COLLEGE OF ENGINEERING & TECHNOLOGY

Department : Mechanical Engineering

Lecturer : Staff

Course : Machine design

Course Code: ME 454

Date : 08/ 06 / 2016

Marks: 40

Time: 12.00:14.00

FINAL EXAMINATION PAPER

ANSWER 4 QUESTIONS ONLY

QUESTION (1) [10 MARKS]

Fig. 1 shows a schematic drawing of a countershaft that supports two V-belt pulleys. The belt tension on the loose side of pulley A is 20 percent of the tension on the tight side. The shaft material has an ultimate strength of 500 MPa and yield strength of 310 MPa . Determine:

(a) The necessary shaft diameter using $k_b = 1.5$ and $k_t = 1$.

(b) Compute the components of the force with which the bearings at *O* and *E* push against the shaft.

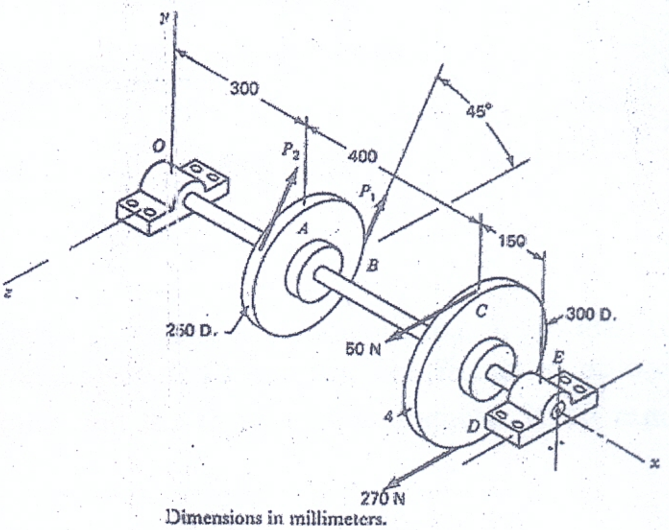

Figure (1)

QUESTION (2) [10 MARKS]

A load "F" of *10 kN* is suspended from a plate "a" held by bolts 1, 2 and 3. The thickness of the plate $h = 14\,mm$, $L_1 = 250\,mm$, $L_2 = L_3 = 100\,mm$. The bolts are made of steel, $S_y = 400\,MPa$.

Determine:

(a) The bolt size with a safety factor of *1.7*.

(b) The stresses in bolts 1 and 3 if bolt 2 is taken out, see Fig. 2.

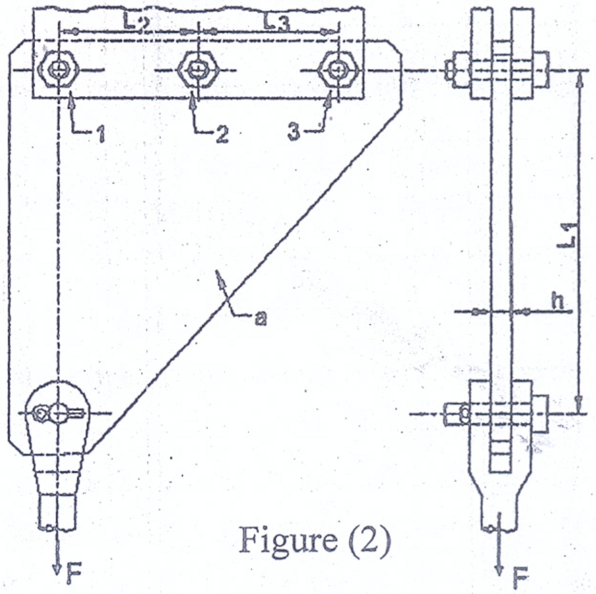

Figure (2)

QUESTION (3) [10 MARKS]

A hollow circular shaft of **200 mm** outside diameter and **175 mm** inside diameter is fitted with a wringing fit to the hole in the boss of a forged flange. The two are then secured by fillet welding as shown in Fig.3. The welded flange is to be bolted to a smooth vertical face, not shown. **Determine** the weld size if the allowable shear stress for the weld is **100 MPa**.

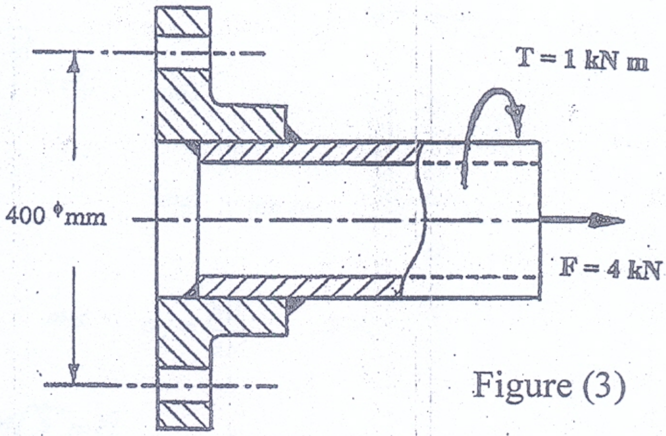

Figure (3)

QUESTION (4) [10 MARKS]

A square power transmission screw of a screw press is required to transmit maximum load of **60 kN**. The screw outside diameter is **70 mm** with a pitch of **12 mm**, the coefficient of friction is **0.12** in the threads and **0.125** in the thrust collar and the thrust collar diameter is **60 mm**. Determine:

(a) The torque required to move the load.
(b) The efficiency of the threads.
(c) The maximum normal and shear stresses in the screw.
(d) The bearing pressure in the threads if the height of nut is 240 mm.

QUESTION (5) [10 MARKS]

(a) Determine the recommended belt velocity for a V-belt drive so that the power transmitted is maximum.

(b) The drive from a motor to a centrifugal pump consists of **three size C V-belt.** The motor pulley has a **240 mm** pitch diameter and the pump pulley has a **400 mm** pitch diameter. The motor runs at **1200 rpm.** The belt angle is **40°**. **What** power can be transmitted if the centre distance is **1 m?** Belt cross sectional area equal $230\ mm^2$, belt density is $1150\ kg/m^3$, coefficient of friction is 0.13 and the allowable tensile stress is $2\ MPa$.

GOOD LUCK

Machine Design (ME 454)

Direct normal stress : $\sigma_d = \dfrac{F}{A}$ Direct shear stress : $\tau_d = \dfrac{F}{A_s}$

Bending stress : $\sigma_b = \dfrac{M\,y}{I}$ Torsion stress : $\tau = \dfrac{T\,r}{J}$

Stresses on inclined planes :

$$\sigma_\theta = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos 2\theta + \tau_{xy}\sin 2\theta \quad \text{and} \quad \tau_\theta = -\frac{\sigma_x - \sigma_y}{2}\sin 2\theta + \tau_{xy}\cos 2\theta$$

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} \quad \text{and} \quad \tan 2\theta_p = \frac{\tau_{xy}}{(\sigma_x - \sigma_y/2)}$$

$$\tau_{\substack{max\\min}} = \pm\sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} \quad \text{and} \quad \tan 2\theta_s = \frac{-(\sigma_x - \sigma_y/2)}{\tau_{xy}}$$

Pr essure vessels :

$$\sigma_1 = \frac{p\,d}{2t} \quad \text{and} \quad \sigma_2 = \frac{p\,d}{4t}$$

Bolted connections :

Tensile load due turning : $f = M\Big/\sum n_i \ell_i^2$ Secondary shear : $s = T\Big/\sum r_i^2$

Pr eloading : $\delta = \dfrac{F\,l}{A\,E}$, $F_b = \left(\dfrac{k_b}{k_b + k_m}\right)F_e + F_i$, $F_m = \left(\dfrac{k_m}{k_b + k_m}\right)F_e - F_i$

$F_P = A_t\,S_P$, $S_P = 0.85\,S_y$, $F_i = \begin{cases} 0.75\,F_P \\ 0.90\,F_P \end{cases}$, $F_i \ge (1 - C)F_e$ where $C = \dfrac{k_b}{k_b + k_m}$

Welded joint s :

Bending stress $\sigma = \dfrac{M\,c}{0.707\,h\,I_u}$, Secondary shear stress $\tau_s = \dfrac{T\,r}{0.707\,h\,J_u}$

Power screws :

$$T_{\substack{lifting\\lowering}} = \frac{F\,d_m}{2}\left(\frac{\pi\,\mu\,d_m \sec\alpha \pm \ell}{\pi\,d_m \mp \mu\,\ell\sec\alpha}\right) + \frac{F\,\mu_c\,d_c}{2} \quad , \quad e = \frac{F\,\ell}{2\pi T}$$

, Self locking : $\mu > \tan\lambda\,\cos\alpha$

Belt drive :

Power $= (F_1 - F_2)V$, Open drive : $\theta_{1,2} = \pi \mp 2\sin^{-1}\left(\dfrac{d_2 - d_1}{2C}\right)$

$$\frac{Power}{m^2} = \left(\sigma_{all} - \omega V^2\right)V\left(\frac{e^{f\theta} - 1}{e^{f\theta}}\right) \quad ; \quad \frac{F_1 - F_c}{F_2 - F_c} = e^{f\theta}$$

, F_c = mass per unit length $\times V^2$

Shaft design;

$$d_o^3 = \frac{16}{\pi\,\tau_{all}(1 - c^4)}\sqrt{\left(k_b M_b + \frac{\alpha F_a d_o(1 + c^2)}{8}\right)^2 + (k_t M_t)^2}$$

$A = 1.414\pi h r$ $J_u = 2\pi r^3$ $I_u = \pi r^3$