Application of Pumps

(1) Reciprocating Pump
(2) Centrifugal Pump
(3) Compressor Pump
(4) Submergible pump
} To pump water to overhead tank in building and also for agriculture

(5) Vane pumps – To pump semi viscous liquid.

(6) Gear pumps – To pump viscous oil for lubrication

(7) Injector Pumps – To pump boiler feed water during its operation

(8) Different types of fuel pumps – To pump petrol or diesel oil in I C engine

(9) Screw Pump – To pump liquid mixed with solid material.

Reciprocating Pump :- classified as

(1) Single Acting
(2) Double Acting

Working of a Single Acting Pump (Reciprocating)

Parts :-

(1) cylinder with a piston
(2) Piston rod, connecting rod, crank and crankshaft
(3) Suction pipe with foot valve and filter
(4) Delivery pipe
(5) Suction valve
(6) Delivery valve

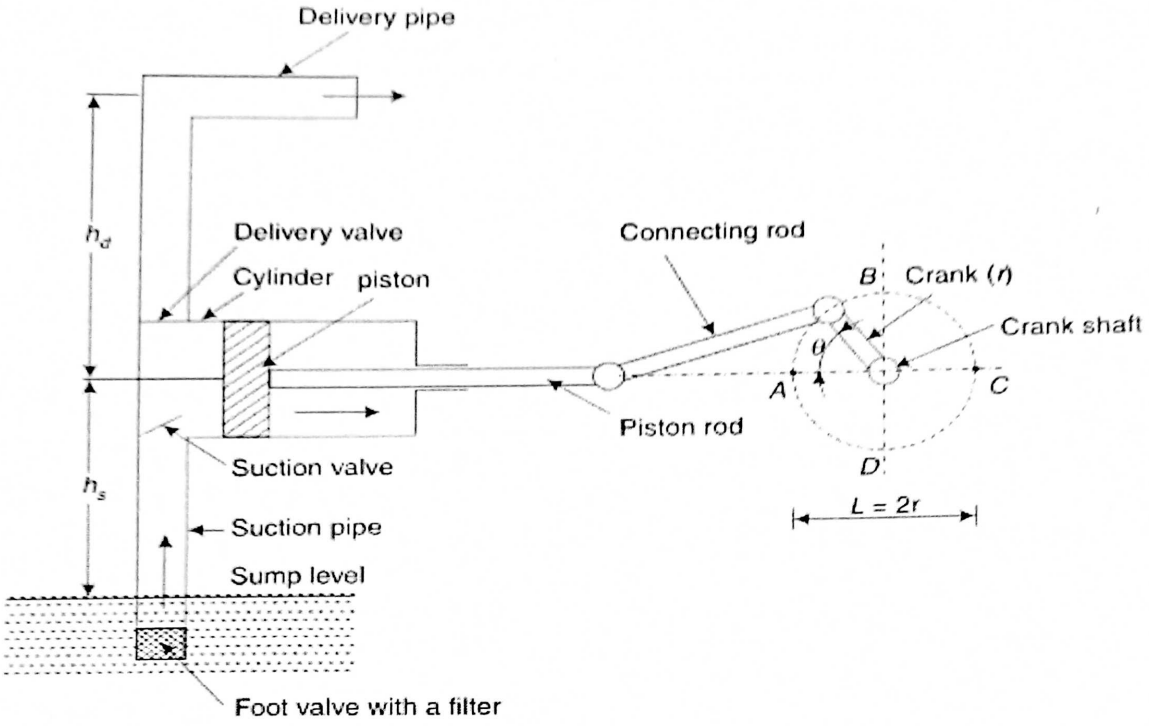
The crankshaft is coupled to an electric motor or diesel engine. When motor or engine started the piston moves to and fro inside the cylinder. When the piston moves right in the direction of arrow a vacuum will be produced in the cylinder due to which the suction valve open and water is sucked up from the sump and enters the cylinder through suction pipe

When the piston moves in left direction pressure is created in water due to which the delivery valve is opened and water is forced into the delivery pipe and finally to the required height.

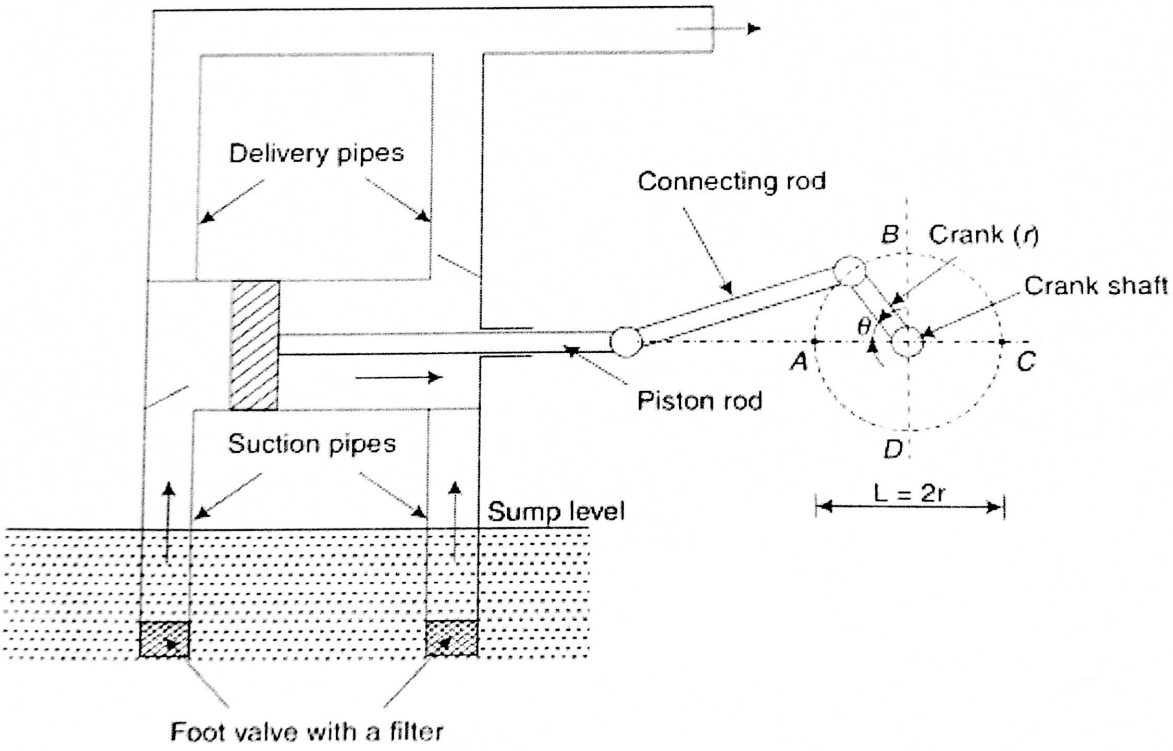
Working of Double Acting pump

In the double acting pump water acts on both sides of piston there are two suction pipes and two delivery pipes. When there is a suction stroke on one side of the piston there will be a delivery stroke on the other side of the piston. Thus for each revolution of the crankshaft there will be two delivery strokes and so double the amount of water is delivered by this pump.

Single Acting Reciprocating Pump



Double Acting Reciprocating Pump



Difference Between Single Acting and Double Acting Pumps

Sl no	Single Acting	Double Acting
(1)	One Suction Pipe	(1) Two suction Pipe
(2)	One delivery pipe	(2) Two delivary pipes
(3)	water act one side of the piston	(3) water acts both side of the piston
(4)	During one rotation of the shaft there is only one valve	(4) Two delivary stroke
(5)	water pumped will be less	(5) Double the amount
(6)	Power of the motor or engine less	(6) Higher power required
(7)	cost is less	(7) Cost is more.

Advantage of Reciprocating pump

(1) It can deliver the required flow rate very precisely
(2) It can deliver fluid at very high pressure.
(3) No priming is the needed in Reciprocating pump.
(4) Efficiency of reciprocating pump is 10% to 20% greater than the efficiency of Centrifugal pump.
(5) It give continous rate of discharge

Disadvantges of Recipro cating pump

(1) The pump is very costly (Capital cost is high)

(2) Viscous fluid are difficult to pump with reciprocating pump

(3) The maintenance cost of the pump is very high. as there is a large number of parts.

(4) The flowrate is less.

Application of Reciprocating pump.

(1) It is used in vehicle washing center

(2) It is used in cycle pump football pump etc

(3) It is used in hydraulic jack.

(4) It is continously used in pneumatic pressure system

(5) It is used in gas Industries

(6) It is also used in oil Industry

(7) It is also used in petroleum Industry

Centrifugal Pump

Main part of centrifugal Pump

(1) Impeller
(2) Casing
(3) Suction pipe fitted with a foot valve and filter will not allow water to come down.
(4) Delivery pipe

Impeller

The Impeller is a metallic disc fitted with number of curved vanes Initially water will be poured inside the casing and process is called priming. So after priming the impeller will be immersed in water inside the casing. when the Impeller is rotated by an electric motor or an engine it will produce centrifugal force due to which kinetic energy or velocity energy will be produced in the water this is finally converted into pressure energy due to which water is pumped.

Casing

The casing surround the Impeller. The area between the

Impeller and casing is gradually increasing till the delivery pipe Due to this the velocity of flow of water will be gradually decreased. Due to the reduction in kinetic energy the pressure energy of water is increased. The following three type of casing normally used:-

(1) Volute casing
(2) Vortex casing
(3) Casing with Guides Vanes or Diffuser Casing.

(1) Volute Casing

The gap between the Impeller and casing is comparatively less, so eddies or turbulence will be formed which reduce the efficiency of the pump. However the size of the casing will be small and the cost of will be less.

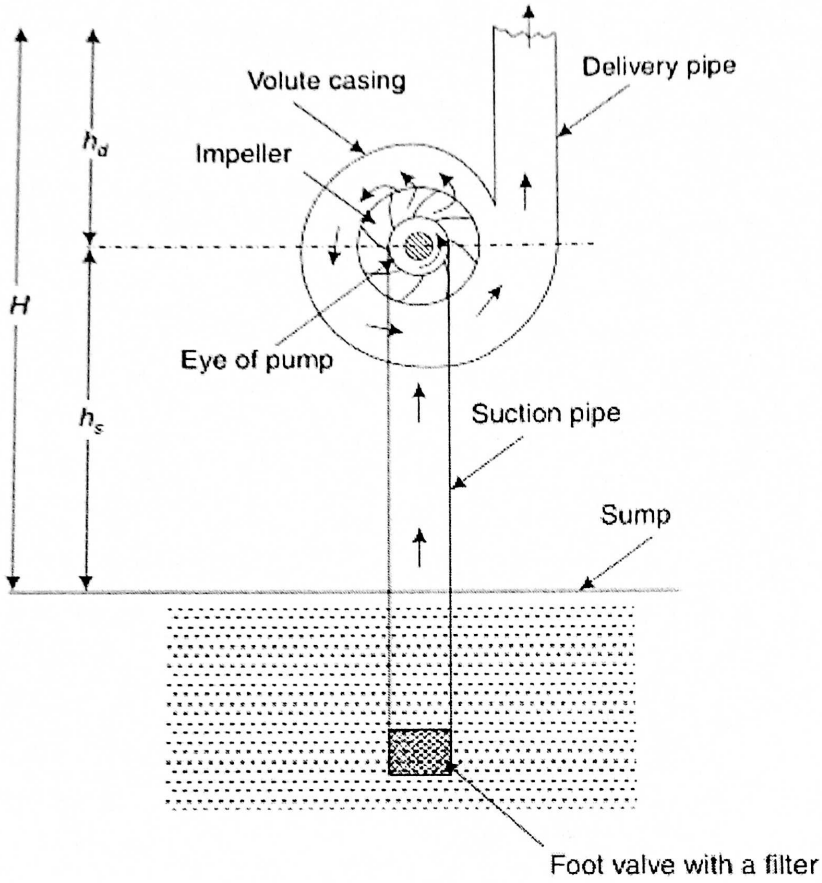
(2) Vortex casing

The space between the Impeller and casing is increased by introducing a circular chamber its eddies and turbulence are reduced the efficiency of the pumps with Vortex casing is increased

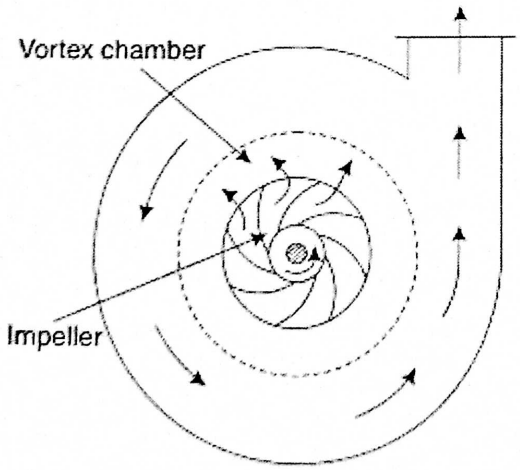
(3) Casing with Guide Vanes or Diffuser Casing.

The Impeller is surrounded by a set of guide vanes or diffuser. The shape of guide vanes should be carefully designed to ensure that the water flow from the Impeller enter the guide vanes without shock. Gradual increase in area of guide vanes reduce the velocity of flow resulting in pressure increase.

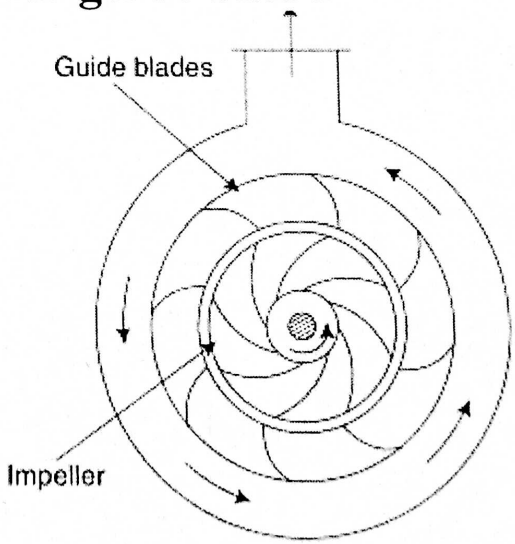
Centrifugal Pump



Vortex casingCasing with guide blade



(a) Vortex casing



(b) Casing with guide blade

Difference between Reciprocating & Centrifugal pump

Sr.No	Reciprocating Pump	Centrifugal Pump
(1)	Can be used for high head	(1) Medium Head
(2)	Can pump less quantity	(2) Large quantity can be pumped.
(3)	Discharge is not continuous	(3) continuous flow.
(4)	Cost is high	(4) cost is low
(5)	Cannot run at high speed	(5) Can run at high speed.
(6)	Cannot run or pump with viscous fluid	(6) Can pump viscous fluid.

Advantages of Centrifugal Pump

(1) centrifugal pump does not have leakage issue.

(2) they can able to pump hazardous as well as sensitive fluid

(3) There is no problem of heat transfer as the space between the motor and chamber is sufficiently large.

(4) There is no power loss due to friction and they are very simple in structure and easy in handling.

Disadvantage of Centrifugal Pump

(1) Manage resonance in centrifugal pump result in small loss of energy.
(2) The risk of the clogging of pipe may arise due to particle attraction nature of magnetic drive.
(3) Vibration due to surrounding atmosphere can damage their pump.
(4) The risk of cavitation is always there.

Application of Centrifugal pump

(1) These pump are used in building in regular water supply.
(2) They are used for fire protection related system.
(3) Centrifugal pumps are used in pharmaceutical Industry.
(4) They are also used coolent recirculation
(5) Used in refrigeration system to flow the refrigerants
(6) These pumps are used in sprinkling, Irrigation drainage system.

I C Engine

Internal Combustion Engine has extensively used in transport by road, rail, sea and air. IC engine have led to major revolution in transport

Classification of I.C. Engine: In following ways

(1) According to the type of fuel used
  (1) petrol Engine
  (2) Diesel Engine
(2) According to the cooling system
  (1) Air cooled
  (2) water cooled
(3) According to the cycle of operation
  (1) four stroke cycle engine
  (2) Two stroke cycle Engine
(4) According to the charge pressure.
  (1) Naturally aspirated engine
  (2) Supercharged/turbocharged engine for higher capacity.
(5) According to the number of Cylinder
  (1) Single cylinder engine

(2) Multi cylinder engine

Main parts of I.C. Engine

(1) cylinder

The cylinder allow the piston to move to and fro. The cylinder is made of cast iron, steel or an aluminium alloy. Sometimes it made by cast-iron.

(2) Cylinder Head.

It is fitted at the top of cylinder. A gasket is provided between cylinder and cylinder head to prevent the leakage of hot gases. The cylinder head also accomodates Inlet, Exhaust valve, sparkplug and injector etc.

(3) piston

It transmit the force exerted by burning gases to the connecting rod and finally to crankshaft. The piston is made of cast-iron or steel or aluminium alloy. The diameter of piston in a large engine is about 1 meter.

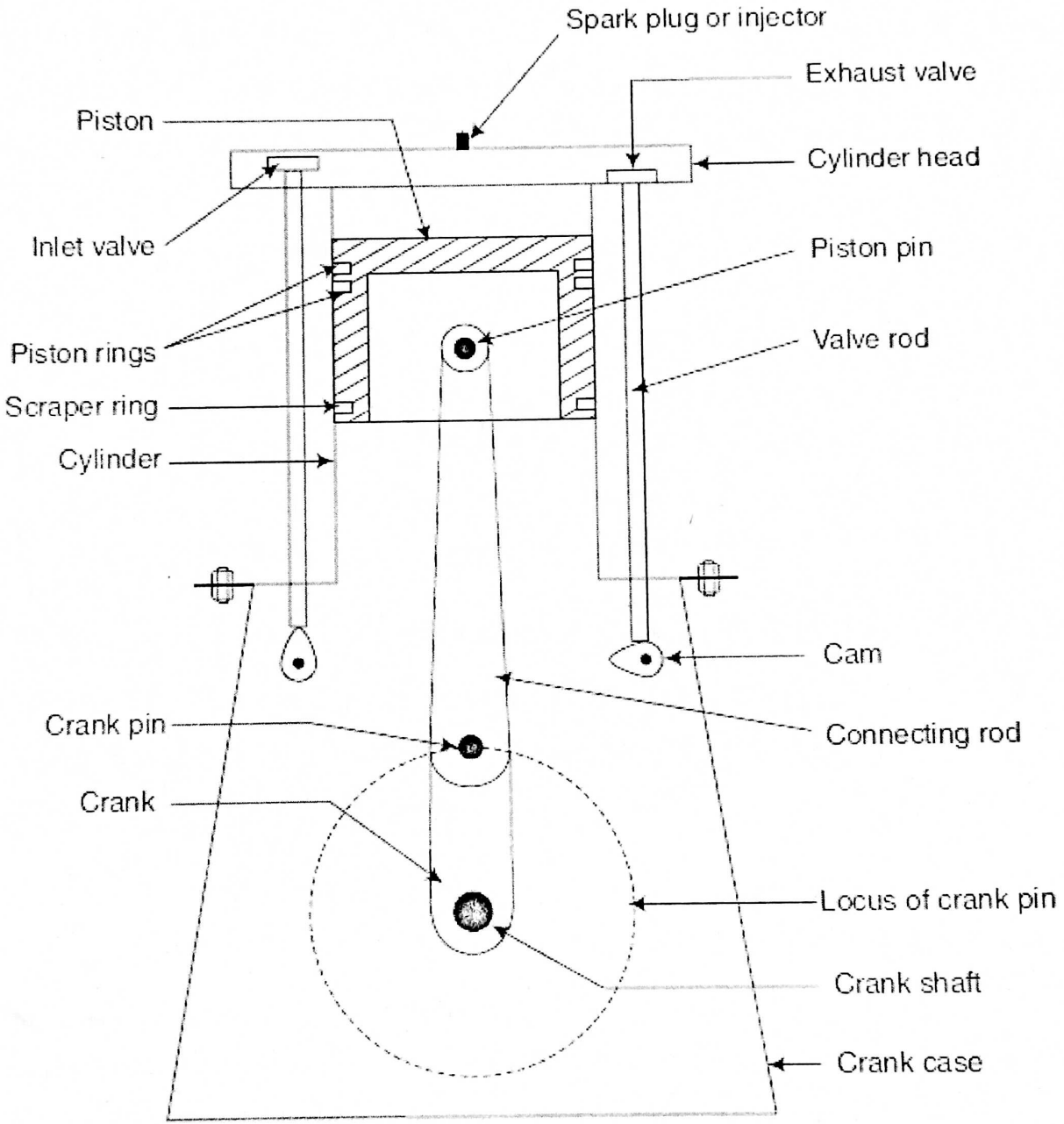
(4) Piston Ring.

Two different types of piston rings are houses in circumference grooves provided on the outer surface of ~~gas~~ piston. The function of upper rings known as compression ring is provided gas tight sealing to maintain compression pressure inside the cylinder and to prevent the leakage of burnt gases into the crankshaft. The function of lower Rings is to scrap the used lubricating oil into the crank case. this ring is called Scraper ring or Oil Ring.

(5) Connecting Rod.

This transmit the force from the piston to crankshaft

Main Parts of IC Engine



It is also helps to converting the reciprocating motion of the piston into the rotary motion of the crank shaft. for lubrication of piston pin in the connecting rod a small hole is provided from big end to small end. The small end of connecting rod is attached to the piston by a piston pin or gudgeon pin.

Crank Shaft

Alloy steel are used to the crank shaft to withstand high stress and strain. The crankshaft is provided with suitable holes to help in lubrication system. The crank serve as a sump for lubricating oil.

Flywheel

It is mounted on the crankshaft. The flywheel store the excess energy during the power stroke of the engine and help the movement of the piston during the remaining idle strokes.

Cams

properly designed cam control the opening and closing of the Inlet and exhaust valve. in the case of four stroke engine cam are rotated by a cam shaft driven by Crank shaft through gear.

Compression Ratio

$$\text{Compression Ratio} = \frac{V_s + V_c}{V_c}$$

V_c = Clearance Volume

V_s = Swept Volume or Stroke Volume

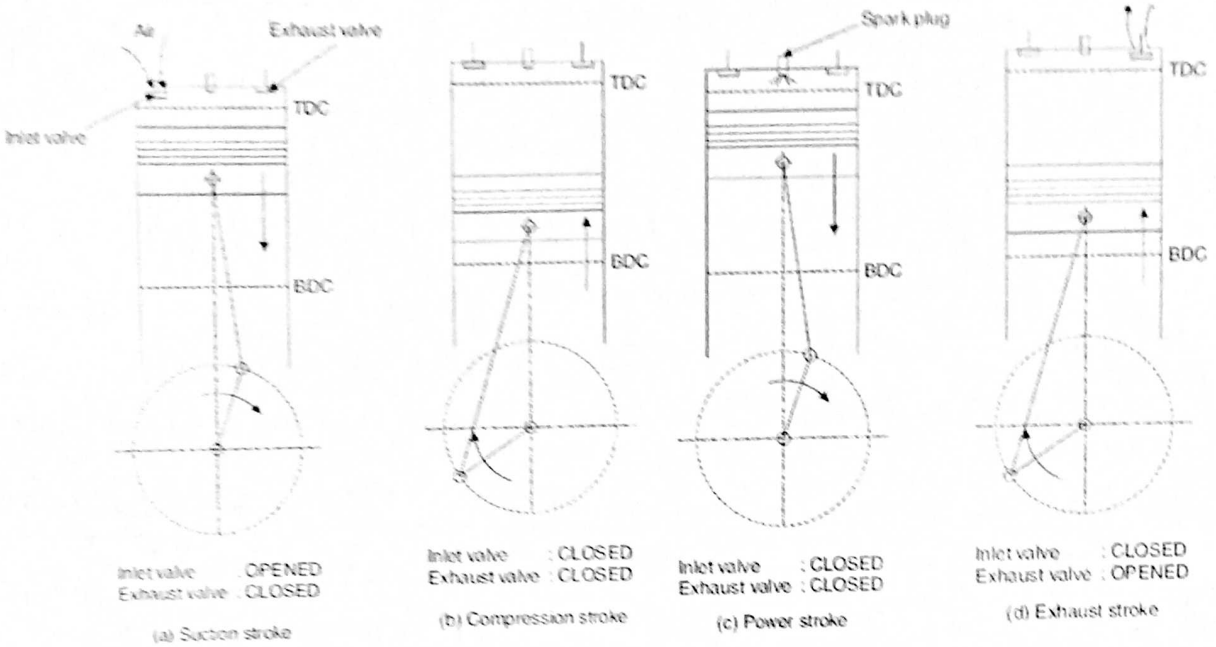
Working of Four Stroke petrol Engine

a) Suction Stroke During this stroke the Inlet valve is kept opened and exhaust valve is closed. The piston come down to the bottom dead centre (BDC) from the top dead centre (TDC). Pressure in the cylinder will be slightly less than the atmospheric pressure. petrol air mixture is correct proportion from carburator is drawn inside the Engine cylinder through inlet valve.

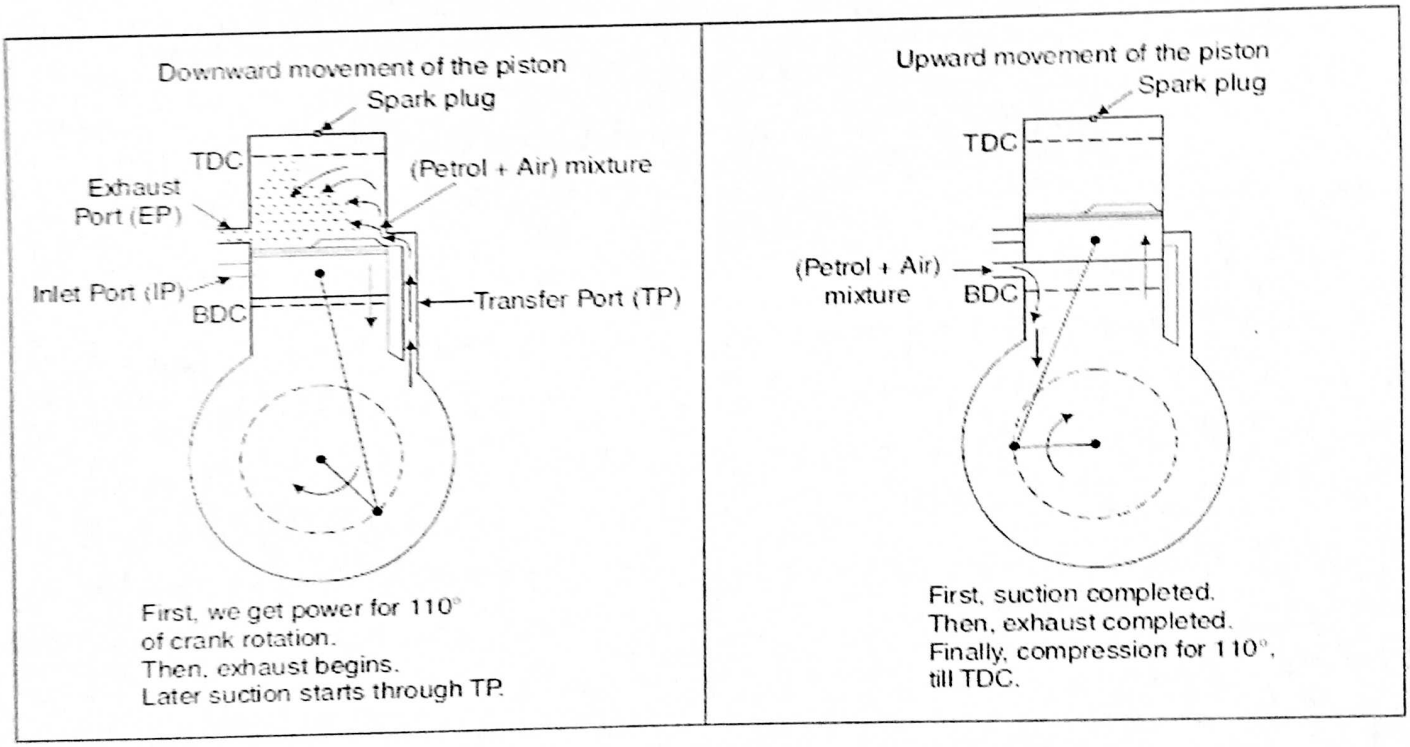
(2) Compression Stroke In this both Inlet and exhaust valve closed. The air fuel mixture is compressed when piston moved up to TDC. The compression ratio varies from 7 – 10 for petrol engine. The ratio between the cylinder volume before compression to the volume after compression is called compression Ratio. At the end of Compression ~~ratio~~ stroke a spark is produced at a spark plug due to which combustion start resulting in high pressure and temperature which are comparatively less than that of a diesel engine

(3) Power Stroke During this stroke both valves are kept closed. The piston is pushed down from TDC to BDC The force above the piston is transmitted to the crank shaft through the connecting rod and crank Mechanism Excess energy due to combustion is stored in the flywheel which kept operation for other three idle stroke.

Four Stroke Engine



Two Stroke Engine



(4) Exhaust Stroke During the stroke the exhaust valve is kept opened and inlet valve is kept closed. The piston moves up from BDC to TDC. The waste gases are sent out through the exhaust valve and the cycle is repeated.

During these four strokes the crank shaft will make two revolutions. The thermal efficiency of a four stroke engine is higher compared to a two stroke cycle engine. Most of cars operates on a 4 stroke engine.

Four Stroke Diesel Engine

Diesel engine are also called compression ignition engine. there is no need for a spark plug.

(1) Junction Stroke :- During this stroke Inlet valve open and exhaust valve closed. The piston moved from TDC to BDC. pressure in cylinder will be slightly less than the atmospheric pressure. Air is drawn inside the engine cylinder through inlet valve.

(2) Compression Stroke :- During this stroke Both inlet and exhaust valves closed. The air is compressed when piston moved from BDC to TDC. The compression ratio varies from 15-20 for diesel Engine. Due to high Compression higher temperature is obtained in the range of 550°c. At this junction diesel oil at high pressure is injected inside

the hot compressed air in an atomised form. Due to the special shape of combustion chamber the mixing of fuel and air takes place rapidly and mixture is ignited due to the high compression ratio temperature without the help of sparkplug. Hence the diesel engine is also called Compression Ignition engine (C I engine) Due to combustion very high pressure is produced.

Power Stroke :- During this both inlet and exhaust ~~strok~~ valve is kept closed. The piston is pushed down from TDC to BDC. The force above piston is transmitted to the crank shaft through connecting rod and crank mechanism Excess energy due to combustion is stored in flywheel which helps the operation of three idle strokes.

Exhaust Stroke :- During this stroke the both valves are in different position exhaust valve opened and closed the Inlet Valve. The piston moved from BDC to TDC the waste gases are sent through the exhaust Valve and cycle is repeated.

During these four strokes the crankshaft will make two revolution. The thermal efficiency of a 4 stroke engine is higher compared to 2 stroke cycle engine. At present most of Cars operated on 4 stroke cycle.

Difference Between Petrol and Diesel Engine

	Petrol Engine	Diesel Engine
(1)	Compression Ratio 7-10	(1) Compression Ratio 15-20
(2)	Petrol air mixture is compressed	(2) air is compressed
(3)	compression pressure 15-20 bar	(3) compression pressure 30-40 bars.
(4)	Thermal efficiency low in 20-25%.	(4) thermal efficiency is 25-30%.

S NO	Petrol Engine	Diesel Engine
(5)	Spark plug needed	(5) No Need of spark plug
(6)	Due to low pressure thickness of parts is less	(6) Due to high pressure thickness of parts is more.
(7)	weight of engine is less	(7) weight of engine is more.
(8)	cost of engine is less	(8) Cost of engine is more
(9)	Operating cost per km is high due to high cost of petrol	(9) Operating cost per km is comparatively low due to low cost

Two stroke engine.

(1) Petrol - two stroke petrol engine
(2) Diesel - two stroke Diesel engine.

Cooling system of engine

(1) water cooling system
(2) Air cooling system

Lubricating system

Types of lubricants

(1) liquid like mineral oil vegitable oil etc
(2) semiliquid like grease
(3) solid lubricants like graphite powder with oil or grease.

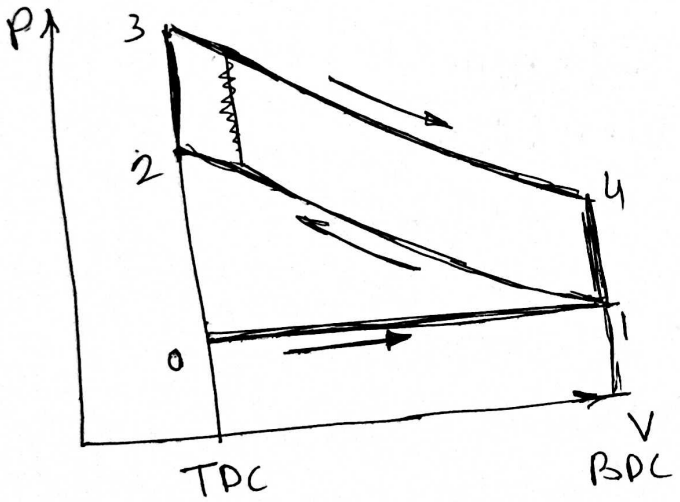
Types of lubrication system

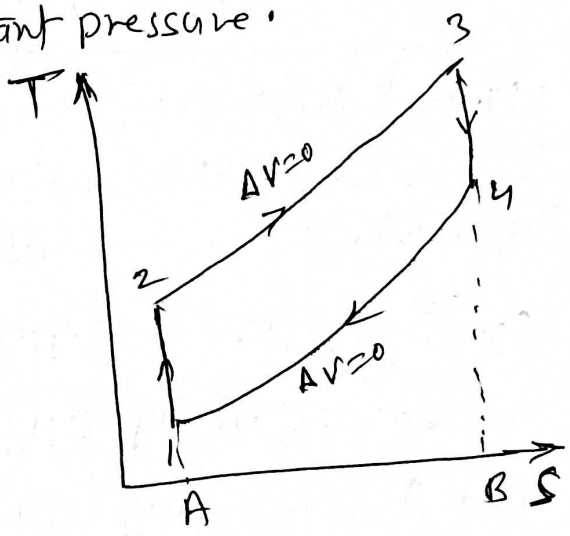
(1) Splash lubrication system
(2) Pressure lubrication
(3) Petroil lubrication

Working cycle

Otto cycle

It is thermodynamic cycle that describe the function of spark ignition piston engine. The otto cycle consist of isentropic compression heat addition at constant volume, isentropic expansion and rejected of heat at constant volume in the case of four stroke otto cycle there are two additional processes one for the exhaust of waste heat and combustion product at constant pressure (isobaric) and one for intake of cool oxygen rich air also at constant pressure.





(1) Process 0–1
A mass of air is drawn into cylinder at constant pressure.

(2) Process 1-2
It is an adiabatic (isentropic) compression of the charge as at piston moves from BDC to TDC

(3) Process 2-3
It is a constant volume heat transfer to the working

- gas from an external source while piston moves from TDC. The process is intended to represent the ignition of the air fuel mixture and subsequent rapid burning

(4) Process 3-4

It is an adiabatic (isentropic) expansion power stroke

(5) Process 4-1

Complete the cycle by a constant volume process in which heat is rejected from the air which piston is at BDC

(6) Process 1-0

The mass is released to the atmosphere in a constant pressure process

Efficiency of Otto cycle

In the process from 1 to 2 and 3 to 4 are isentropic

$$T_4 V_1^{\gamma-1} = T_3 V_2^{\gamma-1}, \quad T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$$

$$(T_4 - T_1) V_1^{\gamma-1} = (T_3 - T_2) V_2^{\gamma-1}$$

$$\frac{T_4 - T_1}{T_3 - T_2} = \left(\frac{V_2}{V_1}\right)^{\gamma-1}$$

$$= \left(\frac{1}{r}\right)^{\gamma-1} \qquad \frac{V_1}{V_2} = \frac{V_1}{V_2} = r \text{ compression ratio}$$

$$\frac{V_1}{V_2} = r.$$

Efficiency $\eta = \frac{\text{work}}{\text{heat Input}}$

$$\eta = \frac{Q_H + Q_L}{Q_H} = 1 + \frac{Q_L}{Q_H}$$

Heat absorbed = $C_v(T_3 - T_2)$

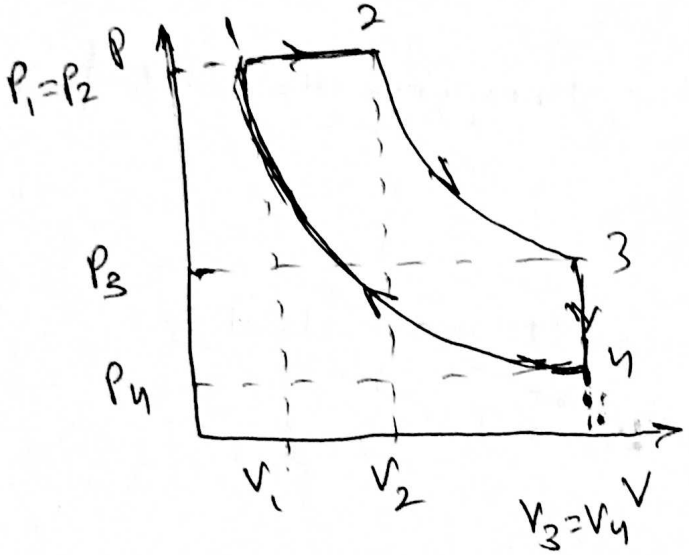
Heat rejected = $C_v(T_1 - T_4)$

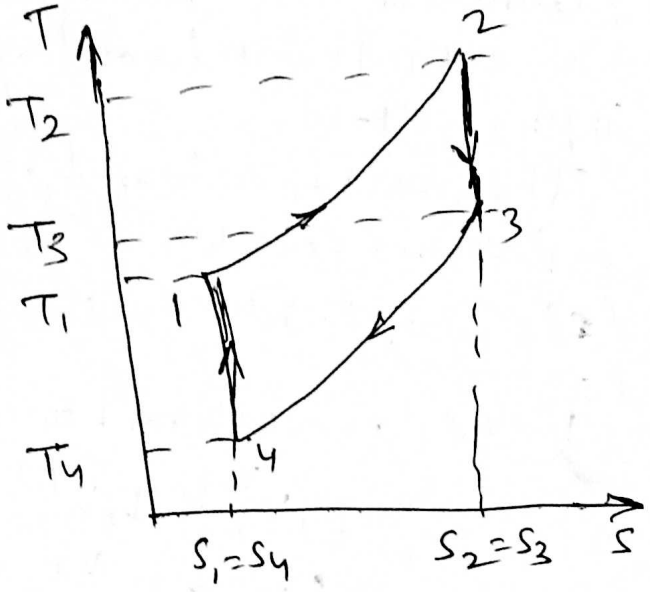
Hence $$\eta = 1 - \frac{T_4 - T_1}{T_3 - T_2}$$

$$\eta = 1 - \frac{1}{r^{\gamma-1}}$$

The heat exchange is positive if heat is flow into the system so Q_L is negative.

Diesel Cycle





① Process 1-2 (Constant Pressure heating)

The air is heated at constant pressure from Initial Temp. T_1 to temp T_2 The heat is cutoff at point 2 so called cutoff point

Heat supplied to air = $mC_p(T_2 - T_1)$

② Process (2-3) Adiabatic Expansion

The air is adiabatically expanded from T_2 temp to T_3 temperature

(3) constant Volume cooling process 3-4

The air is now cooled at constant volume from temp. T_3 to a temp T_4

Heat rejected by the air = $m c_v (T_3 - T_4)$

(4) Process 4-1 (Adiabatic Compression)

The air is compressed adiabatically from temp. T_4 to T_1

work done = Heat supplied − Heat rejected

$= m c_p (T_2 - T_1) - m c_v (T_3 - T_4)$

Air standard efficiency $= \eta = \frac{\text{Work done}}{\text{Heat supplied}}$

$= \frac{m c_p (T_2 - T_1) - m c_v (T_3 - T_4)}{m c_p (T_2 - T_1)}$

$= 1 - \frac{c_v (T_3 - T_4)}{c_p (T_2 - T_1)}$

$= 1 - \frac{1}{\gamma} \frac{(T_3 - T_4)}{T_2 - T_1}$

Compression Ratio $r = \frac{V_4}{V_1}$

cut off ratio $\rho = \frac{V_2}{V_1}$

Expansion Ratio $r_1 = \frac{V_3}{V_2} = \frac{V_4}{V_2}$ $\because V_3 = V_4$

$$= \frac{V_4}{V_1} \times \frac{V_1}{V_2} = \frac{r}{e}$$

$$= r \times \frac{1}{e} = \frac{r}{e}$$

Constant pressure heating process (1-2)

$$= \frac{V_1}{T_1} = \frac{V_2}{T_2} \text{ (Charls law)}$$

$$\therefore T_2 = T_1 \times \frac{V_2}{V_1} = T_1 \times e$$

Similarly adiabatic Compression process (2-3)

$$\frac{T_3}{T_2} = \left(\frac{V_2}{V_3}\right)^{\gamma-1} = \left(\frac{1}{r_1}\right)^{\gamma-1} = \left(\frac{e}{r}\right)^{\gamma-1} \qquad r_1 = \frac{r}{e}$$

In adiabatic compresision process (4-1)

$$\frac{T_1}{T_4} = \left(\frac{V_4}{V_1}\right)^{\gamma-1} = (r)^{\gamma-1}$$

$$T_1 = T_4 (r)^{\gamma-1}$$

Subsitude the value of T_1 we get

$$T_2 = T_4 (r)^{\gamma-1} \times e$$

$$T_3 = T_4 (r)^{\gamma-1} \times e \left(\frac{e}{r}\right)^{\gamma-1} = T_4 e^{\gamma}$$

Now substitute the value of T_1, T_2 and T_3 we get

$$\eta = 1 - \frac{1}{\gamma}\left[\frac{T_4 e^{\gamma} - T_4}{T_4 (r)^{\gamma-1} e - T_4 (r)^{\gamma-1}}\right]$$

$$= 1 - \frac{1}{\gamma^{\gamma-1}}\left[\frac{e^{\gamma} - 1}{\gamma(e-1)}\right]$$

Battery or Coil Ignition system

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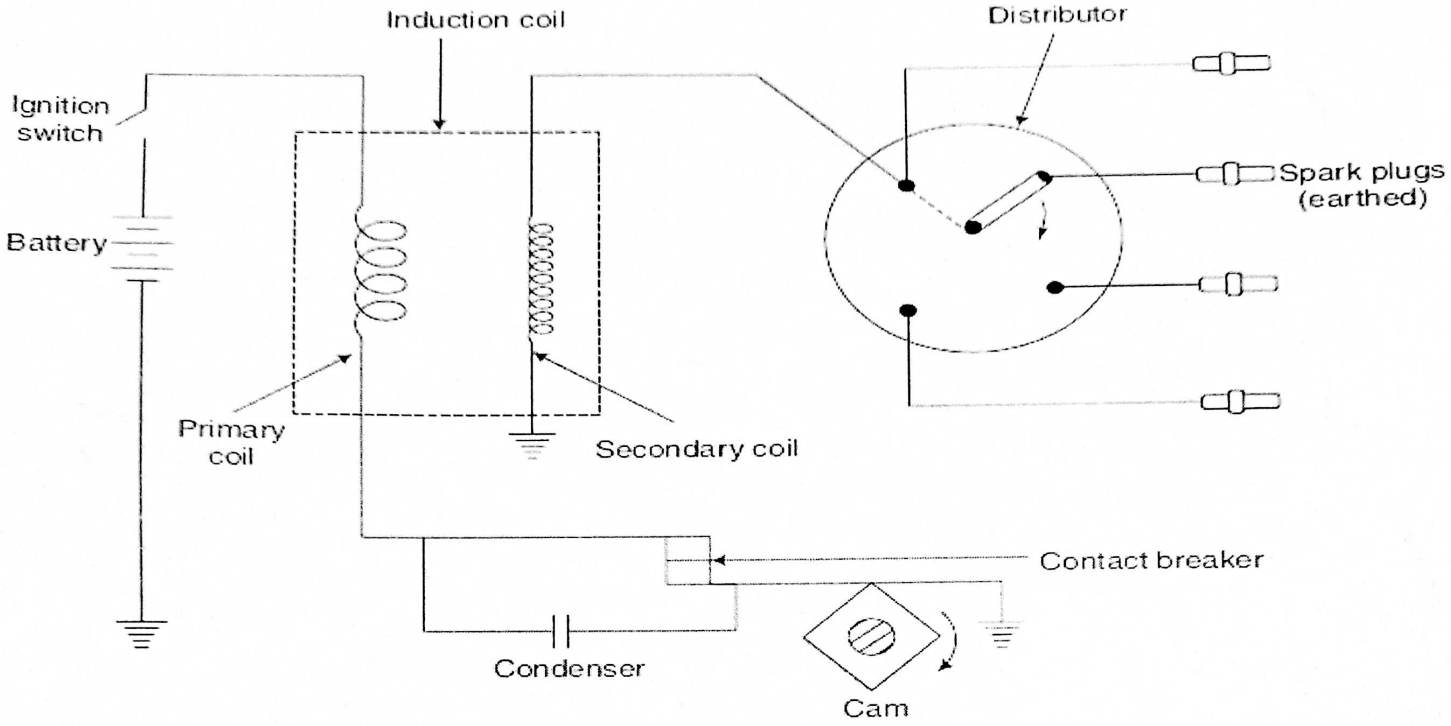

Cooling System