10/8/16

UNIT-2

DESIGN OF SHAFTS AND COUPLING.

Shaft

Shaft is used to transmit the power from prime movers to machine.

Classification of Shaft

Line Shaft:-
It is a shaft which transmits power to several machines.

Spindle Shaft:-
Spindle is a short revolving shaft.

Stub Spindle :-
A shaft that is integral with prime movers or machine is known as stub shaft

Counter Shaft:-
A shaft that connect prime movers to the line shaft of the machine is called counter shaft

i) Based on Torsional Rigidity..

$$\frac{T}{J} = \frac{\tau}{r} = \frac{C\theta}{l}.$$

ii) Based on Strength.

$$\sigma_{eq} = M/Z \quad , \quad \tau_{eq} = \frac{16T}{\pi d^3}$$

iii) Based on critical speed of shaft

$$\frac{1}{(\omega_c)^2} = \frac{1}{(\omega_1)^2} + \frac{1}{(\omega_2)^2} + \frac{1}{(\omega_3)^2} + \frac{1}{(\omega_s)^2}$$

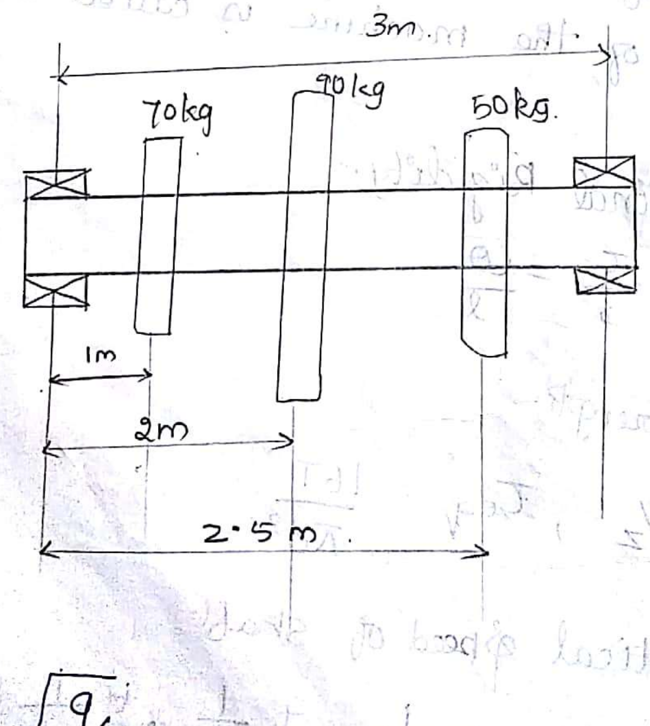
$\omega_1 = \sqrt{g/\delta_1}$ $\omega_2 = \sqrt{g/\delta_2}$ $\omega_3 = \sqrt{g/\delta_3}$

$$\omega_s = \left(\sqrt{\frac{g}{\delta_s}}\right) 1.12$$

$$\delta_1 = \frac{W l_1^2 l_2^2}{3EIl}$$

$$\delta_s = \frac{5 W l^4}{384 EI}$$

1. A turbine shaft of 125 mm diameter has mass of 100 kg per metre length. It is simply supported between the bearings at its ends and carries a 3 rotors of masses 70 kg, 90 kg, 50 kg, at 1m, 2m, and 2.5m respectively from left support. Find the critical speed of shaft. Assume Young's modulus $E = 2 \times 10^{11}$ N/mm². Total length = 3m.



$$W_1 = \sqrt{g/\delta_1}$$

$$\delta_1 = \frac{m_1 g \times l_1^2 \times l_2^2}{3EIl}$$

$$= \frac{70 \times 9.81 \times 1^2 \times 2^2}{3 \times 2\times10^{11} \times \frac{\pi}{64}(0.125)^4 \times 3}$$

$$= 1.27\times10^{-4}\,m$$

$$\omega_1 = \sqrt{g/\delta_1} = \sqrt{\frac{9.81}{1.27\times10^{-4}}}$$

$$= 277.92\ rad/s$$

$$\delta_2 = \frac{m_2 g \times l_1^2 \times l_2^2}{3EIl}$$

$$= \frac{90\times9.81 \times 2^2 \times 1^2}{3\times2\times10^{11}\times\frac{\pi}{64}(0.125)^4\times3}$$

$$= 1.636\times10^{-4}\,m.$$

$$\omega_2 = \sqrt{g/\delta_2}$$

$$= \sqrt{\frac{9.81}{1.636\times10^{-4}}}$$

$$\omega_2 = 244.87\ rad/s.$$

$$\delta_3 = \frac{m_3 g \times l_1^2 \times l_2^2}{3EIl}$$

$$= \frac{50\times9.81\times(2.5)^2\times(0.5)^2}{3\times2\times10^{11}\times\frac{\pi}{64}(0.125)^4\times3}$$

$$= 3.5\times10^{-5}\,m.$$

$$\omega_3 = \sqrt{g/\delta_3}.$$

rad/s

$$\delta_s = \frac{5Wl^4}{384EI}$$

$$= \frac{5 \times 100 \times 3^4 \times 9.81}{384 \times 2 \times 10^{11} \times \frac{\pi}{64}(0.125)^4}$$

$$= 4.316 \times 10^{-4}\ m$$

$$\omega_s = \sqrt{g/\delta_s}$$

$$= 150.75\ rad/s$$

$$\frac{1}{\omega_c^2} = \frac{1}{\omega_1^2} + \frac{1}{\omega_2^2} + \frac{1}{\omega_3^2} + \frac{1}{\omega_s^2}$$

$$= \frac{1}{77239.5} + \frac{1}{59961.3} + \frac{1}{276108.2} + \frac{1}{22725.5}$$

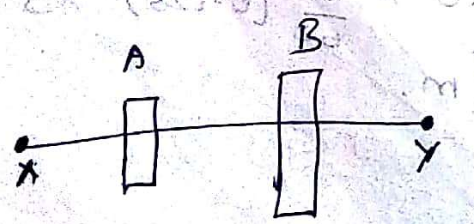
$$\frac{1}{\omega_c^2} = 7.7249 \times 10^{-5}$$

$$\omega_c^2 = 12945.0$$

$$\omega_c = 113.77$$

Whirling & critical speed of shaft :-

The speed at which amount of deflection become infinite is called whirling speed of shaft



$$(M_v)_A = \sqrt{(M_A)_Y^2 + (M_A)_H^2}$$

$$(M_v)_B = \sqrt{(M_B)_V^2 + (M_B)_H^2}$$

$$(M_A)_V = R_{AV}\, X$$