Important Torsional Rigidity and Polar Modulus Formulas PDF

Formulas
Examples
with Units

List of 16
Important Torsional Rigidity and Polar Modulus Formulas

1) Polar Modulus Formulas

1.1) Diameter of Solid Shaft with known Polar Modulus Formula

Evaluate Formula

Formula

$$d = \left(\frac{16 \cdot Z_p}{\pi}\right)^{\frac{1}{3}}$$

Example with Units

$$0.284\,\text{m} = \left(\frac{16 \cdot 4.5\text{e-}3\,\text{m}^3}{3.1416}\right)^{\frac{1}{3}}$$

1.2) Inner diameter of Hollow Shaft using Polar Modulus Formula

Evaluate Formula

Formula

$$d_i = \left(\left(d_o^{\,4}\right) - \left(\frac{Z_p \cdot 16 \cdot d_o}{\pi}\right)\right)^{\frac{1}{4}}$$

Example with Units

$$0.688\,\text{m} = \left(\left(700\,\text{mm}^{\,4}\right) - \left(\frac{4.5\text{e-}3\,\text{m}^3 \cdot 16 \cdot 700\,\text{mm}}{3.1416}\right)\right)^{\frac{1}{4}}$$

1.3) Polar Modulus Formula

Evaluate Formula

Formula

$$Z_p = \frac{J}{R}$$

Example with Units

$$0.0373\,\text{m}^3 = \frac{4.1\text{e-}3\,\text{m}^4}{110\,\text{mm}}$$

1.4) Polar Modulus of Hollow Shaft Formula

Evaluate Formula

Formula

$$Z_p = \frac{\pi \cdot \left(\left(d_o^{\,4}\right) - \left(d_i^{\,4}\right)\right)}{16 \cdot d_o}$$

Example with Units

$$0.0045\,\text{m}^3 = \frac{3.1416 \cdot \left(\left(700\,\text{mm}^{\,4}\right) - \left(0.688\,\text{m}^{\,4}\right)\right)}{16 \cdot 700\,\text{mm}}$$

1.5) Polar Modulus of Solid Shaft Formula

Evaluate Formula

Formula

$$Z_p = \frac{\pi \cdot d^3}{16}$$

Example with Units

$$0.0045\,\text{m}^3 = \frac{3.1416 \cdot 0.284\,\text{m}^3}{16}$$

1.6) Polar Modulus using Maximum Twisting Moment Formula

Evaluate Formula

Formula

$$Z_p = \left(\frac{T}{\tau_{max}}\right)$$

Example with Units

$$0.0007\,\text{m}^3 = \left(\frac{28\,\text{kN*m}}{42\,\text{MPa}}\right)$$

1.7) Polar Moment of Inertia given Torsional Section Modulus Formula

Evaluate Formula

Formula

$$J = Z_p \cdot R$$

Example with Units

$$0.0005\,\text{m}^4 = 4.5\text{e-}3\,\text{m}^3 \cdot 110\,\text{mm}$$

1.8) Polar Moment of Inertia of Solid Shaft Formula

Evaluate Formula

Formula

$$J = \frac{\pi \cdot d^4}{32}$$

Example with Units

$$0.0006\,\text{m}^4 = \frac{3.1416 \cdot 0.284\,\text{m}^4}{32}$$

1.9) Polar Moment of Inertia using Polar Modulus Formula

Evaluate Formula

Formula

$$J = R \cdot Z_p$$

Example with Units

$$0.0005\,\text{m}^4 = 110\,\text{mm} \cdot 4.5\text{e-}3\,\text{m}^3$$

2) Torsional Rigidity Formulas

2.1) Angle of Twist for Shaft using Torsional Rigidity Formula

Evaluate Formula

Formula

$$\theta = \frac{T \cdot L_{shaft}}{TJ}$$

Example with Units

$$1.4202\,\text{rad} = \frac{28\,\text{kN*m} \cdot 4.58\,\text{m}}{90.3\,\text{kN*m}^2}$$

2.2) Length of Shaft using Torsional Rigidity Formula

Evaluate Formula

Formula

$$L_{shaft} = \frac{TJ \cdot \theta}{T}$$

Example with Units

$$4.5795\,\text{m} = \frac{90.3\,\text{kN*m}^2 \cdot 1.42\,\text{rad}}{28\,\text{kN*m}}$$

2.3) Modulus of Rigidity with Known Torsional Rigidity Formula

Evaluate Formula

Formula

$$G = \frac{TJ}{J}$$

Example with Units

$$0.022\,\text{GPa} = \frac{90.3\,\text{kN*m}^2}{4.1\text{e-}3\,\text{m}^4}$$

2.4) Polar Moment of Inertia with Known Torsional Rigidity Formula

Evaluate Formula

Formula

$$J = \frac{TJ}{G}$$

Example with Units

$$0.0041\,\text{m}^4 = \frac{90.3\,\text{kN*m}^2}{0.022\,\text{GPa}}$$

2.5) Torque on Shaft using Torsional Rigidity Formula

Evaluate Formula

Formula

$$T = \frac{TJ \cdot \theta}{L_{shaft}}$$

Example with Units

$$27.9969\,\text{kN*m} = \frac{90.3\,\text{kN*m}^2 \cdot 1.42\,\text{rad}}{4.58\,\text{m}}$$

2.6) Torsional Rigidity Formula

Evaluate Formula

Formula

$$TJ = G \cdot J$$

Example with Units

$$90.2\,\text{kN*m}^2 = 0.022\,\text{GPa} \cdot 4.1\text{e-}3\,\text{m}^4$$

2.7) Torsional Rigidity using Torque and Length of Shaft Formula

Evaluate Formula

Formula

$$TJ = \frac{T \cdot L_{shaft}}{\theta}$$

Example with Units

$$90.3099\,\text{kN*m}^2 = \frac{28\,\text{kN*m} \cdot 4.58\,\text{m}}{1.42\,\text{rad}}$$

Variables used in list of Torsional Rigidity and Polar Modulus Formulas above

- **d** Dia of Shaft *(Meter)*
- d_i Inner Dia of Shaft *(Meter)*
- d_o Outer Diameter of Shaft *(Millimeter)*
- **G** Modulus of Rigidity SOM *(Gigapascal)*
- **J** Polar Moment of Inertia *(Meter⁴)*
- L_{shaft} Length of Shaft *(Meter)*
- **R** Radius of Shaft *(Millimeter)*
- **T** Torque *(Kilonewton Meter)*
- **TJ** Torsional Rigidity *(Kilonewton Square Meter)*
- Z_p Polar Modulus *(Cubic Meter)*
- **θ** Angle of Twist *(Radian)*
- τ_{max} Maximum Shear Stress *(Megapascal)*

Constants, Functions, Measurements used in list of Torsional Rigidity and Polar Modulus Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- Measurement: **Length** in Meter (m), Millimeter (mm)
  Length Unit Conversion
- Measurement: **Volume** in Cubic Meter (m³)
  Volume Unit Conversion
- Measurement: **Pressure** in Gigapascal (GPa)
  Pressure Unit Conversion
- Measurement: **Angle** in Radian (rad)
  Angle Unit Conversion
- Measurement: **Torque** in Kilonewton Meter (kN*m)
  Torque Unit Conversion
- Measurement: **Second Moment of Area** in Meter⁴ (m⁴)
  Second Moment of Area Unit Conversion
- Measurement: **Torsional Rigidity** in Kilonewton Square Meter (kN*m²)
  Torsional Rigidity Unit Conversion
- Measurement: **Stress** in Megapascal (MPa)
  Stress Unit Conversion

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