Important Torsion of Bars Formulas PDF

Formulas
Examples
with Units

List of 13
Important Torsion of Bars Formulas

1) Elastic Perfectly Plastic Materials Formulas

1.1) Elasto Plastic Yielding Torque for Hollow Shaft Formula

Evaluate Formula

Formula

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

Example with Units

$$2.6E{+}8\,\text{N*mm} = 3.1416 \cdot 145\,\text{MPa} \cdot \left(\frac{80\,\text{mm}^3}{2} \cdot \left(1 - \left(\frac{40\,\text{mm}}{80\,\text{mm}} \right)^4 \right) + \left(\frac{2}{3} \cdot 100\,\text{mm}^3 \right) \cdot \left(1 - \left(\frac{80\,\text{mm}}{100\,\text{mm}} \right)^3 \right) \right)$$

1.2) Elasto Plastic Yielding Torque for Solid Shaft Formula

Evaluate Formula

Formula

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

Example with Units

$$2.6E{+}8\,\text{N*mm} = \frac{2}{3} \cdot 3.1416 \cdot 100\,\text{mm}^3 \cdot 145\,\text{MPa} \cdot \left(1 - \frac{1}{4} \cdot \left(\frac{80\,\text{mm}}{100\,\text{mm}} \right)^3 \right)$$

1.3) Full Yielding Torque for Hollow Shaft Formula

Evaluate Formula

Formula

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

Example with Units

$$2.8E{+}8\,\text{N*mm} = \frac{2}{3} \cdot 3.1416 \cdot 100\,\text{mm}^3 \cdot 145\,\text{MPa} \cdot \left(1 - \left(\frac{40\,\text{mm}}{100\,\text{mm}} \right)^3 \right)$$

1.4) Full Yielding Torque for Solid Shaft Formula

Evaluate Formula

Formula

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

Example with Units

$$3E{+}8\,\text{N*mm} = \frac{2}{3} \cdot 3.1416 \cdot 145\,\text{MPa} \cdot 100\,\text{mm}^3$$

1.5) Incipient Yielding Torque for Hollow Shaft Formula

Evaluate Formula

Formula

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

Example with Units

$$2.2E{+}8\,\text{N*mm} = \frac{3.1416}{2} \cdot 100\,\text{mm}^3 \cdot 145\,\text{MPa} \cdot \left(1 - \left(\frac{40\,\text{mm}}{100\,\text{mm}} \right)^4 \right)$$

1.6) Incipient Yielding Torque for Solid Shaft Formula

Evaluate Formula

Formula

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

Example with Units

$$2.3E{+}8\,\text{N*mm} = \frac{3.1416 \cdot 100\,\text{mm}^3 \cdot 145\,\text{MPa}}{2}$$

2) Elastic Work Hardening Material Formulas

2.1) Elasto Plastic Yielding Torque in Work Hardening for Hollow Shaft Formula

Evaluate Formula

Formula

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

Example with Units

$$3.3E{+}8\,\mathrm{N{*}mm} = \frac{2 \cdot 3.1416 \cdot 175\,\mathrm{MPa} \cdot 100\,\mathrm{mm}^{3}}{3} \cdot \left(\frac{3 \cdot 80\,\mathrm{mm}^3}{100\,\mathrm{mm}^{3} \cdot (0.25+3)} - \left(\frac{3}{0.25+3}\right) \cdot \left(\frac{40\,\mathrm{mm}}{80\,\mathrm{mm}}\right)^{0.25} \cdot \left(\frac{40\,\mathrm{mm}}{100\,\mathrm{mm}}\right)^3 + 1 - \left(\frac{80\,\mathrm{mm}}{100\,\mathrm{mm}}\right)^3 \right)$$

2.2) Elasto Plastic Yielding Torque in Work Hardening for Solid Shaft Formula

Evaluate Formula

Formula

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

Example with Units

$$3.5E{+}8\,\mathrm{N{*}mm} = \frac{2 \cdot 3.1416 \cdot 175\,\mathrm{MPa} \cdot 100\,\mathrm{mm}^{3}}{3} \cdot \left(1 - \left(\frac{0.25}{0.25+3}\right) \cdot \left(\frac{80\,\mathrm{mm}}{100\,\mathrm{mm}}\right)^3 \right)$$

2.3) Full Yielding Torque in Work Hardening for Hollow Shaft Formula

Evaluate Formula

Formula

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

Example with Units

$$3.4E{+}8\,\mathrm{N{*}mm} = \frac{2 \cdot 3.1416 \cdot 175\,\mathrm{MPa} \cdot 100\,\mathrm{mm}^{3}}{3} \cdot \left(1 - \left(\frac{40\,\mathrm{mm}}{100\,\mathrm{mm}}\right)^3 \right)$$

2.4) Full Yielding Torque in Work Hardening for Solid Shaft Formula

Evaluate Formula

Formula

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

Example with Units

$$3.7E{+}8\,\mathrm{N{*}mm} = \frac{2 \cdot 3.1416 \cdot 175\,\mathrm{MPa} \cdot 100\,\mathrm{mm}^{3}}{3}$$

2.5) Incipient Yielding Torque in Work Hardening for Hollow Shaft Formula

Evaluate Formula

Formula

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

Example with Units

$$1804.9536\,\mathrm{N{*}mm} = \frac{175\,\mathrm{MPa} \cdot 5800\,\mathrm{mm^4}}{100\,\mathrm{mm}^{0.25}}$$

2.6) Incipient Yielding Torque in Work Hardening Solid Shaft Formula

Evaluate Formula

Formula

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

Example with Units

$$1804.9536\,\mathrm{N{*}mm} = \frac{175\,\mathrm{MPa} \cdot 5800\,\mathrm{mm^4}}{100\,\mathrm{mm}^{0.25}}$$

2.7) Nth Polar Moment of Inertia Formula

Evaluate Formula

Formula

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

Example with Units

$$1E{+}9\,\mathrm{mm^4} = \left(\frac{2 \cdot 3.1416}{0.25+3}\right) \cdot \left(100\,\mathrm{mm}^{0.25+3} - 40\,\mathrm{mm}^{0.25+3} \right)$$

3) Residual Stresses for Non-Linear stress strain Law Formulas

Variables used in list of Torsion of Bars Formulas above

- 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 in list of Torsion of Bars Formulas above

- constant(s): **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 Millimeter⁴ (mm⁴) *Second Moment of Area Unit Conversion*
- Measurement: **Stress** in Megapascal (MPa) *Stress Unit Conversion*

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