PROMOTIONAL COURSE – PROMOTIONAL JE - Course no: CE 27
SUB: I.C. ENGINE & WORKSHOP TECHNOLOGY

Sub-discipline	Lesson	Contents	Period	Total Period
I.C. Engine	**General**	I.C. and E.C. Engine, Advantages and disadvantages,.	**1**	**2**
		Classification of I.C. Engine and Main Systems of I.C. Engine	1	
	Working Principle of I.C. Engine	T.D.C., BDC, Swept volume	1	**10**
		Clearance volume, Compression ratio	1	
		Stroke length, Cylinder bore	1	
		Working Principle of 4 Stroke Diesel Engine (Diesel cycle).	1	
		Working Principle of 2 Stroke Diesel Engine and 2 & 4 Stroke Petrol Engine (Otto cycle).	1	
		Demonstration in I.C. Engine Model Room	1	
		Combustion of fuel, Actual Working cycle of 4 Stroke Diesel Engine	1	
		Deviations between Actual Working cycle and theoretical cycle,	1	
		Firing orders and VT diagram	1	
		Power flow in Multi cylinder engine	1	
	Air Supply system of Diesel Engine	Requirement of Air, Types of Air cleaner, Cleaning and checking of Dry type Air cleaner. Draw backs of choking of Air Cleaner.	1	**2**
		Supercharging, Turbocharger and After cooler, Importance of After cooling	1	
	Fuel Supply system of Diesel Engine	Functions and classification of Fuel supply system	1	**6**
		Block diagram Fuel Injection Pumps Injectors and Filters	1	
		Mico Bosch and Cummins PT Fuel supply system and Difference between them	1	
		Cetaine Number, Octane Number, Delay Period and Knocking of fuel	1	
		Drawbacks of keeping low HSD Oil level in tank	1	
		Removing of Air Lock	1	
	Lubricating System of Diesel Engine.	Different type of Lubricating system, Blow bye, Crank case ventilation	1	**2**
		Reasons of Low lubricating oil pressure and high Oil consumption, Lubricating Circuit	1	
	Cooling system of Diesel Engine	Air Cooling system, Water Cooling system Drawbacks of over cooling	1	**2**
		Reasons for overheating, Demonstration in I.C. Engine Model Room	1	
	Maintenance Steps and Maintenance schedule	Maintenance step, Maintenance schedule	2	**8**
		Precautions in providing Piston ring on Piston	1	
		assembling in Cylinder liner	1	
		Adjustment of Valve (Tappet) clearance	1	
		Adjustment of Injection timing , Inspection of Crankshaft	1	
		Troubleshooting	1	
		Demonstration in Model Room	1	

SUB: INTERNAL COMBUSTION ENGINE & WORKSHOP TECHNOLOGY

I.C. and E.C. Engine, Advantages and disadvantages

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.

ADVANTAGES OF I.C. ENGINE:

1. Compact.
2. Easy Starting
3. Less Maintenance Cost.
4. Very high thermal efficiency.
5. Weight-power ratio is very less.
6. Can generate much more r.p.m. then E.C. Engine.
7. Suitable for motive power due to their light weight.

DISADVANTAGES OF I.C. ENGINE:

1. I.C Engine creates more pollution as compared to E.C. Engine.
2. E.C. Engines are double acting engines while I. C. engines are single acting engines.
3. I.C. Engines can not develop as much power as compared to steam engines (E.C. Engines)

SUB: INTERNAL COMBUSTION ENGINE

Classification of I.C. Engine and Main systems of I.C. Engine

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.

Almost all Engines used on Track Maintenance Machines are Diesel Engines.

2. On the basis of no. of strokes Per working cycle:-
   (i) 2- Stroke Engines
   (ii) 4- Stroke Engines

All Engines used on Track Maintenance Machines are 4-Stroke Engines.

3. On the basis of working Cycle:-
   (i) OTTO- Cycle Engines.
   (ii) Diesel cycle Engines
   (iii) Dual cycle Engine.

All Diesel Engines Work on Diesel cycle.

4. On the basis of Method of ignition of fuel:
   (i) Spark ignition engine
   (ii) Compression ignition engines.

All Engines used on Track Maintenance Machines are Compression ignition Engines.

5. On the basis of method of cooling:
   (i) Air Cooled engine

Ex.: Deutz BF 12L 513C, HA 694, HA 394, VM SUN 6105 I

(ii) Water cooled engine.

Ex.: All Cummins and MWM (Greaves) Engines used on Track Maintenance Machines.

6. On the basis of no. of cylinders:-
   (i) Single cylinder engine
   (ii) Multi-cylinder engine.

12 cylinder Engines: Deutz BF 12L 513C, MWM TBD 232 or 234 V 12, Cummins VTA 1710 L.

3 cylinder Engines: HA 394

6 cylinder Engines: Remaining all Engines of Track Maintenance Machines

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.
5. Electrical System

1. Air Supply System:- 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 bye, 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.

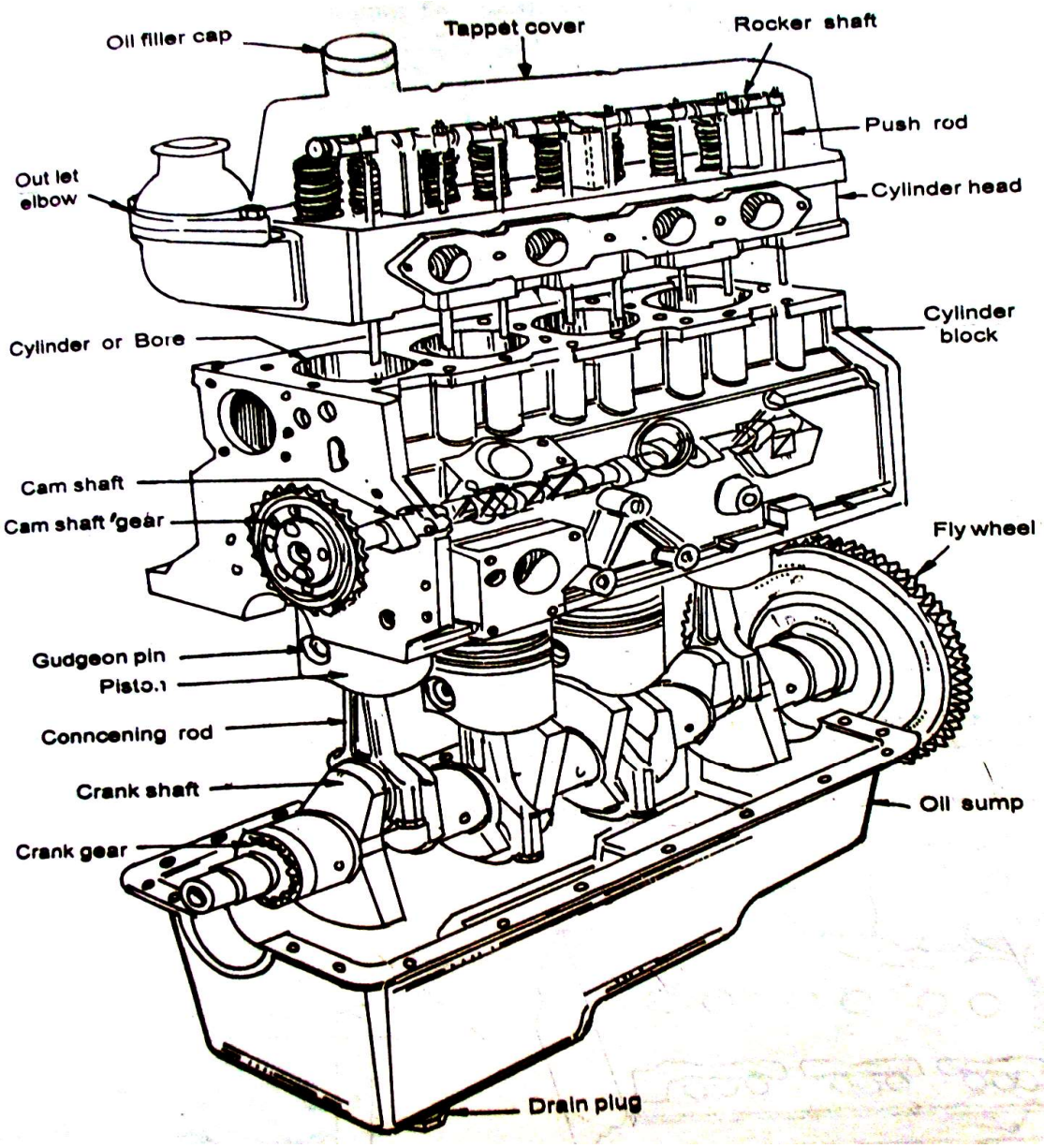
5. Electrical System: - Self starting System, Fuel Control and Safety Systems are covered under Electrical System. These will be studied under the Subject Electrical and Electronics.

Before studying these systems we have to study **Constructional Details of Engine**

SUB:- INTERNAL COMBUSTION ENGINE

Cylinder, Cylinder head, Piston and Piston Rings

ENGINE CONSTRUCTION



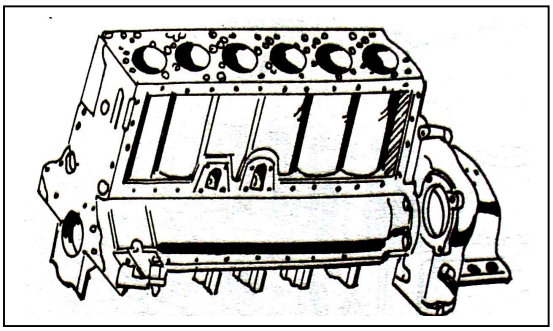
The main parts of the engine are as follows: -

1. Cylinder block and crankcase
2. Cylinder head
3. Oil sump
4. Piston
5. Piston Rings
6. Piston Pin or Gudgeon Pin
7. Connecting Rod
8. Crankshaft
9. Flywheel
10. Camshaft
11. Valve and valve mechanism
12. Accessories: - Air cleaner, Oil filter, Fuel filter, Oil pump.
13. Other parts: - Fuel pump, injector, and vibration damper.

Now we shall study these parts one by one in detail.

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. In Track Machines the Engine Deutz BF 12L 513C has only Crankcase (called Block) and cylinders are assembled individually. Remaining has cylinder Block and crank case as an integral casting.



- 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**

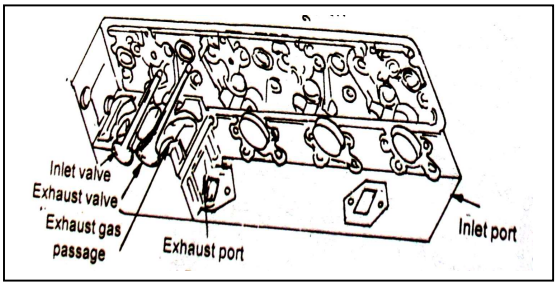
Liner is a thin wall cylinder inserted in the (a) main cylinder of big Engines to prevent the wear of main cylinder or (b) cylinder of water cooled engines to facilitate circulation of cooling water around it.

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. Inlet manifold and Exhaust manifold is fitted to the Cylinder head externally. There are inbuilt passages for flow of lubricating oil. In water-cooled engines, there are also passages for flow of water. Bottom holes of cylinder head for lubricating oil and water, matches with the top holes of cylinder block for the same.

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. Some Engines (Cummins) have two heads caste integrally.

Material: Cast Iron.



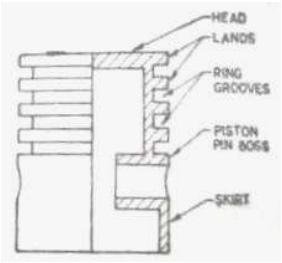
3. Oil Sump

It is the lowest part of the engine. It is attached to the crankcase through setscrews with a gasket in between them. It stores oil for engine lubrication system. There is a drain plug at the bottom of the oil sump. **Material: - Steel sheet or Aluminum.** Although it is the bottom most part susceptible of being loaded during mounting and demounting of the engine so it should be strong enough, but it is made of Steel sheet or Aluminum to facilitate cooling of lube oil and is protected from being loaded by supporting suitably on wooden blocks.

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

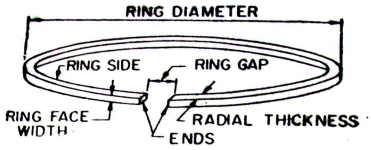


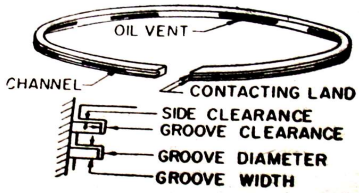
5. Piston Rings

Piston rings are fitted into the grooves of the piston.

There are two types of piston rings-

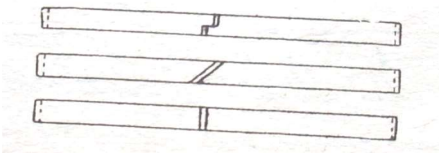
a. Compression ring
b. Oil Control rings





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.

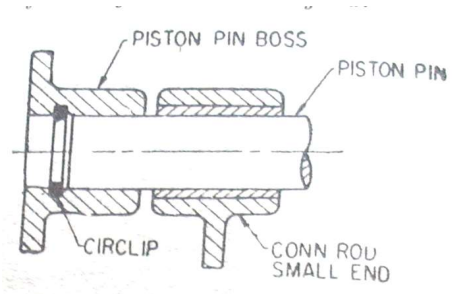
Minimum two compression rings are used in engines. Minimum one oil control ring is used in 4-stroke engines, but no oil control ring in 2-stroke engines. An oil control ring is fitted into the lower groove of the piston. Piston rings are split having lapped, angled or butt joints.

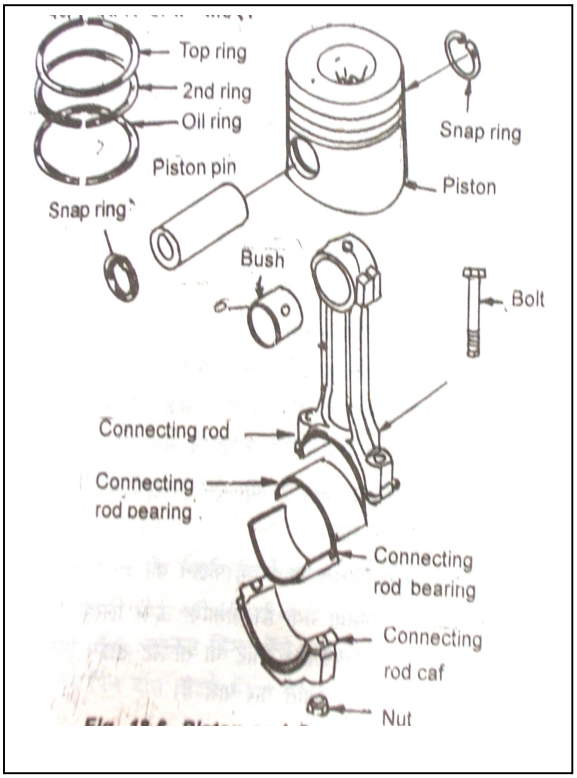


6. Piston Pin or Gudgeon Pin

It connects the piston and the small end of the connecting rod. Piston pin is generally hollow. In most of the engines, piston pin floats in both the piston bosses and small end of the connecting rod. Piston pin axial movement is prevented by fitting circlips in grooves at the outer end of piston bosses.

Material: Steel Alloy (Case hardened)

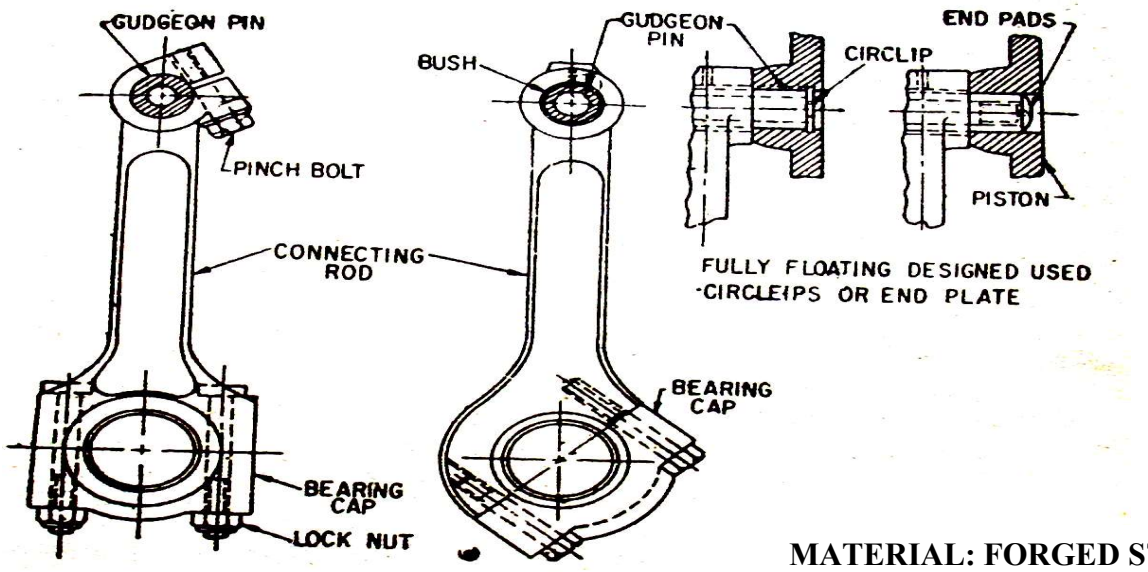




7. Connecting Rod

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.

Connecting rod usually has I- beam cross-section. There is a drill passage from small end to the big end for flow of lubricating oil. The big end may be split at right angle to its length or at another angle. The small end is usually a solid eye fitted with a phosphor bronze bush, or a split eye and a pinching screw to close the eye round the pin. Plain bearing in two parts of white metal is fitted in big end.



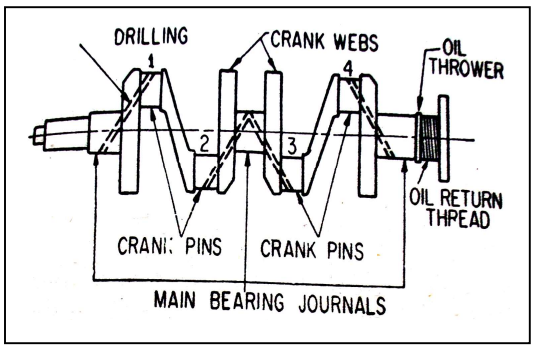
MATERIAL: FORGED STEEL.

All the connecting rods in an engine must be of equal weight. In original assembly, the connecting rods and caps are individually matched to each other and numbered to avoid interchange.

8. Crankshaft

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

a) Crank Pins
b) Webs
c) Balancing Weight and
d) Main Journal



Crankshaft has drilled oil passages though 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. Diesel Engine crankshaft has main journal on either side of each crankpin but a petrol Engine crankshaft has main journal on either side of two crankpins.

Center to center distance between the crank pin and main journal (called Throw) is half of the piston stroke. Thus, one complete revolution of the crankshaft makes two strokes of the piston.

Material: - Steel Alloy

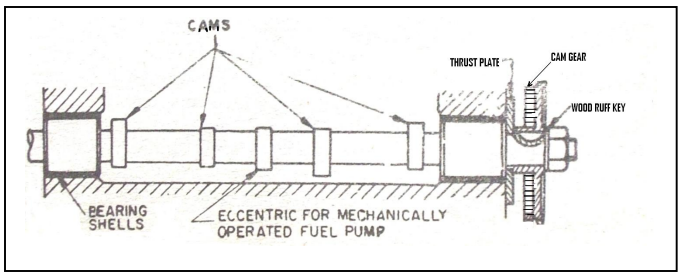
9. Flywheel

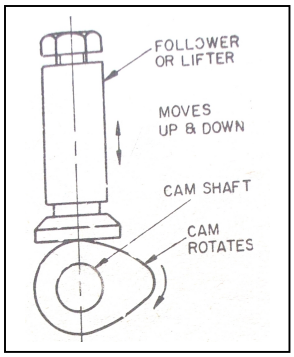
Flywheel is a heavy steel wheel attached to the rear end of crankshaft. During power stroke the engine tends to speed up and during other three strokes it tends to slow down. (a) The Flywheel stores power during power stroke and releases during other three strokes to keep the engine running at the constant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

Flywheel is also used as a part of clutch mechanism (BCM Deutz engine and old Duomatic Cummins engine). Flywheel also has teeth to mesh with self-starter pinion 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.





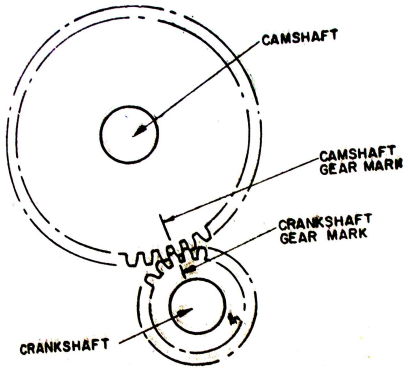
In addition, the camshaft has an eccentric to operate the fuel feed pump and a gear to drive the oil pump.

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

$$\text{Gear ratio} = \frac{\text{No. of teeth on crankshaft gear.}}{\text{No. of teeth on camshaft gear}} = \mathbf{1:2}$$

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.

SUB:- INTERNAL COMBUSTION ENGINE

Inlet and Exhaust valve, Push rod, Rocker arm, Valve clearance, Valve operating mechanism

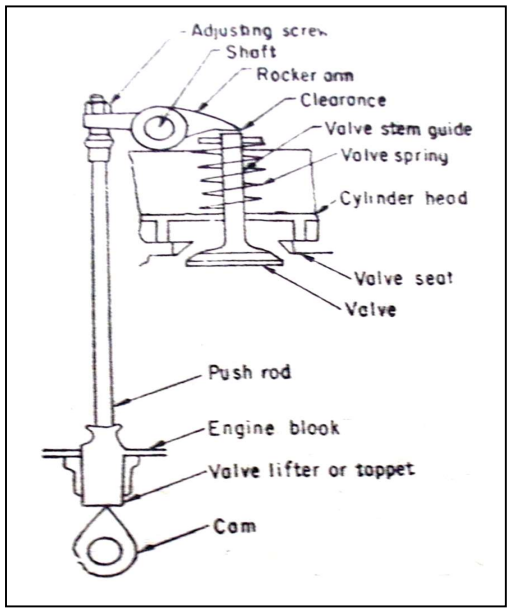
11. Valve and Valve Operating Mechanism

Valve: - Valve is a device to open and close a passage. There are two valves for each cylinder – an inlet valve



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 then 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.

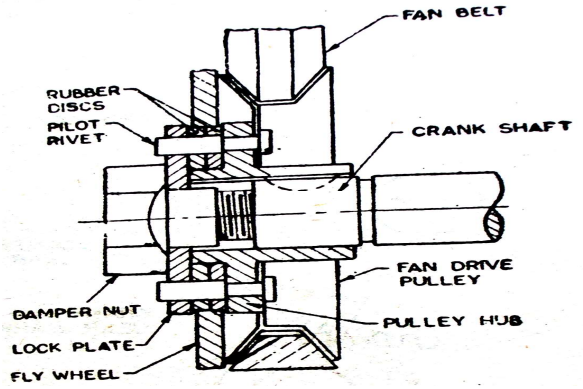
Fuel filter: It screens impurities from fuel *i.e.* HSD so that clean fuel will flow through fuel pump and will go for combustion inside the cylinder.
Oil pump: It is used to supply pressurized oil into the lubricating circuit for engine lubrication.

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:- INTERNAL COMBUSTION ENGINE

T.D.C., B.D.C., Swept volume, Clearance volume, Compression ratio, Stroke length, Cylinder bore.

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 can not go in down word 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 (Vc): The volume of cylinder above TDC.

Swept Volume (Vs): The volume of cylinder between TDC and BDC is called swept volume.

Compression Ratio: It is the ratio between the volume when piston is at BDC (Vs + Vc) and volume when piston is at TDC (Vc)

$$\text{Or,} \qquad \text{C.R (r)} = \frac{Vc + Vs}{Vc}$$

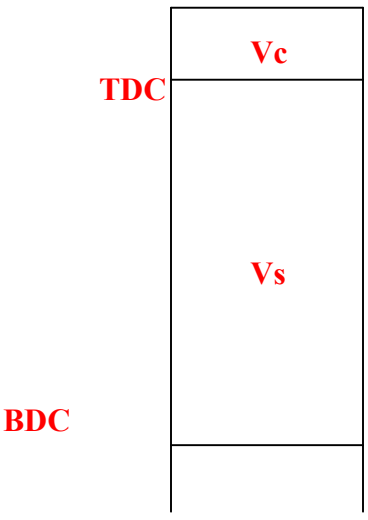
$$Vs = \text{Swept volume} = \frac{\pi}{4} d^2 L \qquad \text{(Volume between TDC \& BDC)}$$

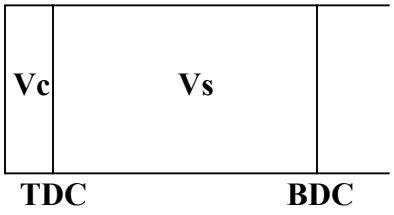
Vc = Clearance volume. (Volume inside the cylinder when piston is at TDC)

d = Bore

L = Stroke Length

C.R for Diesel Engine is in the range of 16:1 to 22:1 and that for Petrol Engine is in the range of 6:1 to 10:1.





SUB: INTERNAL COMBUSTION ENGINE

Working Principle of 4-stroke Diesel Engine (Diesel cycle).

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:-

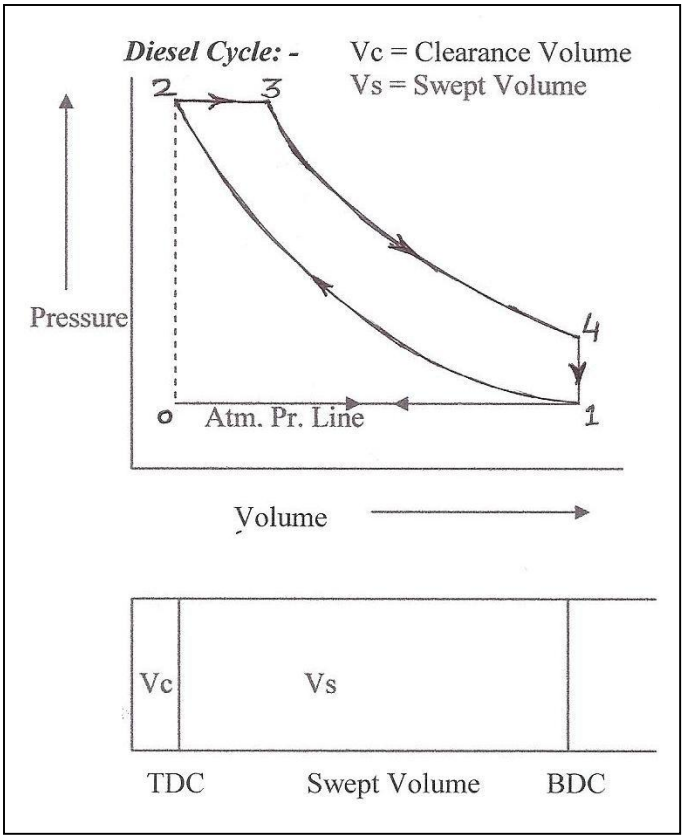
Suction Stroke: - In suction stroke, suction or inlet valve opens. Piston moves from TDC to BDC and vacuum is created inside the engine cylinder. In this process, fresh air will enter inside the engine cylinder at atmospheric pressure. At the end of suction stroke inlet valve is closed.

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^{γ} = constant. In this process pressure and temperature will increase gradually up to 28 bars and 550^0C 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 440^0C. 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.

At Point 2 → Pressure will increase up to 28 bar and temperature up to 550°c.

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.
Point 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.

WORKING PRINCIPLE OF 4- STROKE PETROL ENGINE (OTTO CYCLE)

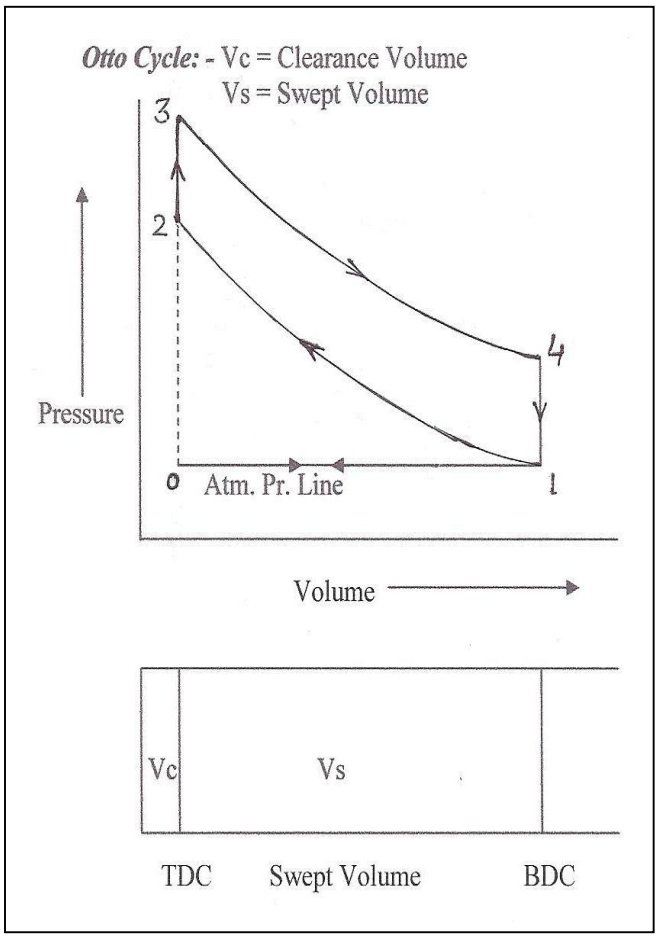
Suction Stroke: In suction stroke, suction or inlet valve opens. Piston moves from TDC to BDC and vacuum is created inside the engine cylinder. In this, Air and petrol mixture from carburetor enters inside the engine cylinder at atmospheric pressure. At the end of suction stroke inlet valve is closed.

Compression Stroke:- In this stroke both valves remain closed. Piston moves from BDC to TDC compressing the air-petrol mixture (charge). Compression of the air-petrol mixture (charge) takes place according to adiabatic process, PV^{γ} = constant. In this process, pressure will increase gradually up to 8 to 13 bars. At the end of compression stroke, an electric spark is given to the compressed charge in the combustion chamber. The charge starts burning.

Power Stroke: - The burning gases expand and 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 and petrol mixture (charge) 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 charge, according to law, $PV^{\gamma} = C$, takes place.

At Point 2 → Pressure will increase up to 8-13 bar.

Power Stroke:

At Point 2 → Spark is given through spark plug.

Point 2-3 → It is known as "Heat addition process at constant volume". Burning of charge takes place at constant volume.

At Point 3 → Burning completes.

Process 3-4 → Adiabatic expansion of flue gases takes place. Piston moves from TDC 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.

WORKING PRINCIPLE OF 2 – STROKE PETROL ENGINE:

In 2-stroke petrol engine one working cycle gets completed in 2-strokes of piston.

Upward Stroke: - As piston moves from BDC to TDC vacuum is created in the crank case chamber. Due to this vacuum air-petrol mixture will enter in the crankcase chamber through inlet port.

Up ward moving piston first covers transfer port and then covers outlet port. After that, air-petrol mixture entrapped in the combustion chamber will be compressed. At the end of upward stroke piston will be at TDC. At this point, sparking takes place. Petrol burns and burning gases expand applying thrust on the piston.

Downward Stroke: - Due to thrust of expanding gases piston moves from TDC to BDC. During this stroke the inlet port is covered by the piston and new charge is compressed in the crankcase. Further downward movement of the piston opens outlet port first; and high pressure burnt gases go out. Then transfer port opens and air-petrol mixture being compressed in the crankcase chamber, starts entering through the transfer port. This air-petrol mixture entering through transfer port strikes with the deflector on piston and rises upward and pushes out the remaining burnt gases. The cylinder is completely filled with the fresh charge, although it is some what diluted with the exhaust gases. Piston reaches BDC and again starts upward stroke.

In this way one working cycle is completed in 2-strokes piston or one revolution of crankshaft.

Note: - 1. Lubrication of engine components is performed by mixing lube oil in the petrol.

2. Due to no oil in the sump, there is no requirement of oil control rings in two stroke petrol engine.

WORKING PRINCIPLE OF 2 - STROKE DIESEL ENGINE: In a 2- stroke diesel engine one working cycle gets completed in 2- stroke of piston.

Upward Stroke: - As piston moves from BDC to TDC vacuum is created in the crank case chamber. Due to this vacuum, fresh air will enter in the crankcase chamber through inlet port.

Upward moving piston first covers transfer port and then covers outlet port. After that, fresh air entrapped in the combustion chamber will be compressed. At the end of upward stroke piston will be at TDC. At this point, diesel is injected through injector in the combustion chamber. Diesel burns and burning gases expand applying thrust on the piston.

Down Ward Stroke: - Due to thrust of expanding gases piston moves from TDC to BDC. During this stroke the inlet port is covered by the piston and fresh air is compressed in the crankcase. Further downward movement of the piston opens outlet port first; and high pressure burnt gases go out. Then transfer port opens and fresh air being compressed in the crankcase chamber, starts entering through the transfer port. This air entering through transfer port strikes with the deflector on piston and rises upward and pushes out the remaining burnt gases. The cylinder is completely filled with the fresh air, although it is some what diluted with the exhaust gases. Piston reaches BDC and again starts upward stroke.

In this way one working cycle is completed in 2-strokes piston or one revolution of crankshaft.

SUB:- INTERNAL COMBUSTION ENGINE

Demonstration in I. C. engine model room.

---

1. Demonstration of following models to realize their working principle:

   (a) 4-stroke diesel engine model.

   (b) 4-stroke petrol engine model.

   (c) 2-stroke diesel engine model.

   (d) 2-stroke petrol engine model.

2. To Identify, realize and note down the components name of following models to bear a clear understanding of I. C. Engines:

   (a) 4-stroke diesel engine model.

   (b) 4-stroke petrol engine model.

   (c) 2-stroke diesel engine model.

   (d) 2-stroke petrol engine model.

(These models are available in I. C. Engine model room.)

SUB:- INTERNAL COMBUSTION ENGINE

Combustion of fuel

COMERICAL MOTOR FUEL: The following three grades of fuel are available in the market for automotive uses:-

1. Super premium grade fuel
2. Premium grade fuel
3. Regular grade fuel

The main constituents of hydro – carbons are hydrogen and oxygen. In our track machine mostly we have diesel engine in which diesel fuel is used.

Properties of high speed diesel:-

Boiling range: 180°c to 300°c
Specific gravity: 0.82 to 0.92
Calorific value: 50 MJ/ kg
Minimum cetane no.: 45

As an impurity in high speed diesel, approximately 1% sulphur is available. This is considered high as per international standard.

LPG: There are two types of LPG- 1. Propane and 2. Butane

A mixture of propane & butane is also used. Its heat energy is less (about 80%) than gasoline, but its high octane value compensates the thermal efficiency of the engine.

CNG: Its main constituents are methane (90 to 95%). A marginal quantity of propane, iso-butane and butane is found. It is stored in a cylinder at high pressure of about 200 bar. CNG is available in earths crust.

COMBUSTION: Combustion is a chemical action which produces heat and light. In an I.C. engine, chemical reaction takes place between fuel and air inside the cylinder. The fuel burns in the presence of air. Oxygen is essential for burning.

$H + O_2 \rightarrow H_2O$

$C + O_2 \rightarrow CO_2$ + Large amount of heat

For combustion of 1 liter of HSD 12,500 to 14,000 liter of fresh air at N.T.P. is required. If less air is available inside the engine cylinder, fuel will not burn completely and instead of carbon di- oxide carbon mono-oxide will be produced.

$C + O_2 \rightarrow 2CO$

Carbon mono-oxide is colorless, taste less and poisonous. It is to be noted that 15 parts of carbon mono-oxide in 10,000 parts of air is dangerous to breath. Higher CO concentration may cause quick paralysis and death. If sufficient air is not delivered to the cylinders the mixture becomes reach and unburnt hydrocarbon will come out with the exhaust gases. It also results in carbon deposits in the combustion chamber. Also engine will give black smoke and out put of engine will decrease. Dilution of lubricating oil will also take place. Wear and tear of engine also increases.

Combustion in C.I. engine may be divided into four stages:-

Stage 1: Ignition Delay: -

The time elapsed between the start of fuel injection and first appearance of flame is called ignition delay. It consists of physical delay (when the fuel atomized, vaporized, mixed with air and heated) and chemical delay (when the chemical reaction starts and accelerates so as to start a flame of measurable pressure rise).

Stage 2: Rapid and Un-Controlled Combustion:-

At the end of delay period high temperature of order of about 450°c to 550°c exists in the combustion chamber. Therefore once the combustion starts, it proceeds very fast due to presence of multiple ignition points. This stage starts at the ends of ignition delay and continues till the maximum pressure is reached.

Stage 3: Controlled Combustion:-

This is a stage of slow combustion and continues till the maximum temperature in the combustion chamber is reached. In this the rate of combustion depends primarily on the rate of mixing of fuel vapours with the air.

Stage 4: After Burning:-

This stage occurs during the expansion stroke. During this stage unused oxygen gradually decreases and mixture is diluted by the combustion products. This stage continues from the point of maximum cycle temperature to about 70° to 80° after TDC.

ACTUAL WORKING CYCLE OF 4-STROKE DIESEL ENGINE

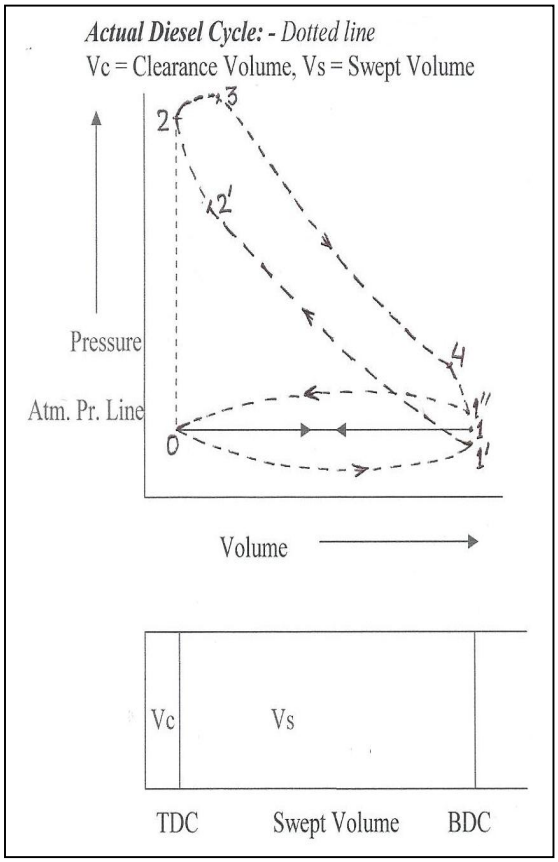
In a 4-stroke diesel engine, actual working cycle can be explained as given below:

Suction Stroke: Inlet valve opens five to ten degree of crank rotation before TDC in exhaust stroke and whenever piston moves from TDC to BDC, vacuum will be created inside the engine cylinder. Due to pressure difference, Fresh air will enter inside the engine cylinder at a pressure less than the atmospheric pressure. Inlet valve is closed 35^0 to 50^0 after BDC in compression stroke.

Compression Stroke: Whenever piston moves from BDC to TDC the air inside the engine cylinder gets compressed according to poly-tropic process. Pressure and temperature will increase and reaches above the burning point of fuel. Just before reaching the piston at TDC, diesel is injected by the injector inside the engine cylinder. Due to sufficient high temperature inside the engine cylinder the diesel catches fire and starts burning.

Power Stroke: Whenever fuel is injected inside the engine cylinder it burns due to high temperature and pressure of compressed air and converts into flue gases. These gases will expand inside the engine cylinder. This expansion of flue gases takes place according to poly-tropic process. Due to expansion of flue gases inside the engine cylinder, force is exerted on the piston and in this way power is generated. Piston moves from TDC to BDC.

Exhaust Stroke: In this stroke piston moves from BDC to TDC. Exhaust valve opens 35^0 to 50^0 before BDC in power stroke and pressure drops to about atmospheric pressure. A little force is exerted on the flue gases by the piston which further increases the pressure above the atmospheric pressure and flue gases are exhausted. Exhaust valve is closed approx. 5^0 to 10^0 after TDC in suction stroke.



From Graph:

Suction Stroke:
Before Point 0 → Inlet valve opens.
After Point 0 → Exhaust Valve closes.
Process 0 -1′ → Suction at slightly less than atmospheric pressure.

Compression Stroke:
After Point 1′ → Inlet valve closes.
Process 1′–2 → Compression stroke. Polytropic compression.
Point 2′ → Start of injection
Point 2 → Injection Cut off

Power Stroke:
Process 2-3- 4-1″ → Power stroke
Process 3 - 4 → Polytropic expansion
At Point 4 → Exhaust valve opens
Process 4 - 1″ → Sudden pressure drop

Exhaust Stroke:

Process 1″-0 → Exhaust stroke at slightly more than atmospheric pressure
Before Point 0 → Exhaust valve closes

VALVE OVERLAP:-

At the end of exhaust stroke and start of suction stroke there is a certain time period during which inlet valve and exhaust valve both remains simultaneously open. This time period is called valve over lap.

Question: The stroke length of a cylinder is 152 mm and injection starts 18° before TDC. What will be the position of piston in respect to BDC?

ACTUAL WORKING CYCLE OF 4-STROKE PETROL ENGINE

In a 4-stroke petrol engine, actual working cycle can be explained as given below:

Suction Stroke: Inlet valve opens five to ten degree of crank rotation before TDC in exhaust stroke and whenever piston moves from TDC to BDC, vacuum will be created inside the engine cylinder. Due to pressure difference, fresh air and petrol mixture (charge) from carburetor will enter inside the engine cylinder at a pressure less than the atmospheric pressure. Inlet valve is closed 35^0 to 50^0 after BDC in compression stroke.

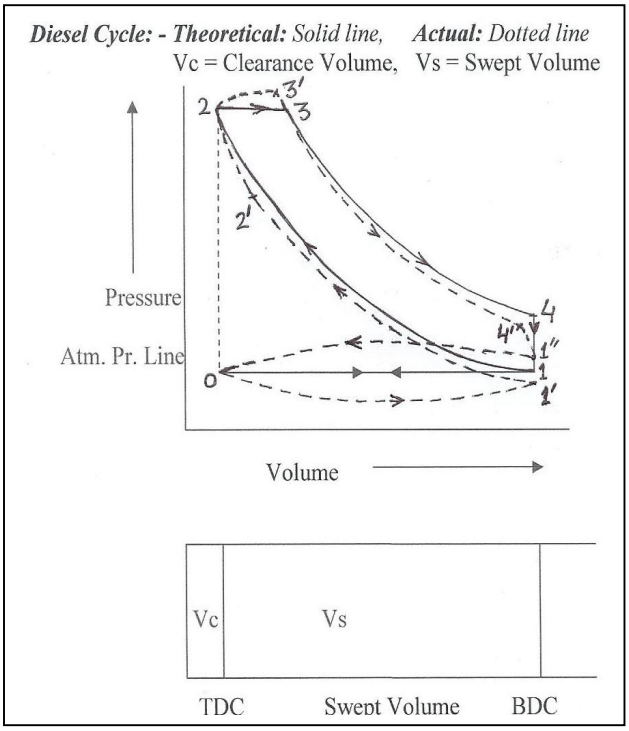
Compression Stroke: Whenever piston moves from BDC to TDC the fresh charge inside the engine cylinder gets compressed according to poly-tropic process. Pressure and temperature will increase. Just before reaching the piston at TDC, spark is produced by the spark plug inside the engine cylinder, by which the charge catches fire and starts burning.

Power Stroke: Burning charges convert into flue gases. These gases will expand inside the engine cylinder. This expansion of flue gases takes place according to poly-tropic process. Due to expansion of flue gases inside the engine cylinder, force is exerted on the piston and in this way power is generated. Piston moves from TDC to BDC.

Exhaust Stroke: In this stroke piston moves from BDC to TDC. Exhaust valve opens 35^0 to 50^0 before BDC in power stroke and pressure drops to about atmospheric pressure. A little force is exerted on the flue gases by the piston which further increases the pressure above the atmospheric pressure and flue gases are exhausted. Exhaust valve is closed approx. 5^0 to 10^0 after TDC in suction stroke.

SUB: INTERNAL COMBUSTION ENGINE

Deviations between actual Working Cycle & Theoretical Cycle



Deviations between theoretical & actual Working Cycle:

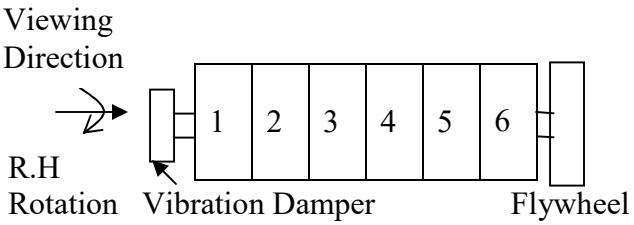
1. Theoretically inlet valve open at TDC in suction stroke. But actually it open 5^0 to 10^0 before TDC in exhaust stroke. Except MWM engine in which it open 1^0 after TDC in suction stroke.
2. Theoretically suction of air takes place at atmospheric pressure but actually it takes place at a pressure less than atmospheric pressure.
3. Theoretically inlet valve close at BDC in suction stroke. But actually it closes 35^0 to 50^0 after BDC in compression stroke.
4. Theoretically compression stroke takes place according to adiabatic process. But actually it takes place according to poly-tropic process.
5. Theoretically injection of fuel start at TDC in compression stroke, but actually it start approx. 14 to 18^0 before (some time 29^0 before) TDC in compression stroke.
6. Theoretically during burning of fuel (process 2-3) pressure remains constant, but actually pressure slightly increase.
7. Theoretically injection stops approx. 18^0 after TDC (Fuel cut off point) in power stroke, but actually injection stops at TDC in compression stroke.
8. Theoretically as soon as we inject the fuel, it burns but actually it takes some time to start burning after injection.
9. Theoretically expansion takes place according to adiabatic processes but actually it is according to poly-tropic process.
10. Theoretically exhaust valve opens at BDC in exhaust stroke but actually it open $35\text{-}50^0$ before BDC power stroke.
11. Theoretically it takes zero time to drop the pressure up to atmospheric pressure (Heat rejection at const. vol. process 4-1) but actually it takes some time.
12. Theoretically exhaust of fuel gases takes place at atmospheric pressure but actually it takes place at a pressure above the atmospheric pressure.
13. Theoretically exhaust valve closes at TDC in exhaust stroke. But actually it closes 5^0 to 10^0 after TDC in suction stroke. Except in MWM engine in which it closes 1^0 before TDC in exhaust stroke.

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.

(A) CUMMINS ENGINES

Cylinders are counted from vibration damper side. Direction of Rotation (DIR) is clockwise viewing from vibration damper side.

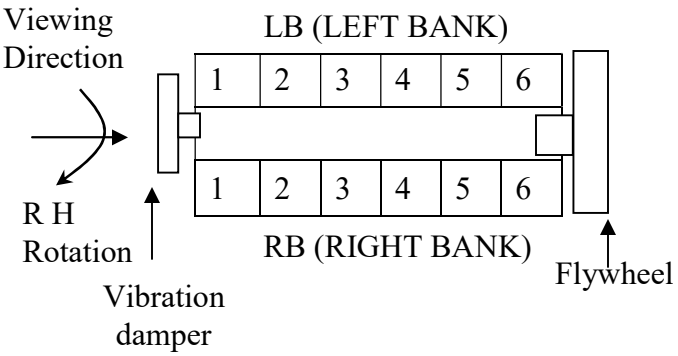
1. 6 Cylinder Engines



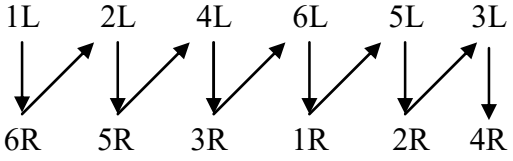
Firing Order:-

1 - 5 – 3 – 6 – 2 – 4

2. 12 Cylinder Engines



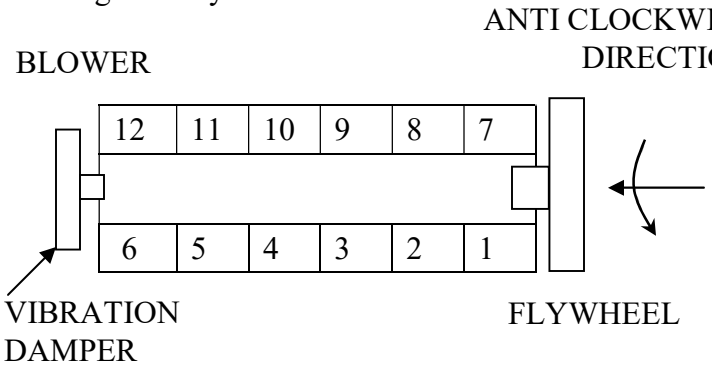
Firing Order:-



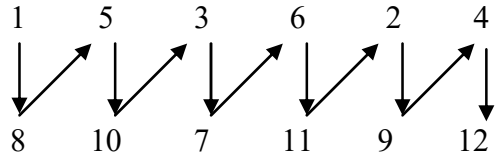
1L - 6R – 2L – 5R – 4L – 3R –
6L - 1R – 5L – 2R – 3L – 4R

(B) 12 CYLINDER DEUTZ ENGINE MODEL BF 12L 513 C (12 Cylinder Engines)

Cylinders are counted from flywheel side. Direction of Rotation (DIR) is anticlockwise viewing from flywheel side.

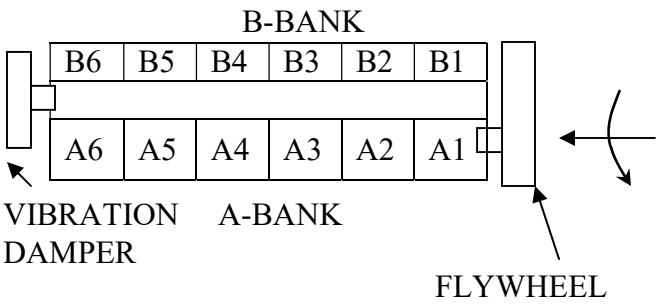


Firing Order:-



1 - 8 - 5 - 10 - 3 - 7 –
6 - 11 - 2 - 9 – 4 - 12

(C) MWM (GREAVES) ENGINE MODEL TBD 232/234 V 12 (12 Cylinder Engines)



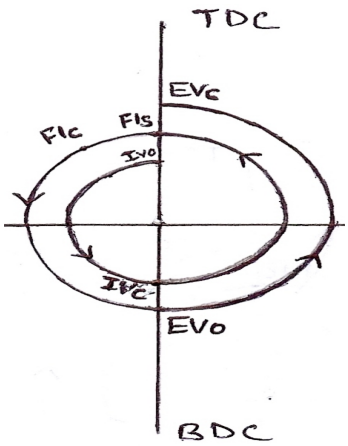
Firing Order:-

A1 A5 A3 A6 A2 A4

B2 B4 B1 B5 B3 B6

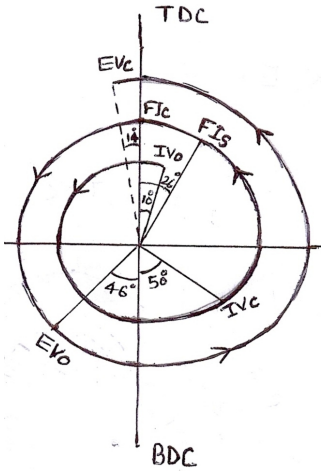
A1 – B2 – A5 – B4 – A3 – B1-
A6 – B5 – A2 – B3 – A4 – B6

THEORITICAL VALVE TIMING DIAGRAM



Inlet Valve Opens (IVO) - at TDC
Inlet Valve Closes (IVC) - at BDC
Fuel Injection Starts (FIS) - at TDC
Fuel Injection Closes (FIC) - Some Degree after TDC
Exhaust Valve Opens (IVO) - at BDC
Exhaust Valve Closes (EVC) - at TDC

ACTUAL VALVE TIMING DIAGRAM OF ASHOK LEYLAND ALU – 680 ENGINES



Inlet Valve Opens (IVO) - 10^0 before BDC

Inlet Valve Closes (IVC) - 50^0 after BDC

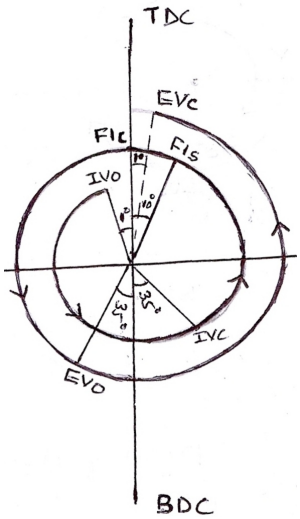
Fuel Injection Starts (FIS) - 26^0 before TDC

Fuel Injection Closes (FIC) - At TDC

Exhaust Valve Opens (IVO) - 46^0 before BDC

Exhaust Valve Closes (EVC) - 14^0 after TDC

ACTUAL VALVE TIMING DIGRAM OF MWM (GREAVES) ENGINE



Inlet Valve Opens (IVO) - 1^0 after TDC

Inlet Valve Closes (IVC) - 35^0 after BDC

Fuel Injection Closes (FIC) - At TDC

Exhaust Valve Opens (IVO) - 35^0 before BDC

Exhaust Valve Closes (EVC) - 1^0 before TDC

SUB:- INTERNAL COMBUSTION ENGINE

Power flow in Multi cylinder engine.

POWER FLOW IN MULTI CYLINDER ENGINE:

Multi cylinder engine runs smoother than single cylinder engine .The more cylinder in an engine the more continuous flow of power and more smoother will be its operation.

POWER FLOW CHART FOR 4 CYLINER ENGINE:-

In four stroke 4 cylinder engine, each power stroke begins at the end of previous power stroke. There is no over lap between power strokes in a four cylinder engine.

In a 4- cylinder engine number of cylinder = 4

Power flow gap $= 720^0 | 4 = 180^0$

Crank rotation → / FIRING ORDER ↓	180^0			180^0			180^0			180^0		
	60^0	60^0	60^0	60^0	60^0	60^0	60^0	60^0	60^0	60^0	60^0	60^0
1	P	P	P	E	E	E	S	S	S	C	C	C
3	C	C	C	P	P	P	E	E	E	S	S	S
4	S	S	S	C	C	C	P	P	P	E	E	E
2	S	E	E	S	S	S	C	C	C	P	P	P

POWER FLOW CHART FOR 6 CYLINER ENGINE:-

In a four stroke 6- cylinder engine number of cylinder = 6

Power flow gap $= 720^0 | 6 = 120^0$

This provides a 60^0 power over lap between successive power strokes. It means that if a cylinder enters in the last 60^0 of its power stroke then the next cylinder as per firing order will enter in the first 60^0 of its power stroke.

Crank rotation → / FIRING ORDER ↓	180^0			180^0			180^0			180^0		
	60^0	60^0	60^0	60^0	60^0	60^0	60^0	60^0	60^0	60^0	60^0	60^0
1	P	P	P	E	E	E	S	S	S	C	C	C
5	C	C	P	P	P	E	E	E	S	S	S	C
3	C	S	S	S	P	P	P	E	E	E	C	C
6	C	C	C	S	S	S	P	P	P	E	E	E
2	E	E	S	S	S	C	C	C	P	P	P	E
4	P	E	E	E	S	S	S	C	C	C	P	P

SUB: INTERNAL COMBUSTION ENGINE

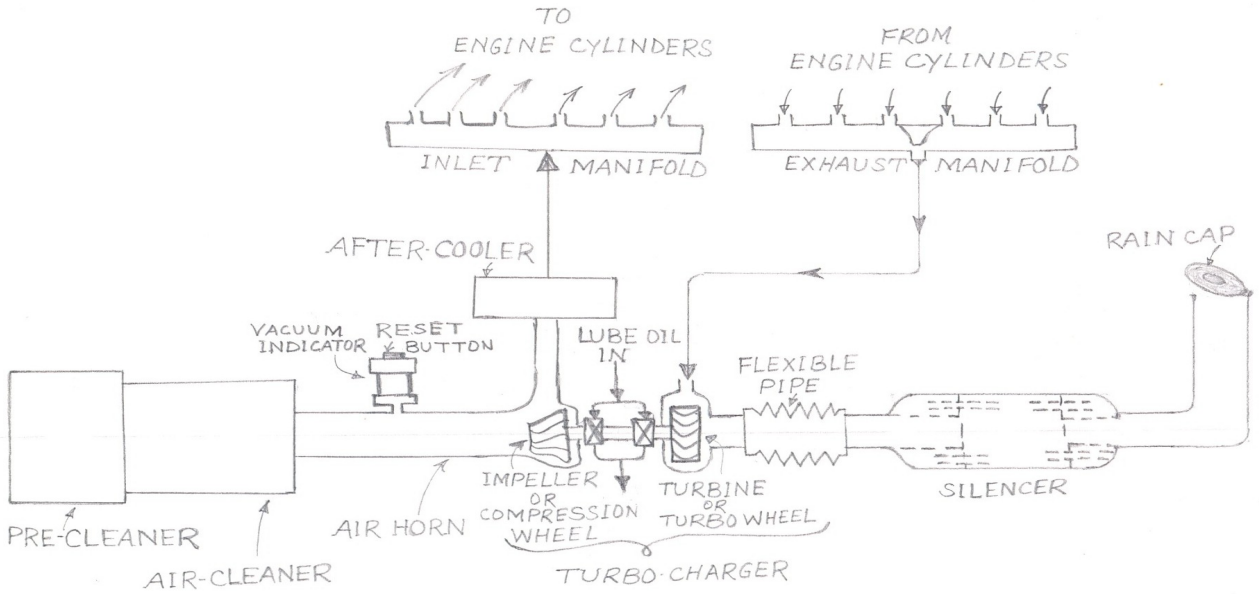
Requirement of Air, Types of Air cleaner.

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% O_2 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 CO_2, 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.

TYPES OF AIR CLEANER: Two types of Air Cleaner

1. Oil bath type air cleaner (BCM Deutz, PQRS HA 694 engines)
2. Dry (paper) type air cleaner (Cummins, Greaves etc. engines)



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 reveres 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 pneumatic air. Oil in the pan is also replaced and filled up to the marked level.

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 chocked, it looks transparent and if becomes chocked then it will give red indication.



Pre-cleaner:

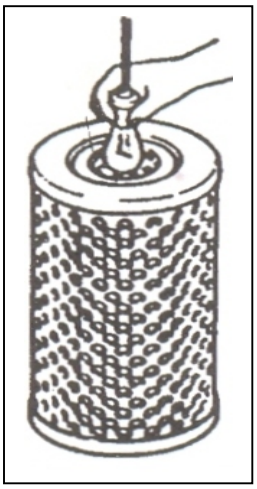
Pre-cleaner is fitted on the air cleaner to arrest the thick dust and soil particles. On the engine which work in very unsafe atmosphere (dusty atmosphere), Pre cleaners are essentially required. Pre-cleaner has screen which arrests the thick soil and straw. After filtering through the screen, the air 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.

SUB:- INTERNAL COMBUSTION ENGINE

Cleaning and checking of dry type Air cleaner, Draw backs of choking of Air Cleaner.

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 bars to 4.5 bar (1.5 to 2.0 bar for BCM Deutz Engine).
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.

AIR CLEANER SERVICE TIPS

1. Don't remove element for inspection.
2. Never tap a filter to clean it.
3. Never judge the filters life by looking at it…. Measure the air flow.
4. Never leave an air cleaner open longer than necessary
5. Don't ignore a worn or damaged gasket in the housing.
6. Don't use a damaged or bunched filter.
7. Never use a warped cover on housing.
8. Never substitute an incorrect element model number.

7-STEP FILTER ELEMENT REPLACEMENT

1. Remove the old element gently like "Baby". Accidentally bumping it while still inside, means dropped dirt and dust that will contaminate the clean side of filter housing.
2. Always clean the inside of the housing carefully. Dirt left spells death for engine. Use a clean, damp cloth to wipe every surface clean.
3. Always clean the gasket sealing surfaces of the housing.
4. Check for uneven dirt patterns.
5. Press your fresh gasket to see that it springs back.
6. Make sure that the gasket seats evenly.
7. Ensure air tight fit on all connections and ducts.

DRAW-BACKS OF CHOCKING OF AIR CLEANER

Air cleaners 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 chock. 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:- INTERNAL COMBUSTION ENGINE

Supercharging Turbocharger and
after cooler, Importance of After cooling.

SUPER CHARGING: The process of supplying air to the engine cylinder above atmospheric pressure is called supercharging. 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 supercharging 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. (Supercharger is also a supercharging device but driven by gear train).

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.

The main care 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 keeps 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 or INTERCOOLER or Air charge cooler: 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 **(Air charge cooler)** of BCM machine.
(ii) Air to water type – Used in MWM **(intercooler)** & Cummins engines (aftercooler).

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.

SUB: INTERNAL COMBUSTION ENGINE

Functions and classification of Fuel supply system, Mico-Bosch fuel supply system, Block diagram.

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)

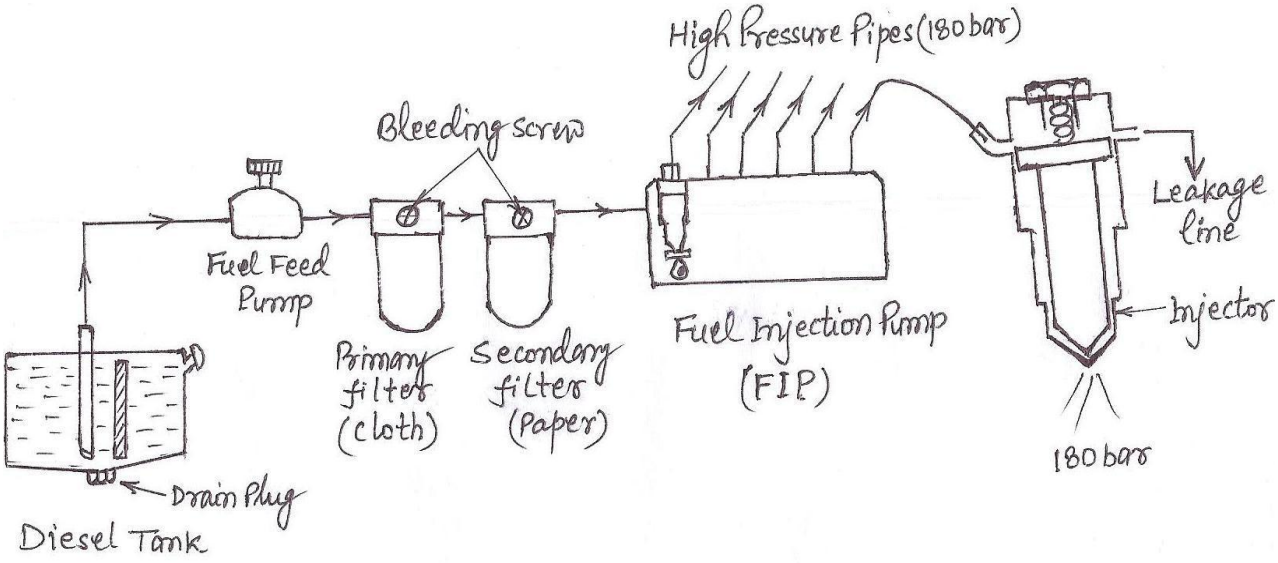
b) Common rail fuel injection system (Cummins P.T. fuel supply system)

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

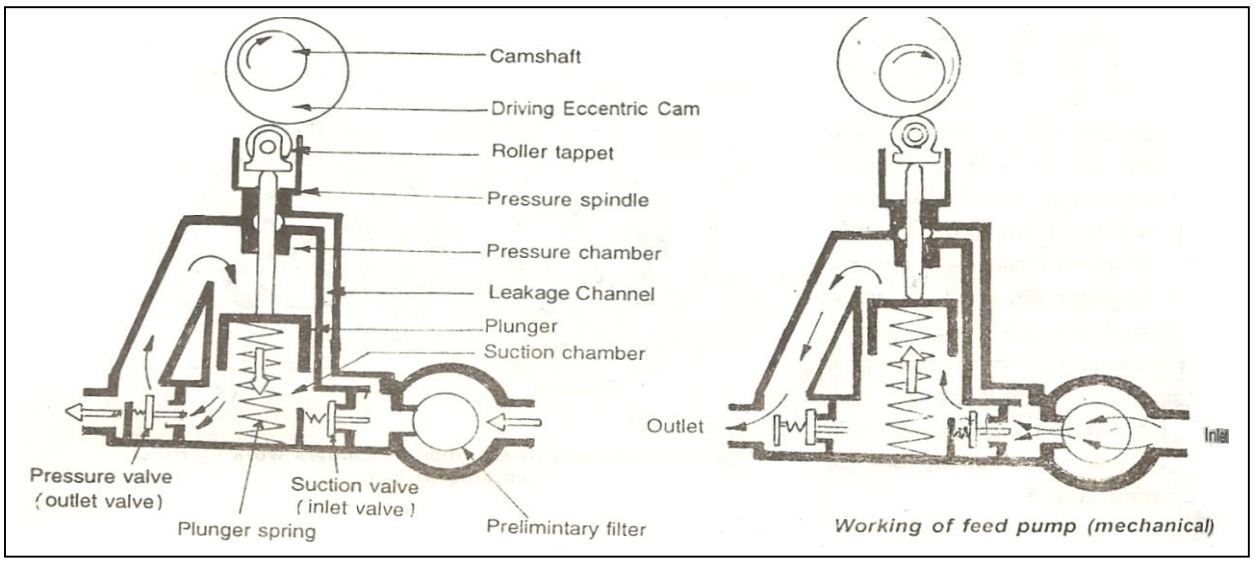


SUB: INTERNAL COMBUSTION ENGINE

Fuel feed pump, Fuel filters, Fuel injection pump.

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

Working: There is a spring on the plunger of the pump. This spring forces the plunger against the tappet. There is an inlet and outlet valve. When 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.



Working of feed pump (mechanical)

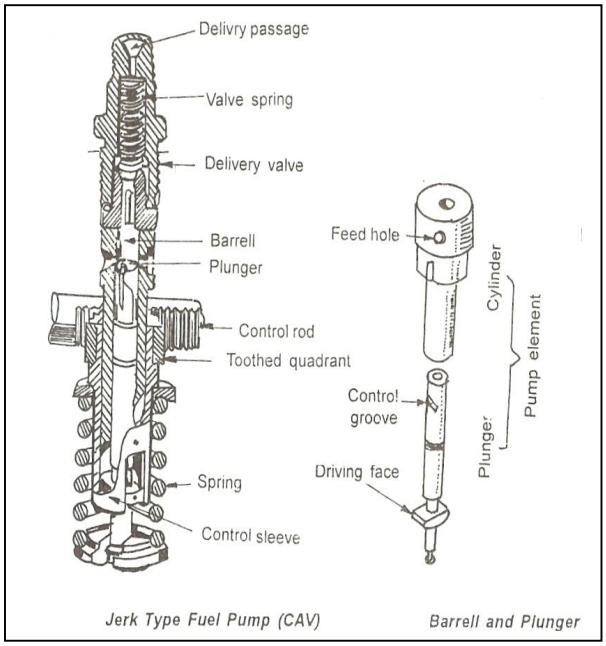
Fuel Filter: In Mico-Bosch fuel system mainly two filters are used.

a) Primary filter and b) 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.

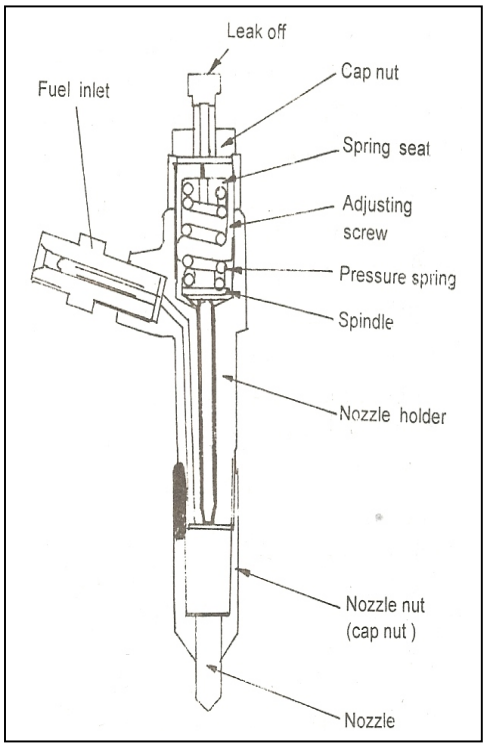


Jerk Type Fuel Pump (CAV) *Barrell and Plunger*

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 the injector gets cut off. The cycle is repeated again and again.

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.



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

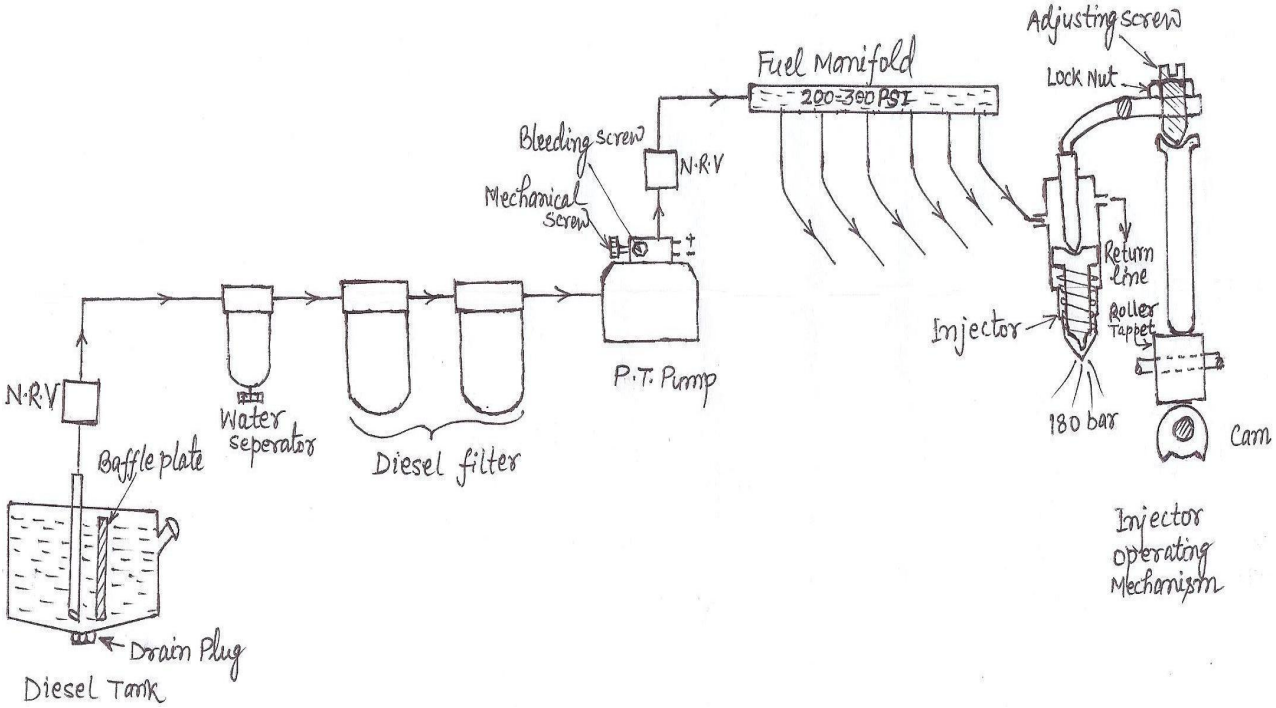
Operating Principle:

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 fitter. 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 plunger, 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:

Now, PTG Fuel 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 AND PT PUMP SYSTEM:

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

+

SUB: INTERNAL COMBUSTION ENGINE

Cetane number, Octane No. Delay Period and Knocking of fuel.

CETANE NUMBER:

In a diesel fuel it is the percentage of Cetane in a mixture of Cetane and α-methyl Naphthalene, which has the same diesel knock characteristics as the fuel under test. Cetane number expresses the auto ignition quality of the diesel fuel. A fuel with shorter ignitions delay period will hare higher Cetane numbers and vice versa. Most diesel fuels have Cetane numbers from 40 to 50.

OCTANE NUMBER:

The octane no. of any fuel is the percentage of iso Octane by volume in the mixture of iso octane and normal heptane which gives the same anti knocks characteristics as the fuel under standard test conditions. These were given arbitrary values. Zero for normal heptane and 100 for iso octane.

IGNITION DELAY:

The time between the fuel injection in the combustion chamber and its actual burning is called the ignition delay or ignition lag.

KNOCKING OF FUEL:

Diesel Knock:

If delay is long, much larger quantity of the fuel is injected before the first droplets burn and this may result in too high rate of combustion, giving rise to very high rates of pressure rise and also higher peak pressures, causing a peculiar thudding sound, known as diesel knock.

Detonation:

Detonation is caused by the sudden instantaneous ignition of the unburnt charge, when the rise in temperature exceeds, the rate of heat dissipation, thus subjecting the un-burnt charge to the temperature and pressure sufficient to cause its ignition

SUB: INTERNAL COMBUSTION ENGINE

Draw backs of keeping low HSD Oil level in tank, removing of Air Lock.

DRAWBACKS OF LOW HSD OIL LEVEL IN DIESEL TANK:

If always we work with low HSD oil level in the tank then following problems will arise.

1. The water present in air of the vacant tank will condense at low temperature and will mix with lubricating substance of fuel. This mixing will form sludge (greasy mix of lubricating substance and water) which is heavier than HSD oil due to presence of water. It will accumulate at the bottom of the tank and frequently cleaning of the tank will be required.
2. Some amount of these water particles will go into the engine cylinders along with fuel. There these will burn which will require heat energy for burning. The part of the heat energy which is to be converted into mechanical power will waste for burning of fuel resulting in decreased output of the engine.
3. Due to too much low oil level, air will enter into the fuel system due to which it becomes impossible to start the engine. Hence, air from the system is required to be removed. If air will enter into the system in block section then it takes about 15 -20 minutes to remove the air which is lost of the valuable working time.
4. Due to mixing of water particles with lubricating substance of fuel lubricating quality of fuel will decrease due to which rapid wear and tear of fuel pump and injectors takes place.
5. Down time of machine will increase as tank will require frequently cleaning.

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 low HSD oil level in 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 –

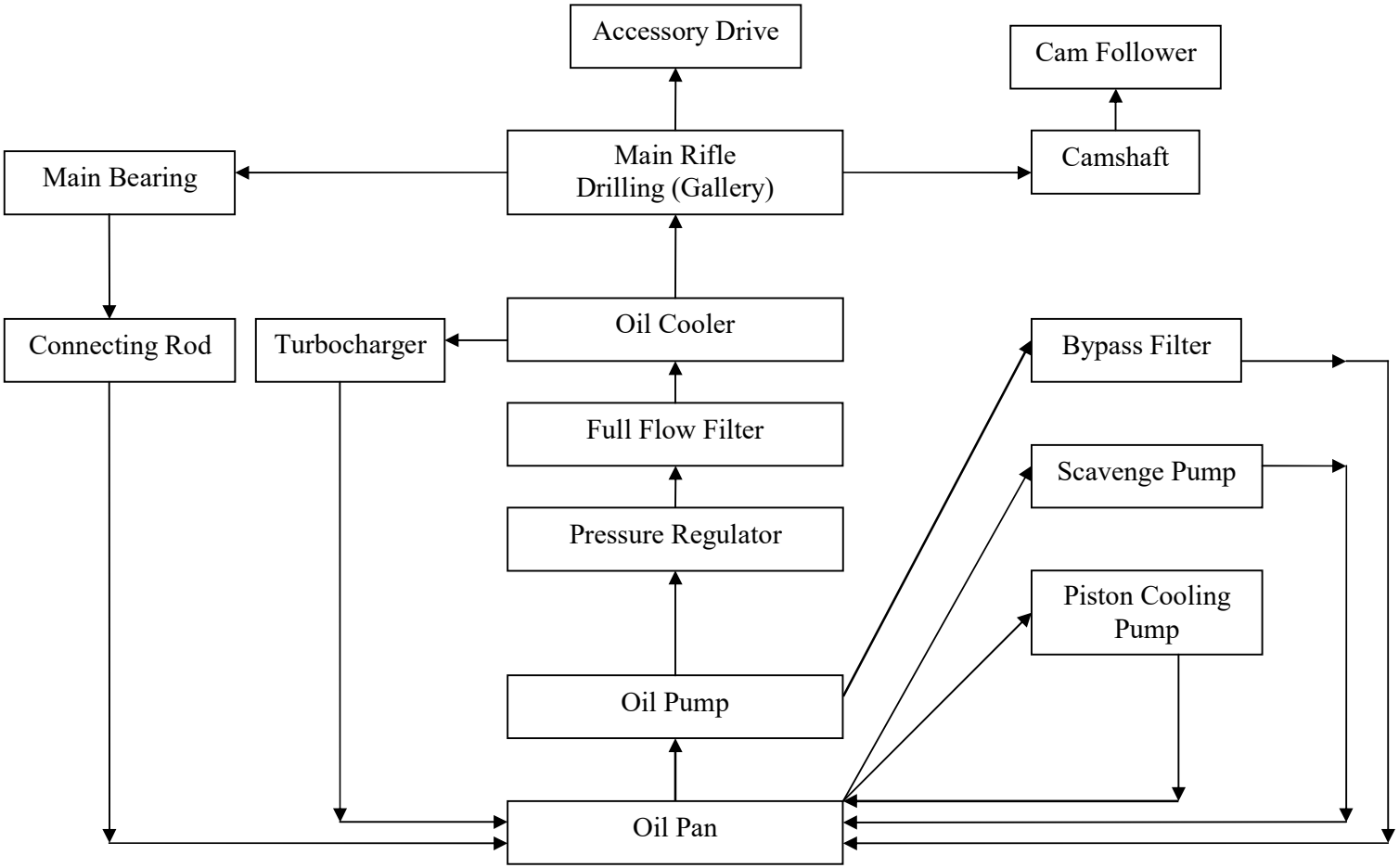
1. Loose vent-screw provided on the body of the fuel filters and fuel injection pump.
2. Do hand priming by fuel feed pump hand operated lever.
3. Priming will be done till oil free form air bubbles starts to come through the first vent screw in the fuel flow direction.
4. As soon as the fuel free from 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 trough 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 loosing and taking out the output pipe and simultaneously loosing 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



LUBRICATING CIRCUIT (Lubricating oil flow schematic)

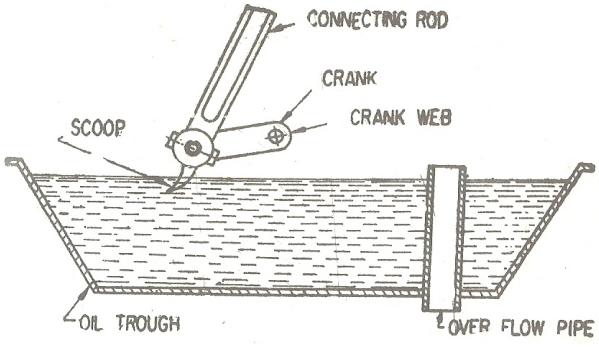
DIFFERENT TYPES OF LUBRICATING SYSTEMS:-

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

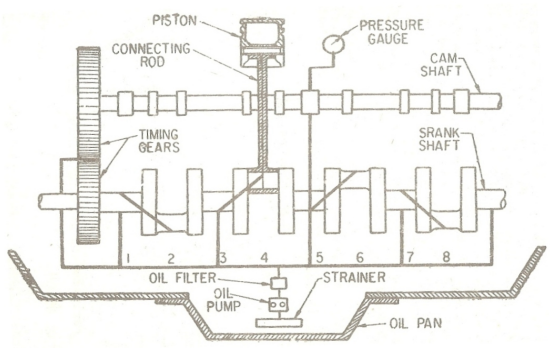


4. Semi Pressure System: It is the combination of splash system and pressure system. Some parts are lubricated by splash system and some parts are lubricated by pressure system.

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 1.0Kg/cm^2 – 4.0 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.

SUB:- INTERNAL COMBUSTON ENGINE

Blow bye, Crankcase ventilation, Reasons for low lubricating oil pressure and high oil consumption

---

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

CRANKCASE VENTILATION

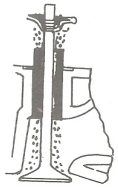
The products of combustion contain manly nitrogen, water and carbon dioxide. Sulphuric acid may also be present due to sulphur content in the fuel. The product of combustion may leak into the crankcase. The crankcase ventilation removes all these unwanted gases and sulphuric acid particles. It prevents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

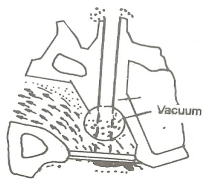
REASONS FOR LOW LUBRICATING OIL PRESSURE

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-cane 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 toped up.
9. Oil leakage should be checked and made fit.
10. If centrifuge is provided in the lube oil system (MWM, Deutz engines), it should be cleaned.
11. Torn the filter paper and check for any metal particles.

SUB:- INTERNAL COMBUSTON ENGINE

Different methods of Engine Cooling, Air Cooling System. Water Cooling system

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

AIR COOLING SYSTEM (BF 12L 513C, SUN 6105 I, HA 694)**:-** 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.

Components: 1.Blower, 2. Fins & Flanges, 3. Cowling, 4. Top cover.

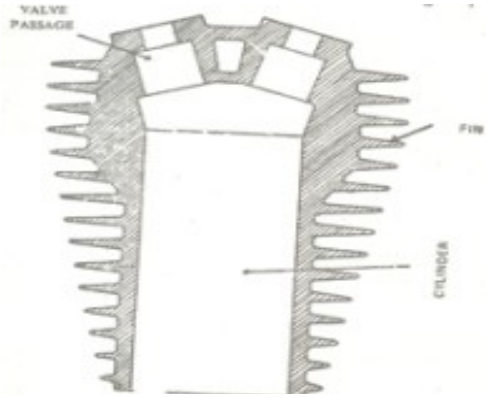
Advantages of air cooling:-

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: -

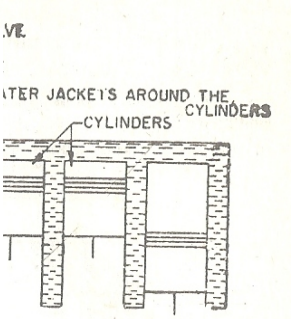
1. Less efficient cooling, because co-efficient of heat transfer for air is less than that of water.
2. Not easy to maintain even cooling all around the cylinder, distortion of the cylinder may take place.
3. More noisy operation.
4. It can be used only where the cylinders are exposed to air stream

Cooling fins: The fins are usually made of about the cylinder wall thickness at their routes, tampering 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

2. WATER COOLING SYSTEM (Cummins, MWM/Greaves): - 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 indicator.

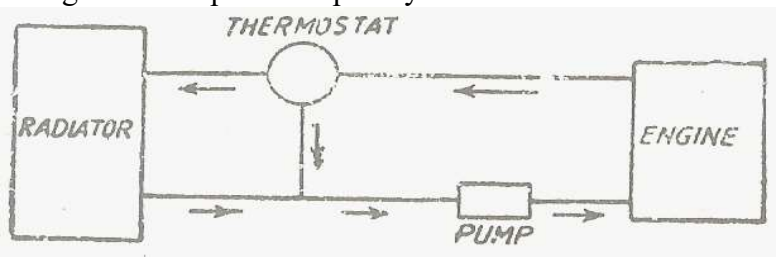
1. Radiator: -



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 consist 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 cap is provided with relief valve and vacuum valve.

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. 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.

3. 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.

4. 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.

5. 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.

6. 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/cm^2. A 1.10 kg/cm^2 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 (or MAXTHERM) 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(or 20:1 for MAXTHERM) 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.

SUB:- INTERNAL COMBUSTON ENGINE

Drawbacks of overcooling and reasons for overheating

Troubles of cooling system: -

1. Loss of coolant due to leaks: - External leaks may be noted by inspection. Internal leaks are caused by faulty head gasket, loose cylinder head, cracked head or engine block.

Internal leak will raise the lubricating oil level in the oil pan. It may also produce clouds of white vapor in the exhaust gases.

2. Over heating:- It is caused by insufficient quantity of water in the cooling system, clogged radiator and water passages, belt slippage, inoperative thermostat, late ignition timing, incorrect valve timing, pre-ignition, too tight bearings, too low engine oil level, clogged exhaust system etc.

3. Over cooling: - An engine running below the normal operating temperature range is called over cooled. It is caused by a thermostat that opens too soon or remains open at al times.

The temperature gauge also may be faulty to give incorrect reading. If it is faulty, it should be replaced.

4. Noises: - Noises in the cooling system may occur due to dry bearings, a loose pulley on the pump or fan shaft, an impeller loose on the shaft or too much end play in the shaft.

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 chocked.** **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

SUB:- INTERNAL COMBUSTON ENGINE

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.

MAINTENANCE SCHEDULES OF CUMMINS ENGINE (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 toping 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.

SUB:- INTERNAL COMBUSTON ENGINE

Maintenance schedules of DEUTZ Engine

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 after1000, 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.

MAINTENANCE SCHEDULES OF MWM ENGINE AS PER OEM

Daily checks:
Prior to starting:

1. Check water level-top up to recommended level. (ref. instruction manual – ph value)
2. Check engine oil level.
3. Check air filter and dust bowl
4. Clean engine and surrounding

After starting

5. Check oil pressure at idling and maximum speed. Minimum oil pressure: 1.5 kg/cm^2 at idling speed and 2.5 kg/cm^2 at rated speed.
6. If oil pressure deviates substantially from recommended, stop the engine and check the trouble shooting chart or call your service representative.
7. Check coolant water temperature. recommended coolant working temperature – 75^0c to 85^0c. Maximum coolant temperature – 95^0 (engine shutting off)
8. Check engine for leakages.

Every 250 hours

1. Change engine oil. (As per RDSO: @ 125 Hrs.)
2. Change oil filters. (As per RDSO: @ 125 Hrs.)
3. Remove sump bottom cover and clean the lube. oil suction strainer.
4. Check rubber sleeves and hose pipes, replace if found defective.
5. Check zinc anodes.
6. Change fuel filter elements. (As per RDSO: @ 125 Hrs.)
7. Check coupling disc on injection pump.
8. Check ‘v’ belts and lubricate raw water pump.
9. Check and re-adjust valve tappet clearance 0.2 mm (cold)
10. Check speed governor and engine shutdown for proper functioning and lubricate linkages.
11. Check battery.

Every 2000 hours

1. Check bearings of water pump and pulley, replace ‘v’ belts.
2. Check flexible coupling and rubber engine mounts.
3. Check injectors.
4. Clean crankcase ventilation/breather. (As per RDSO: @ 200 Hrs.)
5. Check and clean inlet ducts.
6. Remove and clean exhaust piping.
7. Check thermostats
8. Clean heat exchanger
9. Check monitoring functions (engine protection devices).
10. Clean intercooler

11. Renew anti-vibration mounting pads.
12. Clean cooling water passages
13. Check compression
14. Check and service starter & generator.
15. Check all bolts and nuts for specified torques
16. Clean engine and flush radiator.

Every 8000 hours

Further checks to be carried out in order to assess whether top overhauls are required on the engine, only if deterioration is noticed in the engine performance like:

a) Loss of power
b) Heavy smoke
c) Low oil pressure
d) High oil temperature
e) High water temperature
f) Unusual noise and vibration

In the event of any of the above deficiencies occurring in the engine, it is advised that the operator carry out the trouble tracing exercise to eliminate these individual deficiencies. However in case they remain un-rectified compression and injection pressure etc. will reveal whether it is necessary to carry out decarbonisation and/or other repairs.

SUB-DISCIPLINE:- INTERNAL COMBUSTION ENGINE

Maintenance Steps to improve Performance

Cummins 10 maintenance Steps

1. Keep Dirt out of the engine

Dirt is the cause of most wear in an engine.

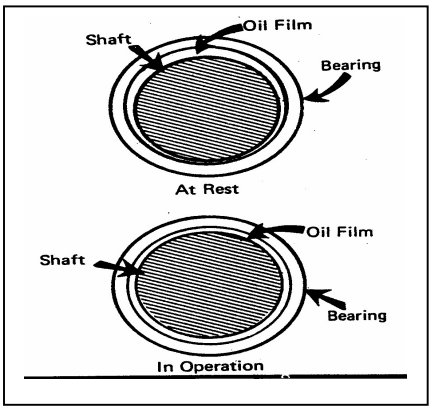
Dirt penetrates the oil film and grinds away the metal.

Valve stems, Guides, faces, Seats, Liner and Piston walls and Piston Rings suffers most from dirty intake air.

Bearings, Shaft Journal also suffer when dirt gets into lubricating oil.

Hence Keep Dirt / Dust out of your engine

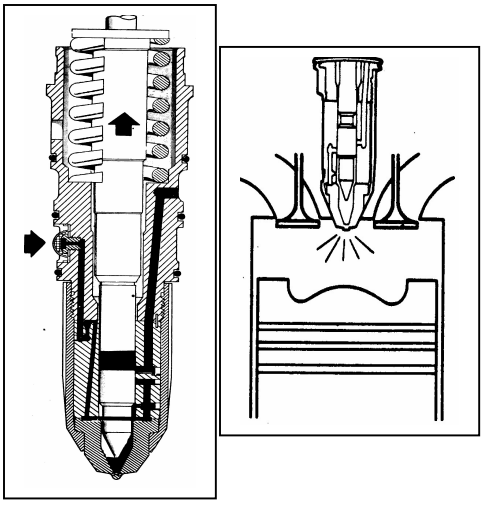
2. Maintain a Lubricating oil film on bearing surfaces.



- Prime the lubricating system as suggested.
- Bar the engine for 2 or 3 rotations while priming.
- Avoid poor lubrication due to low oil pressure, dilution, partially clogged oil passages / filters or improper clearances, incorrect oil level and incorrect grade of oil to eliminate Piston or bearing seizures.

Hence, ensure oil film on Bearing Surfaces is always present.

3. Regulate the Engine's Fuel.



- Violations of requirements such as uniform metered fuel for all cylinders and fine spray of fuel to mix with air would result in low power, smoky exhaust, dilution, hard starting etc.

  Ensure air supply is not restricted beyond limit.

  Hence, ensure the engine's fuel is regulated properly.

4. Control Operating Temperature.



- Water jackets lose ability to ABSORB heat when they become coated with scale, rust or dirt.
- Water pump CIRCULATE less coolant as impeller wear and Belt slip.
- Thermostat fails to CONTROL coolant flow after long period of service.
- Radiators lose ability to DISSIPATE heat as the core becomes choked internally / externally.

5. Guard Against Corrosion.

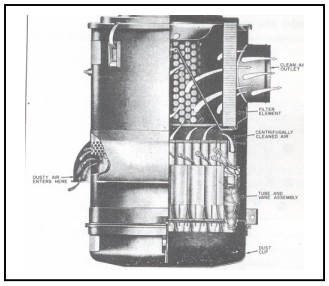
Acid, salt or airs in the coolant are the most causes of corrosion.

Corrosion even accelerates to the extent of Cylinder Block, Liners and Cylinder Head replacement.

Corrosion can be controlled or prevented entirely at little expense of time and money.

Hence, ensure the engine is protected against Corrosion.

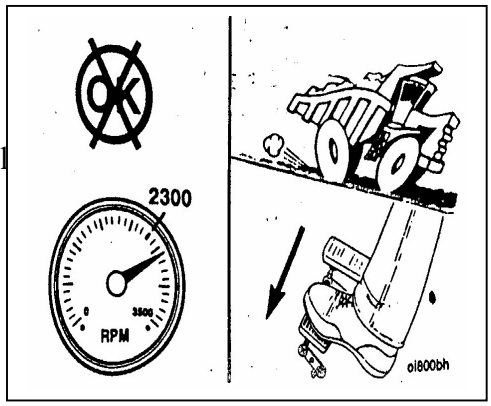
6. Let the Engine Breathe.



- Diesel Engine requires about 12,500 gallons of Air to burn One gallon of Diesel completely.
- Inadequate air supply would result in power loss, wastage of fuel and bearing failure.
- The exhaust system must carry the exhaust gases with out restrictions.

Hence, ensure that intake and exhaust system meets the requirements.

7. Prevent Overspeeding.



Cummins engines are over-speeding during by Governors.

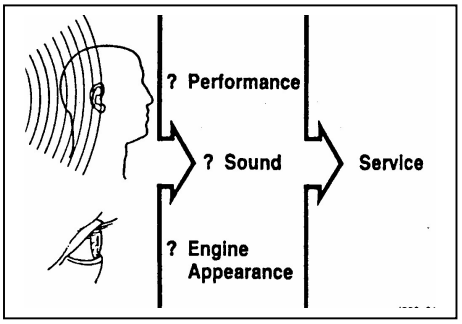
Over-speeding is possible al on a down grade beyond its rated speed.

Over fuelling and lighter cause failures to turbocharger.

Over-speeding causes piston break valves.

Hence, control on engine speed is must.

8. Know your Engine's condition.



- Engine gives symptoms and signs of its condition for the operator or technician to take corrective action.
- Delayed response may lead to serious damages.
- Would help to correct the problems when they are simple.
- Check lube filter element for particles during B checks.

Hence, carry out proactive checks to know your engines condition better.

9. Correct Troubles while they are simple.

Engine gives symptoms and signs of its condition for the operator or technician to take corrective action.

Delayed response may lead to serious damages.

It would help to correct the problems when they are simple.

Preventive measures on warnings would avert costly progressive damages.

Hence, prolonging a complaint must be avoided.

10. Schedule and control your maintenance.

Preventive maintenance is the easiest and least expensive maintenance.

Correct care of your engine would result in longer life, better performance and more economical operation.

SUB:- INTERNAL COMBUSTON ENGINE

Precautions in providing Piston Rings on Piston and assembling in cylinder liner

PRECAUTIONS WHILE FITTING THE PISTON RINGS:

The following precautions must be adhered strictly while fitting the piston rings.

i) Do not fit new piston rings into excessive worn piston grooves.
ii) Do not file the piston ring ends. If is required, file only to a very fine finish so that the ends may seat squarely.
iii) Do not fit piston rings too tight.
iv) Do not fit an over size ring into a tapered piston.
v) Always fit the bottom most ring first.
vi) Do not fit the rings from piston skirt side.
vii) After fitting the rings into the respective grooves, tilt the piston horizontally. The rings should fall freely of its own weight.
viii) Check the side clearance in the grooves. It should be as per the manufacturer's specification.
ix) The end gap of piston ring is approximately 0.001" per inch of piston diameter.
x) Arrange the end gap of piston rings in a manner so that the gaps for all the rings should not fall in one line.
xi) While fitting the piston rings apply sufficient quantity of engine lubricating oil.
xii) After fitting the rings into the grooves, rotate the rings in the grooves so that it is free.
xiii) Make sure that the grooves in the piston are cleaned properly.

PRECAUTIONS IN FITTING PISTON RINGS ASSEMBLY INTO CYLINDER LINER:-

1. Before inserting the piston into the cylinder remove the ridge, which is formed on top of the cylinder. If it is not removed the piston rings may break.

2. Piston rings are compressed by ring compressor for easy and damaged free sliding of piston into liner.

3. Care should be taken to install the piston facing in the right direction. Many pistons have a notch or other making that must face to the front of the engine.

4. While inserting connecting rod into piston liner, take care that big end of C.R. do not scratch the liner or crankshaft main journal.

5. Push the piston into liner gently without applying excessive force.

6. In two stroke cylinders, the ring gaps should not face the port otherwise they may break.

7. To prevent rotation of rings, there are small pins in ring grooves of two-stroke pistons. This pin should be kept between ring gaps.

SUB:- INTERNAL COMBUSTON ENGINE

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. It is provided to accommodate Expansion of valve due to heating. Due to Less valve clearance valve remains always open on operating temperature which results in power loss. Due to More valve clearance there is always gap on operating temperature which results in improper valve opening and noisy operation. Hence its adjustment should not be delayed.

Position for valve Clearance (Tappet) 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 downwards. 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.

After adjusting the valve clearance of cylinder no. (1), rotate fly wheel in the direction of rotation by $720^0/n$ (n = No. of cylinders). If it is 6 cylinder engine then rotate by $720^0/6 = 120^0$ 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.

In this way adjust valve clearance one by one of all cylinder according to firing order by rotating the fly wheel by $1/3^{rd}$ revolution.

Valve Clearance:

	Inlet Valve	**Exhaust Valve**
Cummins engines	0.014"	0.027"
MWM Engine	0.2 mm	0.2 mm
Deutz Engine BF 12L 513C	0.2 mm	0.3 mm
Kirloskar HA 694	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 (180^0) 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.

SUB:- INTERNAL COMBUSTON ENGINE

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.

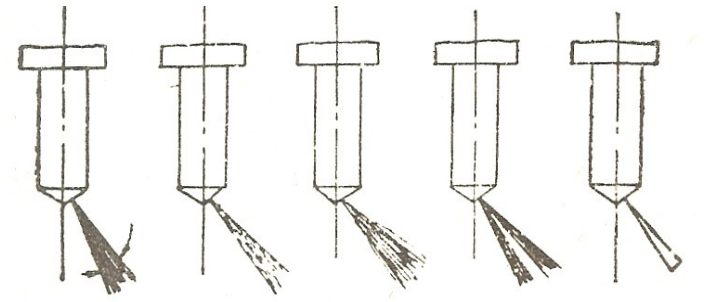
TEST AND ADJUSTMENTS OF INJECTORS

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.

INSPECTION OF CRANK SHAFT:

A) Check for cracks:
Make a very careful inspection for cracks.

B) Alignment check:
Position the crank shaft on a pair of "v" blocks or in the lathe. With the help of dial test indicator take reading on two intermediate journals. Run out should not be more than 0.002".

C) Roughness:
There should not be any sign of roughness on journals and crank pins. It is checked with a copper piece by rubbing a copper piece on the journals or pin, it should not leave any sign.

D) Discolourisation:
Bluing (bluish) color indicates over heating.

E) Bend test:
Place the crank shaft on a pair of "V" blocks on a surface plate turn the crank shaft and bring a pair of crank pins at T.D.C. Taking reading with a dial test indicator for equal height. Bring the same paid crank pins to B.D.C. and note reading; repeat the same on the other pins. From the reading the bend can be checked up.

F) Twist test:
Place the crank shaft on a pair of "v" blocks. Bring no. 1 crank pin at T.D.C. And scribe a vertical line on the fly wheel with the help of Fitter Square. Turn the crank shaft and bring no 1 crank pin to B.D.C. and scribe another vertical line. If both the lines scribe are coinciding, then there is no twist similarly check the other pins also.

G) Bow test:
Place the crank shaft as above and check the reading on the intermediate journals by a dial test indicator. If they are gradually increasing or decreasing outwardly, it means there is a bow.

H) Test for static balance:
Place the crank shaft main journals on a knife edge "V" block with a pair of pins a T.D.C. Push the crank shaft with a finger. If it falls to B.D.C. and stays there the crank shaft is out of balance.

I) Ovality and taper wear:
Check main journals and crank pins with a micro meter to determine if they are out of round. Measurement should be taken in several places; to check for taper wear. If the journals and pins are tapered or out of round more than .003", they should be reground.

SUB:- INTERNAL COMBUSTON ENGINE

Trouble shooting of Cummins Engine.

TROUBLE SHOOTING OF CUMMINS ENGINE AS PER PLASSER MAKE WORSITE 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^{o} C and place thermostat in it. Maintain temperature of water by agitating

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 cylinder head and piston.	6. De-carbonise the engine.
		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.
		5. Poor compression	5. Engine needs to be top overhauled.
12.	Lube oil consumption too high.	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:- INTERNAL COMBUSTON ENGINE

Trouble shooting of Deutz and MWM Engine.

TROUBLE SHOOTING GUIDE OF BALLAST CLEANING MACHINE (RM-80)
ENGINE: DEUTZ - BF-12L 513C 453HP @ 2300 rpm

S. No.	Faults	Probable Causes	Remedial Actions
1.	Engine doesn't start.	1. Emergency stop switch is depressed.	1. 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 explained below: Loosen the Bleed Plug on the fuel filter and operate the priming pump until the fuel is free from air bubbles. Tighten the bleed plug. Then loosen Banjo Plug on injection pump and operate priming pump until fuel is free from air bubbles. Tighten the Banjo Plug.
		3. Shutdown mechanism stuck.	3. Check shut down mechanism i) Release engine shutdown lever from stop position. ii) Check electrical shutdown circuit for proper functioning.
		4. Air in fuel system.	4. Bleed air from fuel system as explained in s. no. 1, item 2 above.4. Bleed air from fuel system as explained in s. no. 1, item 2 above.
		5. Governor is stuck.	5. Replace complete fuel injector pump.
		6. Misconnection of starting switch.	6. Check starting switch and if any misconnection is noticed, rectify it.
		7. Faulty valve clearance	Adjust the valve clearance following these steps: i) Unscrew bolts and remove cylinder cover. ii) Crank the engine until the inlet valve is closed, then turn approximately half turn further. iii) The feeler gauge of 0.20mm and 0.30mm should pass between rocker lever and the cross head for the exhaust and intake valve with suction consequently. This will be done by loosen the lock-nut and readjust by means of setting screw. Renew gasket sealing ring of cylinder head cover. iv) Tighten the lock-nut and readjust valve clearances with the prescribed feeler gauge mentioned in SL(iii)
		8. Not de-clutched.	8. De-clutch where possible
		9. Wrong SAE grade of engine oil or poor quality of oil.	9. Replace by correct type of oil.
		10. Cable connection starter circuit loose / oxidized	10. Check the same.

1.	Engine doesn't start.	11. Weak batteries.	11. Check electrolyte level in the batteries. Terminals should be clean and the charging system should be working. Over-aged batteries should be replaced.
		12. Injectors not properly functioning.	12. Remove faulty injectors and get it overhauled/calibrated or alternatively replace it with new one.
		13. Valves not seating properly.	13. i) Check the valve springs and replace the broken spring if any. ii) Lap the valves. iii) Lap the valve seat, if required.
		14. Too much fuel in engine or flooded engine.	14. i) Clean fuel return pipe. ii) If return pipe is already clean, calibration of fuel pump may be defective and should be got calibrated.
		15. Starter defective or starter relay defective or pinion does not engage.	15. Check, rectify or replace.
2.	Engine stops suddenly during run.	1. No fuel.	1. Fill fuel in the tank and follow steps same as 1(2).
		2. Air in the fuel system.	2. Bleed air from fuel system as explained in steps same as 1(2).
		3. Valve clearances are not proper.	3. Adjust valve clearances as explained in 1.7.
		4. Governor is stuck up.	4. Governor needs repairs/ overhauling in workshop.
		5. Overheating of Engine	5. Take remedial action same as 1(5).
		6. Fuel filter / fuel pre-filter contaminated.	6. Check / clean/replace as per need.
		7. Shut down circuit fails.	7. Check and repair the faulty circuit.
		8. Lube oil pressure too low.	8. i) Check lube oil pump. ii) V-Belt for lube oil pump may be broken. Change with new one. iii) Wrong grade of lube oil. Use proper grade of oil.
3.	Engine misfiring.	1. Dirty fuel filter.	Check fuel filters and if necessary replace the same.
		2. No / less fuel in tank.	2. Fill fuel in the tank and follow steps same as 1(2).
		3. Air in fuel system.	3. Bleed air from the system, same as 1(2).
		4. Faulty Injector/Injection line leaky.	4. Remove the faulty injector and get it overhauled / calibrated. Alternatively, replace the faulty injector with new one.
		5. Faulty valve clearance.	5. Adjust valve clearances
		6. Fuel injection timing improper.	6. Correct the timings or call the service engineer.
4.	Excessive black smoke at idle.	1. Restricted fuel lines.	1. Check the fuel lines.

4.	Excessive black smoke at idle.	2. Plugging of injector spray holes	2. Injectors needs cleaning
		3. Cracked injector body	3. Replace the broken one.
		4. Long idle period	4. Do not run the engine at idle speed for long period.
		5. Gasket blow-by or leakage	5. Replace the defective gasket
		Broken or wrong piston rings	6. Use the piston rings of standard part no. from engine manufacturer
		7. Injectors needs calibrations	7. Get the engine calibrated through specified agency
5	Excessive white smoke at idle	1. Improper grade of fuel.	1. Use proper grade of fuel. It will be better if fuel is tested chemically
		2. Cracked injector body	2. Replace the cracked one
		3. Coolant temperature low	3. During winter season top up the radiator with boiled water to keep the water temperature normal.
		4. Long idle periods	4. Do not run the engine at idle speed for long periods.
		5. In correct valve and injection timing	5. Correct valve and injection timing
6.	Excessive smoke under load	1. Restricted air in take	1. Clean the air filter or replace if required
		2. Dirty turbo charger	2. Get it clean
		3. Poor quality of fuel	3. Same as 5(1).
		4. Restricted fuel lines	4.Check the fuel lines and clean it as per requirement
		5. Fuel pump calibration in correct	5.Get the fuel pump calibrated through specified agency
		6. Injector needs calibration	6. Get the injector calibrated through the specified agency.
		7. Engine due for overhaul	7. Get the engine overhaul through service engineer of engine manufacturer.
7.	Engine running too hot.	1. Coolant level too low.	1. Check coolant level and top up with coolant up to the mark in the filler neck.
		2. Oil cooler/ cooling fins soiled.	2. Clean oil cooler/cooling fins.
		3. Air Blower defective.	3. Check and replace.
		4. Air Blower coupling broken.	4. Replace broken coupling/ bushes.
		5. Faulty valve clearances	5. Adjust the valve clearance, same as 1 (7).
		6. Atmospheric air temperature rise/ hot air circulation.	6. Check.
		7. Oil level too low or high.	7. Keep the oil level within limits.
		8. Engine overloaded.	8. Check and reduce loads.
7.	Engine running	9. Lube oil pressure too low.	9. Engine has to be repaired at workshop.

	too hot.	10. Faulty fuel pump.	10. Repair the pump or replace as required.
		11. Choking of corrugated fins of cylinder.	11. Clean the cylinder fins with water jet during monthly schedule and clean the engine externally daily before and after the block with compressed air jet.
8.	Engine knocking	1. Incorrect Injector setting or defective injector	1. Remove the faulty injector and get it reset or alternatively replace it with new one.
		2. Mechanical damage to piston ring/liners.	2. Call in the service engineer.
		3. Connecting rod bearing damaged	3. Replace connecting rod bearing.
		4. Injection line leaky	4. Check the leakage.
		5. Fuel filter / fuel pre-filter contaminated.	5. Check/clean/replace.
		6. Incorrect tappet clearance.	6. Adjust tappet clearance.
		7. Faulty fuel pump.	7. Repair /Replace the pump.
9	Output of the engine too low.	1. Dirty fuel filters and fuel line.	1. Replace fuel filter and clean fuel line. Same as 3(1).
		2. Air in fuel system.	2. Bleed air from system as explained, same as 1(2).
		3. Faulty Injector/Fuel Pump.	3. Remove faulty injector/Fuel pump and get it overhauled or alternatively replace it with new ones
		4. Faulty valve clearances.	4. Adjust valve clearances same as Sl. No. 1(7).
		5. Air filter choked.	5. Clean/replace air filter element.
		6. Leakage of compression	6. Engine needs repairs in work-shop.
		7. Governor sticking.	7. Governor needs repairs in workshop
10	Oil pressure low.	1. Dirty lube oil filter.	1. Replace the lube oil filter element.
		2. Improper oil grade	2. Use proper grade of engine oil.
		3. Oil control valve not working.	3. Call the service engineer for repair of control valve.
		4. Oil level too low	4. Fill the oil up-to the required level
		5. Excessive inclination of engine	5. Check
		6. Dirty oil cooler.	6. Call in the service engineer for cleaning of the oil cooler.
		7. Excessive wear in connecting rod/ main bearing.	7. Engine needs to be overhauled in workshop.
		8. Mixing of diesel or coolant in Engine oil.	8. Call the service engineer of OEM.
11.	Oil film present in crank case	1. Incorrect compression.	1. Engine needs repairs at work-shop or call in the service engineer.
		2. Wrong grade of	2. Use lube oil of proper brand and grade as recommended

	ventilation.	lube oil.	by the OEM.
12.	Engine speed is irregular.	1. Air in fuel system.	1. Bleed air from the system , same as sl.no.1 (2).
		2. Governor struck-up.	2. Call in the service engineer. Governor needs repairs.
		3. Incorrect firing order	3. Adjust firing order (1,8,5,10,3,7,6,11,2,9,4,12).
		4. Incorrect fuel pump calibration.	4. Get the fuel pump calibrated through specified agency.
13	Fuel consumption too high.	1. Incorrect setting of Injector.	1. Replace or overhaul faulty injector.
		2 Incorrect valve and injection timing	2. Get the engine timing reset.
		3. Clogged air filter.	3. Clean air filter.
		4. Poor compression.	4. Call the service engineer. Engine needs repairs in workshop.
		5. Lube oil level too high	5. Keep the oil level within limits.
14.	Lube oil consumption too high.	1. Incorrect lube oil brand	1. Use proper grade and quality lube oil as recommended by OEM.
		2. Excessive inclination of engine.	2. Check.
		3. Oil level too high.	3. Keep the oil level within limits.
		4.Oil leaking from compressor.	4. Overhaul the compressor
		5.Poor compression.	5. Replace compression rings or valve, valve seat or lap.
		6. Broken or wrong piston rings / piston / liner.	6. Engine is due for overhauling.
15.	Mixing of diesel in oil.	1. Defective injector.	1. Replace the defective injector.
		2. Long idle periods	2. Do not run the engine at idle speed for long periods.
		3. Internal/external fuel leakage.	3. Prevent the leakage

TROUBLE SHOOTING GUIDE OF BALLAST CLEANING MACHINE (RM-80)

POSSIBLE DISTURBANCES IN TURBO-CHARGED DIESEL ENGINES WITHOUT BOOST PRESSURE CONTROL VALVES

16.1	Lack of power boost pressure too low.	1.0 Air filter system dirty. Suction and pressure pipes deformed and /or leaking.	1.0 Examine filter system, service or replace filter if required. Check and repair or replace pipes, tighten un-tight joints.
		1.1 Too high flow resistance in the exhaust gas system and / or leakage un-stream of turbine.	1.1 Check exhaust brake, pipes, gaskets and silencers, carry out repairs required.
		1.2 Injection unit and/or fuel system defective	1.2 Check setting values and function, correct if required.
		1.3 Compression too low	1.3 Check valves, cylinders and pistons, service or replace defective parts if required.

		1.4 Charge air cooler dirty.	1.4 Clean unit and replace if necessary.
		1.5 Turbocharger defective. Wheels rubbing on housing walls.	1.5 Examine turbocharger, repair or replace if necessary.
16.2	Power and / or boost pressure too high.	Injection unit defective	Check setting values and correct if required.
16.3	Black exhaust smoke.	Same as points 1.0, 1.3, 1.4, 1.5	See points 1.0, 1.3, 1.4, 1.5
16.4	Blue exhaust smoke	1. Worn valve guides and piston rings.	1. Measure blow-by volume at crankcase outlet. Overhaul engine if required.
		2. Compressor side and / or turbine-side sealing in the turbocharger defective.	2. Examine turbocharger, repair or replace it as required.
		3 Turbocharger oil drain-pipe clogged and / or deformed.	3. Clean oil drain pipe, repair if necessary.
16.5	Oil leakage at turbocharger.	1. Oil-feed pipe and/or oil drain pipe loose and leaking	1. Clean Turbocharger, check for leakage and rectify.
		2.Leakage at connection between compressor and bearing housings	2. Repair or replace turbocharger.

17.0 IMPORTANT: In case of engine failure during traffic block working

17.1	Machine stopped during working in block section/ engine no. 1 failed	Engine failed/cordon shaft connecting engine no. 1 and gear box failed/ Failure on main gear box no. 1 in block section.	Since engine no. 1 failed, to reduce the time and avoid process of connection and disconnection of pipes, the system is modified for speedy winding up. In this system arrangement has been made to receive hydraulic pressure from external source, so that various assemblies can be lifted and locked in case of failure of both the engines.
			After locking up the various assemblies such as chain trough, lifting unit etc, the machine can be moved with only engine no. 2 working and axle no. 3 & 4 powered. The electrical circuit of axle 1 and 2 automatically gets disconnected. When engine no. 1 shut down and separates isolation of these switches is not necessary.
17.2	Machine stopped during working in traffic block / engine no. 2 of the machine failed.	Engine no. 2 failed / cordon shaft connecting engine and gearbox failed/failure of main gearbox.	The winding of the machine can be done as usual because the hydraulic pump for these operations are run by the engine no. 1. After winding up, the machine can run with axle no. 1 and 2 powered. Electrical isolation of axle no. 3 & 4 takes place when engine no. 2 is shut down.

17.3	Both engine no. 1 and 2 failed in the block section.	It is not possible to start either of the engine during traffic block / working.	Immediately ask for assisting power. Separate backup system is not provided on this machine. Normally these machines are followed by tamping machines. In this case a separate hydraulic pipe can be connected from the tamping machine to the BCM as explained in item 15.1 and winding up of the machine can be carried out. For this purpose hydraulic pipe SAE 100R2 size 5/8" of 30 meter long with end fittings should be kept on the machine. After winding up, the section can be cleared by coupling to the tamping machine or by assisting engine. BCM other than Sl. No. 285 to 291 are provided hand operated hydraulic system (back up system) to wind up the machine.

TROUBLE SHOOTING MANUAL OF 09 –32 CONTINUOUS TAMPING MACHINE ENGINE (MWM TBD 232 V 12)

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.Bleed air from fuel system in the 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 priming pump until fuel emerges free of bubbles. Tighten the banjo plug.
		3. Shut down mechanism stuck	3. Check the electrical supply at coil if it is ok, then lubricate the piston of shut down coil mechanism with lube oil and operate it manually. If still not working, then coil may be defective. Replace it with new one.
		4. Air in fuel system.	4. Bleed air from fuel system as explained in s.no.1,item 2 above.
		5. Governor is stuck.	5. Call in the service engineer. Governor needs repairs.
		6. Misconnection of starting switch.	6. Check starting switch and if any misconnection is noticed, rectify it.
		7. Valve clearance is not proper.	To check valve clearances, follow these steps: Unscrew bolts and remove cylinder cover. Crank engine until the inlet valve is closed. Then turn approx. ½ turn further. The feeler gauge should pass between the valve cone end and the rocker lever with suction. If the valve clearances need resetting, loosen the lock nut and readjust by means of the set screw. Tighten lock nut and recheck valve clearances. Renew gasket, sealing ring and fit cylinder head cover.
		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 it overhauled/calibrated or alternatively replace it 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.

		11. Too much fuel in engine.	11. Clean fuel return pipe.
2.	Engine stops	1. No fuel.	1. Fill fuel in the tank and follow steps as 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 is not proper.	3. Adjust valve clearances. See s.no.1, item no.7 above.
		4. Governor is stuck.	4. Call in, the service engineer. Governor needs repairs.
		5. Overheating of engine	5. Take remedial action as in s.no.5 below.
		6. Shut down circuit fails.	6. Recheck and repair the circuit.
3.	Engine misfiring	1. Dirty fuel filter.	Check fuel filters and if necessary- i) Change fuel filter. ii) Change fuel filter elements. iii) Clean the inlet filter.
		2. No / less fuel in tank.	2. Fill fuel in the tank and follow step in s. no.1, item no.2.
		3. Air in fuel system.	3. Bleed air from the system. Same as s. no.1, item no.2.
		4. Defective Injector.	4. Remove the defective injector and get it overhauled / calibrated/ replace with new one.
		5. Valve clearance is not proper.	5 Adjust valve clearances as in s. no.1, item no.7.
		6. Fuel injection timing not proper.	6. Correct the timings or call the service engineer.
4.	Excessive engine smoking.	1. Engine oil level too high.	1. Check oil level. For this purpose, draw dipstick and clean with lint-free cloth. Return dipstick, wait a little until the oil has wetted the dipstick. Then remove dipstick again and check oil level.
		2. Defective injector	2. Same as s.no.1, item no.9.
		3. Valve clearance is not proper.	3. Same as s. no.1, item no.7.
		4. Air in fuel system.	4. Same as s. no.1, item no.2.
		5. Clogged air cleaner.	5. Clean element and change oil.
		6. Excessive carbon on cylinder head and piston.	6. De-carbonise the engine.
		7. Engine overloaded.	7. Check and reduce the load.
5.	Engine running too	1. Coolant level too low.	1. Check coolant level and top up with coolant up to the mark in the filler neck.

	hot.	2. Defective thermostat	2. Check thermostat as 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 water in container to approx. 85^{o} C and place thermostat in it. Maintain temperature of water by agitating. iv) By short circuiting and radiator opening, check whether the thermostat opens fully. If not, call in the Service Engineer to fit new thermostat. Or Alternatively check temperature of coolant in radiator for functioning of thermostat.
		3. Defective water pump.	3. Call in the service engineer to check/repair water pump.
		4. V-belt for water pump needs adjustment.	4. Remove V-belt guard and check V-belt tension. To adjust, release take-up pulley mount or generator and regulate tension in the belt. Then tighten the take-up pulley. If required, replace the V-belt.
		5. Oil cooler properly not working.	5. Call service engineer for repair/ replacement of Oil Cooler.
		6. Valve clearance is not proper.	6. Adjust valve clearance as explained in s. no.1, item no.7.
		7. Air filter is choked.	7. Clean air filter.
		8. RPM of coolant fan is too low.	8. Adjust RPM of the motor to 1650. Check hydraulic system and change pump and motor if necessary.
		9. Water radiator choked.	9. Get the radiator cleaned in work-shop.
		10.Radiator cap missing or worn out	10. Fit new cap.
		11. Water Hose too old.	11. Replace water hose.
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. Call in the service engineer.
		3. Valve clearance is not proper.	3. Adjust valve clearances, as explained in s. no.1, item no.7.
		4. Fuel injection timing not proper.	4. Same as s. no. 3, item 6.
7.	Output of the engine too low	1. Dirty fuel filter and fuel line.	1. Clean fuel filter see s. no.3, item no.1.
		2. Air in fuel system.	2. Bleed air from system as explained in s. no.1, item no.2.

		3. Defective Injector.	3. Remove defective injector and get it overhauled or replace it with new one.
		4. Valve clearances are not proper.	4. Adjust valve clearances as explained in s. no.1, item no.7.
		5. Air filter choked.	5. Clean air filter element and change oil.
		6. Improper compression	6. Engine needs repairs in workshop.
		7. Governor is stuck.	7. Call in the service engineer. Governor needs repairs.
8.	Oil pressure low.	1. Dirty lube oil filter.	1. Replace the lube oil filter.
		2. Oil control valve not working.	2. Call the service engineer for repair of control valve.
		3. Dirty oil cooler	3. Call in the service engineer for cleaning of the oil cooler.
9.	Oil film present in crank case ventilation	1. Incorrect compression.	1. Engine needs repairs in workshop.
		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. Call in the service engineer. Governor needs repairs.
11.	Fuel consumption too high.	1. Incorrect lube oil brand.	1. Use proper grade and quality lube oil.
		2. Incorrect setting of Injector.	2. Replace or overhaul Defective injector.
		3 Incorrect engine timing.	3. Get the engine timing reset.
		4. Clogged air filter.	4. Clean air filter.
		5. Poor compression	5. Engine needs repairs in workshop.
12.	Lube oil consumption too high.	1. Incorrect lube oil brand.	1. Use proper grade and quality lube oil as recommended by OEM.
		2. Poor compression	2. Engine needs repair in workshop.
		3. Oil filter dirty.	3. Replace the filter as explained in s.no.8 item no.1.

Sub-discipline:- INTERNAL COMBUSTON ENGINE (Lessons: X Sessions: 49)
Lesson-X: Maintenance Steps Session-47-49: 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.