I. C. ENGINES

Internal Comburstion Engines

Comparision of Petrol and Diesel Engines:

Petrol Engine	Diesel Engine
1. It works on Otto cycle.	It works on diesel cycle.
2. Air and petrol are mixed in the carburetor before they enter into the cylinder.	Diesel is fed into the cylinder by fuel injection and is mixed with air inside the cylinder.
3. It compresses a mixture of air and petrol and is ignited by an electric spark. (Spark Ignition).	It compresses only air and ignition is accomplished by the heat of compression. (Compression Ignition).
4. Cylinder is fitted with a spark plug.	Cylinder is fitted with a fuel injector.
5. Less thermal efficiency and more fuel consumption.	More thermal efficiency and less fuel consumption.
6. Compression ratio ranges from 7: 1 to 12: 1	Compression ratio ranges from 16:1 to 22:1
7. Less initial cost and more running cost.	More initial cost and less running cost.
8. Light weight and occupies less space.	Heavy and occupies more space.
9. Easy to start even in cold weather.	Difficult to start in cold weather and requires heater plugs.
10. Fuel (petrol) is costlier and more volatile.	Fuel (diesel) is cheaper and less volatile.
11. Used in light vehicles like cars, motor cycle, scooters, etc.	Used in heavy duty vehicles like tractors, trucks, buses, locomotives, etc.

Comparision0f Four Stroke and Two Stroke I.C. Engines:

Four Stroke Cycle Engine	Two Stroke Cycle Engine
1. One Working stroke for every two revolutions of the Crank shaft.	One working stroke for every revolution of the crank shaft.
2. Turning moment on the crank shaft is not even, hence heavier flywheel is required.	Turning moment on the crank shaft is more even, hence lighter flywheel is required.
3. More output due to full fresh charge intake and full burnt gases exhaust.	Less output due to mixing of fresh charge with the burnt gases.

4. Less fuel consumption	More fuel consumption.
5. Higher thermal efficiency.	Lower thermal efficiency
6. Engine design is complicated.	Engine design is simple.
7. Lesser rate of wear and tear.	Greater rate of wear and tear.
8. It has inlet and exhaust valves.	It has inlet and exhaust ports.
9. Engine is heavy and bulky.	For the same power, the engine is light and compact.
10. It requires lesser cooling and lubrication.	It requires greater cooling and lubrication. (consumes more lubricating oil)
11. Complicated lubricating system.	Simple lubricating system.
12. More initial cost.	Less initial cost.
13. Less running noise.	More running noise
14. Used in cars, buses, trucks, tractors, etc.	Used in mopeds, motor cycles, scooters, etc.

I.C. Engine Relations:

Indicated Power(IP):

The power developed inside the engine cylinder is called Indicated Power or IP.

The indicated power of the four stroke and two stroke engines are found as follows:

Let P_{mep} = Mean Effective Pressure, N/m^2

L = Length of Stroke, m

A = Area of Cross section of the Cylinder, sq m

N = RPM of the Crankshaft.

n = No. of cycles /min

Work Produced by the piston / Cycle = Mean Force Acting on the piston X Piston displacement in one stroke

$= P_{mep} * L * A$ N-m

Work Produced by the piston / min = Work Produced by the piston / Cycle X No. of Cycles / min

$= P_{mep} * L * A * n$ N-m/min

i.e., Indicated Power IP $= i * P_{mep} * L * A * n / 60000$ kN-m/sec or kW

where i = no. of cylinders

n = N/2 for four-stroke engine and N for a two stroke engine

In four stroke I.C. engines, one cycle will be completed in *two revolutions* of the crank shaft. Therefore the work will be produced in every *alternate revolutions of* the crankshaft. Thus the *number of cycles per minute will be equal to half the number of revolutions per minute.*

Brake Power:

The power developed by the engine at the output shaft or crank shaft is called brake power. Indicated power produced inside the engine cylinder is transmitted to the crank shaft through the piston, connecting rod and crank. A certain fraction of the indicated power produced inside the cylinder is lost due to friction of the moving parts of the engine. Therefore net power available at the crankshaft will be equal to the *difference between the Indicated power produced inside the engine cylinder and the power lost due to friction.* The net power available at the crankshaft is measured by applying the brake (offering resistance to the rotation of the crank shaft) and is therefore called *brake power. The amount* of the power lost in friction is called *friction power.* The *friction power is the difference between the indicated power and the brake power.*

Friction Power = Indicated power - Brake Power

$$FP = IP - BP$$

Brake power is calculated as follows:

W = Net load acting on the brake drum, kg

R = Radius of the brake drum, m

N = Revolutions per Minute of the crankshaft

T = Torque applied due to the net load W on the brake drum, N-m

= W*R kg-m

= 9.81*W*R N-m

Brake Power = $\dfrac{2\pi NT}{60000}$ kW

Mechanical Efficiency:

It is the efficiency of the moving parts of the mechanism transmitting the indicated power to the crank shaft. Therefore it is *defined as the ratio of the brake power and the indicated power.* It is expressed as a percentage.

Mechanical Efficiency = η_{mech} = BP / IP * 100

Thermal Efficiency:

It is the efficiency of conversion of the heat energy produced by the actual combustion of the fuel into the power output of the engine. Therefore *it is defined as the ratio of the power developed by the engine to the heat supplied by the fuel in the same interval of time. It is expressed in percentage.*

$$\text{Thermal Efficiency} = \frac{\text{Power Output}}{\text{Heat Energy Supplied by the Fuel}} * 100$$

The power output to be used in the above equation may be *brake power* or *indicated power* accordingly the thermal efficiency is called *brake thermal efficiency* or *indicated thermal efficiency.*

The brake thermal efficiency is defined as the ratio of brake power to the heat supplied by the fuel. It is expressed as a percentage.

$$\text{Brake Thermal Efficiency} = \frac{\text{Brake Power}}{\text{Heat Energy Supplied by the Fuel}} * 100$$

$$\eta_{bth} = \frac{BP}{m_f * CV} * 100$$

Where, m_f = mass of the fuel supplied kg/s
CV = Calorific Value of the fuel kJ/kg

The indicated thermal efficiency is defined as the ratio of indicated power to the heat supplied by the fuel. It is expressed in percentage.

$$\text{Indicated Thermal Efficiency} = \frac{\text{Indicated Power}}{\text{Heat Energy Supplied by the Fuel}} * 100$$

$$\eta_{ith} = \frac{IP}{m_f * CV} * 100$$

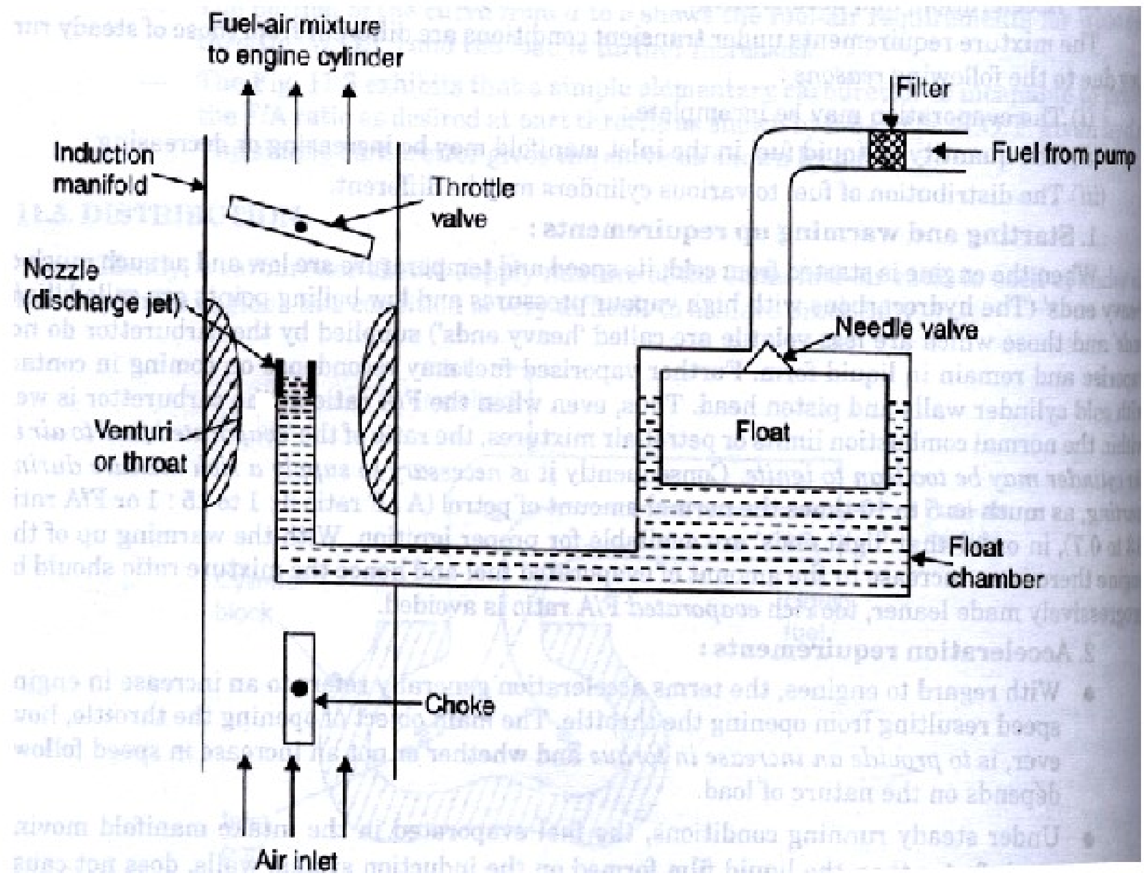
Carburettor

Function: The main function of a carburetor is to vaporize & atomize the fuel & to mix thoroughly with air at a fixed normal proportion.

Vaporization: Change in state of fuel from liquid to vapour.

Atomization: Breaking up of the fuel into small particles.

Working of a Simple Carburetor:



- As the fuel level drops, the float comes down thereby opening the needle valve and enabling the petrol to enter into the float chamber.
- Purpose of needle valve is to maintain a constant level of petrol in the float chamber.
- During suction stroke, pressure at the throat reduces and because of the reduced pressure developed at the venturi region petrol comes out of the nozzle as a fine spray & gets vaporized.

- The amount of petrol issuing from the jet is proportional to the velocity of air flowing through the venturi tube which in turn depends upon the position of the throttle valve operated by the accelerator.
- Choke is used for starting the engine when it is in the cold condition.

Lubrication

Purpose of lubrication:

- To reduce the friction between the surfaces of machine parts.
- To carry away the heat generated due to friction & to cool the parts.
- To clean the parts by washing away the deposition of carbon & metal particles caused by wear.
- To seal the space between the piston & cylinder & to prevent the leakage of working fluid.
- To cushion the parts against vibration & impact.

Types of lubricants:

Type of lubricant	Examples	Application
Solid lubricants	Wax, graphite, soap, graphite with grease	Used where oil film cant be maintained due to high pressure
Liquid lubricants	Mineral oils, vegetable oils, animal oils	Ordinary machinery, steam & I C engines.
Semi solid lubricants	Grease	Used where low speed & high pressure exist.

Properties of an ideal lubricant:

1. **Viscosity:**

   It is the property of a lubricant by virtue of which it offers resistance to shear. If the viscosity is too low, then a liquid film cannot be maintained between the two moving surfaces. If the viscosity is too high, then it will offer resistance to the moving surfaces of the parts. Viscosity decreases with increase in temperature. Viscosity of an ideal lubricant should not change with varying operating temperature

2. **Flash & fire points:**

   Flash point:

   It is the lowest temperature at which the fumes of oil will not catch fire but the flash occurs when the flame is brought into contact with it.

   Fire point:

   It is the lowest temperature at which the oil fumes catches fire & will continue to burn when the flame is brought in contact with it.

   So a good lubricant should posses a flash point temperature higher than the temperature at which it is used.

3. **Oiliness:**

It is the ability of the lubricating oil to adhere to the rubbing surfaces. When a thin film of oil is subjected to high pressure, the oil film will be squeezed out of the lubricated surfaces. So a good lubricant should adhere to the surfaces and maintain an oil film between the rubbing surfaces.

4. **Cloud & pour points:**

   Cloud point:

   It is the temperature at which the wax & other substances in the oil separate out from the oil, when the lubricant oil is cooled.

   Pour or freezing point:

   It is the temperature at which the oil stops to flow when cooled.

   These two points will indicate the suitability of lubricants for use in cold conditions.

5. **Carbon residue:**

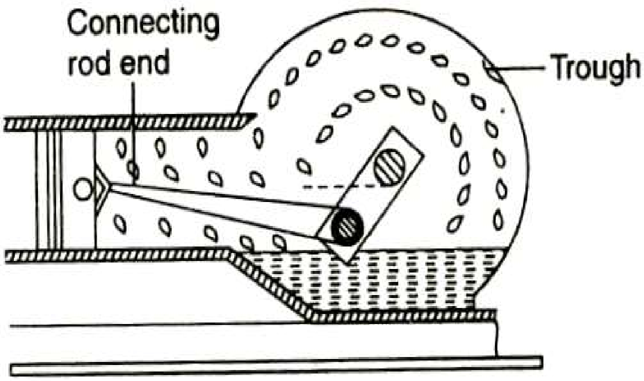
Lubricant oil contains high percentage of carbon in combined form. At higher temperature, they decompose depositing a certain amount of carbon. The deposition of carbon is highly objectionable. A good lubricant oil should deposit a least amount of carbon while in use at higher temperatures.

6. **Volatility:**

When working temperatures are high, some oils vaporize leaving behind a residual oil having different lubricating properties. A good lubricating oil should have low volatility.

Commonly used lubrication systems in I. C engines:

Splash lubrication:



Splash lubrication is generally used in a 4 stroke IC engine to lubricate parts such as cylinder, piston, gudgeon pin, connecting rod, bearings etc.

The oil is contained in the crank case of the engine.

As the piston reciprocates up and down the crank with the big end of the connecting rod partly dips into the oil sump and continuously splashes the oil to the surfaces of the cylinder and the piston.