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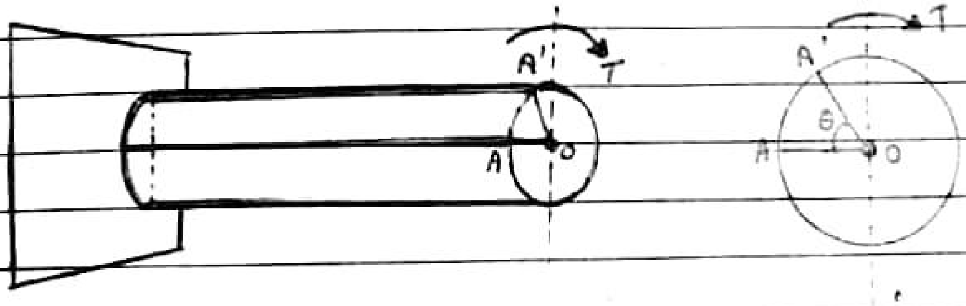
Question :- 51 : Write notes on Torsion of Gastropods with diagrams and classification

Answer :- Torsion means twisting a structural Member when it is loaded by couple that produces rotation about longitudinal axis.

• If be intensity of shear stress, on any layer at a distance r from the centre of shaft, then

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



Torsion in shaft and combined stresses

Sign Convention :-

• Sign convention of torque can be explained by right hand thumb rule.

- A positive torque is that in which there is tightening effect of nut on the bolt. from either side of the cross-section. If torque is applied in the direction of right hand fingers than right hand thumbs direction represents movement of the nut.

T = Torque

- Rate of twist:

$$\left(\frac{\theta}{l}\right) \frac{\theta}{l} = \frac{T}{GJ}$$

- Total angle of twist:

$$\theta = \frac{Tl}{GJ}$$

Where, T = Torque,

- J = Polar moment of Inertia
- G = Modulus of rigidity,
- θ = Angle of twist
- L = Length of shaft,
- GJ = Torsional rigidity

$\frac{GJ}{l}$ →

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- Torsional stiffness:

$$\frac{l}{GJ} \rightarrow$$

- Torsional Flexibility

$$\frac{EA}{l} \rightarrow$$

- Axial stiffness;

$$\frac{l}{EA} \rightarrow$$

Moment of Inertia about polar Axis:

- For solid circular shaft,:

$$J = \frac{\pi d^4}{32}, \quad \tau_{max} = \frac{16T}{\pi d^3}$$

- For hollow circular shaft :

$$J = \frac{\pi}{32}(d_0^4 - d_i^4)$$

Power Transmitted in the shaft:

- Power transmitted by shaft :

$$P = \frac{2\pi N T}{60000} \text{ kW}$$

Where, N = Rotation per minute.

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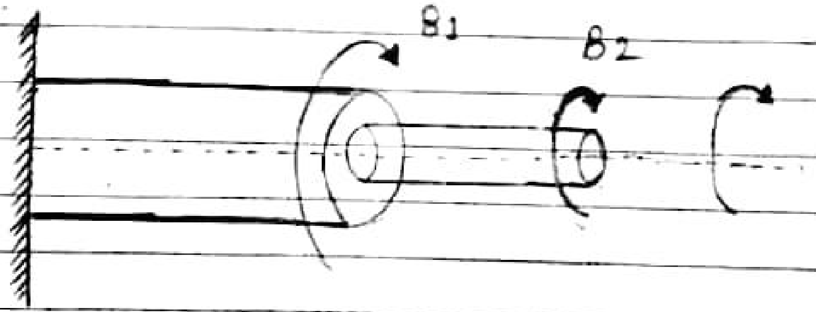
Compound shaft

An improved type of compound coupling for connecting in series and parallel are given below.

1. Series connection : series connection of compound shaft as shown in figure. Due to series connection the torque on shaft 1 will be equal to shaft 2 and the total angular deformation will be equal to the sum of deformation of 1st shaft and 2nd shaft.



Series connection

$$\theta = \theta_1 + \theta_2$$

$$T = T_1 = T_2$$

Therefore,

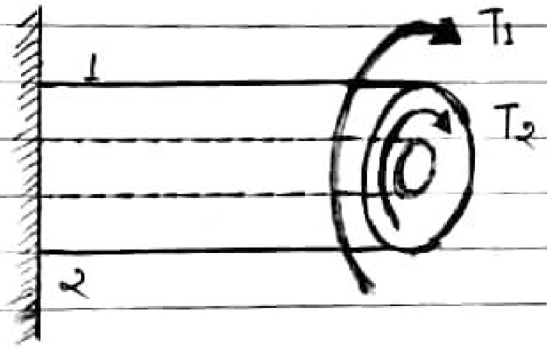
$$\theta = \frac{TL_1}{G_1 J_1} + \frac{TL_2}{G_2 J_2}$$

Where,

θ_1 = Angular deformation of 1st shaft

θ_2 = Angular deformation of 2nd shaft

1. Parallel Connection :– Parallel connection of compound shaft as shown in figure. Due to parallel connection of compound shaft the total torque will be equal to the sum of torque of shaft 1 and torque of shaft 2 and the deflection will be same in both the shafts.



Parallel Connection

$$\theta_1 = \theta_2$$
$$T = T_1 + T_2$$

Therefore,

$$\frac{T_1 L}{G_1 J_1} = \frac{T_2 L}{G_2 J_2}$$

Strain energy (U) stored in shaft due to torsion:

$$U = \frac{1}{2} T.\theta = \frac{1}{2} \frac{T^2}{G.J} = \frac{\tau^2 max}{4G} \text{. volume of shaft}$$

- G = Shear Modulus
- T = Torque
- J = Moment of inertia about polar axis.