Problems on propeller shaft

1. An automobile engine develops 28 kW at 1500 rpm and its bottom gear ratio is 3.06. If a propeller shaft of 40 mm outside diameter is to be used, determine the inside diameter of mild steel tube to be used, assuming a safe shear stress of 55×10^3 kPa for the M.S.

Given:

$P = 28\,kW = 28 \times 10^3\,W$

$N = 1500$ rpm

Bottom Gear ratio $(G) = 3.06$

$d_o = 40\,mm$

$f_s = 55 \times 10^3\,kPa = 55 \times 10^6\,Pa$ (or) 55 MPa $= 55\,N/mm^2$

To find:

d_i

Solution

$$P = \frac{2 \pi N T_e}{60}$$

$$28 \times 10^3 = \frac{2 \times \pi \times 1500 \times T_e}{60}$$

$\boxed{T_e = 178.25\,N\text{-}m}$ (or) $178.25 \times 10^3\,N.mm$

⑤ → ④

WKT,

$$\frac{T_t}{I_p} = \frac{f_s}{y}$$

$$T_t = T_e \times G = 178.25 \times 10^3 \times 3.06$$

$$\boxed{T_t = 545.45 \times 10^3}$$

$$I_p = \frac{\pi}{32}(d_o^4 - d_i^4)$$

$$\boxed{I_p = \frac{\pi}{32}(40^4 - d_i^4)}$$

$$y = \frac{d_o}{2} = \frac{40}{2}$$

$$\boxed{y = 20\,mm}$$

$$\frac{T_t}{I_p} = \frac{f_s}{y}$$

$$\frac{545.45 \times 10^3}{\frac{\pi}{32}(40^4 - d_i^4)} = \frac{55}{20}$$

$$\boxed{d_i = 27.1\,mm}$$

Result.

$d_i = 27.1\,mm$

2. An automobile engine develops a maximum torque of 162 N/m. The low gear ratio of transmission is 2.75, while the back axle ratio is 4.25. The effective wheel radius is 0.325 m and the coefficient of friction between the tyre and the road surface is 0.6. If the permissible shear stress is 32373 X 10^4 Pa, determine the maximum shaft diameter, assuming that the load is nearly torsional. What is the maximum load on each wheel.

Given

$T_e = 162 \text{ N·m} = 162 \times 10^3 \text{ N·mm}$

$G = 2.75$

$G_{Axle} = 4.25$

[radius of tyre] $r = 0.325 \text{ m} = 325 \text{ mm}$

$\mu = 0.6$

$f_s = 32373 \times 10^4 \text{ Pa} = 323.73 \times 10^6 \text{ Pa}$

$= 323.73 \text{ N/mm}^2$

To find:

(i) d

(ii) Load on each wheel

Solution

$$\frac{T_t}{I_P} = \frac{f_s}{y}$$

$$T_t = T_e \times G \times G_T$$

$$= 162 \times 10^3 \times 2.75 \times 4.25$$

$$\boxed{T_t = 1893.375 \times 10^3 \text{ N.mm}}$$

$$I_P = \frac{\pi}{32} d^4$$

$$\frac{T_t}{I_P} = \frac{f_s}{y}$$

$$\frac{1893.375 \times 10^3}{\frac{\pi}{32} \times d^4} = \frac{323.73}{\frac{d}{2}}$$

$$\boxed{d = 31 \text{ mm}}$$

Load on each wheel = $\frac{\text{Tractive effort}}{\mu}$

Tractive effort = $\frac{T_t}{r} = \frac{1893.375 \times 10^3}{325}$

$$\boxed{\text{Tractive effort} = 5825.77 \text{ N}}$$

$$\text{Load on each wheel} = \frac{5825.77}{0.6}$$

$$\boxed{\text{Load on each wheel} = 9709.6\,N}$$

Result:

$d = 31\,mm$

Load on each wheel $= 9709.6\,N$

3) An engine develops 29.5 kW at 2000 rpm when the torque developed is maximum. The bottom gear ratio 3:1 and the back axle reduction is 4.5:1. The load on each driving axle is 7307.5 N when the car is fully loaded. Diameter of road wheel over the tyres is 0.71 m and the coefficient of adhesion between tyre and road is 0.6. If permissible stress in the material of the shaft is not allowed to exceed 22072.5×10^4 Pa, find the diameter of the axle shaft

Given

$P = 29.5\,kW = 29.5 \times 10^3\,W$

$G_r = 3:1 \Rightarrow 3$

$G_{axle} = 4.5:1 \Rightarrow 4.5$

$N = 2000$ rpm

Load on driving axle = 7357.5 N

diameter of tyre = 0.71 m

[radius of tyre] $r = 0.355$ m

$= 355$ mm

$\mu = 0.6$

$f_{s_{max}} = 22072.5 \times 10^4$ Pa

$= 220.725 \times 10^6$ Pa

$= 220.725$ N/mm^2

To find:

(i) d

Solution:

$$\frac{T_t}{I_p} = \frac{f_s}{r}$$

$$P = \frac{2\pi N T_e}{60}$$

$$29.5 \times 10^3 = \frac{2 \times \pi \times 2000 \times T_e}{60}$$

$$\boxed{T_e = 140.85 \text{ N.m}}$$

(or)

$$T_e = 140.85 \times 10^3 \text{ N.mm}$$

$T_t = T_e \times G_T \times G_{axle}$

$= 140.85 \times 10^3 \times 3 \times 4.5$

$\boxed{T_t = 1901.475 \times 10^3 \ N\cdot mm}$

$\frac{T_t}{I_P} = \frac{f_s}{y}$

$\frac{1901.475 \times 10^3}{\frac{\pi}{32} \times d^4} = \frac{220.725}{\frac{d}{2}}$

$\boxed{d = 35.3 \ mm}$

friction force on each wheel (or) Tractive effort $= \frac{T_t}{Y} = \frac{1901.475 \times 10^3}{355}$

$= 5356.26 \ N$

The frictional force develops horizontal shear stress and the axle weight develops Vertical shear stress

Maximum Vertical stress $= \frac{4}{3} \times$ Average shear stress

$= \frac{4}{3} \times \frac{7357.5}{\frac{\pi}{4} \times (35.3)^2}$

$= 10.02 \ N/mm^2$

Maximum horizontal shear stress $= \frac{4}{3} \times$ Average shear stress

$$= \frac{4}{3} \times \frac{5356.26}{\frac{\pi}{4} \times 35.9^2}$$

$$= 7.3\ N/mm^2$$

Since both the stress is less compare to the design stress. So the shaft is quite safe.

Result:

$d = 35.9\ mm$