B.Tech.

First Semester Examination

Basics of Mechanical Engineering (ME-101F)

Q. 1. (a) Differentiate between water tube boiler and fire tube boiler.

Ans. Comparison Between 'Fire-tube and Water tube' Boiler :

S. No.	Particulars	Fire-Tube Boiler	Water-Tube Boiler
(i)	Position of water and hot gases	Hot gases inside the tubes and water outside the tubes.	Water inside the tubes and hot gases outside the tubes.
(ii)	Mode of firing	Generally internally fired	Externally fired
(iii)	Operating pressure	Operating pressure limited to 16 bar.	Can work under as high pressure as 100 bar.
(iv)	Rate of steam production	Lower	Higher
(v)	Suitability	Not suitable for large power plants.	Suitable for large power plants.
(vi)	Risk on bursting	Involves lesser risk on explosion due to lower pressure	Involves more risk on bursting due to high pressure

Q. 1. (b) What do you mean by boiler mountings and accessories ? Discuss any five Accessories in detail with neat sketch. 10

Ans. Mountings : The items such as stop valve. Safety valves, water level gauges, fusible plug, blow-off cock, pressure gauges. Water level indicator etc. are termed as mountings and a boiler cannot work safely without them.

Accessories : The items such as superheaters, economiser, feed pumps etc. are termed as accessories and they form integral part of the boiler. They increase the efficiency of the boiler. The following accessories are discussed :

Economiser : An economiser is a device in which the waste heat of the flue gases is utilised for heating the feed water.

Injector : The function of an injector is to feed water into the boiler. It is commonly employed for vertical and locomotive boilers and does not find its application in large capacity high pressure boilers. It is also used where the space is not available for the installation of a feed pump.

In an injector the water is delivered to the boiler by steam pressure; the kinetic energy of steam is used to increase the pressure and velocity of the feed water.

Superheater: The function of a superheater is to increase the temperature of the steam above its saturation point. The superheater is very important accessory of a boiler and can be used both on fire-tube and water-tube boilers. The small boilers are not commonly provided with a superheater.

Steam **Separator**: Thesteam 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. This is accomplished by the use of a steam separator. Thus, the tunction of a steam separator is to remove the entrained water particles from the steam conveyed to the steam engine or turbine. It is installed as close to the steam engine as possible on the main steam pipe from the boiler.

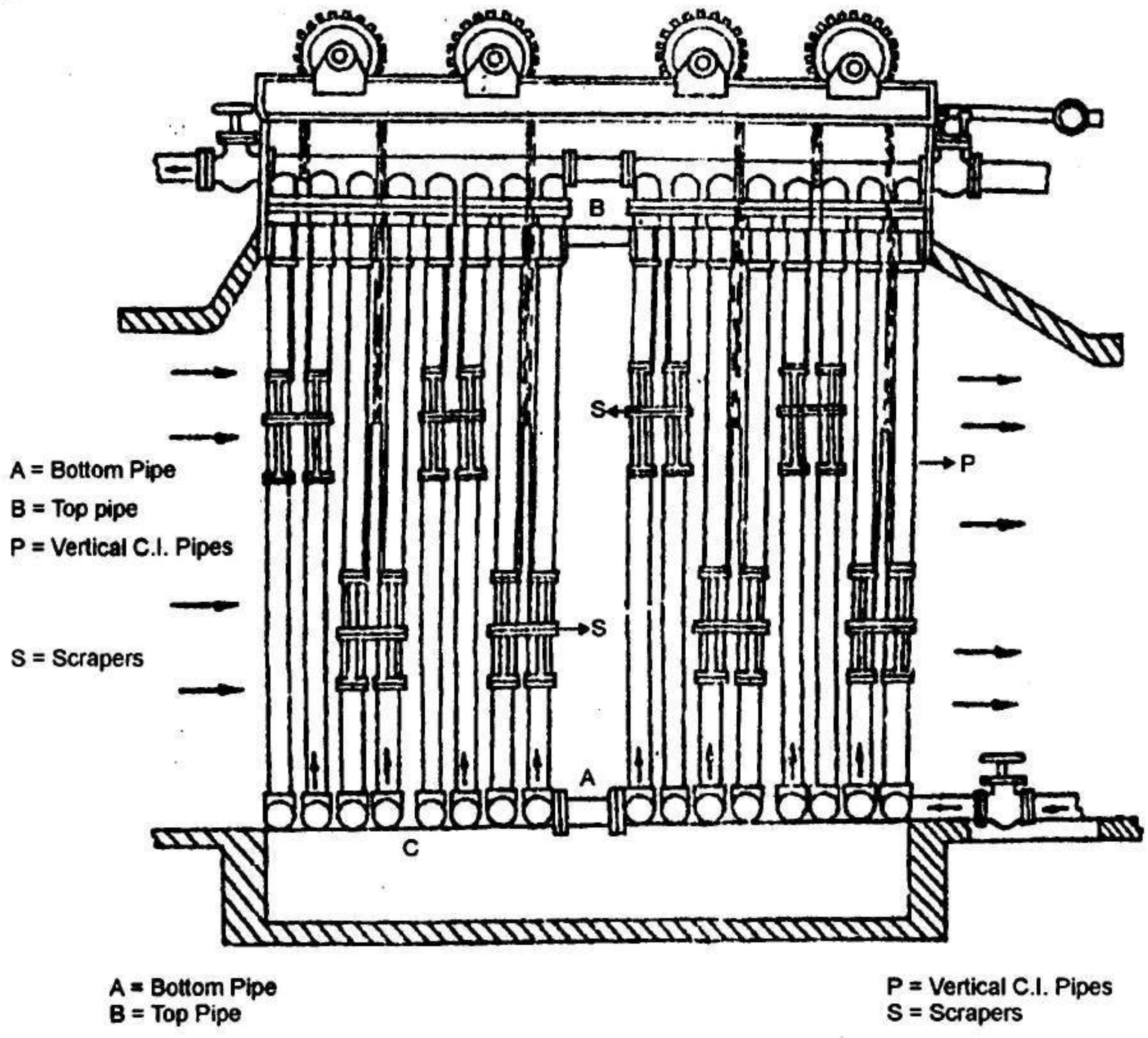


Fig. Economiser

Air Preheater : The function of the air pre-heater 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 preheater.

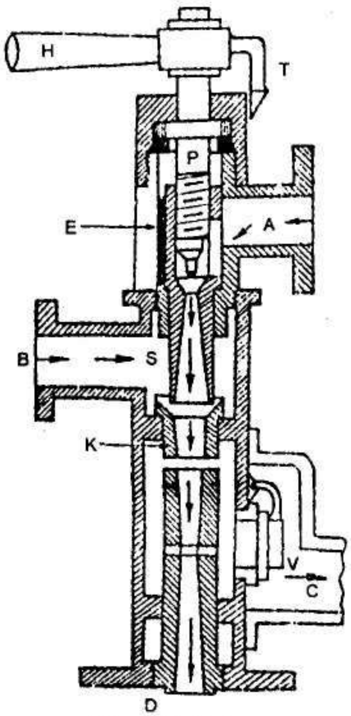


Fig. Injector

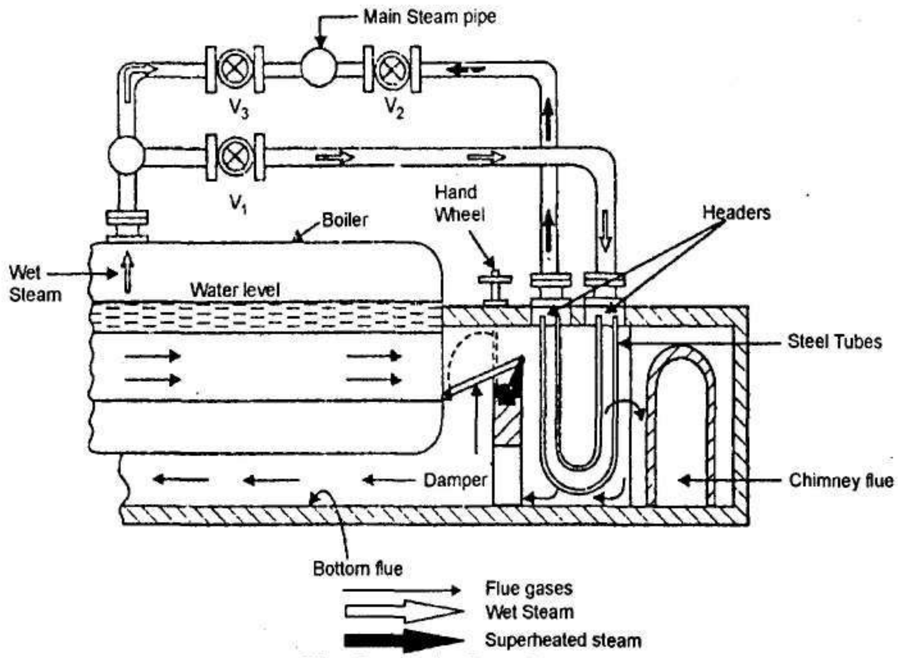


Fig. Sugden's Superheater

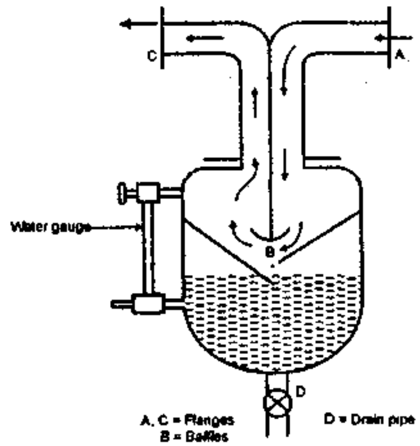


Fig. Baffle Plate steam separator

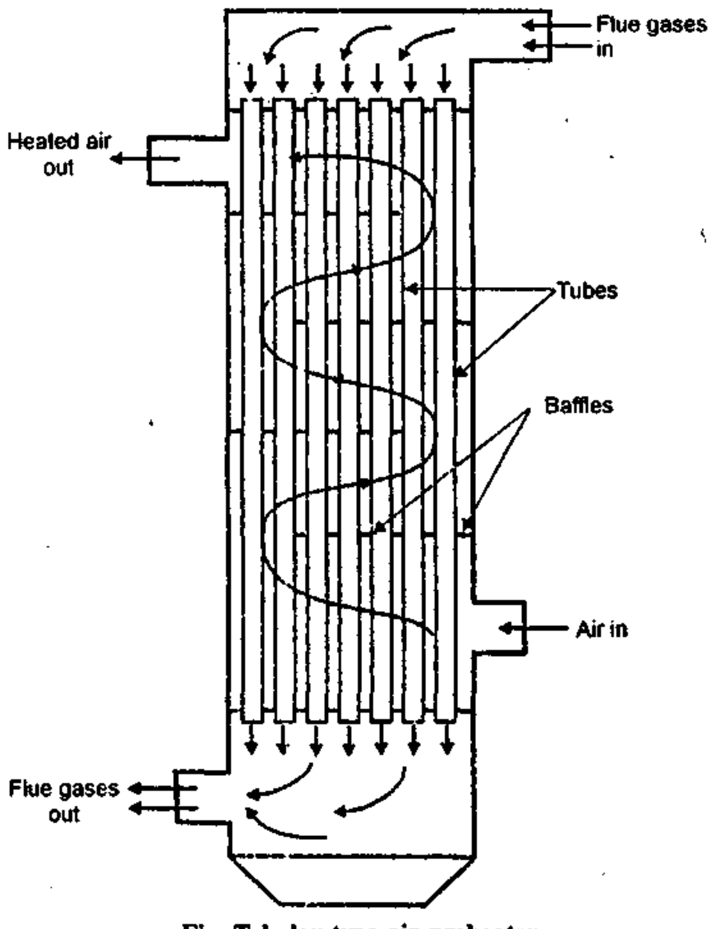


Fig. Tubular type air preheater

Q. 2 (a) Diffrentiate between jet condensers and surface condensers.

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

In surface condensers, the exhaust steam and water do not come into direct contact. The steam passes over the outer surface of tubes through which a supply of cooling water is maintained.

A jet condenser is simpler and cheaper than a surface condenser. It should be installed when the cooling water is cheaply and easily made suitable for boiler feed or when a cheap source of boiler and feed water is available. A surface condenser is most commonly used because the condensate obtained is not thrown as a waste but returned to the boiler.

Q. 1(b) What do you mean by cooling towers and cooling ponds ? Classify various types of cooling towers with neat sketch.

Ans. the cooling ponds are the simplest of the device for recooling of the cooling water. A cooling pond consists of a large, shallow pool into which the hot water is allowed to come in contact with the atmospheric air.

In power plants the hot water from condenser is cooled in cooling tower, so that it can be reused in condenser for condensation of steam. In a cooling tower water is made to trickle down drop by drop so that it comes in contact with the air moving in the opposite direction.

The cooling towers may also be classified as follows:

(i) Natural draught cooling towers

(ii) Mechanical draught cooling towers

(iii) Forced draught cooling towers

(iv) Induced draught cooling towers.

(i) Natural Draught Cooling Tower : In this type of tower, the hot water from the condenser is pumped to the troughs and nozzles situated near the bottom.

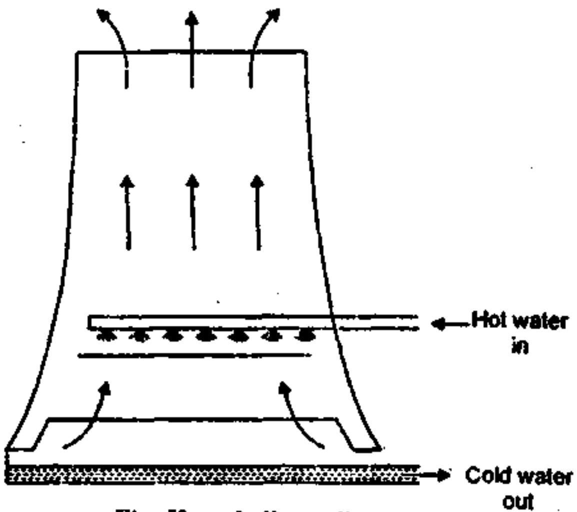


Fig. Hyperbolic cooling tower

(ii) Mechanical Draught Cooling Towers : In these towers the draught of air for cooling the tower is produced mechanically by means of propeller fans. These towers are usually built in cells or units, the capacity depending upon the number of cells used.

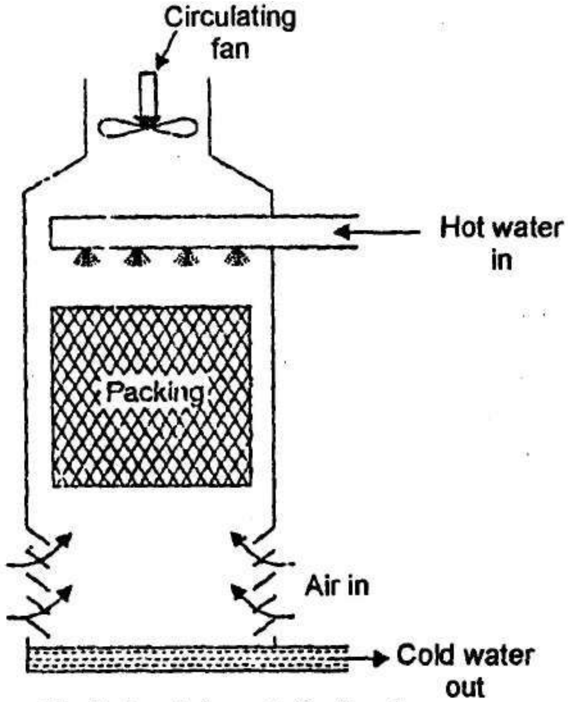


Fig. Induced draught Cooling tower

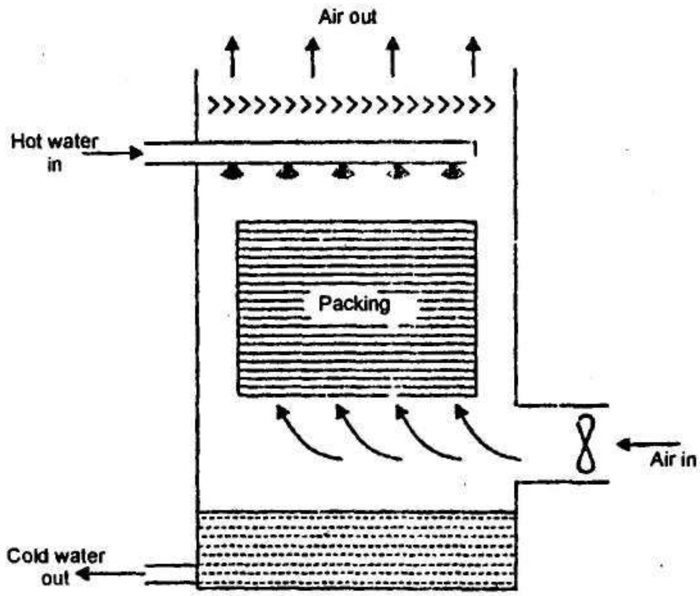
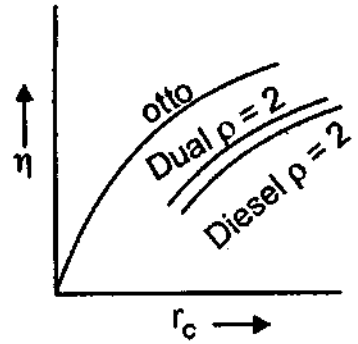


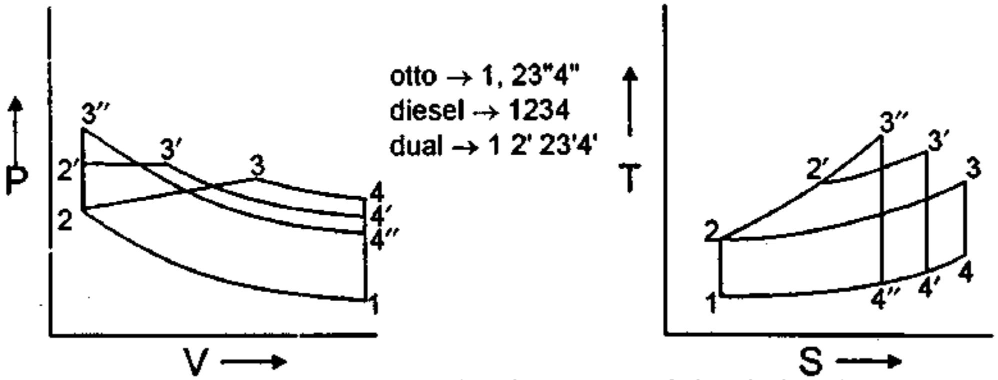
Fig. Forced draught cooling tower

Q. 3. (a) Comparison of Otto, Diesel and Dual cycles. **10**

Ans. Figure shows comparison of otto, diesel and dual combustion cycles at various compression ratio and with given cut off ratio for diesel and dual cycles. For the given compression ratio.

$$\eta_{otto} > \eta_{dual} > \eta_{diesel}$$



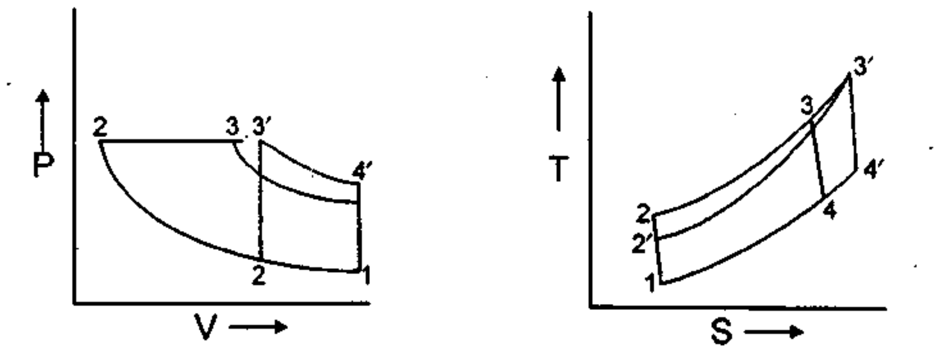


For the same compression ratio and same heat input, otto cycle has the least heat rejected hence

$$\eta_{otto} > \eta_{dual} > \eta_{diesel}$$

For constant maximum pressure and heat supplied, diesel cycle has least heat rejected, hence

$$\eta_{diesel} > \eta_{dual} > \eta_{otto}$$



Q. 3. (b) Differentiate between two stroke and four stroke engines.

Ans. Comparison of four stroke and two stroke cycle engines :

S. No.	Four Stroke Cycle Engines	Two Stroke Cycle Engines
(i)	The cycle is completed in four strokes of the piston or in two revolutions of the crankshaft. Thus, one power stroke is obtained in every two revolutions of the crankshaft.	The cycle is completed in two strokes of the piston or in one revolution of the crankshaft. Thus, one power stroke is obtained in each revolution of the crankshaft.
(ii)	Turning-movement is not so uniform and hence heavier flywheel is needed.	More uniform turning movement and hence lighter fly-wheel is needed.
(iii)	Power produced for same size of engine is small or for the same power the engine is heavy and bulky.	Power produced for same size of engine in more or for the same power the engine is light and compact.
(iv)	Lesser cooling and lubrication requirements. Lesser rate of wear and tear.	Greater cooling and lubrication requirement. Greater rate of wear and tear.
(v)	The four stroke engine contains valve and valve mechanism.	Two stroke engines have no valves but only ports.

Q. 4. (a) It is desired to generator 1000 kW of power and survey reveals that 450 m of static head and a minimum flow of 03 m /sec is available. Comment whether the task can be accomplished by installing a Pelton wheel that turns 1000 revolutions per minute and has an efficiency of 80%. Further design the Pelton wheel by assuming suitable data for coefficient of velocity, speed ratio and velocity coefficient of the jet. **12**

Ans. Power available from turbine shaft

$$P = \omega\phi H \eta_o = 9810 \times 0.3 \times 450 \times 0.8 = 1060 \text{ kW}$$

Hence task can be accomplished velocity of jet

$$V = K_V \sqrt{2gH} = 0.98\sqrt{2 \times 9.81 \times 450}$$

$$= 92.08 \text{ m/s} \quad (\text{assuming } K_V = 0.98)$$

Tangential velocity of wheel

$$u = K_V \sqrt{2gH} = 0.46\sqrt{2 \times 9.81 \times 450} = 43.2 \text{ m/s}$$

Now, $$u = \frac{\pi DN}{60}$$

$\therefore$ $$D = \frac{43.2 \times 60}{\pi \times 1000} = 0.826 \text{ m}$$

Water flow rate $$\varphi = C_d \sqrt{2gH} \times \frac{\pi}{4} d^2$$

$\therefore$ Nozzle diameter, $$d = \frac{4 \times 0.3}{0.94 \times \sqrt{2 \times 9.81 \times 450}} = 6.58 \text{ cm}$$

Width of buckets $= 3.5 \times 6.58 = 23.03$ cm

Depth of bucket $= 1 \times 6.58 = 6.58$ cm

Radial length of bucket $= 2.5 \times 6.58 = 16.45$ cm

No. of buckets, $Z = 0.5\frac{D}{d} + 15$

$\Rightarrow$ $Z = 0.5 \times \frac{0.826}{0.0658} + 15 = 21.27$

Hence $Z = 22$

Q. 4. (b) Differentiate between Impulse and Reaction hydraulic turbines.

S. No.	Impulse Turbine	Reaction Turbine
(i)	All the available energy of fluid is converted into KE by nozzle.	Only portion of energy is transformed into KE before fluid enters the runner.
(ii)	The jet is uncontinued and at atmospheric pressure throughout the action of water on the runner.	Water enter the runner with excess pressure and then both velocity and pressure change as water passes runner.
(iii)	Water may be allowed to enter a part or whole of circumference of wheel.	Water is admitted over the circumference of wheel.
(iv)	The unit is installed above the tail race.	Unit is kept entirely submerged in water below tail race.
(v)	Flow regulation is possible without loss.	Flow regulation is always with loss.
(vi)	The relative velocity of water on runner may remain constant or reduce slightly due to friction.	Relative velocity always increases.
(vii)	Casing has no hydraulic function to perform.	Casing is essential since unit is sealed from atmosphere.

Q. 5. (a) Derive V.R. for single start, double start and triple start worm and worm wheel **and compare their results.**

Ans. Assume that worm rotates through one revolution about its axis. Then angle turned by it will be 2K. The lead of worm **is** the distance moved by pitch circle at the gear wheel. Thus, angle turned by it during the same time will be I/R_2 or $2I/d_2$.

Velocity ratio, $VR = \frac{\text{Angle turned by gear}}{\text{Angle turned by worm}}$

$$= \frac{2l/d_2}{2\pi} = \frac{1}{\pi d_2}$$

For single start, lead (l) = axial pitch (P_a)

$\therefore$ $VR = \frac{P_a}{\pi d_2}$

For double start, $VR = \frac{2P_a}{\pi d_2}$

For tripple start, $VR = \dfrac{3P_a}{\pi d_2}$

Q. 5. (b) Prove that

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

In Case of Screw Jack, where ϕ is called angle of friction.

Ans. The effort required at mean radius of screw jack to lift load w is

$$P = w \tan(\alpha + \phi)$$

If there is no friction, then $p = w \tan \alpha$

$\therefore$ Efficiency

$$\eta = \frac{\text{Ideal effort}}{\text{Actual effort}}$$

$$= \frac{w \tan\alpha}{w \tan(\alpha + \phi)} = \frac{\tan\alpha}{\tan(\alpha + \phi)}$$

For maximum efficiency $\dfrac{d\eta}{d\alpha} = 0$

$$\frac{d}{d\alpha}\frac{\tan\alpha}{\tan(\phi + \alpha)} = 0$$

$$\frac{\sec^2\alpha \tan(\alpha + \phi) - \sec^2(\alpha + \phi)\tan\alpha}{\tan^2(\alpha + \phi)} = 0$$

$\Rightarrow \sec^2\alpha \tan(\alpha + \phi) = \sec^2(\alpha + \phi)\tan\alpha$

$\Rightarrow \sin(\alpha + \phi)\cos(\alpha + \phi) = \sin\alpha\cos\alpha$

$\Rightarrow \alpha = 45° - \phi/2$

$\therefore$

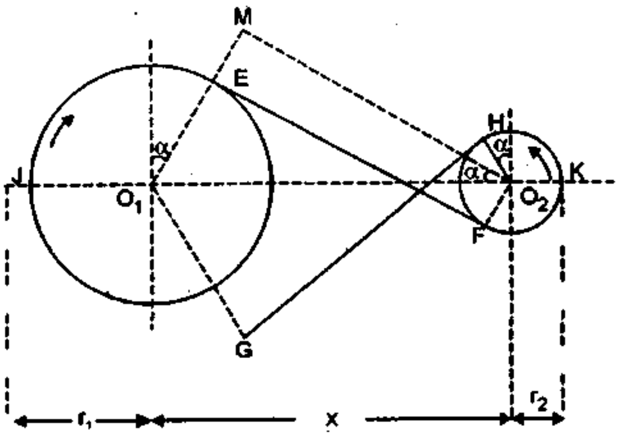
$$\eta_{max} = \frac{\tan(45° - \phi/2)}{\tan(45° + \phi/2)} = \left(\frac{1 - \tan\phi/2}{1 + \tan\phi/2}\right)^2$$

$$= \left(\frac{\cos\frac{\phi}{2} - \sin\frac{\phi}{2}}{\cos\frac{\phi}{2} + \sin\frac{\phi}{2}}\right)^2$$

$$= \frac{1 - 2\sin\frac{\phi}{2}\cos\frac{\phi}{2}}{1 + 2\sin\frac{\phi}{2}\cos\frac{\phi}{2}}$$

$$= \frac{1 - \sin\phi}{1 + \sin\phi}$$

Q.6 (a) Prove that for crossed belt drive system the length of belt is given by $l = \pi(r_1 + r_2) + \dfrac{(r_1 + r_2)^2}{x} + 2x$. r_1, r_2 are radii of drive and driven pulleys x is the distance between centers of two pulleys.



From the geometry of figure, length of belt

$$L = \text{Arc } GJE + EF + \text{Arc } FKH + HG$$
$$= 2\,(\text{Arc } JE + EF + \text{Arc } FK)$$

$$\sin\alpha = \frac{O_1 M}{O_1 O_2} = \frac{O_1 E + EM}{O_1 O_2} = \frac{r_1 + r_2}{x} \approx \alpha$$

$\Rightarrow$

$$\text{Arc } JE = r_1\left(\frac{\pi}{2} + \alpha\right)$$
$$\text{Arc } FK = r_2\left(\frac{\pi}{2} + \alpha\right)$$
$$EF = MO_2 = \sqrt{(O_1 O_2)^2 - (O_1 M)^2} = \sqrt{x^2 - (r_1 + r_2)^2}$$
$$= x\sqrt{1 - \left(\frac{r_1 + r_2}{x}\right)^2}$$
$$= x\left[1 - \frac{1}{2}\left(\frac{r_1 + r_2}{x}\right)^2 + \ldots\ldots\ldots\right] = x - \frac{(r_1 + r_2)^2}{2x}$$

$\therefore$

$$L = 2\left[r_1\left(\frac{\pi}{2} + \alpha\right) + x - \frac{(r_1 + r_2)^2}{2x} + r_2\left(\frac{\pi}{2} + \alpha\right)\right].$$
$$= 2\left[\frac{\pi}{2}(r_1 + r_2) + \alpha(r_1 + r_2) + x - \frac{(r_1 + r_2)^2}{2x}\right]$$
$$= \pi(r_1 + r_2) + 2\alpha(r_1 + r_2) + 2x - \frac{(r_1 + r_2)^2}{x}$$
$$L = \pi(r_1 + r_2) + 2\left(\frac{r_1 + r_2}{x}\right)(r_1 + r_2) + 2x - \frac{(r_1 + r_2)^2}{x}$$

$$= \pi (r_1 + r_2) + 2x + \frac{(r_1 + r_2)^2}{x}$$

Q. 6. (b) What do you mean by clutch ? Discuss single plate clutch system with neat sketch.

Ans. A clutch is a device used to transmit the rotary motion of one shaft to another when desired.

Disc Clutch (Single-Plate Clutch): A disc clutch consists of a clutch plate attached to a splined hub which is free to slide axially on splines cut on the driven shaft. The clutch plate is made of steel and has a ring of friction lining on each side. The engine shaft supports a rigidly fixed flywheel.

A spring-loaded pressure plate presses the clutch plate firmly against the flywheel when the clutch is engaged. When disengaged, the springs press against a cover attached to the flywheel. Thus, both the flywheel and the pressure plate rotate with the input shaft. The movement of the clutch pedal is transferred to the pressure plate through a thrust bearing.

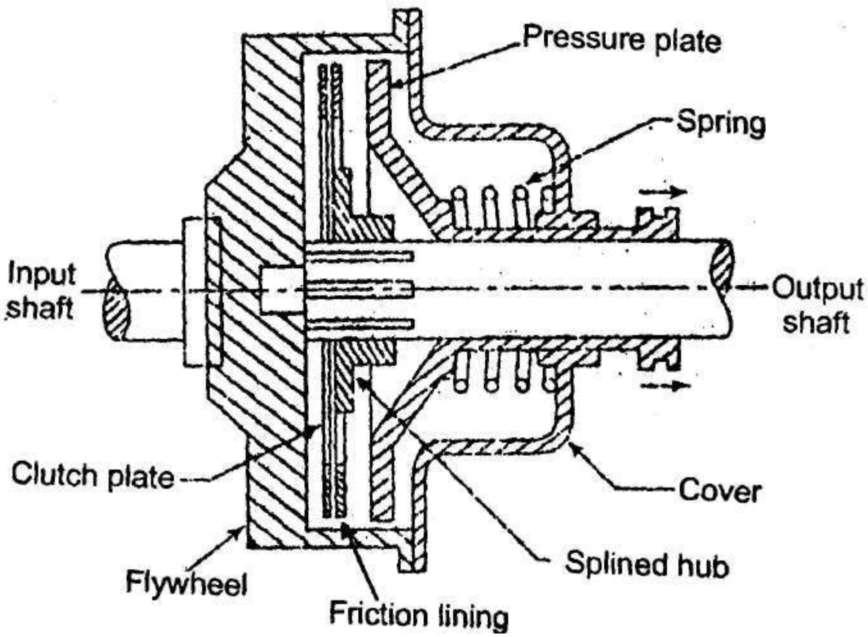
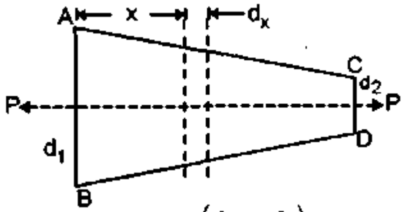


Figure shows the pressure plate pulled back by the release levers and the friction linings on the clutch plate are no longer in contact with the pressure plate or the flywheel. The flywheel rotates without driving the clutch plate and thus, the driven shaft.

When the foot is taken off the clutch pedal, the pressure on the thrust bearing is released. As a result, the springs become free to move the pressure plate to bring it in contact with the clutch plate. The clutch plate slides on the splined hub and is tightly gripped between the pressure plate and the flywheel. The friction between the linings on the clutch plate, and the flywheel on one side and the pressure plate on the other, cause the clutch plate and hence, the driven shaft to rotate.

Q. 7. (a) Derive an expression for extension of a tapered bar.

Ans. Let diameter of bar 'd" at distance x from AB



$$d' = d_1 - \left(\frac{d_1 - d_2}{l}\right)x$$

Let $\frac{d_1 - d_2}{e} = K \quad \therefore d' = d_1 - Kx$

Cross section area at distance x, $A' = \frac{\pi}{4} d'^2 = \frac{\pi}{4}(d_1 - Kx)^2$

Intensity of stress on the section $= P' = \frac{P}{A'} = \frac{4P}{\pi (d_1 - Kx)^2}$

Strain $e' = \frac{p'}{E} = \frac{4P}{\pi E (d_1 - Kx)^2}$

$\therefore$ Extension of elemental length $dx = e'\,dx$

Total extension $= \delta = \int_0^l e'\,dx = \frac{4P}{\pi E}\int_0^l \frac{dx}{(d_1 - Kx)^2}$

$$= -\frac{4P}{\pi EK}\left[\frac{-1}{d_1 - Kl} + \frac{1}{d_1}\right]$$

Putting $K = \frac{d_1 - d_2}{e}$

$$\Rightarrow \quad \delta = \frac{4Pl}{\pi E (d_1 - d_2)}\left[\frac{1}{d_1 - d_1 + d_2} - \frac{1}{d_1}\right]$$

$$= \frac{4Pl}{\pi E\, d_1 d_2}$$

Q. 7. (b) A thin walled tube, when subjected to internal pressure and Torque; has the following set of stresses produced at a point on its wall surface.

(i) 50 N/mm^2 & 30 N/mm^2 at right angles to each other, both tensile.

(ii) Complimentary shear stress of 40 N/mm determine the normal, tangential stresses on the planes which are equally inclined to the direct stresses. How the results would be affected if due to end thrust, 30 N/mm stress becomes compressive and other stresses remain unchanged.

Ans. The normal and tangential stresses on any plane

$$P_n = \frac{P + P'}{2} + \frac{P - P'}{2}\cos 2\theta + q \sin 2\theta$$

$$P_t = \frac{P - P'}{2}\sin 2\theta - q\cos 2\theta$$

Given, $P = 50\ \text{N/mm}^2 \quad P' = 30\ \text{N/mm}^2 \quad q = 40\ \text{N/m}^2$

The planes are equally inclined, hence

When $\theta = 45°$

$$P_n = \frac{50+30}{2} + \frac{50-30}{2}\cos 90 + 40\sin 90$$

$$= 80\ N/mm^2 \quad \text{(tensile)}$$

$$P_t = \frac{50-30}{2}\sin 90 - 40\cos 90$$

$$= 10\ N/mm^2$$

When $\theta = 135°$

$$P_n = 40 + 10\cos 270 + 40\sin 270 = 0$$

$$P_t = 10\sin 270 - 40\cos 270 = -10\ N/mm^2$$

In the case end thrust

$P = 50\ N/mm^2,\quad P' = -30\ N/mm^2,\quad q = 40\ N/mm^2$

When $\theta = 45°$
$$P_n = \frac{50-30}{2} + \frac{50+30}{2}\cos 90 + 40\sin 90 = 50\ N/mm^2$$

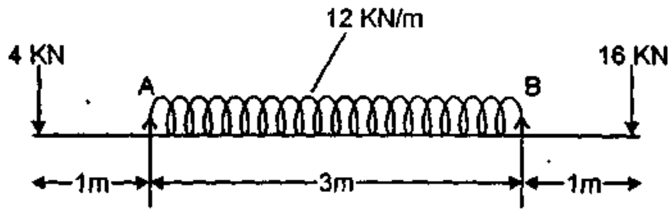
$$P_t = \frac{50+30}{2}\sin 90 - 40\cos 90 = 40\ N/mm^2$$

When $\theta = 135°$
$$P_n = 10 + 40\cos 270 + 40\sin 270$$

$$= -30\ N/mm^2 \quad \text{(compressive)}$$

$$P_t = 40\sin 270 - 40\cos 270 = -40\ N/mm^2$$

Q. 8. Determine the reactions and construct the shear force and bending moment diagram for the beam loaded as shown in the figure. Also find the points of contraflexure.



BD = 1m; AB = 3 m; CA = 1m

Ans. SF Calculations : Taking moments about D

$$4 \times 5 - R_A \times 4 + 12 \times 3 \times 2.5 - R_B \times 1 = 0$$

$$\Sigma F_V = 0$$

$\therefore\ 4 + 16 + 12 \times 3 - R_A - R_B = 0$

$\Rightarrow$
$$R_A = 18\ KN \qquad R_B = 38\ KN$$

$$SF_C = 4\ KN$$

$$SF_A = 4\ KN, \qquad SF_A = 4 - 18 = -14\ KN$$

$$SF_B = -14 + 12 \times 3 = 22\ KN$$

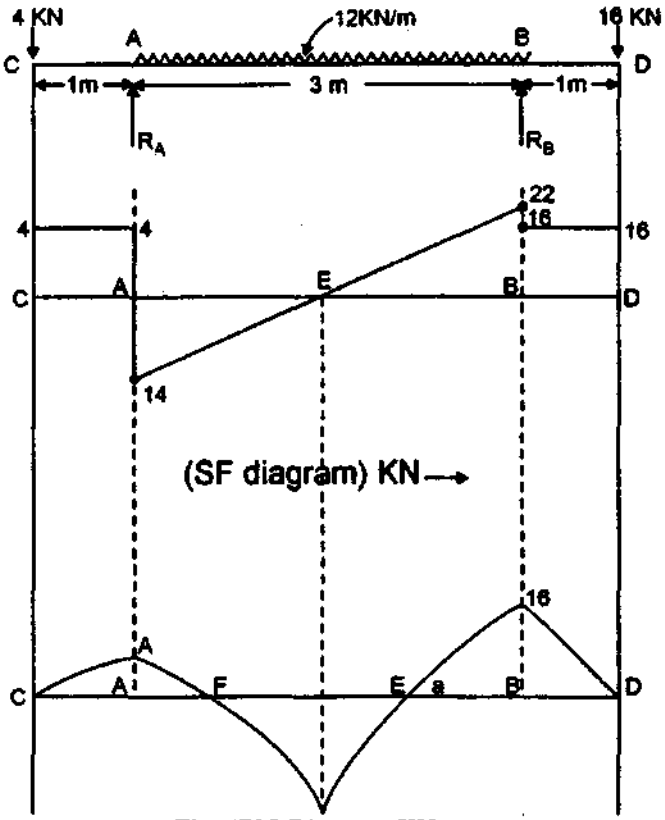


Fig. (BM Diagram KNm →

$$SF_B = 22 - 38 = 16 \text{ KN}$$

$$SF_D = 0$$

BM Calculations : $BM_C = 0, \quad BM_A = 4 \times 1 = 4 \text{ KNm}$

$$BM_B = 4 \times 4 - 18 \times 3 + 12 \times 3 \times 1.5 = 16 \text{ KNm}$$

$$BM_D = 0$$

$$SF_E = 0$$

Let $CE = x$

$\therefore \quad 4 - 18 + 12(x-1) = 0$

$\Rightarrow \quad x = 2.17 \text{ m}$

$$BM_E = 4 \times 2.17 - 18 \times 1.17 + 12 \times \frac{(1.17)^2}{2}$$

$$= -4.17 \text{ KNm}$$

Point of contraflexture are F & G

$$BM_F = 0$$

$$4 \times x - 18(x-1) + 12\frac{(x-1)^2}{2} = 0$$

$$\Rightarrow \quad 6x^2 - 14x - 12x + 18 + 6 = 0$$

$$\Rightarrow \quad 6x^2 - 26x + 24 = 0$$

$$x = \frac{26 \pm \sqrt{(26)^2 - 4 \times 6 \times 24}}{12}$$

$$\therefore \quad CF = 1.33 \text{ m}$$

$$CG = 3 \text{ m}$$