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THOTTIAM, NAMAKKAL-621215.
DEPARTMENT OF MECHANICAL ENGINEERING
SIXTH SEMESTER / III YEAR
ME6601 – DESIGN OF TRANSMISSION SYSTEM (Regulation-2013)**

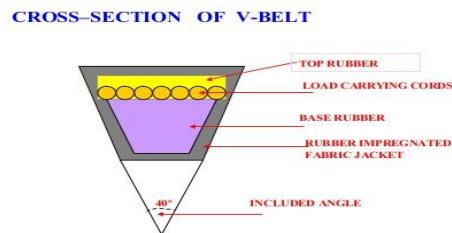
UNIT -I

PART-A

1. How is a Wire rope specified?

Ans: They are specified by the no. of strands & the no. of wires in each strand.

2. Sketch the cross section of a V-belt and label its important parts.



3. Why is the face of a pulley crowned?

Ans: The crowning tends to keep the belt in centre on a pulley rim while in motion.

4. What are the five parts of roller chain?

Ans: Pin link, Roller link, Pins, Bushes & Roller

5. Give the relationship of ratio of tensions in a V-belt drive.

Ans: $T_1/T_2 = e^{\mu \alpha \operatorname{cosec} \beta}$

6. What is a silent chain? In what situations, silent chains are preferred?

Ans: i) Inverted tooth chains are called silent chains because of their relatively quiet operation.

ii) They are preferred for high-power, high speed & smooth operation

7. Define maximum tension in a belt.

Ans: Tension on tight side of the belt + Centrifugal tension

8. Give the condition for maximum power transmission in terms of centrifugal tension in case of belt drive.

Ans: The power transmitted shall be maximum when the centrifugal tension (T_c) is one third of the maximum belt tension (T).

9. Why tight side of the flat belt should be at the bottom side of the pulley?

Ans: Because the driving pulley pulls the belt from bottom side and delivers it to the upper side. So it is obvious that the bottom side of the belt is tight.

10. What is meant by 'chordal action of chain'?

Ans: When chain passes over the sprocket, it moves as a series of chords instead of a continuous arc as in the case of a belt drive. It results in varying speed of the chain drive. This phenomenon is known as chordal action.

PART-B

A compressor is to be actuated from a 10 kW electric motor. The speed of the motor shaft is 1000 rpm and the compressor speed being 350 rpm. The minimum centre distance is 500 mm. The compressor operates 16 hours per day. Design a suitable chain drive.

Design a flat belt drive to transmit 25 kW at 720 rpm to an aluminium rolling machine with a speed reduction of 3.0. The distance between the shafts is 3 m. Diameter of rolling machine pulley is 1.2 m.

Design a chain drive to activate a compressor from a 15 kW electric motor at 960 rpm. The compressor speed is 300 rpm. The chain tension may be adjusted by shifting the motor on rails. The compressor is to work 8 hours/day.

Design a flat belt drive to transmit 110 kW for a system consisting of two pulleys of diameters 0.9 m and 1.2 m respectively, for a centre distance of 3.6 m, belt speed of 20 m/s and coefficient of friction = 0.3. There is a slip of 1.2 % at each pulley and 5% friction loss at each shaft with 20% over load.

The transporter of a heat treatment furnace is driven by a 4 kW, 1440 rpm, induction motor through a chain drive with a speed reduction ratio of 2.4. The transmission is horizontal with bath type of lubrication. Rating is continuous with 3 shifts per day. Design the complete chain drive assuming simplex type and centre distance of approximately 500 mm.

A 2.5 kW of power is transmitted by an open belt drive. The linear velocity of the belt is 2.5 m/s. The angle of lap on the smaller pulley is 165° . The co-efficient of friction is 0.3. Determine the effect on power transmission in the following cases :

- (i) Initial tension in the belt is increased by 8%,
- (ii) Initial tension in the belt is decreased by 8%,
- (iii) Angle of lap is increased by 8% by the use of an idler pulley, for the same speed and the tension on the tight side, and
- (iv) Co-efficient of friction is increased by 8% by suitable dressing to the friction surface of the belt. Also state which of the above methods suggested could be more effective?

A blower is to run at 600 rpm. Power to the blower is available from a motor rated 8kW at 1500 rpm. Design a chain drive for the system if the centre distance is to be 800 mm. (16)

Design a V-belt drive to transmit 50kW at 1440 rpm from an electric motor to a textile machine running 24 hours a day. The speed of the machine shaft is 480 rpm. (16)

A 15 kW squirrel cage motor, 1250 r.p.m. is driving a centrifugal pump at 550 r.p.m. The centrifugal pump is located at 700 mm from the motor. Design a chain drive.

A crane is lifting a load of 18 kN through a wire rope and a hook. The weight of the hook etc., is 10 kN. The load is to be lifted with an acceleration of 1 m/sec^2 . Calculate the diameter of the wire rope. The rope diameter may be taken as 30 times the diameter of the rope. Take a factor of safety of 6 and Young's modulus for the wire rope $0.8 \times 10^6 \text{ N/mm}^2$. The ultimate stress may be taken as 1800 N/mm^2 . The cross-sectional area of the wire rope may be taken as 0.38 times the square of the wire rope diameter.

UNIT -II

PART-A

1. Mention a few gear materials.

Ans: Metallic gears – steel, cast iron

Non-Metallic gears – wood, compressed paper & synthetic resins

2. State an advantage and disadvantage of helical gear. Ans: Advantage:

Produce less noise than spur gears
Dis Advantage: Subjected to axial thrust loads

3. Why is tangential component of gear tooth force called useful component? Ans: Because it transmits power.

4. Compare the contact between mating teeth of spur and helical gears.

Ans: i) In spur gears the line of contact is parallel to the axis of rotation. The total length of contact line is equal to the face width.

ii) In helical gears the line of contact is diagonal across the face of the tooth. The total length of contact line is greater than the face width. This lowers the unit loading & increases load carrying capacity.

5. What is backlash in gears?

Ans: It is the difference between the tooth space and the tooth thickness along the pitch circle.

6. What is the advantage of helical gear over spur gear? Ans: i) Helical gears

produce less noise than spur gears.

ii) Helical gears have a greater load capacity than equivalent spur gears.

7. Why is a gear tooth subjected to dynamic loading?

Ans: Inaccuracies of tooth spacing, Irregularities in tooth profiles, Misalignment between bearings.

8. State the law of gearing or conditions of correct gearing.

Ans: It states that for obtaining a constant velocity ratio, at any instant of teeth the common normal at each of contact should always pass through a pitch point, situated on the line joining the centers of rotation of the pair of mating parts.

9. What are the commonly used gear tooth profiles? Ans: Involute &

Cycloidal

10. State about herring bone gear.

Ans: The double helical gears connecting two parallel shafts are known as herringbone gears. They are used in heavy machinery and gear boxes.

PART -B

A motor shaft rotating at 1440 rpm has to transmit 15 kW to a low speed shaft rotating at 500 rpm. The teeth are 20° involute with 25 teeth on the pinion. Both the pinion and gear are made of cast iron with a maximum safe stress of 56 MPa. A safe stress of 35 MPa may be taken for the shaft on which the gear is mounted. Design and sketch the spur gear drive to suit the above conditions. The starting torque may be assumed as 1.25 times the running torque.

A helical gear speed reducer is to be designed. The rated power of the speed reducer is 75 kW at a pinion speed of 1200 rpm. The speed ratio is 3 to 1. For medium shock conditions and 24 hours operation; determine, the module, face width, number of teeth in each gear. The teeth are 20° full depth in the normal plane. Assume suitable material.

In a spur gear drive for a rock crusher, the gears are made of case hardened alloy steel. The pinion is transmitting 18 kW at 1200 rpm with a gear ratio of 3.5. The gear is to work 8 hours/day for 3 years. Design the drive's major dimensions, check for compressive and bending stresses and sketch the arrangement.

For intermittent duty of an elevator, two cylindrical gears have to transmit 10 kW at a pinion speed of 1200 rpm. Design the gear pair for the following specifications : Gear ratio 3.5, pressure angle 20° , involute full depth, helix angle 15° . Gears are expected to work 6 hours a day for 10 years. Use alloy steel 40 Ni 2 Cr 1 Mo 28 for both pinion and gear.

A train of spur gears is shown in Fig. 1. Pinion 1 runs at 1750 rpm and transmits 2.5 kW power to idler gear 2. The teeth are cut on the 20° full depth system and have a module of 2.5 mm. The number of teeth on gears 1, 2 and 3 are 20, 50 and 30 respectively. Calculate :

- (i) the torque on each gear shaft and
- (ii) the components of gear tooth forces.

Also draw a free body diagram of gear 2 showing all the forces which act upon it and determine the reaction on the idler gear shaft.

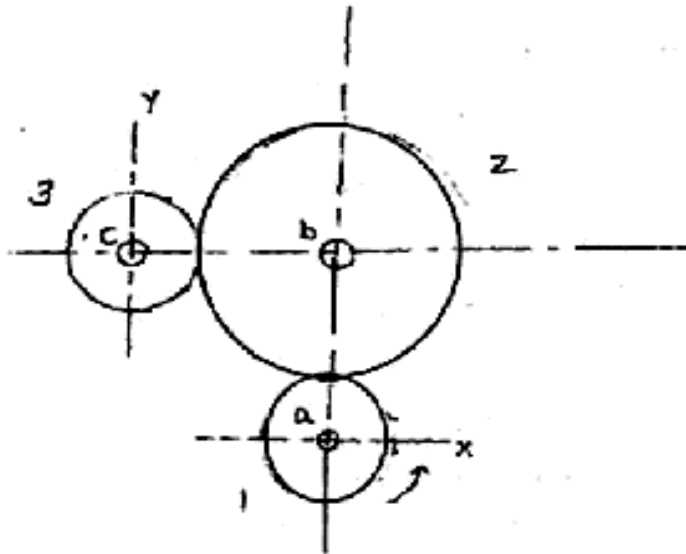


Fig.1

A pair of helical gears subjected to heavy shock loading is to transmit 37.5 kW at 1750 rpm of the pinion. The speed reduction ratio is 4 and the helix angle is 15° . The service is continuous and the teeth are 20° full depth in the normal plane. Select suitable material and design the gears. Check for working stresses and sketch the drive.

A motor shaft running at 1440 rpm has to transmit 15 kW power to a low speed shaft rotating at 480 rpm. The pinion has 25 teeth. Both pinion and gear are made of C45 steel. Design a suitable spur gear drive.

Design a pair of helical gears to transmit 30 kW at a speed reduction ratio of 4:1. The input shaft runs at 2000 rpm. Both pinion and gear are 15Ni2cr1Mo15 under carburized Condition.

A motor shaft rotating at 1500 rpm has to transmit 15 kW to a low speed shaft with a speed reduction of 3:1. Assume starting torque to be 25% higher than the running torque. The teeth are 20° involute with 25 teeth on the pinion. Both the pinion and gear are made of C45 steel. Design a spur gear drive to suit the above conditions and check for compressive and bending stresses and plastic deformation. Also sketch the spur gear drive. (16)

UNIT -III

PART-A

1. When do we employ crossed helical gear?

Ans: A pair of crossed-helical gears also known as spiral gears are used to connect and transmit motion between two non-parallel and non-intersecting shafts. As the contact between the mating teeth is always a point, these gears are suitable only for transmitting a small amount of power.

2. Mention two characteristics of hypoid gear.

Ans: They are similar in appearance to spiral-bevel gears. Their pitch surfaces are hyperboloids rather than cones. Axis of pinion is offset from the axis of the gear.

3. What are the various forces acting on a bevel gear? Ans: Tangential force, Axial force & Radial force

4. Usually worm is made of hard material and worm gear is made of softer material – justify.

Ans: A material strength is set so that an amount of wear of the worm becomes larger than that of the worm wheel.

5. When is bevel gear preferred?

Ans: They are used to transmit power between two intersecting shafts.

6. Calculate the angle between the shafts of a crossed helical gears made of two right handed helical gears of 15° helix angle each.

Ans: Shaft angle, $\Theta = \beta_1 + \beta_2 = 2\beta = 2(15^\circ) = 30^\circ$

7. State the use of bevel gears.

Ans: They are used to transmit power between two intersecting shafts.

8. State the advantage of worm gear drive in weight lifting machine.

Ans: The worm gear drives are irreversible. It means that the motion cannot be transmitted from worm wheel to the worm. This property of irreversible is advantageous in load hoisting applications like cranes and lifts.

9. Why is the crossed helical gear drive not used for power transmission?

Ans: As the contact between the mating teeth of crossed helical gears is always a point, these gears are suitable only for transmitting a small amount of power.

That's why mostly these gears are not used for power transmission.

10. Why is the efficiency of a worm gear drive comparatively low? Ans: Because of power loss due to friction caused by sliding.

PART -B

A pair of cast iron bevel gears connect two shafts at right angles. The pitch diameters of the pinion and gear are 80 mm and 100 mm respectively. The tooth profiles of the gears are of $14 \frac{1}{2}^\circ$ composite form. The allowable static stress for both the gears is 55 MPa. If the pinion transmits 2.75 kW at 1100 rpm, find the module and number of teeth on each gear and check the design. Take surface endurance limit as 630 MPa and modulus of elasticity for cast iron as 84 kN/mm^2 .

Design a bevel gear drive to transmit 10 kW at 1440 rpm. Gear ratio is 3, material for pinion and gear is C45 steel. Minimum number of teeth is to be 20.

Design worm and gear speed reducer to transmit 22 kW at a speed of 1440 rpm. The desired velocity ratio is 24 : 1. An efficiency of at least 85% is desired. Assume that the worm is made of hardened steel and the gear of phosphor bronze. Take the centre distance as 100 mm.

A hardened steel worm rotates at 1440 rpm and transmits 11 kW to a phosphor bronze gear with gear ratio of 15. Design the worm gear drive and determine the power loss by heat generation.

Design a bevel gear drive to transmit 3.5 kW Speed ratio = 4. Driving shaft speed = 200 rpm. The drive is non-reversible. Pinion is of steel and wheel of CI. Assume a life of 25000 hours.

A 2 kW power is applied to a worm shaft at 720 rpm. The worm is of quadruple start type with 50 mm as pitch circle diameter. The worm gear has 40 teeth with 5 mm module. The pressure angle in the diametral plane is 20° . Determine (i) the lead angle of the worm, (ii) velocity ratio, and (iii) centre distance. Also, calculate efficiency of the worm gear drive, and power lost in friction. (16)

In a spiral gear drive connecting two shafts, the approximate centre distance is 400 mm and the speed ratio is 3. The angle between the two shafts is 50° and the normal pitch is 18 mm. The spiral angles for the driving and driven wheels are equal. Find,

- (1) Number of teeth on each wheel
- (2) Exact centre distance and
- (3) Efficiency of the drive, if friction angle = 6° . (10)

Design a bevel gear drive to transmit 3.5 kW with the following specifications : speed ratio = 4; driving shaft speed = 200 r.p.m.; drive is non-reversible; material for pinion is steel; material for wheel is cast iron; and life 25000 hours.

A 25 kW motor running at 1200 rpm drives a compressor at 780 rpm through a 90° bevel gearing arrangement. The pinion has 30 teeth. The pressure angle of the teeth is 20° . Both the pinion and gear are made of heat treated cast iron grade 35. Determine the cone distance, average module and face width of the gears. (16)

Design a worm gear drive to transmit a power of 22.5 kW. The worm speed is 1440 r.p.m. and the speed of the wheel is 60 r.p.m. The drive should have a minimum efficiency of 80% and above. Select suitable materials for the worm and wheel and decide upon the dimensions of the drive.

UNIT -IV

PART-A

1. What are the points to be considered while designing a sliding mesh type of multi-speed gear box?

Ans: i) The transmission ratio in a gear box is limited by $\frac{1}{4} < i < 2$

ii) Speed ratio of any stage should not be greater than 8.

2. Which type of gear is used in constant mesh gear box? Justify.

Ans: Helical gears are used in constant mesh gear boxes to provide quieter and smooth operation.

3. Compare sliding mesh and synchromesh gear box.

Ans: sliding mesh gear box: It derives its name from the fact that the meshing of the gears takes place by sliding of gears on each other. With sliding mesh gear box, double de-clutching is necessary to bring the two sets of dog teeth to the same speed so that they can be slid into engagement quietly.

Synchromesh gear box: To eliminate the need to de-clutch, the synchromesh gear box was introduced. The basic gear box is laid out in the same manner as the constant mesh, but with the addition of a cone clutch fitted between the dog and gear members.

4. Where are multi-speed gear boxes employed?

Ans: They are employed wherever the variable spindle speeds are necessary.

5. Name the series in which speeds are arranged in multi-speed gear boxes. **Ans:** Basic series of preferred numbers are R5, R10, R20, R40 & R80.

6. List six standard speeds starting from 18 rpm with a step ratio 1.4.

Ans: For the step ratio $\Phi = 1.4$, the R20 series, the standard speeds are 18, 20, 22.4, 25, 28 & 31.5 rpm.

7. Sketch the kinematic layout of gears for 3 speeds between two shafts. **Ans:** Refer page no: 9.11

Dots by V.Jayakumar

8. Differentiate ray diagram and structural diagram.

Ans: Ray diagram is a graphical representation of the structural formula.

Structural diagram is a kinematic layout that shows the arrangement of gears in a gear box.

9. List out the basic rules to be followed for optimum gear box design.

Ans: i) The transmission ratio in a gear box is limited by $\frac{1}{4} < i < 2$

ii) Speed ratio of any stage should not be greater than 8.

10. What is step ratio? Name the series in which speeds of multi-speed gear box are arranged.

Ans: When the spindle speeds are arranged in geometric progression, then the ratio between the two adjacent speeds is

known as speed ratio.

Basic series are R5, R10, and R20 & R40.

PART – B

The maximum and minimum speeds of nine speed gear box are to be 600 rpm and 100 rpm respectively. The drive is from an electric motor giving 3 kW at 1440 rpm. Design the gear box. Construct the speed diagram and sketch the arrangement of gear box.

Design a 12 speed gear box for a headstock of a lathe. The maximum and minimum speeds are 600 rpm and 25 rpm respectively. The drive is from a electric motor giving 2.25 kW at 1440 rpm. Construct the speed diagram and sketch the arrangement of the gear box.

Design a nine speed gear box for a minimum speed of 35 rpm and a maximum speed of 560 rpm. Draw the speed diagram and kinematic arrangement showing number of teeth in all gears. Check whether all the speeds obtained through the selected gears are within $\pm 3\%$.

Design a 12 speed gear box for an all geared headstock of a lathe by drawing speed diagram. Show the details in a kinematic lay out. The maximum and minimum speeds are to be 1400 rpm and 112 rpm respectively. Take the input drive speed to be the 1400 rpm.

A nine speed gear box, used as a head stock gear box of a turret lathe, is to provide a speed range of 180 rpm to 1800 rpm. Using standard step ratio, draw the speed diagram, and the kinematic layout. Also find and fix the number of teeth on all gears.

A 14 speed gear box is required to furnish output speeds in the range of 125 to 2500 rpm. Draw the speed diagram and the kinematic arrangement.

Sketch the arrangements of a six speed gear box. The minimum and maximum speeds required are around 460 and 1400 rpm. Drive speed is 1440 rpm. Construct speed diagram of the gear box and obtain various reduction ratios. Use standard output speeds and standard step ratio. Calculate number of teeth in each gear and verify whether the actual output speeds are within $\pm 2\%$ of standard speeds. (16)

Design the layout of a 12 speed gear box for a milling machine having an output of speeds ranging from 180 to 2000 rpm. Power is applied to the gear box from a 6 kW induction motor at 1440 rpm. Choose standard step ratio and construct the speed diagram. Decide upon the various reduction ratios and number of teeth on each gear wheel. Sketch the arrangement of the gear box. (16)

A machine tool gear box is to have 9 speeds. The gear box is driven by an electric motor whose shaft rotational speed is 1400 r.p.m. The gear box is connected to the motor by a belt drive. The maximum and minimum speeds required at the gear box output are 1000 r.p.m. and 200 r.p.m. respectively. Suitable speed reduction can also be provided in the belt drive. What is the step ratio and what are the values of 9 speeds? Sketch the arrangement. Obtain the number of teeth on each gear and also the actual output speeds.

A six speed gear box is required to provide output speeds in the range of 125 to 400 r.p.m. with a step ratio of 1.25 and transmit a power of 5 kW at 710 r.p.m. Draw the speed diagram and kinematic diagram. Determine the number of teeth module and face width of all gears, assuming suitable materials for the gears. Determine the length of the gear box along the axis of the gear shaft.

UNIT –V
PART-A

1. Name the profile of cam that gives no jerk.

Ans: Circle –arc cam gives no jerk. Because the derivative of acceleration of cam is zero.

2. Give the reasons for left and right shoes of the internal expansion brakes having different actuating forces.

Ans: Depending upon the direction of the drum rotation, one shoe would be a leading shoe and another shoe is a trailing shoe. The leading shoe is self energizing whereas the trailing shoe is not. In the leading shoe, the friction force helps the applied force and hence more actuating force than the trailing force.

3. What are the effects of temperature rise in clutches?

Ans: i) Excessive surface temperature results in premature clutch failure.

ii) May cause the individual plates to be welded together in metal clutches.

iii) May cause excessive wear in non-metal clutches.

4. What is the significance of pressure angle in cam design?

Ans: The pressure angle is very important in cam design as it represents steepness of the cam profile. If the pressure angle is too large, a reciprocating follower will jam in its bearings.

5. State the advantage of cam mechanisms.

Ans: Cams are used for transmitting desired motion to a follower by direct contact. Cam mechanisms are used in the operation of IC engine valves.

6. How the ‘uniform rate of wear’ assumption is valid for clutches?

Ans: In clutches, the value of normal pressure, axial load for the given clutch is limited by the rate of wear that can be tolerated in the brake linings. Moreover, the assumption of uniform rate wear gives a lower calculated clutch capacity than the assumption of uniform pressure. Hence clutches are usually designed on the basis of uniform wear.

7. Name four profiles normally used in cams.

Ans: Uniform velocity, Simple harmonic motion, Uniform acceleration & retardation, Cycloidal motion.

8. Under what condition of a clutch, uniform rate of wear assumption is more valid?

Ans: If the clutch is old one.

9. When do we use multiple disk clutches?

Ans: It is used when large amount of torque is to be transmitted. In a multi plate clutch, the number of frictional linings and the metal plates are increased which increases the capacity of the clutch to transmit torque.

10. Differentiate between self-energizing and self-locking brakes.

Ans: When the frictional force is sufficient enough to apply the brake with no external force, then the brake is said to

be **self-locking brake**.

When the frictional force helps in applying the brake, then the brake is said to be self-energised brake.

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PART-B

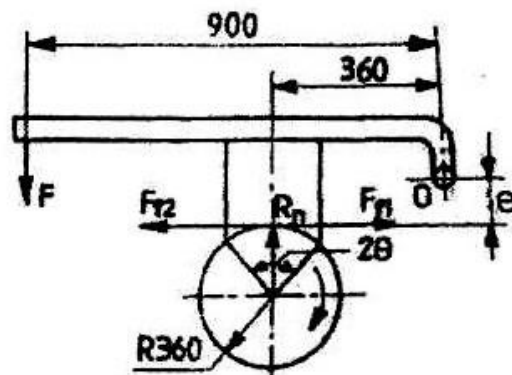
A friction clutch is required to transmit 25 kW at 2000 rpm. It is to be of single plate disc type with both sides. The pressure is exerted by means of springs and limited to 70 kN/m². If the maximum possible outer diameter of the clutch plate is 300 mm, find the required inner diameter of the clutch plate and the total force exerted by the springs. Assume the wear to be uniform and coefficient of friction as 0.3.

An internal expanding shoe brake has the following dimensions : Diameter of the drum = 300 mm, distance between the fulcrum centers = 80 mm, distance of fulcrum centers and that of cam axis, both from the drum centre = 100 mm, distance of line of action of braking force from the cam axis = 90 mm, distance between the points where the cam acts on the two brake shoes = 30 mm. Each shoe subtends an angle of 90° at the drum centre. If the braking force is 750 N and the coefficient of friction is 0.3, find the braking torque on the drum. Assume the reactions between the brake shoes and the drum passes through the points bisects the contact angle. Also assume that forces exerted by the cam ends on the two shoes are equal.

A single plate clutch is used for an engine that develops a maximum torque of 120 N-m. Assume a factor of safety of 1.5 to account for slippage at full engine torque. The permissible intensity of pressure is 350 kPa and the coefficient of friction is 0.35. Calculate the inner and outer diameters of the friction lining and the axial force to be exerted by the springs to engage the clutch.

A leather faced conical friction clutch has a cone angle of 30°. The intensity of pressure between the contact surface is not to exceed 6×10^4 N/m² and the breadth of the conical surface is not to be greater than 1/3 of the mean radius, if $\mu = 0.20$ and the clutch transmits 37 kW at 2000 rpm. Find the dimensions of contact surface. Assume a service factor of 2.5.

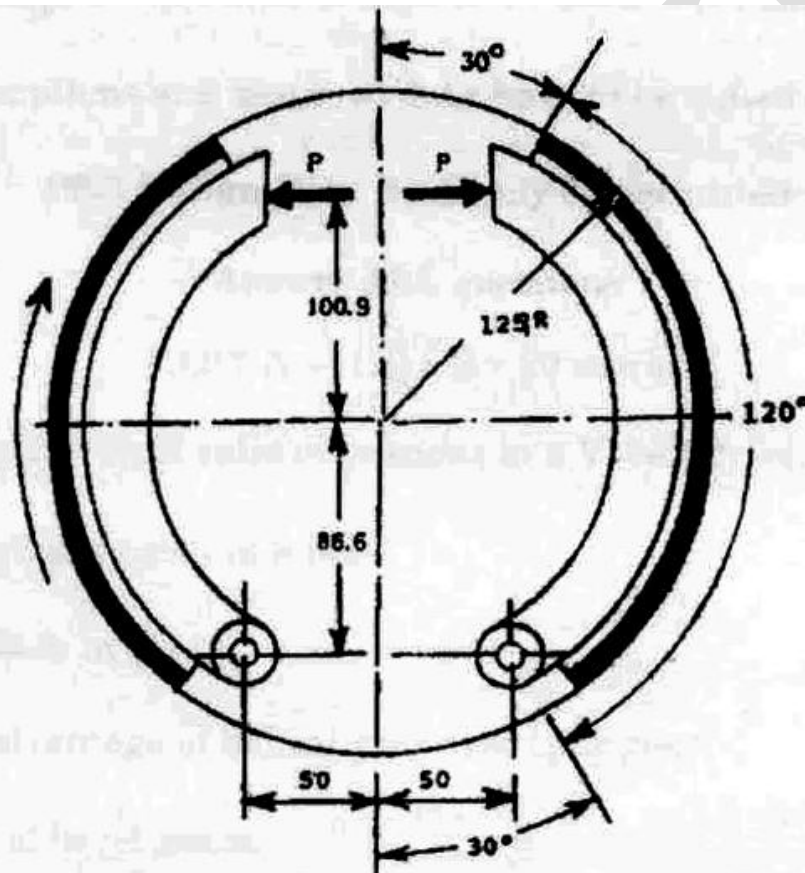
A 360 mm radius Brake drum contacts a single shoe as shown in Figure 15 (b) and resists a torque of 225 Nm at 500 rpm. The co-efficient of friction is 0.3. Determine (i) the normal reaction on the shoe, (ii) the force to be applied at the lever end for counter clockwise rotation of the drum if $e = 0$ (iii) the force to be applied at the lever end for clockwise rotation of the drum if $e = 40$ mm, (iv) the force to be applied at the lever end for counter clockwise rotation of the drum if $e = 40$ mm.



A multi-disk clutch consists of five steel plates and four bronze plates. The inner and outer diameters of friction disks are 75 mm and 150 mm respectively. The coefficient of friction is 0.1 and the intensity of pressure is limited to 0.3 N/mm^2 . Assuming the uniform wear theory, calculate (i) the required operating force, and (ii) power transmitting capacity at 750 rpm. (16)

Derive an expression for the braking torque considering a single shoe brake. Explain self-locking and self-energising brakes.

An automotive type internal-expanding double-shoe brake is shown in figure 15 b. The face width of the friction lining is 40 mm and the intensity of normal pressure is limited to 1 N/mm^2 . The coefficient of friction is 0.32. The angle θ_1 can be assumed to be zero. Calculate (i) the actuating force P , and (ii) the torque-absorbing capacity of the brake. (16)



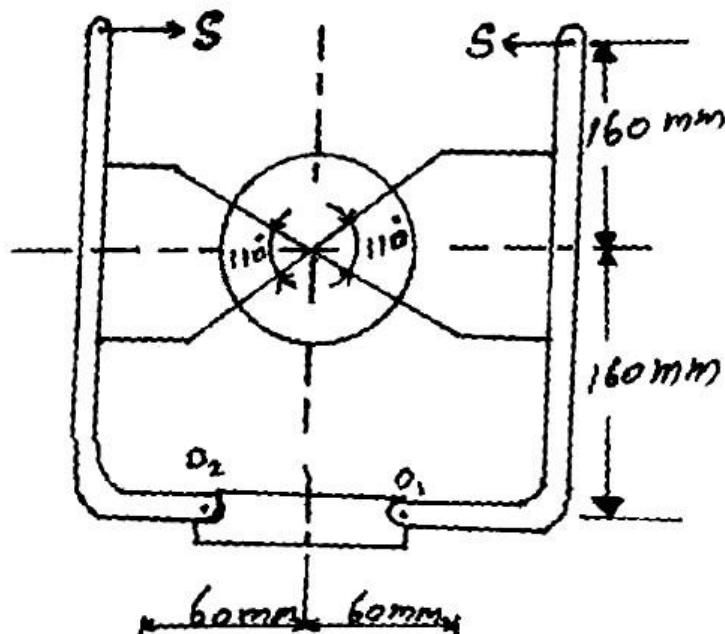
A cycloidal cam with a central roller follower has a rise of 25 mm in cam angle of 70° . Base circle radius is 90 mm and the follower roller radius is 20 mm. Speed of rotation of the cam is 5000 rpm. Mass of the follower is 0.5 kg. Find the maximum value of the acceleration of the follower, corresponding pressure angle, stiffness of the spring used with the follower and maximum cam force. The friction between the follower and the guide may be ignored.

The layout of a double block brake is shown in Fig. 2. The brake is rated at 250 N-m at 650 r.p.m. The drum diameter is 250 mm. Assuming coefficient of friction to be 0.3 and for conditions of service a pV value of 1000 (kPa) m/s may be assumed.

Determine :

- (i) spring force 'S' required to set the brake, and
- (ii) width of shoes.

Which shoe will have greater rate of wear and what will be the ratio of rates of wear of the two shoes?



A plate clutch has 3 discs on the driving shaft and 2 discs on the driven shaft, providing 4 pairs of contact surfaces. The outside diameter of the contact surfaces is 240 mm and inside diameter 120 mm. Assuming uniform pressure and $\mu = 0.3$, find the total spring load for pressing the plates together to transmit 25 kW at 1575 rpm. If there are 6 springs each of stiffness 13 kN/m and each of the contact surfaces have worn away by 1.25 mm, find the maximum power that can be transmitted, assuming uniform wear.

Design a cam for operating the exhaust valve of an oil engine. It is required to give equal uniform acceleration and retardation during opening and closing of the valve, each of which corresponding to 60° of cam rotation. The valve should remain in the fully open position for 20° of cam rotation. The lift of the valve is 37.5 mm and the least radius of the cam is 50 mm, the follower is provided with a roller of 50 mm diameter and its line of stroke passes through the axis of the cam.