POORNIMA
COLLEGE OF ENGINEERING

Assignment Sheet-5

Campus: PCE **Course:** B.Tech. **Class/Section:** III **Date: :- 20/01/2019**

Name of Faculty: PKT **Name of Subject:** Design Machine of Machine Element-II **Code:** 6ME1A

Date of Preparation: ……………..….. **Scheduled Date of Submission: …………….**

Q. No.	Questions	COs	POs	PSOs
1	A cast iron pulley transmits 20 kW at 300 RPM. The diameter of pulley is 550 mm and has four straight arms of elliptical cross-section in which the major axis is twice the minor axis. Find the dimensions of the arm if the allowable bending stress is 15 MPa. Mention the plane in which the major axis of the arm should lie.	CO2	PO2	PSO1
2	A flat belt is required to transmit 30 kW from a pulley of 1.5 m effective diameter running at 300RPM. The angle of contact is spread over 11/24 of the circumference. The coefficient of friction between the belt and pulley surface is 0.3. Determine, taking centrifugal tension into account, width of the belt required. It is given that the belt thickness is 9.5 mm, density of its material is 1100 kg/m3 and the related permissible working stress is 2.5 MPa.	CO3	PO2	PSO2
3	A pulley of 0.9 m diameter revolving at 200 r.p.m. is to transmit 7.5 kW. Find the width of a leather belt if the maximum tension is not to exceed 145 N in 10 mm width. The tension in the tight side is twice that in the slack side. Determine the diameter of the shaft and the dimensions of the various parts of the pulley, assuming it to have six arms. Maximum shear stress is not to exceed 63 MPa.	CO2	PO2	PSO1
4	An open belt connects two flat pulleys. The pulley diameters are 300 mm and 450 mm and the corresponding angles of lap are 160° and 210°. The smaller pulley runs at 200 r.p.m. The coefficient of friction between the belt and pulley is 0.25. It is found that the belt is on the point of slipping when 3 kW is transmitted. To increase the power transmitted two alternatives are suggested, namely (i) increasing the initial tension by 10%, and (ii) increasing the coefficient of friction by 10% by the application of a suitable dressing to the belt. Which of these two methods would be more effective? Find the percentage increase in power possible in each case.	CO4	PO3	PSO2
5	An overhung pulley transmits 35 kW at 240 r.p.m. The belt drive is vertical and the angle of wrap may be taken as 180°. The distance of the pulley centre line from the nearest bearing is 350 mm. μ = 0.25. Determine : 1. Diameter of the pulley ; 2. Width of the belt assuming thickness of 10 mm ; 3. Diameter of the shaft ; 4. Dimensions of the key for securing the pulley on to the shaft ; and 5. Size of the arms six in number. The section of the arm may be taken as elliptical, the major axis being twice the minor axis. The following stresses may be taken for design purposes : Shaft Tension and compression — 80 MPa, Key Shear — 50 MPa, Belt : Tension — 2.5 MPa, Pulley rim : Tension — 4.5 MPa, Pulley arms : Tension — 15 MPa	CO3	PO3	PSO2

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Solⁿ 1

given $P = 20\,kW$ $N = 300$ rpm $d = 550$ mm $n =$

$\sigma_b = 15\,MPa$

Also given that, major axis $= 2 \times$ minor axis

$$\boxed{a = 2b}$$

Torque, $T = \frac{P \times 60}{2\pi N}$

$$T = \frac{20 \times 10^3 \times 60}{2 \times \pi \times 300} = 636.62\ N\text{-}m$$

Maximum bending moment

$n = 20$ of arms

$$M = \frac{2T}{n} = \frac{2 \times 636.62}{4} = 318.3\ N\text{-}m$$

Section modulus $z = \frac{\pi}{32} \times b \times (a)^2$

$$= \frac{\pi}{8} b^3$$

$$\sigma_b = \frac{M}{z} = \frac{318.3 \times 10^{-3} \times 8}{\pi (b)^3} = 15$$

$$b^3 = 54 \times 10^3$$

$$\boxed{b = 37.806\ mm}$$

$$\boxed{a = 2b = 75.613\ mm}$$

→ the major axis will be in the place of rotation.

Sol 2:- given $P = 30\,kW$, $d = 1.5\,m$.

$\mu = 0.3$ $t = 4.5\,mm$ $\rho = 1100\,kg$

$$V = \omega r = \frac{2\pi N}{60} \times r = 23.562\ m/s$$

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$(T_1 - T_2) v = P$

$(T_1 - T_2) 23.562 = 30 \times 10^3$

$T_1 - T_2 = 1273.24\ N$ — (1)

$\frac{T_1}{T_2} = e^{\mu\theta}$

$\frac{T_1}{T_2} = e^{0.3 \times 2.88} = 2.373$ — (2)

from (1) & (2)

$2.373 T_2 - T_2 = 127324$

$T_2 = 926.67$

$T_1 = 2199\ N$

mass $m = \rho \times A = 1100 \times 9.5 \times 6 \times 10^{-3}$

$m = 10.456\ kg/m$

centrifugal tension $T_c = mv^2 = 5801.56\ N$

$T_{max} = T_2 + T_c = \sigma \times b \times t$

$2199 + 5801.56 = 237506$

$b = 0.1225\ m$

$b = 122.5\ mm$

standard width of belt = 125 mm

Sol/23 given $D = 0.9 m$, $N = 200\ rpm$, $P = 7.5\ kW$

$T_1 = 2T_2$ $\quad n = 6$ $\quad e = 63\ mPa$

$v = \frac{2\pi N \times R}{60} = 9.426\ m/s$

$(T_1 - T_2) v = 7500 = P$

$T_1 - T_2 = 796\ N$

$2T_2 - T_2 = 796$

$T_2 = 796$

$T_1 = 2T_2 = 1592\,N$

width of belt

Tension = 14.5 N/mm

$b = \frac{1592}{14.5} = 109.76\,mm$

width $b = 112\,mm$

Diameter of shaft

$T = \frac{P \times 60}{2\pi N} = \frac{7500 \times 60}{2 \times \pi \times 200}$

$= 358.1\,N\cdot m$

we know $T = \frac{\pi}{16} \tau d^3$

$d^3 = \frac{16 \times 358.1 \times 10^3}{\pi \times 63}$

$d = 30.7 \approx 35\,mm$

Dimension of various parts –

(a) width & thickness of pully

width $B = 112 + 13 = 125\,mm$

thickness $t = \frac{D}{300} + 2 = 5\,mm$

(b) Dimension of arm –

Assume $M = \frac{2T}{N}$ $\quad a = 2b$

$= \frac{2 \times 358.1}{6} = 119.367\,N\text{-}m$

$z = \frac{\pi}{32} \times b \times a^2 = \frac{\pi}{8} b^3$

$\sigma_b = 15\,MPa$

$15 = \frac{M}{z} = \frac{119.367 \times 10^3}{\pi \times b^3} \times 8$

$b = 27.26 \approx 30\,mm$

$a = 2b = 60\,mm$

Dimension of Hub –

Diameter $2d = 2 \times 35 = 70$ mm

Hub Length $= \frac{\pi}{2} \times d = \frac{\pi}{2} \times 35 = 55$ mm

$l = \frac{2}{3} \times 125 = 82.33 \simeq 85$ mm

Soln 4 given $d_1 = 300$ mm $d_2 = 450$ mm $\mu = 0.25$

$\theta_1 = 300$ $\theta_2 = 210^\circ$ $N_1 = 200$ rpm

→ $\mu\theta_1 = 0.25 \times 2.8 \simeq 0.7$ smaller

$\mu\theta_2 = 0.25 \times 3.66 = 0.915$ larger

$v = \frac{\pi d N}{60} = \frac{\pi \times 0.3 \times 200}{60} = 3.142$ m/s

$(T_1 - T_2) v = P$

$(T_1 - T_2) \times 3.142 = 3000$

$T_1 - T_2 = 955$ N — ①

$\frac{T_1}{T_2} = e^{\mu\theta} = e^{0.7} \simeq 2.015$ — ①

from ① & ②

$T_2 = 941$ N
$T_1 = 1896$ N

$T_1 = 2058.7$

power transmitted

$$P = (T_1 - T_2) V = (2058.7 - 1035) \times 3.142$$

$$P = 3301 \text{ kN}$$

(ii) Power transmitted when friction increased by 10%

$$\mu = 0.25$$

$$\mu' = 0.25 \times 1.1 = 0.275$$

$$\frac{T_1}{T_2} = e^{\mu\theta_1} = e^{0.275 \times 2.8} = 2.16$$

$$T_1 + T_2 = 2T_0 = 2 \times 1418.5 = 2837 \text{ N}$$

$$T_2 = 898$$

$$T_1 = 1939 \text{ N}$$

$$P = (T_1 - T_2) V = (1939 - 898) \times 3.142$$

$$P = 3270 \text{ N} = 3.271 \text{ KW}$$

power increase

(a) % increase when tension increased

$$= \frac{3.3 - 3}{3} \times 100 = 10\%$$

(b) % increase when friction increased

$$= \frac{3.271 - 3}{3} \times 100 = 9.03\%$$

⇒ we shall adopt the method of increasing initial tension.

Solⁿ 5

Given $P = 35 \text{ kW}$ $N = 240$ $\theta = 180°$ $L = 35$

$\mu = 0.25$ $t = 10 \text{ mm}$

$T_a = T_b = 50 \text{ MPa}$ $\sigma = 2.3$

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① Dimension of pulley –

D = dia of pulley

$\sigma = 4.5 MPa$

$4.5 \times 10^6 = \rho v^2 = 7200 v^2$

$v = 25\ m/s$

$V = \frac{\pi D N}{60} = 25 = \frac{\pi \times D \times 240}{60}$

$D = 2m$

② width of belt

$(T_1 - T_2) N = 35000$

$T_1 - T_2 = 1400\ N$ — ①

$\frac{T_1}{T_2} = e^{\mu\theta} = e^{0.25 \times \pi} = 2.195$ — ②

from ① & ②

$T_2 = 1172\ N$

$T_1 = 2572\ N$

$T_c = mv^2 = \rho A v^2 = 1000 \times 10 \times 6 \times 10^{-6} \times 25$

$= 6.25 b N$

$T_{max} = \sigma b t = 2.5 \times 6 \times 10 = 25 b N$

we know, $T_{max} = T_1 + T_c$

$25b = 2572 + 6.25b$

$b = 137\ mm \approx 140\ mm$

③ Diameter of shaft

$T = \frac{P \times 60}{2\pi N} = 1393\ N\text{-}m$

Bending $M = (T_1 + T_2 + 2T_c)L$

$= (1172 + 2572 + 2 \times 87...$

$= 1923\ N\text{-}m$

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$T_e = \sqrt{T^2 + M^2} = 2375 \, N\text{-}m$

$T_e = \frac{\pi}{16} \times \tau_s \times d^3$

$2375 \times 10^3 = \frac{\pi}{16} \times 50 \times d^3$

$d = 62.3 \approx 65 \, mm$

④ Dimension of key –

$t = 12 \, mm$

l = length of key.

$T = l w \tau \times d/2$

$1396 \times 10^3 = l \times 20 \times 50 \times \frac{65}{2}$

$l = 42.8 \, mm$

$\text{length} = \frac{\pi}{2} \times 65 = 102 \, mm$

⑤ size of arms ($a = 2b$) given

$M = \frac{2T}{n} = 464333 \, N\text{-}m$

$z = \frac{\pi}{8} b^3$

$\sigma_b = 15 = \frac{M}{z} = \frac{464333 \times 8}{\pi \times b^3}$

$b = 42.8 \approx 45 \, mm$

$a = 2b = 90 \, mm$

Solⁿ 6 given $n = 1m$ $P = 95 \, kW$ $d_1 = 300 \, mm$

$N_1 = 1000 \, rpm$ $N_2 = 375 \, rpm$

$\alpha = 20°$

$a = 400 \, mm^2$

$\sigma = 2.1 \, MPa$ $\rho = 1100 \, kg/m^3$

we know, $\frac{N_1}{N_2} = \frac{d_2}{d_1} \Rightarrow d_2 = \frac{N_1}{N_2} \times d_1 = 800$ mm

dia of pulley $d_2 = 800$ mm

$\beta = \sin^{-1}\left(\frac{d_2 - d_1}{2x}\right) = 14.47^0$

$\theta = 180^\circ - 2\beta = 151^\circ$

$V = \frac{\pi d_1 N_1}{60} = \frac{\pi \times 300 \times 1000}{60} = 15.71$ m/s

$T_c = mv^2 = \rho A v^2 = 1100 \times 400 \times 10^{-6} \times (15.71)^2$
$= 108.6$ N

$T_{max} = \sigma \times a = 2.1 \times 400 = 840$ N

we know that,

$T_{max} = T_1 + T_c$

$T_1 = T_{max} - T_c = 840 - 108.6$

$T_1 = 731.4$ N

(1) belts required $P = (T_1 - T_2) v$

$P = 10.171$ kW

No of belt $= \frac{95}{10.171} = 9.34 \simeq 10$ belt

(2) Diameter of shaft

$T = \frac{P \times 60}{2\pi N_2} = 2420$ N-m

$Te = \frac{\pi}{16} \times D^3 = 3181.4 \times 10^3 = \frac{\pi}{16} \times 42 \times D^3$

$D = 72.79$ mm $\simeq 75$ mm