B.Tech.

First Semester Examination

Basics of Mechanical Engineering (ME-101F)

Q. 1. (a) Explain with neat sketch working and construction of Cochran Boiler.

Ans. **Cochran Boiler**: **It** is a type of vertical multi-tubular boiler and has a number of horizontal fire tubes.

Construction :

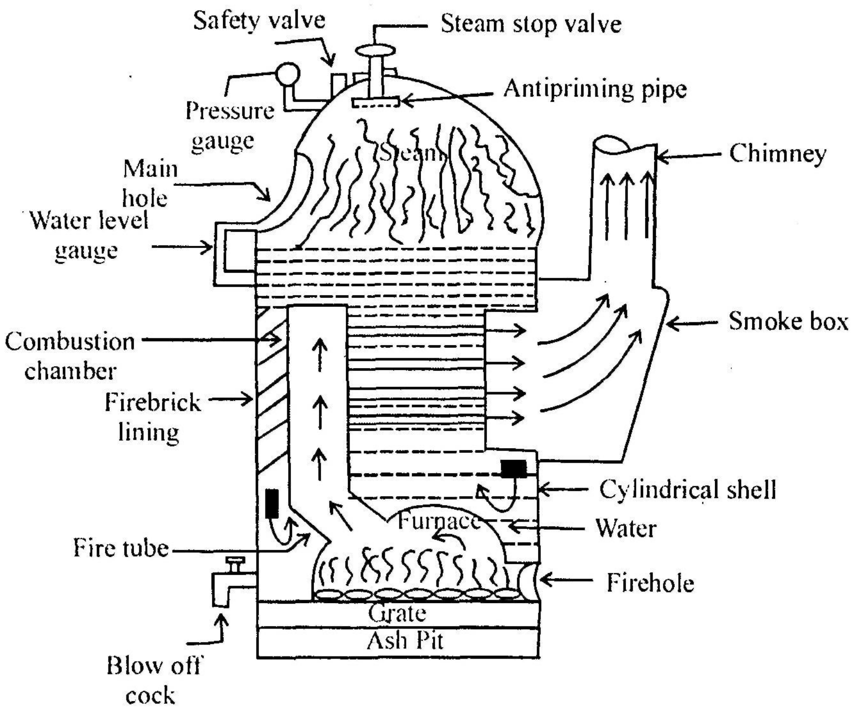


Fig. Cochran Boiler

Cochran boiler consists of a cylindrical shell with a dome shaped top where the space provided for steam. Its crown has a hemispherical shape and thus provides maximum volume of space. Its furnace is seamless, below it there is a grate and ash pit. It has a combustion chamber and smoke box, which are connected through fire tubes. Smoke box is connected to chimney. Various mountings are also fitted on it like

(i) Water level indicator (ii) Safety valve

(iii) Steam stop valve (iv) Blow-off cock

(v) Pressure gauge.

Working : The fuel is burnt on the grate inside the furnace. The gases of combustion produced by burning of fuel enter the combustion chamber through the flue tube and strike against the fire brick lining which directs them to pass through number of horizontal tubes, being surrounded by water. After which the gases escape to the atmosphere through smoke box and chimney.

The water surrounded over the fix typs get heated and converted into steam. This steamis being collected into the crown of boiler. This steam is supplied by steam stop valve.

Q. 1. (b) Explain 05 boiler mountings and 02 accessories.

Ans. Boiler Mountings:

(i) Water level Indicator (ii) Pressure gauge

(iii) Safety valve (iv) Stop valve

(v) Blow off cock.

Boiler Accessories :

(i) Air pre heater

(ii) Steam separator.

(i) Air Pre-heater:

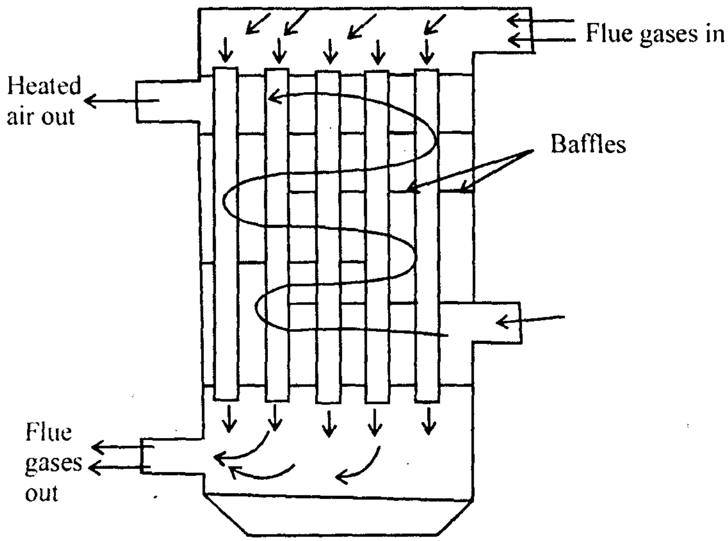


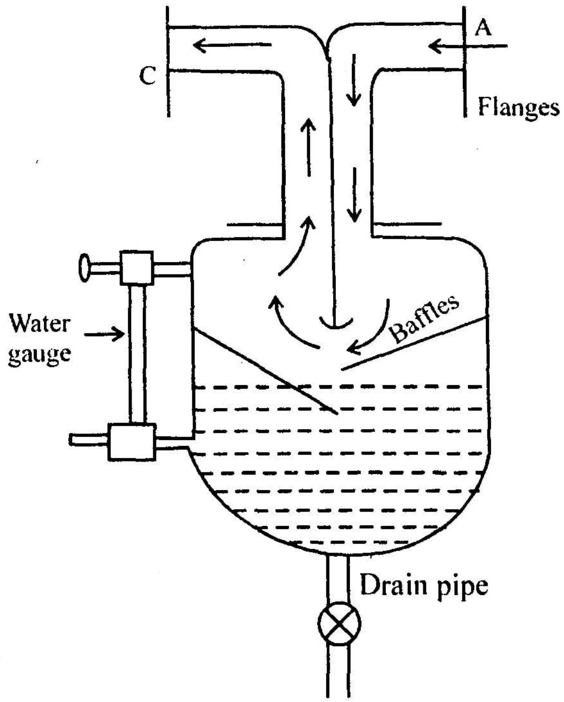
Fig. Tubular Type Air Preheater

The function of air preheater is to increase the temperature of air before it enters the furnace. It is generally placed after the economiser; so the flue gases pass through the economiser and then to the air pre-heater.

An air-preheater consists of plates or tubes with hot gases on one side and and air on the other. If preheats the air to be supplied do the furnace. Preheated air accelerates the combustion and facilitates the burning of coal.

(ii) Steam Separator : The steam available from a boiler may be either wet, dry; or superheated; but in many cases there will be loss of heat from it during its passage through the steam pipe from the boiler to the engine tending to produce wetness.

The use of wet steam in an engine or turbine is uneconomical besides involving some risk; hence it is usual to endeavour to separate any water that may be present from the steam before the latter enters the engine. The function of a steam separator is to remove the entrained water particles from the steam conveyed to the steam engine or turbine.



Boiler **Mountings:**

(i) Water **Level Indicator**: **It** is used to check the water level in side the boiler. When the level of water goes down then from that heat pressure of steam increases immediately which may cause of danger. So, the level of water should not be low.

(ii) Pressure Gauge : Pressure gauge is used to measure the pressure inside the boiler. It is very necessary to maintain the pressure inside the boiler. So, pressure gauge is used.

Pressure gauge are of following two types :

(i) Bourdon pressure gauge.

(ii) Diaphragm type gauge.

(iii) Safety **Valve** : Every boiler has its working pressure but when the steam pressure exceeds this working pressure then there is a possibility ot explosion in boiler. So, to prevent the boiler from explosion safety valve is used.

(iv) Stop Valve : This valve is used to exhaust the steam from boiler to the steam engine/turbine. The quantity of steam is also be controlled.

5. Blow-off Cock: It has two worker:

1. For clearning, checking and maintenance purposes it is being used.

2. When boiler is running and we have to release some water or mud or waste etc., it is being used.

Q. 2. (a) **Explain difference between impulse and reaction turbine.**

Ans. **Difference between Impulse and Reaction Turbine**:

1. In impulse turbine, there are nozzle and moving blades are in series while there are fixed blades and moving blades are present in Reaction turbine (No nozzle is present in reaction turbine).

2. In impulse turbine pressure falls in nozzle while in reaction turbine in fixed blade boiler pressure falls.
3. In impulse turbine velocity (or kinetic energy) of steam increases in nozzle while this work is to be done by fixed blades in the reaction turbine.
4. Compounding is to be done for impulse turbines to increase there efficiency while no compounding is necessary in reaction turbine.
5. In impulse turbine pressure drop per stage is more than reaction turbine.
6. The number of stages are required less in impulse turbine while required more in reaction turbine.
7. Not much power can be developed in impulse turbine than reaction turbine.
8. Efficiency of impulse turbine is lower than reaction turbine.
9. Impulse turbine requires less space than reaction turbine.
10. Blade manufacturing of impulse turbine is not difficult as in reaction turbine it is difficult.

Q.2.(b) Explain Jet condensors in detail.

Ans. Jet Condensors : In jet condensors, the exhaust steam and water come in direct contact with each other and temperature of condensate is same as that of cooling water leaving the condenser. The cooling water is usually sprayed into the exhaust steam to cause rapid condensation.

Classification :

- Parallel flow type
  - Low level type
  - High level type
- Counter flow type
  - Low level type
  - High level type
- Ejector type

Parallel Flow Type : Both the exhaust steam and cooling water find their entry at the top of the condensor and then flow downwards and condensate and water are finally collected at the bottom.

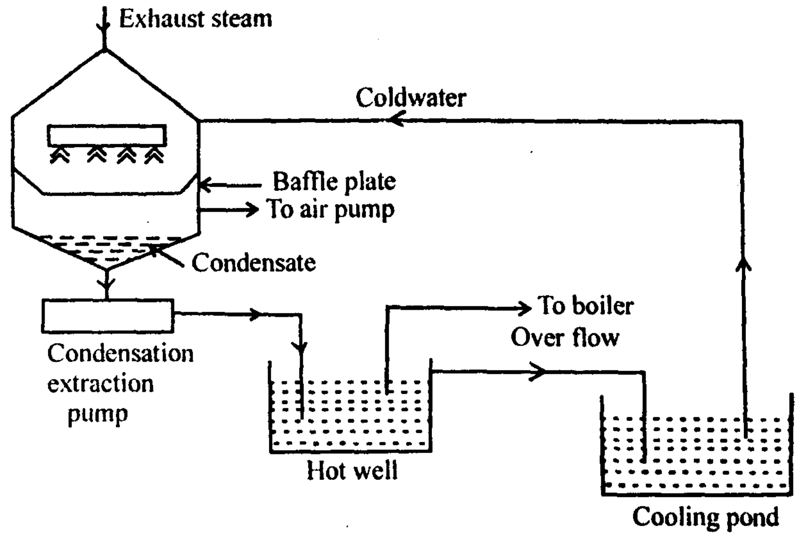


Fig. Parallel Flow Low Level Jet Condenser

Counter Flow Type: The steam and cooling water enter the condensor from opposite directions. Generally, the exhaust steam travels in upward direction and meet the cooling water which flows down ward.

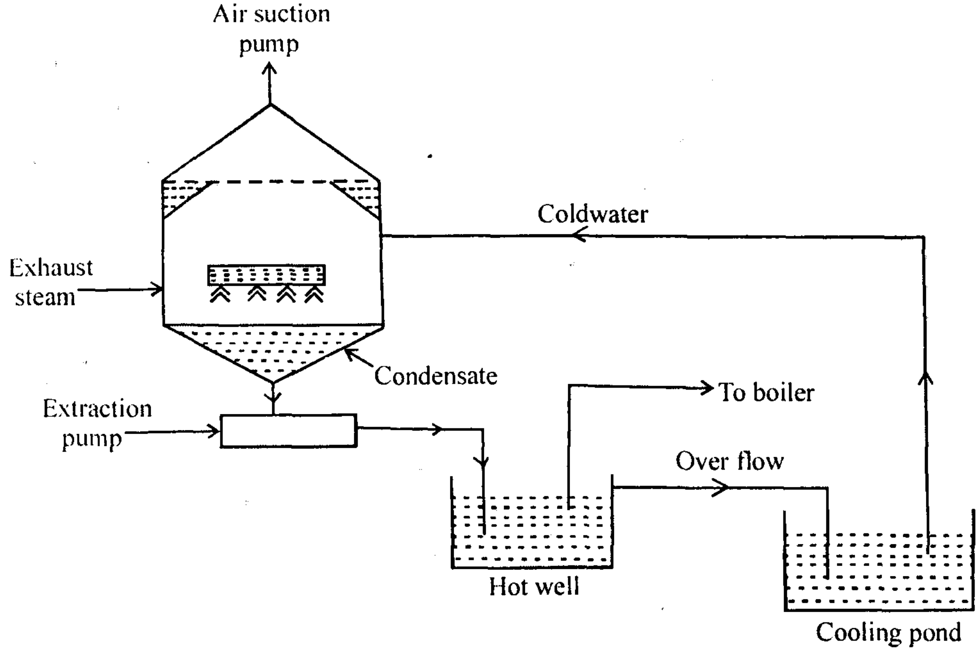


Fig. Low Level Jet Condensor (Counter flow)

Ejector Condensor :

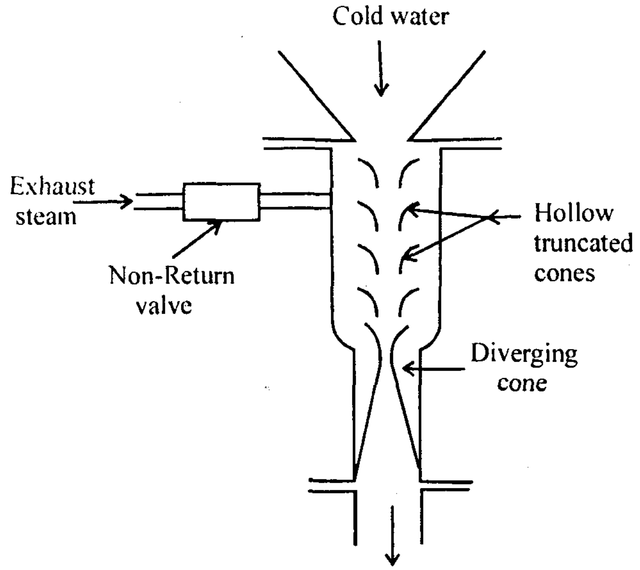


Fig. Ejector Condensor

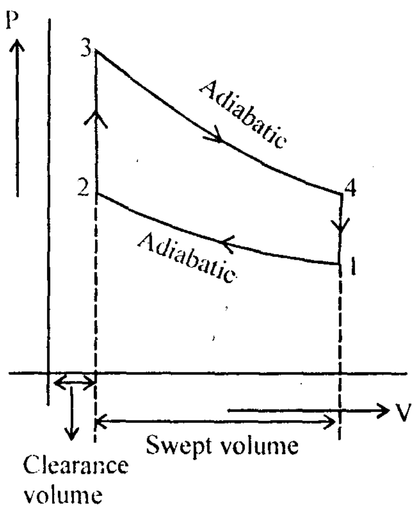
In ejector condensor, the exhaust steam and cooling water mix in hollow truncated cones. The cold water having a head of about 6 metres flow down through the number of cones and as it moves its velocity increases due to drop in pressure. In diverging cone a portion of kinetic energy gets converted into pressure energy which is more than the atmospheric so that condensate consisting of condensed steam, cooling water and air is discharged into the hot well.

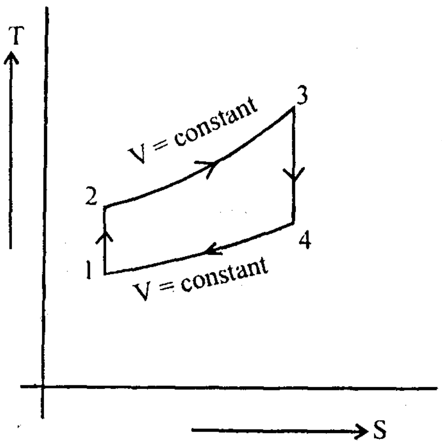
Q. 3. (a) Difference between 2 and 4 stroke engines.

Two Stroke Engine	Four Stroke Engine
1. It has one power stroke in each cycle.	1. It has one power stroke in two revolution of crank shaft.
2. It is lighter in weight and requireless space.	2. It is comparatively heavier in weight and require more space.
3. It needs lighter flywheel.	3. It needs comparatively heavier fly wheel.
4. It has ports of place of valve. So, its operating is simple.	4. Its operating is complicated.
5. It has good scavenging process for low speed engine.	5. It has comparatively less scavenging process for low speed engine.

Q. 3. (b) Calculate efficiency of OHo cycle.

Ans. Efficiency of Otto Cycle:





Consider 1 kg of air (working substance) :

Heat supplied at constant volume

$$= C_v(T_3 - T_2) \qquad \text{(In process 2–3)}$$

Heat rejected at constant volume

$$= C_v(T_4 - T_1) \qquad \text{(In process 4–1)}$$

Work done = Heat supplied – Heat rejected

$$= C_v(T_3 - T_2) - C_v(T_4 - T_1)$$

$$\text{Efficiency} = \frac{\text{Workdone}}{\text{Heat supplied}} = \frac{C_v[(T_3 - T_2) - (T_4 - T_1)]}{C_v(T_3 - T_2)}$$

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

Let compression ratio

$$r_c = \frac{v_1}{v_2}$$

Expansion ratio $\quad r_e = \frac{v_4}{v_3} \qquad \{r_e = r_c = r\}$

So, $\quad \frac{T_2}{T_1} = \left(\frac{v_1}{v_2}\right)^{\gamma-1}$

So, $\quad T_2 = T_1 . r^{\gamma-1}$

Similarly $\quad T_3 = T_4 . r^{\gamma-1}$

So, $\quad \eta_{otto} = 1 - \frac{(T_4 - T_1)}{T_4.(r)^{\gamma-1} - T_1.(r)^{\gamma-1}} = 1 - \frac{T_4 - T_1}{(T_4 - T_1).(r)^{\gamma-1}}$

$$\boxed{\eta_{otto} = 1 - \frac{1}{(r)^{\gamma-1}}}.$$

Q. 4. (a) Explain construction and working of Francis turbine.

Ans. Francis Turbine:

Construction and Working: Figure shows schematic diagram of a francis turbine. The main parts are:

1. **Penstock**: It is a large size conduit which conveys water from the upstream to the dam/reservoir to the turbine runner.

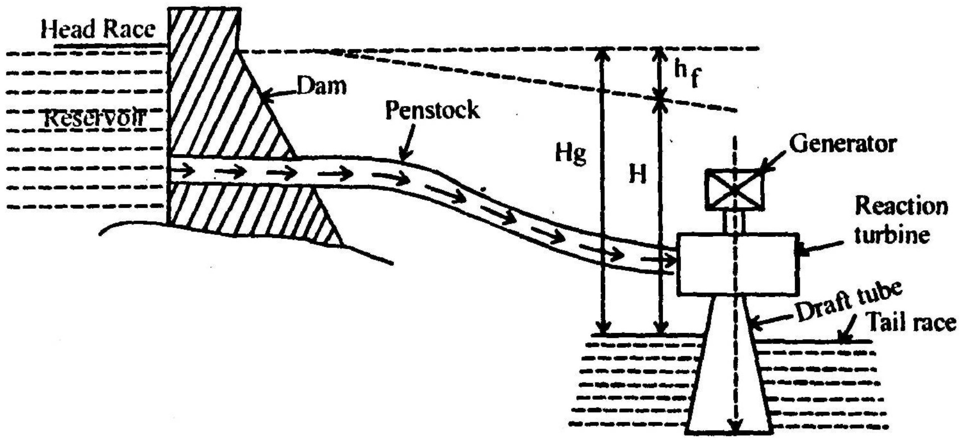
2. Spiral Casing: **It** constitutes a closed passage whose cross-sectional area gradually decreases along the flow direction, area is maximum at inlet and nearly zero at exit.

3. **Guide** Vanes: These vanes direct the water on to the runner at an angle appropriate to the design, the motion of them is given by means of handwheel or by a governor.

4. Governing Mechanism: It changes the position of the guide blades/vanes to affect a variation in water flow rate, when the load conditions on the turbine change.

5. **Runner and Runner Blades**: The driving force on the runner is both due to impulse and reaction effect. The number of runner blades usually varies between 16 to 24.

6. **Draft Tube**: It is gradually expanding tube which discharges water, passing through the runner to the tail race.



Working: Francis turbine has a purely radait flow runner. Water under pressure, enters the runner from the guide vanes towards the centre in radial direction and discharges out of the runner axially. Francis turbine operates under medium heads. Water is brought down to the turbine through a penstock and directed to a number of stationary orifices fixed all around the circumference of the runner. These stationary orifices are called as guidevanes.

The head acting on the turbine is transformed into kinetic energy and pressure head. Due to the difference of pressure between guide vanes and the runner (called reaction pressure), the motion of runner occurs. That is why a franics turbine is also also known as reaction turbine.

The pressure at inlet is more than that at outlet. In francis turbine runner is always full of water. The moment of runner is affected by the change of both the potential and kinetic energies of water. After doing the work the water is discharged to the tail race through a closed tube called draft tube.

Q. 4.(b)What is specific speed of turbine. How turbines are selected?

Ans Tur bine Speed of Turbine: The specific speed of a turbine is defined as: "The speed of a turbine which is identical in shape, geometrical dimensions, blade angles, gate opening etc., which would develop unit power when working under a unit head."

The overall efficiency (η_0) of any turbine is :

$$\eta_0 = \frac{\text{Power available at the shaft of the turbine (shaft power)}}{\text{Power supplied at the inlet of the turbine (water power)}}$$

$$\eta_0 = \frac{P}{\omega . Q . H} \quad ...(i)$$

P = Shaft power

ω = Weight density of water.

Q = Discharge through turbine

H = Head

$$P = \eta_0 \times \omega . Q . H \quad ...(iii)$$

So, $P \propto Q \times H$ (as η_0 & ω are constant)

Now let, D = Diameter of actual turbine

N = Speed of actual turbine.

u = Tangential velocity of turbine.

N_S = Specific speed of turbine.

V = Absolute velocity of the water.

As we know that $u \propto v$

So, $$v \propto \sqrt{H}$$

and $$u \propto \sqrt{H} \quad \text{...(iii)}$$

But $$u = \frac{\pi DN}{60}$$

So, $$u \propto D.N \quad \text{...(iv)}$$

From equation (iii) & (iv)

$$\sqrt{H} \propto D.N.$$

$$D \propto \frac{\sqrt{H}}{N}$$

Discharge (Q) through the turbine is

$$Q = \text{Area} \times \text{velocity}$$

$$\text{area} \propto B \times D$$

$$\propto D^2 \qquad (\because B \propto D)$$

$$Q \propto D^2.\sqrt{H}$$

$$Q \propto \left(\frac{\sqrt{H}}{N}\right)^2.\sqrt{H} \qquad \left\{\because D \propto \frac{\sqrt{H}}{N}\right\}$$

$$Q \propto \frac{H^{3/2}}{N^2} \quad \text{...(v)}$$

Now from equations (ii) & (v)

$$P \propto \frac{H^{3/2}}{N^2} \times H$$

$$P = K\frac{H^{5/2}}{N^2}$$

Now if $$P = 1kw, H = 1m$$

Then, $$N = N_S$$

So, $$1 = K.\frac{(1)^{5/2}}{N_S^2}$$

$$N_S^2 = K$$

So, $$P = N_S^2 . \frac{H^{5/2}}{N^2}$$

$$N_S^2 = \frac{N^2 . P}{H^{5/2}}$$

$$\boxed{N_S = \frac{N\sqrt{P}}{H^{5/4}}}.$$

Selection of Turbine:

1. It runner of high specific speed is used for a given head and power output, the overall cost of installation is lower. The selection of too high specific speed reaction runner would reduce the size of runner.

2. The runner of too high specific speed with high available head increases the cost of turbine on account of high mechanical strength required.

The runner of too low specific speed with low available head increases the cost of generator due to low turbine speed.

3. An increase in specific speed of turbine is accompained by lower maximum efficiency and greater depth of excavation of the draft tube. In choosing a high specific speed turbine, an increase in cost of excavation of foundation and draft tube should be considered in addition to the efficiency. The weighted efficiency over the operating range of turbine is more important in selection of a turbine instead of maximum efficiency.

Type of Turbine	Specific Speed (N_S)
1. Pelton turbine	12–70
2. Francis turbine	
(i) High head	80–150
(ii) Medium head	150–250
(iii) Low head	250–400
3. Kaplan and propeller	300–1000

Q. 5. (a) What is irreversible machine?

Ans. Irreversible Machine : Irreversible processes are those processes which proceeds always in for ward direction and can't be go in to the backward direction. The machine which works on the irreversible process is called irreversible machine.

Example : Heat engine is a machine which works on the irreversible process. It takes heat from the high temperature source and transfers it to the low temperature sink and due to their transfer there is a work done.

If Q_1 is the heat taken from high temperature source and Q_2 is the heat given to lower temperature sink then work done

$$W = Q_1 - Q_2.$$

Q. 5. (b)Calculate in screw jack

$$\eta_{max} = \frac{1 - \sin\phi}{1 + \sin\phi}.$$

Ans. Efficiency of Screw Jack:

$$\text{Efficiency } \eta = \frac{\text{Ieal effort}}{\text{Actual effort}}$$

$$= \frac{P_0}{P}$$

$$P_0 = W.\tan\alpha$$

$$P = W\tan(\alpha+\phi) \qquad \text{Where} \qquad \alpha = \text{Helix angle}$$

$$\mu = \text{Coeff., of friction} \qquad \phi = \text{Angle of friction}$$

$$\eta = \frac{W\tan\alpha}{W\tan(\alpha+\phi)} = \frac{\tan\alpha}{\tan(\alpha+\phi)} \quad ...(i)$$

For maximum efficiency,

$$\eta = \frac{\sin\alpha/\cos\alpha}{\sin(\alpha+\phi)/\cos(\alpha+\phi)} = \frac{2\sin\alpha.\cos(\alpha+\phi)}{2\cos\alpha.\sin(\alpha+\phi)}$$

$$= \frac{\sin(2\alpha+\phi)-\sin\phi}{\sin(2\alpha+\phi)+\sin\phi} \quad ...(iii)$$

The efficiency is maximum when $\sin(2\alpha+\phi)$ is maximum.

So, $\sin(2\alpha+\phi) = 1$

When $2\alpha+\phi = 90°$

$$2\alpha = 90° - \phi$$

$$\alpha = 45° - \frac{\phi}{2}$$

Substituting the value of 2α in equation (ii)

$$\eta_{max.} = \frac{\sin(90-\phi+\phi)\phi\sin\phi}{\sin(90-\phi+\phi)\sin\phi}$$

$$\eta_{max.} = \frac{\sin 90 - \sin\phi}{\sin 90 + \sin\phi}$$

$$\boxed{\eta_{max.} = \frac{1-\sin\phi}{1+\sin\phi}}$$

Q. 6. (a) Explain with diagram single plate clutch.

Ans. Single Plate Clutch : A single disc or plate clutch consists of a clutch plate whose both sides are faced with a frictional material. It is mounted on the hub which is free to move axially along he splines of the driven shaft. The pressure plate is mounted inside the clutch body which is bolted to the flywheel. Both the pressure plate and the flywheel rotate with the engine crank shaft or the driving shaft. The pressure plate pushes the clutch plate towards the flywheel by a set of strong springs which are arranged radially inside the body. The three levers (also known as release levers or fingers) are carried on pivots suspended from the case of the body. These are arranged in such a manner so that the pressure plate moves away from the flywheel by the inward movement of a trust bearing. The bearing is mounted upon a forked shaft and moves forward when the clutch pedal is pressed.

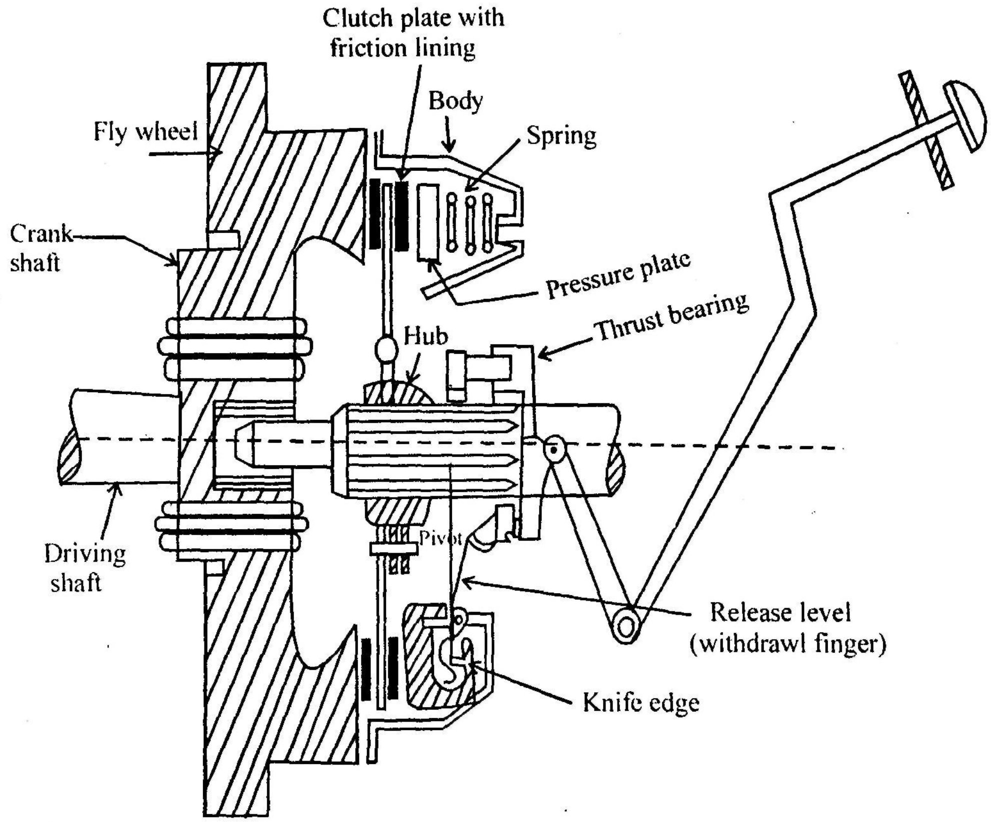


Fig. Single Plate Clutch

When the clutch pedal is pressed down, its linkage forces the thrust release bearing to move in towards the flywheel and pressing the longer ends of the levers inward.

The axial pressure exerted by the spring provides a frictional force in the circumferential direction when the relative motion between the driving and driven members tends to take place. If the torque due to this frictional force exceeds the torque to be transmitted, then no slipping takes place and the power is transmitted from the driving shaft to the driven shaft.

Q. 6. **(b)Explain principle, construction and working of hydrarulic brake.**

Ans. Hydraulic Brake:

Construction:

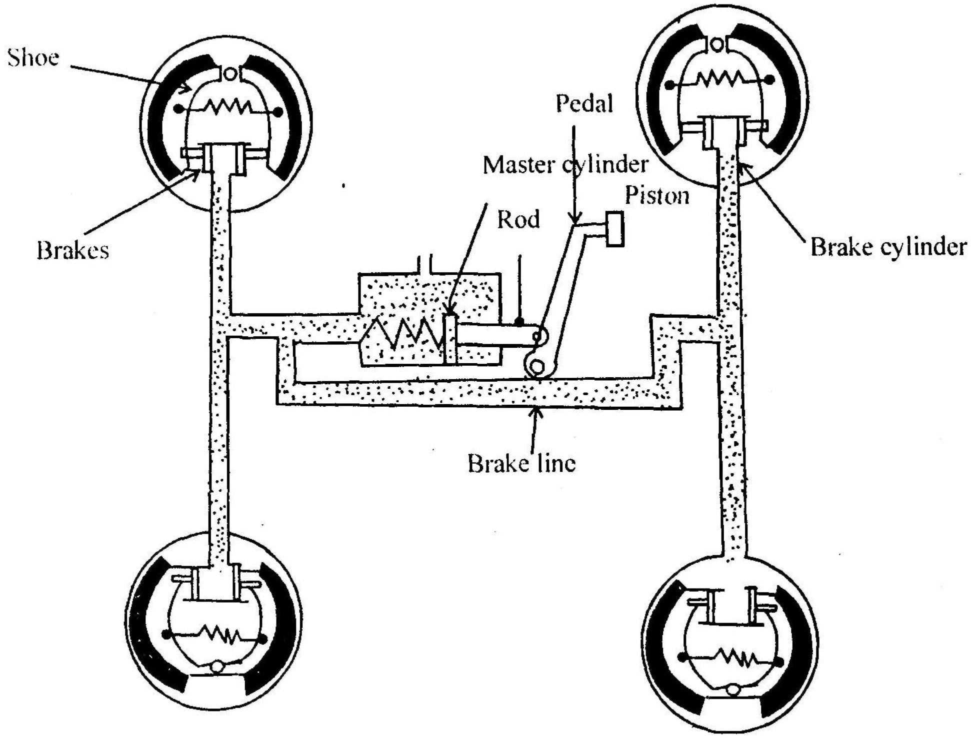
It consists of following main parts :

(i) Master cylinder

(ii) Wheel cylinder

(iii) Brake fluid (or brake oil) pipelines.

It consists of a master cylinder which is connected to four cylinders through a pipeline. The wheel cylinder consists of brakes and shoe arrangement.

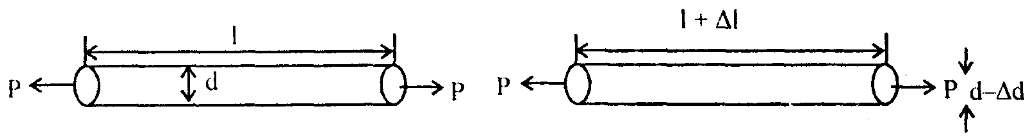


Principle : **It** works on the principle of Pascal's law, which states that "The confined liquid transmits pressure intensity equally in all directions."

Working : When the driver depresses pedal, the effort is transmitted through rod to piston of master cylinder. The piston moves in the cylinder and compress return spring forcing out the fluid from the cylinder into brake line through a by-pass. Piston of a brake cylinders are acted upon by the fluid and press against shoes, bringing their linings tightly against the working surfaces of the drums as soon as the pedal is released, the return spring pushes piston back. At the same time, the compression springs of the brake shoe move pistons to their initial position and the fluid begins to the flow in the reverse direction.

Q. 7(a) **What is Poisson's ratio?**

Ans. Poisson's Ratio: The lateral strain bears a constant ratio to the linear strain. This constant is known as 'Poisson's Ratio.'



$$\text{Poisson Ratio} = \frac{\text{Lateral Strain}}{\text{Linear Strain}}$$

It is denoted by 1/m or μ.

When a bar of length l is pulled by a force P(tensile) then there is an increase in length by Δl and decrease in diameter by Δd.

So, $$\boxed{\mu = \frac{\Delta d / d}{\Delta l / l}}.$$

Q. 7. (b)Find relationship between elastic consts.

An$. Relationship between Elastic Constants:

Bulk modulus $$K = \frac{\text{Direct stress}}{\text{Volumetric strain}}$$

$$= \frac{\sigma}{\Delta V / V}$$

Relation between bulk modulus and Young modulus :

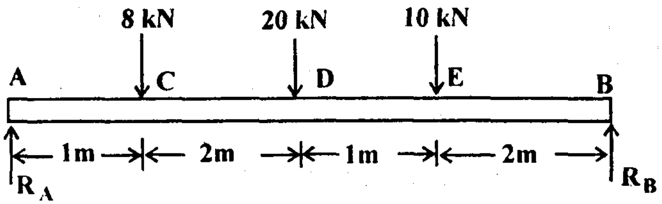
$$K = \frac{\sigma}{\Delta V / V} = \frac{m.E}{3(m-2)} \quad \left\{ \because m = \frac{1}{\mu} = \frac{1}{\text{Poisson's ratio}} \right\}$$

Relation between Young's Modulus and Modulus of Rigidity :

$$G = \frac{m.E}{2(m+1)}$$

$$\boxed{G = \frac{E}{2(1+\mu)}}.$$

Q. 8. A simply supported beam is carrying point loads as shown in fig. Draw SFD and BMD for the beam.



Ans. On balancing the vertical forces

$$R_A + R_B = 8 + 20 + 10$$

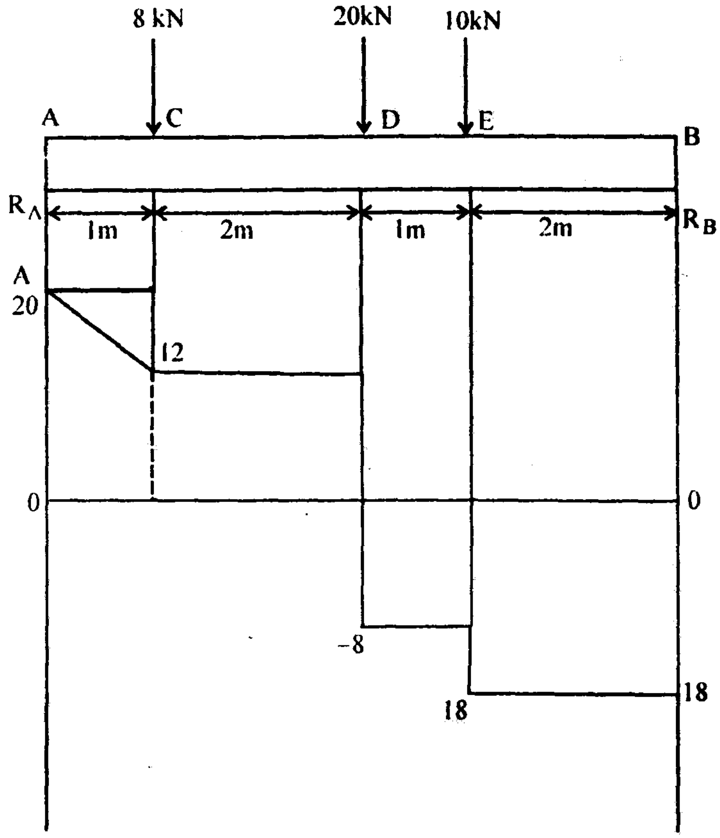
$$R_A + R_B = 38 \quad \text{...(i)}$$

On taking moment about point A we get

$$8 \times 1 + 20 \times 3 + 10 \times 4 = R_B \times 6$$

$$R_B = \frac{8+60+40}{6} = 18\,KN$$

$$R_A = 20\,KN$$

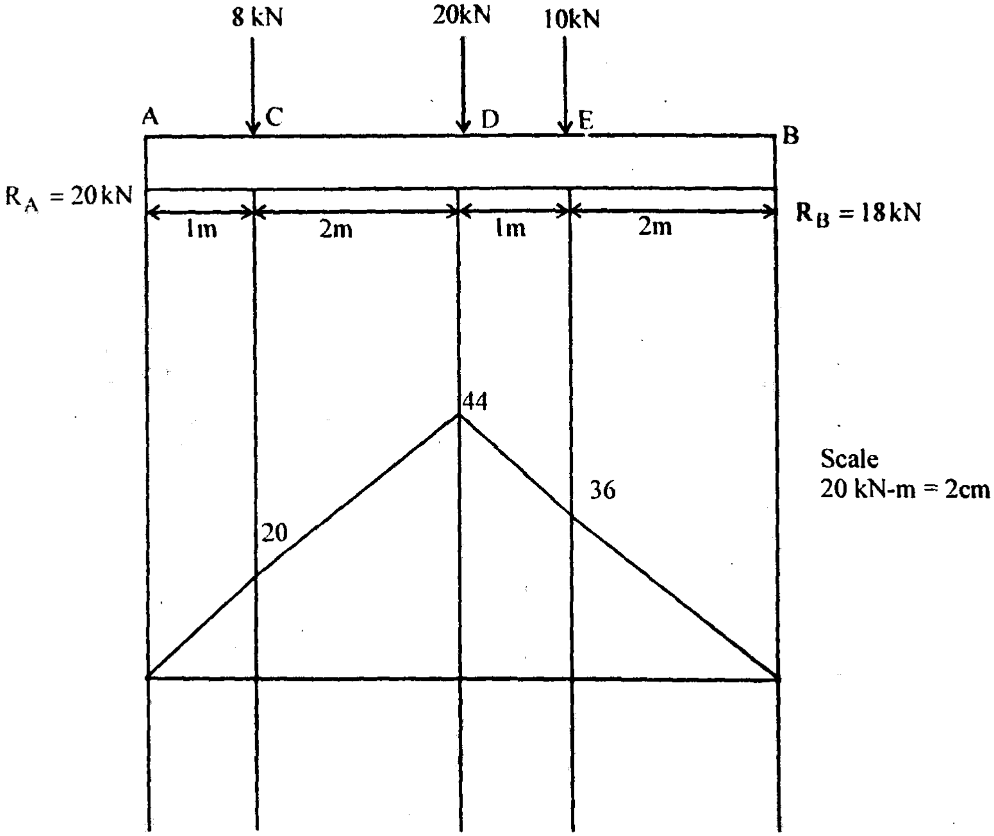


Shear Force Diagram

Scale 20KN = 4 cm

Shear force :

At A	= 20 KN
At C	= 12 KN
At D	= −8 KN
At E	= −18 KN
At B	= 0



Bending moment diagram

$M_B = 0$

$M_E = R_B \times 2 = 18 \times 2 = 36 \, Kn - m$

$M_D = 3R_B - 10 \times 1 = 18 \times 3 - 10 = 44 \times KN - m$

$M_C = R_B \times 5 - 10 \times 3 - 20 \times 2$

$= 90 - 30 - 40 = 20 \, KN - m$

$M_A = 0.$