Torsion of Bars Formulas

List of 13 Torsion of Bars Formulas

Torsion of Bars

Elastic Perfectly Plastic Materials

1) Elasto Plastic Yielding Torque for Hollow Shaft

Open Calculator

fx $$T_{ep} = \pi \cdot \tau_0 \cdot \left(\frac{\rho^3}{2} \cdot \left(1 - \left(\frac{r_1}{\rho} \right)^4 \right) + \left(\frac{2}{3} \cdot r_2^3 \right) \cdot \left(1 - \left(\frac{\rho}{r_2} \right)^3 \right) \right)$$

ex $$2.6E\text{\^{}}8N^*mm = \pi \cdot 145MPa \cdot \left(\frac{(80mm)^3}{2} \cdot \left(1 - \left(\frac{40mm}{80mm} \right)^4 \right) + \left(\frac{2}{3} \cdot (100mm)^3 \right) \cdot \left(1 - \left(\frac{80mm}{100mm} \right)^3 \right) \right)$$

2) Elasto Plastic Yielding Torque for Solid Shaft

Open Calculator

fx $$T_{ep} = \frac{2}{3} \cdot \pi \cdot r_2^3 \cdot \tau_0 \cdot \left(1 - \frac{1}{4} \cdot \left(\frac{\rho}{r_2} \right)^3 \right)$$

ex $$2.6E\text{\^{}}8N^*mm = \frac{2}{3} \cdot \pi \cdot (100mm)^3 \cdot 145MPa \cdot \left(1 - \frac{1}{4} \cdot \left(\frac{80mm}{100mm} \right)^3 \right)$$

3) Full Yielding Torque for Hollow Shaft

Open Calculator

fx $$T_f = \frac{2}{3} \cdot \pi \cdot r_2^3 \cdot \tau_0 \cdot \left(1 - \left(\frac{r_1}{r_2} \right)^3 \right)$$

ex $$2.8E\text{\^{}}8N^*mm = \frac{2}{3} \cdot \pi \cdot (100mm)^3 \cdot 145MPa \cdot \left(1 - \left(\frac{40mm}{100mm} \right)^3 \right)$$

4) Full Yielding Torque for Solid Shaft

Open Calculator

fx $$T_f = \frac{2}{3} \cdot \pi \cdot \tau_0 \cdot r_2^3$$

ex $$3E\text{\^{}}8N^*mm = \frac{2}{3} \cdot \pi \cdot 145MPa \cdot (100mm)^3$$

5) Incipient Yielding Torque for Hollow Shaft

Open Calculator

fx $$T_i = \frac{\pi}{2} \cdot r_2^3 \cdot \tau_0 \cdot \left(1 - \left(\frac{r_1}{r_2}\right)^4\right)$$

ex $$2.2E\hat{}8N{*}mm = \frac{\pi}{2} \cdot (100mm)^3 \cdot 145MPa \cdot \left(1 - \left(\frac{40mm}{100mm}\right)^4\right)$$

6) Incipient Yielding Torque for Solid Shaft

Open Calculator

fx $$T_i = \frac{\pi \cdot r_2^3 \cdot \tau_0}{2}$$

ex $$2.3E\hat{}8N{*}mm = \frac{\pi \cdot (100mm)^3 \cdot 145MPa}{2}$$

Elastic Work Hardening Material

7) Elasto Plastic Yielding Torque in Work Hardening for Hollow Shaft

Open Calculator

fx $$T_{ep} = \frac{2 \cdot \pi \cdot \tau_{nonlinear} \cdot r_2^3}{3} \cdot \left(\frac{3 \cdot \rho^3}{r_2^3 \cdot (n+3)} - \left(\frac{3}{n+3}\right) \cdot \left(\frac{r_1}{\rho}\right)^n \cdot \left(\frac{r_1}{r_2}\right)^3 + 1 - \left(\frac{\rho}{r_2}\right)^3\right)$$

ex $$3.3E\hat{}8N{*}mm = \frac{2 \cdot \pi \cdot 175MPa \cdot (100mm)^3}{3} \cdot \left(\frac{3 \cdot (80mm)^3}{(100mm)^3 \cdot (0.25+3)} - \left(\frac{3}{0.25+3}\right) \cdot \left(\frac{40mm}{80mm}\right)^{0.25} \cdot \left(\frac{4}{10}\right.\right.$$

8) Elasto Plastic Yielding Torque in Work Hardening for Solid Shaft

Open Calculator

fx $$T_{ep} = \frac{2 \cdot \pi \cdot \tau_{nonlinear} \cdot r_2^3}{3} \cdot \left(1 - \left(\frac{n}{n+3}\right) \cdot \left(\frac{\rho}{r_2}\right)^3\right)$$

ex $$3.5E\hat{}8N{*}mm = \frac{2 \cdot \pi \cdot 175MPa \cdot (100mm)^3}{3} \cdot \left(1 - \left(\frac{0.25}{0.25+3}\right) \cdot \left(\frac{80mm}{100mm}\right)^3\right)$$

9) Full Yielding Torque in Work Hardening for Hollow Shaft

Open Calculator

$$T_f = \frac{2 \cdot \pi \cdot \tau_{nonlinear} \cdot r_2^3}{3} \cdot \left(1 - \left(\frac{r_1}{r_2}\right)^3\right)$$

$$3.4E^8N*mm = \frac{2 \cdot \pi \cdot 175MPa \cdot (100mm)^3}{3} \cdot \left(1 - \left(\frac{40mm}{100mm}\right)^3\right)$$

10) Full Yielding Torque in Work Hardening for Solid Shaft

Open Calculator

$$T_f = \frac{2 \cdot \pi \cdot \tau_{nonlinear} \cdot r_2^3}{3}$$

$$3.7E^8N*mm = \frac{2 \cdot \pi \cdot 175MPa \cdot (100mm)^3}{3}$$

11) Incipient Yielding Torque in Work Hardening for Hollow Shaft

Open Calculator

$$T_i = \frac{\tau_{nonlinear} \cdot J_n}{r_2^n}$$

$$1804.954N*mm = \frac{175MPa \cdot 5800mm^4}{(100mm)^{0.25}}$$

12) Incipient Yielding Torque in Work Hardening Solid Shaft

Open Calculator

$$T_i = \frac{\tau_{nonlinear} \cdot J_n}{r_2^n}$$

$$1804.954N*mm = \frac{175MPa \cdot 5800mm^4}{(100mm)^{0.25}}$$

13) Nth Polar Moment of Inertia

Open Calculator

$$J_n = \left(\frac{2 \cdot \pi}{n + 3}\right) \cdot \left(r_2^{n+3} - r_1^{n+3}\right)$$

$$1E^9mm^4 = \left(\frac{2 \cdot \pi}{0.25 + 3}\right) \cdot \left((100mm)^{0.25+3} - (40mm)^{0.25+3}\right)$$

Residual Stresses For Idealized Stress Strain Law

Residual Stresses for Non-Linear stress strain Law

Variables Used

- J_n Nth Polar Moment of Inertia *(Millimeter⁴)*
- n Material Constant
- r_1 Inner Radius of Shaft *(Millimeter)*
- r_2 Outer Radius of Shaft *(Millimeter)*
- T_{ep} Elasto Plastic Yielding Torque *(Newton Millimeter)*
- T_f Full Yielding Torque *(Newton Millimeter)*
- T_i Incipient Yielding Torque *(Newton Millimeter)*
- ρ Radius of Plastic Front *(Millimeter)*
- τ_0 Yield Stress in Shear *(Megapascal)*
- $\tau_{nonlinear}$ Yield Shear Stress(non-linear) *(Megapascal)*

Constants, Functions, Measurements used

- Constant: **pi**, 3.14159265358979323846264338327950288
  Archimedes' constant
- Measurement: **Length** in Millimeter (mm)
  Length Unit Conversion
- Measurement: **Torque** in Newton Millimeter (N*mm)
  Torque Unit Conversion
- Measurement: **Second Moment of Area** in Millimeter^4 (mm^4)
  Second Moment of Area Unit Conversion
- Measurement: **Stress** in Megapascal (MPa)
  Stress Unit Conversion

Check other formula lists

- **Nonlinear Behavior of Beams Formulas**
- **Plastic Bending of Beams Formulas**
- **Residual Stresses for Non-Linear Stress Strain Relations Formulas**
- **Residual Stresses in Plastic Bending Formulas**
- **Torsion of Bars Formulas**

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