The solutions for first semester exam.

Q1) Design a V-belt system to transmit a power of 20 KW between two shafts @ 1000 r.p.m. with a reduction ratio of 4. Take a safety factor of (1.2) and taking into account that no more than (4) belts are to be used with a suitable minimum center distance.

solu.

The design power $= 20 * 1.2 = 24$ KW

from table (4) for (22-30) KW at 1200 r.p.m.

the options are Type C or D

take type C

from table (3) the minimum diameter for the small pulley $d = 225$ mm

$\therefore D = (225) * 4 = 900$ mm

$C.D. = 1.5 D = 1350$ mm

$$\alpha = \frac{900 - 225}{2(1350)} = 0.25 \text{ rad}$$

since $\theta = \pi - 2\alpha \therefore \theta = 2.64 \text{ rad} = 151^\circ$

$$K = \frac{0.2}{60}(31) + 0.8 = 0.904$$

$Kd = 203.5 < 305$ (for type (C) from table 5)

$$v = \frac{\pi(225)1000}{60000} = 11.78 \text{ m/s}$$

to find the Power/belt ratio, tak the formula for type (C) belt from table 5.

$$\frac{\text{Power}}{\text{belt}} = v\left[\frac{1.082}{v^{0.09}} - \frac{100.6}{Kd} - 0.000237 v^2\right]$$

(2)

$\therefore \frac{\text{Power}}{\text{belt}} = 3.994$ KW

$\therefore$ number of belts $= \frac{24.0}{3.994} = 6.01$

This number is more than the ~~allowable~~ allowed

back to table (3) and change the value of (d) from the range (225 - 325)

let $d = 300$ mm

$\therefore D = 1200$ mm $\rightarrow$ C.D. $= 1800$ mm

$\alpha = \frac{1200 - 300}{2(1800)} = 0.25$ rad

$\therefore \theta = 151^\circ \rightarrow k = 0.904$

$kd = 271.2 < 305$

$v = \frac{\pi (300) 1000}{60\,000} = 15.7$ m/s

$\frac{\text{Power}}{\text{belt}} = 6.51$ KW

number of belts $= \frac{24.0}{6.51} = 3.68$ say 4 belts

Length of each belt (L)

$L = \pi (600 + 150) + 2(1800) + \frac{(600-150)^2}{1800}$

$= 6068.7 = 6.068$ m

Q2/ A bush roller chain drive is used to transmit 5 kW of power from the driving shaft an a hydraulic motor runs @ 400 r.p.m. to the driven shaft which runs @ 90 r.p.m.. The drive is required to operate three hours daily. The driven machine is such that load can be regarded as fairly constant with jerk and impact and the system is to be lubricated periodically. Design the chain drive by calculating leading dimensions, number of teeth on the sprockets and specify the breaking strength of the chain and give the suitable center distance.

solu:

to find the Service factr (K_S) from the given conditions

$K_1 = 1$, $K_2 = 1.5$, $K_3 = 1$

$K_S = K_1 K_2 K_3 = 1 * 1.5 * 1 = 1.5$

design power = $5(1.5) = 7.5$ kW

from table (21.4) The suitable chain type is (12-B)

from table (21.1)

$P = 19.05$ mm , $W_B = 28.9$ kN

$V.R. = \frac{400}{90} = 4.44$ say 5

from table (21.5)

$T_P = 21$

$\therefore T_G = 21 \frac{400}{90} = 93.3$ say 94

$D_P = 19.05 \operatorname{cosec}\left(\frac{180}{21}\right) = 127.8$ mm

$D_G = 19.05 \operatorname{cosec}\left(\frac{180}{94}\right) = 570.1$ mm

The minimum C.D. = 30P = 571.5 mm

$$v = \frac{\pi \, 127.8 \, (400)}{60000} = 2.67 \text{ m/s}$$

$$W = \frac{5000}{2.67} = 1873 \text{ N}$$

This value from table (21.2)

$$\text{Factor of Safety} = \frac{28900}{1873} = 15.43 > 9.35$$

$$K = \frac{94+21}{2} + \frac{2(571.5)}{19.05} + \left(\frac{94-21}{2\pi}\right)^2 \frac{19.05}{571.5}$$

$= 121.99$ say 122

$$C.D = \frac{19.05}{4}\left[122 - \frac{94-21}{2} + \sqrt{\left(122 - \frac{94+21}{2}\right)^2 - 8\left(\frac{94-21}{2\pi}\right)^2}\right]$$

$= 571.2$

$(C.D)_{correct} = 571.2 - 2.2 = 569$ mm

$L = (122)(19.05) = 2324.1$ mm

Q3) A pair of straight teeth spur gears is to transmit 18 KW when the pinion rotates at 350 r.p.m.. The velocity ratio is (1:3). The allowable static stress for the pinion and gear materials are 120 Mpa and 100 Mpa respectively. The pinion has 15 teeth and its face width is 14 times the module. Determine 1. module ; 2. face width ; 3. pitch circle diameters of both the pinion and the gear from the stand point of strength only, taking into consideration the effect of the dynamic loading.

Soln.

$$v = \frac{\pi D_P N_P}{60} = \frac{\pi m T_P N_P}{60} = \frac{\pi (m) 15 (350)}{60}$$

$= 0.274 m$ m/s

from table (28.10) assume $C_s = 1$

$$W_T = \frac{P}{v} C_s = \frac{18000}{0.274 m}(1) = \frac{65.7 \times 10^3}{m}$$

$$C_v = \frac{3}{3+v} = \frac{3}{3+0.274 m}$$

assume the gear type is 20° full depth

$$\therefore y = 0.154 - \frac{0.912}{T}$$

$$y_P = 0.154 - \frac{0.912}{15} = 0.0932$$

$$y_G = 0.154 - \frac{0.912}{45} = 0.1337$$

$\sigma_{oP} y_P = 120 (0.0932) = 11.184$

$\sigma_{oG} y_G = 100 (0.1337) = 13.37$

$\therefore$ The pinion is the weaker

$$W_T = \sigma_{wp}\, b \pi m y_p = (\sigma_{op} C_v)\, b \pi m y_p$$

$$\frac{65700}{m} = 120\left(\frac{3}{3+0.274m}\right) 14\, m\, \pi m\, 0.0932$$

$$\frac{65700}{m} = \frac{1475.7\, m^2}{3+0.274\, m}$$

$$m^3 - 12.2m - 133.56 = 0$$

solving this equation by hit and ~~trail~~ trial method

$m = 5.91$

The standard module is 6 mm

$\therefore$ take $m = 6$ mm (Ans.)

$b = 14(6) = 84$ mm (Ans.)

$D_P = m T_P = 6(15) = 90$ mm (Ans.)

$D_G = m T_G = 6(45) = 270$ mm (Ans.)