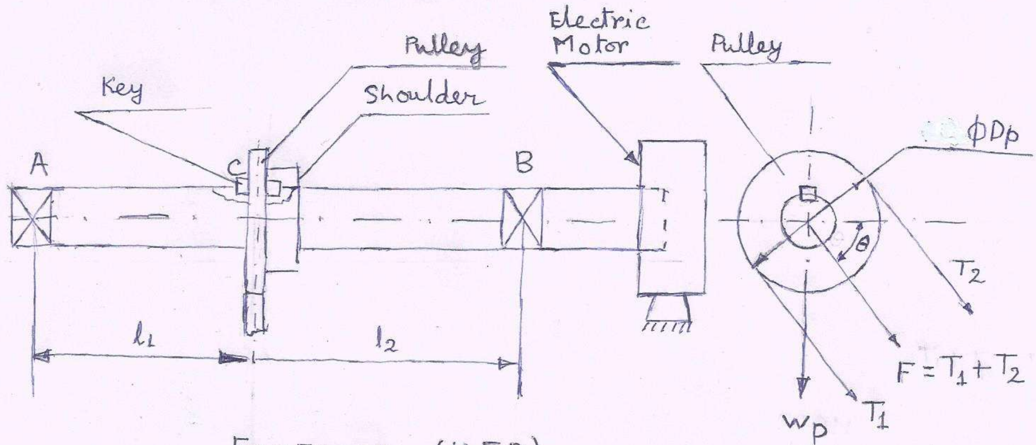
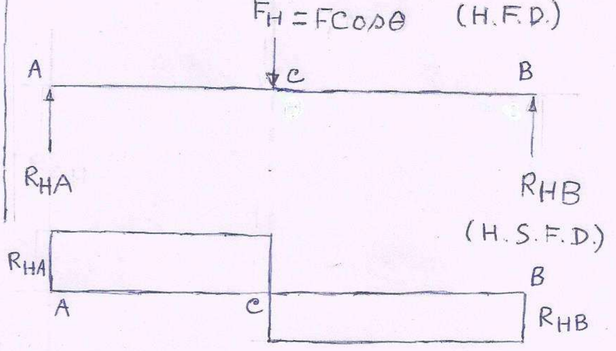
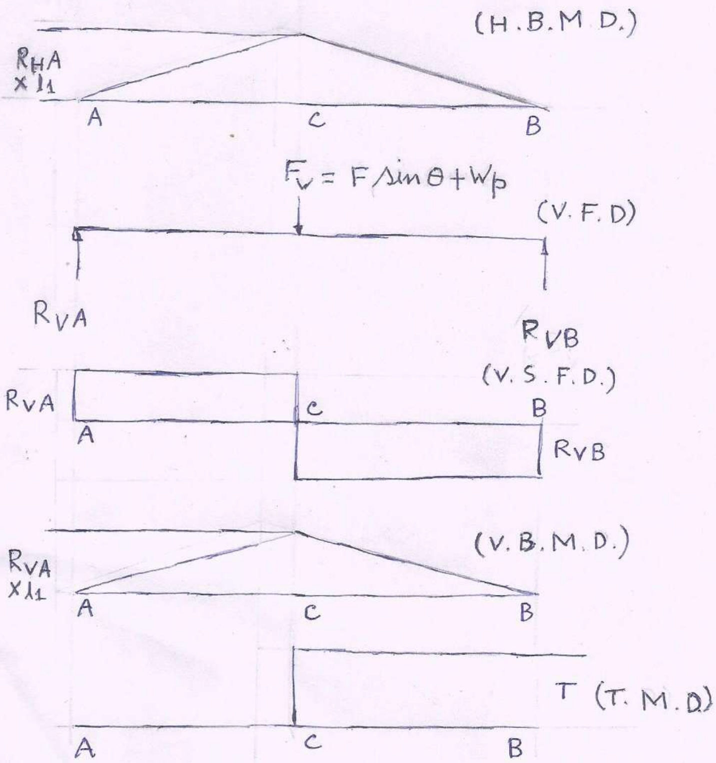
AKM
Shaft Problem - page 1







F → Force
H → Horizontal
V → Vertical
S → Shear
B → Bending
T → Twisting
M → Moment
D → Diagram

$l_1 = 1200\,mm$

$l_2 = 1300\,mm$

$T_1 = 1800N$

$T_2 = 840N$

$w_p = 500N$

$D_p = 500\,mm$

$\theta = 64^\circ$

Material = Fe E 200

F.S. = 2.5

$K_m = 1.6$

$K_t = 1.2$

From Design Data Book,

$\sigma_{yield} = 200\,MPa$.

$\tau_{yield} = \frac{200}{2} = 100\,MPa$

$[\tau] = \frac{100}{2.5} = 40\,MPa$

Torque calculation:

$T = (1800 - 840) \times \frac{D_P}{2}$

$= 960 \times \frac{500}{2} = 240000\,N\text{-}mm$

C is most critical point

$M = 1932629.473\,N\text{-}mm$.

$F = T_1 + T_2 = 1800N + 840 = 2640N$

$F_H = F\cos\theta = 2640\cos 64^\circ = 1157.299828\,N$

$F_V = F\sin\theta + w_p = 2640\sin 64^\circ + 500$

$= 2372.816282 + 500 = 2872.816282\,N$

$R_{HA} = \frac{2640 \times 1300}{1200 + 1300}\cos 64^\circ = \frac{1157.299828 \times 1300}{2500}$

$= 601.7959103\,N$

$R_{HB} = \frac{1157.299828 \times 1200}{1200 + 1300} = 555.5039172\,N$

$R_{VA} = \frac{2872.816282 \times 1300}{1200 + 1300} = 1493.864466\,N$

$R_{VB} = \frac{2872.816282 \times 1200}{1200 + 1300} = 1378.951814\,N$.

$M_{HC} = R_{HA} \times l_1 = 601.7959103 \times 1200$

$= 722155.0924\,N\text{-}mm$

$M_{VC} = R_{VA} \times l_1 = 1493.864466 \times 1200$

$= 1792637.36\,N\text{-}mm$

$M_C = \sqrt{M_{HC}^2 + M_{VC}^2}$

$= \sqrt{(722155.0924)^2 + (1792637.36)^2}$

$= 1932629.473\,N\text{-}mm$

$T_e = \sqrt{(K_m M)^2 + (K_t T)^2} = \sqrt{(1.6 \times 1932629.473)^2 + (1.2 \times 240000)^2}$

$= 3105589.977\,N\text{-}mm$

$d \geqslant \sqrt[3]{\frac{16\,T_e}{\pi[\tau]}}\,;\; d \geqslant \sqrt[3]{\frac{16 \times 3105589.977}{\pi \times 40}}\,;\; d \geqslant \sqrt[3]{395415.9969}$

$d \geqslant 73.3980877\,mm\,;\; d \geqslant 73.3980877 \times 1.1 : d \geqslant 80.73789647\,mm$

We take, $d = 82\,mm$ For commercial shaft, we take, $d = 85\,mm$ or $90\,mm$ (as available)

N.B.: ~~They~~ Keyway is located at point c where Te is maximum and is critical. So the value of allowable stress is further reduced by 25% which equivalent to multiplying with 1.1 i.e. increasing the diameter by 10%. $\sqrt[3]{\frac{1}{0.75}} = 1.100642416 \approx 1.1$.