B.Tech.

Fifth Semester Examination

Mechanical Machine Design-I (ME-303-F)

Note : Attempt any *five* questions. All questions carry equal marks.

Q. 1. (a) Discuss the influence of standardisation and manufacturing process on the design of a component.

Ans. Standardization is defined as obligatory norms, to which various characteristics of a product should conform. The characteristics include materials, dimensions & quality of the product, method of testing etc.

(i) Standards for materials

(ii) Shaps & dimensions of commonly used machine elements

(iii) Standards for fits, tolerances

(iv) Standing for testing of products

(v) Standards for engineering

(vi) International standards

(vii) National standards

(viii) Company standards.

Q. 1. (b) Explain the importance of ergonomic and aesthetic consideration in a machine design.

Ans. Ergonomics is defined as the relationship between man & machine & the application of anatomical, physiological & psychological principles to solve the problems arising from man-machine relationship.

Ergonomics means the natural laws of work. From design consideration, the topics included in ergonomic studies are as follows :

(i) Anatomical factors in design of driver's seat.

(ii) Layout of instrument dials and display panels for accurate perception by the operators.

(iii) Design of hand levers & hand wheels.

(iv) Energy expenditure in hand & poor operations.

(v) Lighting, Noise & climatic conditions in machine environment.

Q. 2. (a) Discuss the factors which are considered in the selection of a material for a machine component.

Ans. (i) Availability : The material should be reading available in the market, in large enough quantities to meet the requirement.

(ii) Cost : For every application, there is a limiting cost beyond which the designer count go.

(iii) Mechanical Properties : The important mechanical properties of materials from the considerations of design are strength, rigidity, toughness, servilience, smoke resistance etc.

These properties are measured in terms of following quantities :

(i) Strength   (ii) Rigidity   (iii) Ductility

(iv) Hardness   (v) Toughness   (vi) Frictional properties.

Q. 2. (b) What is factor of safety ? Explain the factors influencing the choice of factor of safety.

Ans. (i) Always keep the stressed areas of the part in compression.

(ii) Round all external corners. It has 2 advantages—it improves the endurance strength of the component & reduces the formation of brittle chilled edges.

(iii) Wherever possible, the section thickness throughout should be held as uniform as compatible with overall design consideration.

(iv) Avoid concentration of metal at the junctions.

(v) Avoid very thin sections.

(vi) Shot blast the parts wherever possible.

Q. 3. A wall bracket is attached to a wall by means of four identical bolts, two at A and two at B, shown in figure. Assuming that the bracket is held against the wall and prevented from tipping about point C by all four bolts and using an allowable tensile stress in the bolts as 35 N/mm², determine the standard size of the bolts on the basis a suitable theory of failure.
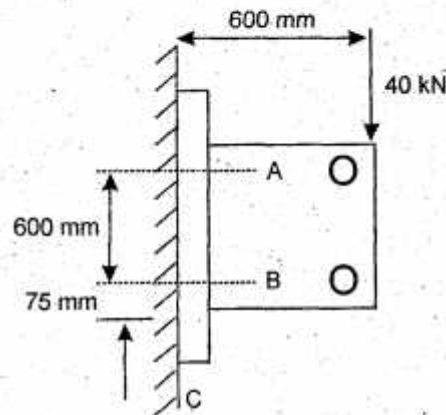
Ans.
$$P = 25 \, kN$$
$$e = 100 \, mm$$
$$l_1 = 150 \, mm$$
$$l_2 = 25 \, mm$$

There is no pre-load in the bolts. The bolts are made of plain carbon steel 45C8 & the factor of safety is 2·5.

Using the maximum shear stress theory,

$$\tau = \frac{\delta sy}{(fs)} = \frac{0.5 \, \delta yt}{fs}$$

$$= \frac{0.5 \, (380)}{2.5}$$

$$= 76 \, N/mm^2$$

$$P_1' = P_2' = \frac{P}{no. \, of \, bolts}$$

$$= \frac{25 \times 10^3}{4}$$

$$= 6250 \, N$$

The direct shear stress is given by :

$$\tau = \frac{6250}{A} \text{ N/mm}^2$$

$$P_1'' = \frac{Pe\, l_1}{2(l_1^2 + l_2^2)}$$

$$= \frac{(25 \times 10^3)(100)(150)}{2(150^2 + 25^2)}$$

$$= 8108.11 \text{ N}$$

$$\sigma_t = \frac{P_1''}{A} = \frac{8108.11}{A} \text{ N/mm}^2$$

$$\tau_{max} = \sqrt{\left(\frac{\sigma_t}{2}\right)^2 + (\tau)^2}$$

$$= \sqrt{\left(\frac{8108.11}{2A}\right)^2 + \left(\frac{6250}{A}\right)^2}$$

$$= \frac{7449.69}{A} \text{ N/mm}^2$$

Equating this value of τ_{max} to permissible shear stress,

$$\frac{7449.69}{A} = 76$$

$$\boxed{A = 98.02 \text{ mm}^2}$$

Q. 4. Two steel rods of equal diameter are required to join with a cotter joint. Each rod is subjected to an axial tensile force of 60 kN. Design and draw the joint specifying its main dimensions.

Ans.

$$\tau = \frac{\delta xy}{fs}$$

$$= \frac{0.577 \delta yt}{fs} = \frac{(0.577)(380)}{3} = 73.09 \text{ N/mm}^2$$

$$P_1' = P_2' = P_3' = \frac{P}{3} = \frac{5000}{3} = 1666.67 \text{ N}$$

$$P_1'' = P_3'' = \frac{(P_e)(r_1)}{r_1^2 + r_3^2} = \frac{(5000 \times 305)(75)}{(75^2 + 75^2)}$$

$$= 10166.67 \text{ N}$$

The resultant shear force on belt 3 is maximum.

Thus,

$$P_3 = P_3' + P_3''$$

$$= 1666.673 + 10166.67$$

$$= 11833.34 \text{ N}$$

$$\frac{P_3}{A} = \tau$$

$$\frac{11833.34}{A} = 73.09$$

$$A = 161.9 \text{ mm}^2$$

Q. 5. A V-belt drive is to transmit 15 kW to a compressor. The motor speed is 1440 rpm and the compressor pulley runs at 480 rpm. Give complete design of the drive.

Ans. Plot a point with coordinates 7.5 kW & 1440 rpm speed in fig. It is observed that for this application, the cross-section for the V belt is B. For cross-section B, the minimum pitch diameter for the pulley is 200 mm from table.

Here,
$$d = 200 \text{ mm}$$

$$D = \frac{200 \times 1440}{480} = 600 \text{ mm}$$

$$L = 2C + \frac{A(d+D)}{2} + \frac{(D-d)^2}{4C}$$

$$= 2(1000) + \frac{A(600+200)}{2} + \frac{(600-200)^2}{4(1000)}$$

$$= 3296.64 \text{ mm}$$

$$Li = L - 43$$

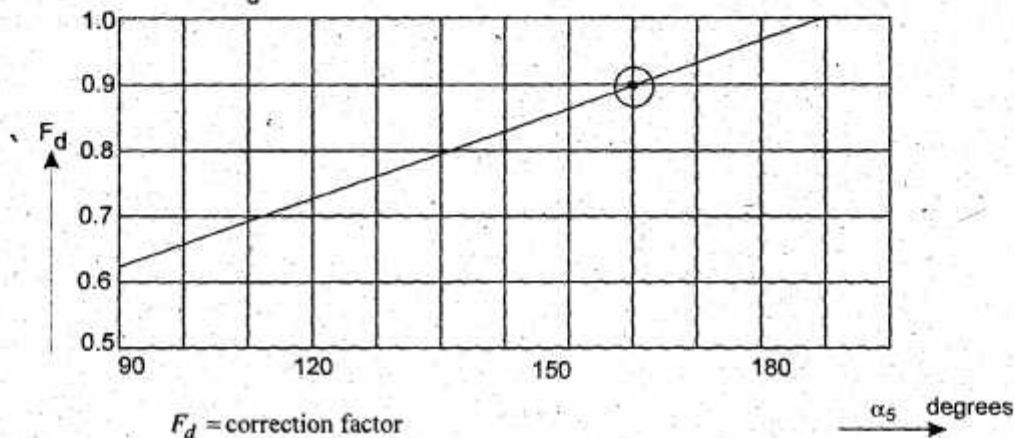$$= 3296.64 - 43$$

$$= 3253.64 \text{ mm}$$

$$F_l = 1.08$$

$$F_a = 1.30$$

$$\propto_s = 180 - 2\sin^{-1}\left(\frac{D-d}{2C}\right)$$

$$= 180 - 2\sin^{-1}\left(\frac{600-200}{2 \times 1000}\right)$$

$$= 150.93°$$

$$F_d = 0.94$$

$$F_d = \text{correction factor}$$

$$\text{No. of belts} = \frac{(P_t)(F_a)}{(\text{kW rating})(F_a)(F_l)}$$

$$= \frac{(7.5)(1.30)}{(5.23)(0.94)(1.08)}$$

$$= 1.84 \text{ or}$$

$$\boxed{= 2 \text{ belts}} \quad \text{Ans.}$$

Q. 6. Design and draw a bushed pin type flexible coupling for connecting the motor and the centrifugal pump shafts. The motor delivers 25 kW power at 720 rpm. The starting torque of the motor can be assumed to be 125 % of the rated torque.

Ans.

$$M_t = \frac{60 \times 10^6 (kW)}{2\pi n} = \frac{60 \times 10^6 (15)}{2\pi (720)}$$

$$= 198943.68 \text{ N-mm}$$

$$\delta_{xy} = 0.577 \delta_{yt}$$

$$= 0.577 (220)$$

$$= 126.94 \text{ N/mm}^2$$

$$\tau = \frac{\delta_{xy}}{fs} = \frac{126.94}{2.5} = 50.78 \text{ N/mm}^2$$

Each coil is subjected to double shear & the expression for toque is written as

$$M_t = 2A\tau \, RN$$

Where, A = cross-sectional area of each coil.

R = radial distance of coil from the axis of shaft

N = No. of coils.

Re-arranging the terms,

$$N = \frac{M_t}{2A\tau R} = \frac{198943.68}{2(4 \times 2)(50.78)(30)}$$

$$= 8.19$$

$$\boxed{N = 9 \text{ coils}}$$

Q. 7. (a) Compare dry and wet clutch design.

Ans. A multi-disk clutch consists of 2 sets of disks, A and B. Disks of set A are usually made of hardened steel, while those of set B are made of bronze. Disks of set A are connected to the driven shaft by means of splines.

Because of splines, they are free to move in an axial direction. There are four through belts which pass through the holes in disks of set B.

A clearance fit between the belt & the holes in use. For the uniform-pressure criterion,

$$(M_t)_f = \frac{\mu P_2}{3}\left(\frac{D^3 - d^3}{D^2 - d^2}\right)$$

For uniform wear criterion,

$$(M_t)_f = \frac{\mu P_2}{4}(D + d)$$

Q. 7. (b) A multiple-disc clutch is to be made up of 6 steel and 5 bronze discs, with an inner radius of 25 mm. Determine the outer diameter and the axial pressure to transmit a torsional moment of 18 Nm.

Ans.

$$P = \frac{\pi \, p_a d}{2} (D-d)$$

$$= \frac{\pi (0.3)(75)}{2} (150-75)$$

$$= 2650.72 \text{ N}$$

$$Z = 8$$

$$(M_t)_f = \frac{\mu P_2}{4} (D+d)$$

$$= \frac{(0.1)(2650.72)(8)}{4} (150+75)$$

$$= 119282.4 \text{ N-m}$$

$$kW = \frac{2\pi n (M_t)_f}{60 \times 10^6}$$

$$= \frac{2\pi (750)(119282.4)}{60 \times 10^6}$$

$$= 9.37 \text{ Ans.}$$

Q. 8. (a) Is self locking in brakes desirable ? If so, under what conditions ?

Ans. A brake is defined as a mechanical device which is used to absorb the energy possessed by a moving system or mechanism by means of friction.

The primary purpose of the brake is to slow or completely stop the motion of a moving system, such as a rating drum, machine or vehicle.

The first step in design of mechanical brake is to determine the braking torque capacity for the given application.

$$KE = \frac{1}{2} m (v_1^2 - v_2^2)$$

$$KE = \frac{1}{2} I (w_1^2 - w_2^2)$$

$$KE = \frac{1}{2} m K^2 (w_1^2 - w_2^2)$$

$$PE = mgh$$

$$E = M_t Q$$

Q. 8.(b) A single-block brake with torque capacity of 15 N-m is shown in figure. The coefficient of friction is 0.3 and the maximum pressure on the brake lining is 1 N/mm^2. The width of the block is equal to its length. Calculate :

(i) the actuating force

(ii) the dimensions of the block

(iii) the resultant hinge-pin reaction and

(iv) the rate of heat generated, if the brake drum rotates at 50 rpm.
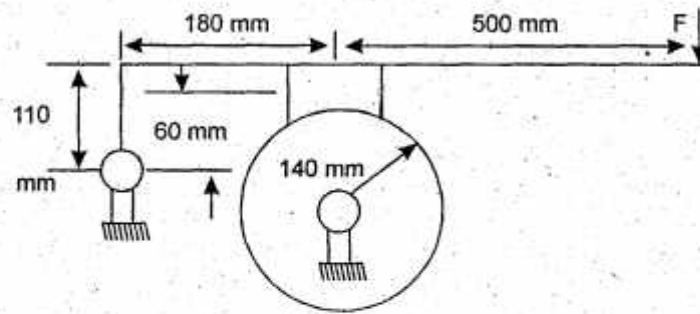
Ans.

$$N = \frac{Mr}{\mu R} = \frac{250 \times 10^3}{0.35 \times 200} = 357143\,N$$

$$\mu N\,(50) + P\,(500) - N\,(200) = 0$$

$$0.35\,(3571.43)\,50 + P\,(500) - 3571.43\,(200) = 0$$

$$P = 1303.57\,N$$

$$R_x = \mu N$$
$$= 0.35\,(3571.43)$$
$$= 1250\,N.$$

$$R_y = N - P$$
$$= 3571.43 - 1303.57$$
$$= 2267.86\,N$$

$$R = \sqrt{(1250)^2 + (2267.86)^2}$$

$$\boxed{R = 2589.53\,N}$$

$$-\mu N\,(50) + P\,(500) - N\,(200) = 0$$

$$\boxed{P = 1533.57\,N}$$

$$R_x = \mu N$$
$$= 1250N$$

$$R_y = N - P$$
$$= 3571.43 - 1553.57$$

$$R_y = 2017.86N$$

$$R = \sqrt{(1250)^2 + (2017.86)^2}$$

$$\boxed{R = 2373.66\,N} \quad \textbf{Ans.}$$