Belt drive sheet

No ① power = ?? $d_1 = 200\ mm$ $d_2 = 400\ mm$

$c = 1.5m = 1500mm$ $n_1 = 900\ rpm$

$\mu = 0.3$ $A = 50 * 5\ mm^2$

$W = 11 * 10^3\ \frac{N}{m^3}$ $\sigma_{all} = 2\ MPa$

soln

$$\theta_1 = 180 - 2\sin^{-1}\frac{d_2 - d_1}{2c}$$

$$= 180 - 2\sin^{-1}\frac{400-200}{2*1500} = 172.35^\circ$$

$$V = \frac{\pi d_1 n_1}{60} = \frac{\pi * 200 * 900}{60} * 10^{-3} = 9.42\ m/s$$

$$F_c = \frac{W}{g}V^2 = \frac{11 * 10^3 * 50 * 5 * 10^{-6}}{9.8} * (9.42)^2 = 24.87\ Newton$$

$$F_1 = \sigma_{all} A = 2 * (50 * 5) = 500\ N$$

$$\frac{F_1 - F_c}{F_2 - F_c} = e^{\mu\theta}$$

$$F_2 = F_c + \frac{F_1 - F_c}{e^{\mu\theta}} = 24.87 + \frac{500 - 24.87}{e^{0.3 * 172.4 * \frac{\pi}{180}}} = 217.5N$$

$$power = (F_1 - F_2) * v$$

$$= (500 - 217.5) * 9.42$$

$$= 2660.9 \quad watt$$

$$= 2.66 \quad KW$$

No (2) V-belt

$N = ??$ power = 2000 watt $n_1 = 900$ rpm

$C = 1500$ mm $d_2 = 400$ mm $d_1 = 200$ mm

$\mu = 0.3$ $W = 11 * 10^3 \frac{N}{m^3}$ $A = 140$ mm^2

$\beta = \frac{38}{2} = 19^\circ$ $K_s = 1$ $\sigma_{all} = 2.5$ MPa

Soln

$$\theta_1 = 180 - 2 \sin^{-1} \frac{d_2 - d_1}{2C}$$

$$= 180 - 2 \sin^{-1} \frac{400 - 200}{2 * 1500} = 172.35^\circ$$

$$V = \frac{\pi d_1 n_1}{60} = \frac{\pi * 200 * 900}{60} * 10^{-3} = 9.42 \text{ m/s}$$

$$F_1 = \sigma_{all} A = 2.5 * 140 = 350 \text{ N}$$

$$F_c = \frac{W}{g} V^2 = \frac{11 * 10^3 * 140 * 10^{-6}}{9.8} * (9.42)^2 = 13.94 \text{ N}$$

$$\frac{F_1 - F_c}{F_2 - F_c} = e^{\mu_e \theta}$$ for V-belt $\mu_e = \frac{\mu}{\sin \beta}$

$$F_2 = F_c + \frac{F_1 - F_c}{e^{\mu_e \theta}} = 13.94 + \frac{350 - 13.94}{e^{\frac{0.3 * 172.35 * \pi}{\sin 19 \ 180}}} = 34.96 \text{ N}$$

$$\text{power} = K_s (F_1 - F_2) * v * N$$

$$2000 = 1 * (350 - 34.96) * 9.42 * N$$

$$N = 0.6739$$

$$\simeq 1$$

No ③ V-belt

$A = 80\ mm^2$ power = 5000 watt $N = ??$

$d_1 = 200\ mm$ $n_1 = 900$ rpm $C = 1000\ mm$

$\frac{d_2}{d_1} = \frac{3}{1}$ $W = 11 * 10^3\ \frac{N}{m^3}$ $\sigma_{all} = 2.5\ MPa$

$\mu = 0.3$ $\beta = 19^\circ$ $K_s = 1.2$

Soln

$$\theta_1 = 180 - 2\sin^{-1}\frac{d_2 - d_1}{2C}$$

$$= 180 - 2\sin^{-1}\frac{600 - 200}{2 * 1000}$$

$$= 156.93^\circ$$

$\frac{d_2}{d_1} = \frac{3}{1}$

$d_2 = 3d_1$

$= 3 * 200$

$= 600\ mm$

$$V = \frac{\pi d_1 n_1}{60} = \frac{\pi * 200 * 900}{60} * 10^{-3} = 9.42\ m/s$$

$$F_c = \frac{W}{g} V^2 = \frac{11 * 10^3 * 80 * 10^{-6}}{9.8} * (9.42)^2 = 7.98\ N$$

$$F_1 = \sigma_{all} A = 2.5 * 80 = 200\ N$$

$$\frac{F_1 - F_c}{F_2 - F_c} = e^{\mu_e \theta}$$

$$\mu_e = \frac{\mu}{\sin\beta} = \frac{0.3}{\sin 19} = 0.92$$

$$F_2 = F_c + \frac{F_1 - F_c}{e^{\mu_e \theta}}$$

$$= 7.98 + \frac{200 - 7.98}{e^{0.92 * 156.93 * \frac{\pi}{180}}} = 23.37\ N$$

$$power = K_s * (F_1 - F_2) * V * N$$

$$5000 = 1.2\ (200 - 23.37) * 9.42\ N$$

$$N = 2.5 \simeq 3$$

No (4)

max. power = ?? v = ??

$A = 50 * 4\ mm^2$ $\theta = 2.5$ rad

$\sigma_{all} = 2$ MPa $\mu = 0.3$ $W = 10.5 * 10^3\ \frac{N}{m^3}$

soln

$$F_1 = \sigma_{all} A = 2 * 50 * 4 = 400\ N$$

$$F_c = \frac{W}{g} v^2 = \frac{10.5 * 10^3 * 50 * 4 * 10^{-6}}{9.81} v^2 = 0.214\ v^2$$

$$\frac{F_1 - F_c}{F_2 - F_c} = e^{\mu\theta} = e^{0.3*2.5} = 2.117$$

$$F_2 = F_c + \frac{(F_1 - F_c)}{e^{\mu\theta}} = 0.214 v^2 + \frac{(400 - 0.214 v^2)}{2.117}$$

$$F_2 = 0.113 v^2 + 188.95$$

$$\text{power} = (F_1 - F_2)\ v$$

$$= (400 - 0.113 v^2 - 188.95) * v$$

$$\text{power} = 211\ v - 0.113 v^3 \longrightarrow (1)$$

$$\frac{\partial \text{power}}{\partial v} = 0 = 211 - 0.113 * 3 v^2$$

$$211 - 0.339 v^2 = 0$$

$$v^* = \sqrt{\frac{211}{0.339}} = 24.95\ m/s$$

sub. in (1)

$$\text{power} = 211 * 24.95 - 0.113 * (24.95)^3$$

$$= 3509.398 \text{ watt}$$

$$= 3.5 \text{ KW}$$

Another Soln

$$v^* = \sqrt{\frac{F_1 g}{3W}} = \sqrt{\frac{400 * 9.8}{3 * 2.1}}$$

$v^* = 24.94$ m/s

$F_1 = \sigma_{all} * A$

$= 2 * 50 * 4 = 40$

$W = 10.5 * 10^3 * 50 * 4 * 1$

$= 2.1$ N

$$F_c = \frac{W}{g} v^{*2} = \frac{2.1}{9.8} * (24.94)^2 = 133 \text{ N}$$

$$\frac{F_1 - F_c}{F_2 - F_c} = e^{\mu\theta} = e^{0.3 * 2.5} = 2.117$$

$$F_2 = F_c + \frac{F_1 - F_c}{e^{\mu\theta}}$$

$$= 133 + \frac{400 - 133}{2.117} = 259 \text{ N}$$

max. power $= (F_1 - F_2) v^*$

$= (400 - 259) * 24.94$

$= 3515.83$ watt

$= 3.5$ KW

No (5) V-belt

max. power = ?? v = ??

$\sigma_{all} = 2.5$ MPa $A = 80\ mm^2$ $N = 3$

$\mu = 0.3$ $\beta = \frac{39}{2} = 19.5°$ $W = 11\ KN/m^3$

$\theta = 2.5$ rad $d_1 = 200$ mm

Soln

$$F_1 = \sigma_{all} A = 2.5 * 80 = 200 \quad N$$

$$W = 11 * 10^3 * 80 * 10^{-6} = 0.88\ N$$

$$v^* = \sqrt{\frac{F_1 g}{3W}} = \sqrt{\frac{200 * 9.8}{3 * 0.88}} = 27.25\ m/s$$

$$F_c = \frac{W}{g} v^{*2} = \frac{0.88}{9.8} * (27.25)^2 = 66.6\ N$$

$$\frac{F_1 - F_c}{F_2 - F_c} = e^{\mu_e \theta} = e^{\frac{\mu}{\sin\beta}\theta} = e^{\frac{0.3}{\sin 19.5} * 2.5} = 2.25$$

$$F_2 = F_c + \frac{F_1 - F_c}{e^{\mu_e \theta}} = 66.6 + \frac{200 - 66.6}{2.25} = 125.97\ N$$

max. power $= (F_1 - F_2)\, v^* * N$

$= (200 - 125.97) * 27.25 * 3$

$= 6051.698$ watt

$= 6$ KW