaged gaskets. f) Leak at the water temperature gauge.
2. Internal leakage	a) Defective cylinder head gasket. b) Cracked cylinder wall. c) Loose cylinder head bolt.
3. Poor circulation	a) Restriction in system. b) Insufficient coolant c) Inoperative water pump. d) Loose fan belt. e) Inoperative thermostat.
4. OVER HEATING	a) Poor circulation due to any reason. b) Thermostat doesn't opens properly. c) Dirty oil sludge in the engine. d) Low lube oil level. e) Lube oil too thick. Low lube oil level. f) Lube oil too thick. g) Radiator fins choked. h) Incorrect ignition timing. i) Incorrect valve timing j) Tight bearing. k) Clogged exhaust system. l) Dragging brakes.
5. Over cooling	a) Defective thermostat. b) Faulty temperature gauge.
6. Corrosion	a) Excessive impurity in water. b) Incorrect quality / quantity of corrosion resistant additive.

For coolant to be used on Cummins Engines: pH value- 8.5 to 10.5

For coolant to be used on MWM Engines: pH value- 8.0 to 10.0

DEMONSTRATION IN I.C. ENGINE MODEL ROOM

1. To demonstrate Air Cooling System components.
2. To demonstrate Water Cooling System components.
3. To study working of Thermostat.
4. To draw water flow circuit of the model engine.

Lesson- IX: Maintenance Steps. Session-16: Maintenance Schedules.

MAINTENANCE SCHEDULES OF CUMMINS ENGINES (KTA 1150-L AND NTA 855-L) AS PER 09-3X CSM OF RDSO

SCHEDULE – I (TO BE DONE DAILY)

- (i) Check the engine oil level for both engines and top up if required.
- (ii) Check coolant level in radiator for both engines.
- (iii) Check and prevent the water leaks, if any.
- (iv) Check the air cleaner vacuum indicator for both engines. If indicator is red, the outer filter is to be cleaned.
- (v) Check the tension of V-belts and correct it, if required for both engines.
- (vi) Drain the air tanks after the day's work.
- (vii) Drain the water separator before starting the engine.
- (viii) Record the maximum engine temperature of the day's work.
- (ix) Clean the engine and premises.
- (x) Check fuel level in Diesel tank.
- (xi) Check oil pressure of both the engines on load after two hours working.
- (xii) Check the oil leakage from fuel line.
- (xiii) Check the oil pressure at idle RPM.

SCHEDULE – II (TO BE DONE AFTER 50 HOURS OF ENGINE RUNNING)

- (i) Check the condition of V- belts.
- (ii) Check the condition of brake shoes.
- (iii) Check electrolyte level and Specific Gravity of batteries.
- (iv) Clean the outer air filter element.
- (v) Drain the water bowl of diesel tank.

SCHEDULE – III (TO BE DONE AFTER 100 HOURS OF ENGINE RUNNING)

- (i) Check high water temperature safety device.
- (ii) Check low lube oil pressure safety device.
- (iii) Check the throttle control linkage
- (iv) Examine the mounting bolts of the engine.

SCHEDULE-IV (TO BE DONE AFTER 200 HOURS OF ENGINE RUNNING)

- (i) Change the engine oil.
- (ii) Change lube oil filter element.
- (iii) Change fuel filter element.
- (iv) Lubricate the bearings of all the engine pulleys with grease.
- (v) Change super lube. oil by-pass filter element.
- (vi) Clean crank case breather.
- (vii) Clean the mesh of radiator by pressurized air.
- (viii) Replace the outer and inner engine air cleaner element.

Note: Item no. (i), (ii), (iii) and (v) will be done after 250 engine hours.

Item no. (viii) will be done after 500 engine hours.

SCHEDULE-V

(TO BE DONE AFTER 1000, 3000 and 5000 HOURS OF ENGINE RUNNING)

- (i) Change worn out water hoses.
- (ii) Overhaul the self starter.
- (iii) Overhaul the alternators.
- (iv) Overhaul the injectors.
- (v) Overhaul the fuel injection pumps.
- (vi) Replace the rocker cover gaskets.
- (vii) Clean the engine radiator externally.
- (viii) Clean the diesel tank.
- (ix) Clean the cooling coil.
- (x) Replace the batteries on condition basis.
- (xi) Check the water pump pulley.
- (xii) Check coolant for PH value.
- (xiii) Change the filter cartridge of air dryer

SCHEDULE-VI (IOH)

(TO BE DONE AFTER 2000 and 4000 HOURS OF ENGINE RUNNING)

- (i) Top overhauls the engines, if required.
- (ii) Overhaul the air compressor.
- (iii) Replace all the water hoses.
- (iv) Overhaul the water separator and air oiler.
- (v) Overhaul the air unloader.

SCHEDULE-VII (POH)

(TO BE DONE AFTER 6000 HOURS OF ENGINE RUNNING)

- (i) Overhaul or replace the engine.
- (ii) Overhaul the radiator fan drive assembly.
- (iii) Replace the engine mounting pads.
- (iv) Check the engine damper for dynamic balance.
- (v) Replace the water separator and air oiler.
- (vi) Replace the air unloader.
- (vii) Check and clean the cooling coil.
- (viii) Test the air tank for rated air pressure

IMPORTANT

- (i) Premixed CAC will be used for topping up the radiator.
- (ii) API CF-4 15W40 lube oil to be used in engine.
- (iii) Engine oil pressure should be minimum 1.5 kg/sq.cm at idle & 2.5 kg/sq.cm on load at rated RPM after two hours working.
- (iv) RPM of engine radiator fan should not be less than 1600 for proper cooling.
- (v) Radiator may be replaced if it is blocked more than 20% during service or badly leaking and not economical to repair.
- (vi) Tension of V-belt will be checked at center of belt and it should not be more than 15mm.

MAINTENANCE SCHEDULES OF DEUTZ ENGINE MODEL BF 12 L 513 C AS PER BCM RM-80 OF R.D.S.O

Schedule – I (To be done daily)

1. Check level of the lube oil and top up, if required.
2. Check fuel level and top up if required.
3. Check for any oil leakage from the fuel pump, injectors, fuel supply, and return pipes.
4. Check engine oil pressure after warming up-
 - (a) at idle speed (min. 1.5 kg/sq.cm)
 - (b) on rated speed (min. 2.5 kg/sq.cm).
5. Check & correct the tension of alternator V-belt.
6. Check the contamination indicators (pilot lamps) for dry type air filter.
7. Record the maximum engine temperature of the day.
8. Clean engines and their premises.
9. Check the functioning of engine clutch.

Schedule II (To be done after 50 engine hours)

1. Clean air cleaner element (outer) with 1.5 bar pressure of dry air.
2. Change oil in the wet type air filter.
3. Clean the fins of engines and air charge cooler.
4. Clean batteries plug connections and apply petroleum jelly.
5. Check electrolyte level in batteries and specific gravity
 - i. [Minimum specific gravity = 1.24].

Schedule III (To be done after 100 engine hours)

1. Clean fuel pre-filter (wire mesh).
2. Change the twin stage fuel filter element.

Schedule IV (To be done after 200 engine hours)

1. Change engine oil.
2. Change lube oil filters.
3. Check tappet clearances and adjust if required.
4. Check engine hoses for leakage and condition and do needful.
5. Grease clutch drive shaft bearings.
6. Check clutch fluid level in container.

Schedule V (To be done after 1000, 3000, 5000 engine hours)

1. Lubricate the accelerating mechanism with oil.
2. Check high pressure fuel pipes clamps.
3. Clean the diesel tanks.
4. Decarbonise cooling coil and check the fittings.
5. Replace the crank case breather element.
6. Change dry type air filter element.
7. Test engine temperature indicator.
8. Change batteries, if required.

Schedule VI (To be done after 2000, 4000 engine hours)

1. Check engine timing and do needful.
2. Check and clean air reservoir.
3. Check the air compressor. Overhaul if necessary.
4. Replace V-belts on condition basis.
5. Overhaul the alternator and starter.
6. Clean turbocharger and do needful.
7. Check anti vibration mountings of the engine and change, if required.
8. Calibrate the fuel injection pump.
9. Calibrate the fuel injectors.

Schedule VII (To be done after 6000 engine hours)

1. De-carbonise the engine heads.
2. Check crank shaft and cam shaft end play.
3. Overhaul the air compressor.
4. Change air inlet hoses.
5. Overhaul blower assembly.
6. Change all the high pressure fuel pipes, pipe clamp, flexible fuel hoses and rubber hoses.
7. Overhaul turbo charger.
8. Change shaft seals and bearings of the clutch drive shaft assembly.
9. Check the exhaust manifold for any defect and clean the same.
10. Change shut down valve on condition basis.
11. Replace twin filter body.
12. Replace cooling coil.
13. Change anti-vibration mountings of the engine.
14. Renew the engine wiring with temperature proof wires.
15. Change engine safety system, if required.

Lesson- IX: Maintenance Steps. Session-17: Adjustment of Valve (Tappet) clearance.

Valve Clearance:

The intentional gap in between the Rocker arm & valve stem (or cross head in case of Cummins Engines) is known as valve clearance.

Position for valve Clearance adjustment

When both the valves are fully closed then there will be maximum gap in between the valve stem & Rocker Arm, at that time valve clearance is to be adjusted.

When the piston of any cylinder is at TDC or near TDC in compression stroke, at that time valve clearance should be adjusted because at that time there will be maximum gap in between valve stem & Rocker Arm.

We can identify the correct position of piston by the following method:

i) In case of engine fitted with Mico Bosch Fuel supply system.

(a) Remove Injector of cylinder no. (1) & insert a rod which will rest on the piston. Now rotate the fly wheel in the direction of rotation. With the movement of fly wheel & the piston, rod will also lift. There will be a point up to which the rod will lift & then it goes in down ward direction. The point, at which it happens, is TDC. Now check whether it is TDC of compression stroke or exhaust stroke. If it is at TDC of compression stroke then the rocker arm of inlet & exhaust valve will not press the valve stem & both the rocker arm will be loose. If it is TDC of exhaust stroke then both the rocker arm will be in contact with valve stems.

If piston is at TDC of exhaust stroke then rotate the fly wheel by one complete revolution. Now it will reach at TDC of compression stroke.

(b) There is another method to identify the correct position of piston. Loosen the delivery pipe of cylinder no. (1) from the fuel injection pumps and rotate the fly wheel in the direction of rotation. When the piston of that cylinder is about to reach at TDC in compression stroke, the fuel starts coming out from the delivery pipe. This is the correct position to adjust the valve clearance because at that time both the valves are fully closed.

(ii) In case of engines fitted with Cummins P.T. fuel supply system such as NT-743 C, NTA-855-L and KTA 1150-L engines, there are 3 push rods & 3 rocker arms for each cylinder, one for inlet valves, one for exhaust valves & middle one for the operation of injectors. Just before completing the compression stroke when cylinder is ready to receive the fuel, first of all the middle rocker arm, which is provided for injector, starts lifting & then it comes down words. During the movement of this rocker arm, both the valve will be fully closed & there will be maximum gap in between the rocker arm & cross head (valve clearance is the gap between the rocker arm & cross head). At that time we can adjust the valve clearance.

In few engines there are marking on the fly wheel or drive pulley, according to which we can adjust the valve clearance.

To adjust the valve clearances, after bringing the piston at correct position loosen the lock nut of adjusting screw which is provided on the push rod.

Place filler gauge of sufficient thickness in the gap & adjust the adjusting screw by screw driver. Now tighten the lock nut.

Having adjusted the valve clearance of cylinder no.(1), rotate fly wheel in the direction of rotation by $720^\circ/n$ (n = No. of cylinders). If it is 6 cylinder engine then rotate by $720^\circ/6 = 120^\circ$ in the direction of rotation i.e. $1/3$ rev. of crank shaft & get next cylinder, according to firing order, ready to adjust the valve clearance.

just valve clearance one by one of all cylinder according to firing order by rotating the fly wheel by 1/3rd revolution.

Valve Clearance:

	Inlet Valve	Exhaust Valve
Cummins engines	0.014"	0.027"
MWM Engine	0.2 mm	0.2 mm
Deutz Engine	0.2 mm	0.3 mm
Kirloskar Engine	0.15 mm	0.15 mm

ADJUSTMENT OF VALVE TAPPET CLEARANCE IN MWM 232 & 234 V-12 ENGINES:

Firing Order of MWM TBD-232 & 234, V-12 Engines:

A1,	B2,	A5,	B4,	A3,	B1
A6,	B5,	A2,	B3,	A4,	B6

Procedure – As per Operation & Maintenance Manual:

1. Remove rocker covers of all 'A' bank cylinders.
2. Check the condition of the rocker Lever adjusting screw threads and locknut threads. If the threads are damaged, replace respective adjusting screw or locknut.
3. Rotate the crankshaft in direction of rotation i.e., anti-clockwise viewed from flywheel side until intake valve of A1 cylinder is just closed. Mark the position and then rotate the crankshaft further by 180 degrees which signifies No. A1 piston is approximately at Top Dead Centre in compression stroke.
4. Set intake and exhaust valve clearance to 0.2mm (0.008"). Install rocker cover of A1 to indicate the completion of tappet setting.

NOTE:

- a) While adjusting the valve clearance the right hand rocker lever is exhaust and left side is intake.
- b) Rocker lever or valve which aligns with exhaust manifold exit is exhaust rocker lever or exhaust valve and the remaining is intake valve.

Continue to rotate the crankshaft in D. O. R. i.e. anti-clockwise until intake valve of A2 cylinder is just closed. Further rotate the crankshaft by ½ turn (180°) and set valve clearance to 0.2mm (0.008")

Follow the same procedure:

For A3, A4, A5 & A6.

After the completion of 'A' bank tappet adjustment, move to 'B' bank and commence with B1 cylinder and follow the same procedure as followed in 'A' bank.

Lesson- IX: Maintenance Steps. Session-18: Adjustment of Injection timing and testing of Nozzles.

ADJUSTMENT OF INJECTION TIMING:-

- (1) Place the pump on the foundation and tighten its foundation bolt by hand.
- (2) Loose the bolts of pump coupling.
- (3) Rotate the engine and bring the piston of one no. cylinder at T.D.C of compression stroke. Generally one no. cylinder is nearest to radiator. At this time, check the T.D.C mark on flywheel by inspection hole of flywheel housing.
- (4) Rotate the engine a little in reverse direction and bring the 'INJ' mark on Flywheel in coincidence with the pointer of inspection hole, so that the injection will start before the T.D.C of piston.
- (5) Open the inspection plate of fuel pump and rotate the pump in its direction of rotation till the one no. plunger starts lifting.
- (6) In this position tight the engine coupling with pump coupling.

Now rough timing has been set and for fine adjustment, do the following works:-

- (7) Remove delivery valve holder, delivery valve, spring peg seat and joint washer.
- (8) Fit spill cut-off at the place of holder.
- (9) Connect fuel inlet line with pump.
- (10) Do hand priming and fill the fuel gallery of pump.
- (11) When gallery becomes full, remove the air through vent screw till the clear diesel starts coming.
- (12) Bring the control lever or control rack in full position.
- (13) Loose the fine adjustment bolt on pump coupling.
- (14) Rotate the coupling by hand as much as its movement for fine adjustment. Stop rotating when diesel stops coming out through spill pipe. Remember that plunger should be in lifting position, not in down going position.
- (15) Tight the fine adjustment bolt at this time.
- (16) Unscrew the spill cut-off pipe and fit the delivery valve and its parts after cleaning in diesel.
- (17) Fit all injection pipes after cleaning.
- (18) Tight the pump foundation completely and check the coupling bolt and adjusting bolt.
- (19) Fit the inspection cover of pump.
- (20) Fill lubricating oil in injection pump and governor as per manufacturer; oil is filled in mechanical governor, not in pneumatic governor.
- (21) Keep injector pipe loose at injectors and rotate the engine by self starter. When the diesel starts coming through the pipes, then tight the pipes at injectors.
- (22) Self start the engine and after warming up adjust idle speed by stop screw.
- (23) Diesel should not leak through pipes, filters or bleeding screw.

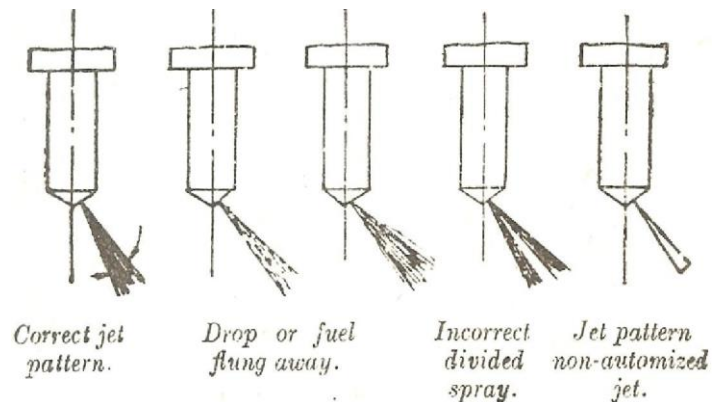
TESTS OF INJECTORS

These tests are done on injector testing machine to test an injector:

1. Pressure test.
2. Leak-off test.
3. Spray test.

1. **Pressure test:** - Clamp the injector on the tester and operate the tester pump. Note the reading of the dial indicator at which the injector nozzle starts spraying. It gives pressure reading. It should be the same as recommended by the company. If it is less, then tighten the adjusting screw of the injector. If it is more, then loosen the adjusting screw. Repeat the process until the correct pressure reading is obtained. Finally, tighten the lock nut.

2. **Leak off test:** - Clamp the injector on the tester and built up the pressure about 150Kg/cm^2 by operating the tester pump. Keep this pressure for about 10 seconds. If the pressure drops, it shows that there is leakage in the injector. Check the nozzle seat and nozzle valve needle and nozzle body. Correct the seat and needle by grinding and lapping, and after that again do the leak off test.



3. **Spray test:** - Spray test is also done on the same injector testing machine. While operating the tester pump, see carefully the spray. It should not like a current of oil or with drops splitting away, but it should be fully atomized.

TROUBLE SHOOTING OF CUMMINS ENGINE AS PER PLASSER MAKE WORISITE TAMPERS (08-32) OF RDSO

S. No.	Faults	Probable Causes	Remedial Actions
1.	Engine does not start	1. Emergency stop switch is pressed.	Emergency stop switch should be in release position.
		2. No fuel in the tank.	2. Fill fuel in the tank and bleed air from fuel system as given in following steps: i) Loosen the bleed plug on the fuel filter and operate the priming pump until the fuel emerges free of bubbles. Tighten the bleed plug. ii) Then loosen banjo plug on injection pump and operate the priming pump until fuel emerges free of bubbles. Tighten the banjo plug.
		3. Shut down mechanism is stuck	3. Check the electrical supply at coil. if it is ok, then lubricate the piston of shut down coil and mechanism with lube oil and operate it manually. If still not working, then coil may be defective. Replace it.
		4. Air in fuel system.	4. Bleed air from fuel system as explained in item no. 2 above.
		5. Governor is stuck.	5. Replace the complete fuel injection pump.
		6. Misconnection of starting switch.	6. Check starting switch and if any misconnection is noticed, rectify it.
		7. Valve clearance is not proper.	7. Adjust the valve clearance as given in engine manual.
		8. Weak batteries.	8. Check electrolyte level in the batteries. Terminals should be clean and the charging system should be working. Over-aged batteries should be replaced.
		9. Injectors not properly functioning.	9. Remove defective injectors and get them overhauled/calibrated or replace them with new one.
		10. Valves not seating properly.	10. i) Check the valves spring and replace the broken spring if any. ii) Lap the valves. iii) Lap the valve seat, if required.
2.	Engine running too hot.	1. Coolant level too low.	1. Check coolant level and top up to the mark in the filler neck.
		2. Defective thermostat	2. Check thermostat as given in the following steps: i) Drain cooling water and catch it for reuse.

			ii) Loosen hose clamps, pull back hoses and then remove thermostat. iii) Heat the water in container to approx. 85° C and place thermostat in it. Maintain temperature of water by agitating
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2.	Engine running too hot.	2. Defective thermostat	iv) By short-circuiting and radiator opening, check whether the thermostat opens fully. If not, then install new thermostat.
		3. Defective water pump.	3. Check/repair the water pump.
		4. V-belt for water pump needs adjustment.	4. Check the V-belt tension. To adjust, release the guide pulley and regulate tension in the belt. Then tighten the guide pulley. If required, replace the V-belt.
		5. Oil cooler not working properly.	5. Repair / replace the Oil Cooler.
		6. Valve clearance is not proper.	6. Adjust the valve clearance as explained in engine manual.
		7. Air filter is choked.	7. Clean the air filter.
		8. RPM of coolant fan is too low.	8. Adjust the RPM of the motor to 1600. Check hydraulic system and change pump and motor if necessary.
		9. Water radiator choked.	9. Get the radiator cleaned.
		10. Radiator cap missing or worn out	10. Fit new cap.
		11. Water hose too old.	11. Replace the water hose.
3.	Engine misfiring	1. Dirty fuel filter.	1. Check fuel filters and if necessary Change it filter.
		2. No / less fuel in tank.	2. Fill fuel in the tank and follow steps as given in s. no.1, item no.2.
		3. Air in fuel system.	3. Bleed air from the fuel system as explained in s. no.1, item no.2.
		4. Defective Injector.	4. Remove the defective injector and get them overhauled/calibrated/ replace with new one.
		5. Valve clearance is not proper.	5 Adjust valve clearances as given in engine manual
		6. Fuel injection timing not proper.	6. Adjust the timings.
4.	Excessive engine smoking.	1. Engine oil level too high.	1. Check oil level. For this, draw dipstick and clean with lint-free cloth. Return dipstick, wait a little until the oil has wetted the dipstick. Then remove the dipstick again and check oil level.
		2. Defective injector	2. Follow the s.no.1, item no.9.
		3. Valve clearance is not proper.	3. Follow the s. no.1, item no.7.
		4. Air in fuel system.	4. Follow the s.no.1, item no.2.
		5. Clogged air cleaner.	5. Clean the element or change if required.
		6. Excessive carbon on	6. De-carbonise the engine.

		Cylinder head and piston.	
		7. Engine overloaded.	7. Check and reduce the load.
5.	Engine stops	1. No fuel.	1. Fill fuel in the tank and follow the steps as given in s. no. 1, item no.2.
		2. Air in the fuel system.	2. Bleed air from fuel system as explained in s.no.1, item no.2.
		3. Valve clearances are not proper.	3. Adjust the valve clearances as explained in s.no.1, item no.7 above.
		4. Governor is stuck.	4. Replace complete fuel injection pump.
		5. Overheating of engine	5. Take remedial action as given in s.no.5 below.
		6. Shut down circuit fails.	6. Check the electrical circuit and repair as required.
6.	Engine knocking	1. Incorrect Injector setting.	1. Remove the faulty injector and get it reset or replace it with new one.
		2. Mechanical damage to piston/cylinder.	2. Get the engine top overhauled.
		3. Valve clearance is not proper.	3. Adjust the valve clearance as given in engine manual.
		4. Fuel injection timing is not proper.	4. Correct the timings.
7.	Output of the engine too low	1. Dirty fuel filters and fuel line.	1. Check the fuel filters and if necessary change it.
		2. Air in fuel system.	2. Bleed the air from system as explained in s. no.1, item no.2.
		3. Defective Injectors.	3. Remove the defective injectors and get them overhauled or replace with new one.
		4. Valve clearances are not proper.	4. Adjust the valve clearances as given in engine manual.
		5. Air filter choked.	5. Clean the air filter element or replace if required.
		6. Improper compression	6. Engine needs to be top overhauled.
		7. Governor is stuck.	7. Replace the complete fuel injection pump.
8.	Oil pressure low.	1. Dirty lube oil filter.	1. Replace the lube oil filter.
		2. Oil control valve not working.	2. Repair the control valve or replace it.
		3. Dirty oil cooler	3. Clean the oil cooler.
9.	Oil film present in crank case ventilation	1. Incorrect compression.	1. Engine needs to be top overhauled
		2. Lube oil brands.	2. Use lube oil of proper brand and grade as recommended by the OEM.
10.	Engine speed is irregular.	1. Air in fuel system	1. Bleed air from the system as explained in s. no.1, item no.2.
		2. Governor is stuck.	2. Replace complete fuel injection pump.
11.	Fuel consumption too high.	1. Use of incorrect lube oil brand.	1. Use proper grade and quality lube oil.
		2. Incorrect setting of Injector.	2. Overhaul/ Replace the defective injectors.
		3. Incorrect engine timing.	3. Get the engine timing reset.
		4. Clogged air filter.	4. Clean the air filter.

12	Lube oil consumption too high.	Poor compression	5. Engine needs to be top overhauled.
		1. Incorrect lube oil brand.	1. Use proper grade and quality lube oil as recommended by OEM.
		2. Poor compression	2. Engine needs to be top overhauled.
		3. Oil filter dirty.	3. Replace the filter.

Sub-discipline:- INTERNAL COMBUSTION ENGINE (Lessons: IX Sessions: 22)

Lesson- IX: Maintenance Steps. Session-20, 21 & 22: 1 day visit to TM Workshop, PD/MGS.

(A) To see & note down the various components of a dismantled I. C. Engine available at TM Workshop, PD/ MGS; such as

1. Deutz Engine
2. MWM Engine
3. Cummins Engine
4. Kirloskar Engine etc.

(B) To see & note down the various components of Workshop Machines available at TM Workshop, PD/ MGS; Such as

1. Lathe Machines
2. Radial drill Machine
3. Shaper
4. Planner etc.

(C) To see & note down the various components of Track Maintenance Machines available at TM Workshop, PD/ MGS; Such as

1. SBCM
2. BCM
3. BRM
4. Plain Track Tampers
5. Points & Crossing Tampers
6. Track Laying Machines etc.