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Transmission of power by circular shafts

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Power transmitted by the shaft

Workdone by the torque = $T.2\pi N$ N-m/min

Power transmitted by the shaft = P kW

$= P \times 10^3$ N-m/sec $\quad (1W = 1\ J/sec = 1\ Nm/sec)$

$= 60\ P \times 10^3$ N-m/min

Equating the workdone by the torque to Power transmitted by the shaft,

$$P = \frac{2\pi NT}{60000}\ \text{kW} \quad \Leftrightarrow \quad P = \frac{2\pi NT}{45000}\ \text{HP}$$

P : Power transmitted by the shaft

N : Rotational speed of the shaft, rpm

T : Average or mean torque, Nm

Average or mean torque is considered for computing the power.

For determining the diameter of shaft, the maximum torque (and not average torque) is taken into account because the maximum shear stress developed is ensured to be within safe limits.

Stresses in shafts

- The maximum shear stress occurs at the outermost surface of the cross section.
- The maximum longitudinal shear stress occurs at the surface of the shaft on the longitudinal planes passing through the longitudinal axis of the shaft.
- The maximum tensile stress (major principal stress) occurs at planes 45° to the maximum shearing stress planes at the surface of the shaft.
- The maximum compressive stress (minor principal stress) occurs on the planes at 45° to the longitudinal and the cross sectional planes at the surface of the shaft. This stress is equal to the maximum shear stress on the cross section.
- Maximum shear stress on the cross section of the shaft is the significant stress for design.
- For most engineering materials, shear strength is small as compared to the tensile and compressive stresses.

MODULUS OF RUPTURE

Modulus of rupture is defined as the maximum fictitious shear stress required to rupture the shaft based on the ultimate torque.

$$\tau_r = \frac{T_u . R}{J}$$

τ_r : Modulus of rupture in torsion

T_u : Ultimate torque at failure

R : Outer radius of the shaft

J : Polar moment of inertia

The torsion formula is not applicable beyond the limit of proportionality.

The actual shear stress at the ultimate torque is uniformly distributed across the cross section.


Thank You