Thick-Walled Cylinder Stresses (Lamé Equations)

Hoop, radial and longitudinal stresses at the bore and the outside of a thick-walled cylinder under internal and external pressure by the Lamé equations.

Method: G. Lamé (1852); Timoshenko; Strength of Materials Part II

Input parameters

Unit system: SI

Parameter	Value	Unit
Internal pressure (gauge)	30.000	MPa
External pressure (gauge)	0	MPa
Inside radius	50.000	mm
Outside radius	80.000	mm

Calculated results

Parameter	Value	Unit
Hoop stress at the bore	68.462	MPa
Hoop stress at the outside	38.462	MPa
Radial stress at the bore	-30.000	MPa
Radial stress at the outside	0	MPa
Longitudinal stress (closed ends)	19.231	MPa
Stress intensity at the bore (Tresca)	98.462	MPa

Notes for this case

- Elastic stresses away from ends and openings; tensile positive. Design thickness for a pressure vessel comes from the code you work to.

Formula and method

$$A = \frac{p_i r_i^2 - p_o r_o^2}{r_o^2 - r_i^2}, \quad B = \frac{(p_i - p_o) r_i^2 r_o^2}{r_o^2 - r_i^2}$$

$$\sigma_\theta = A + \frac{B}{r^2}, \quad \sigma_r = A - \frac{B}{r^2}, \quad \sigma_l = A$$

Variables

p_i	Internal pressure (gauge)	Pa
p_o	External pressure (gauge)	Pa
r_i	Inside radius	m
r_o	Outside radius	m
$\sigma_{\theta,i}$	Hoop stress at the bore	Pa
$\sigma_{\theta,o}$	Hoop stress at the outside	Pa
$\sigma_{r,i}$	Radial stress at the bore	Pa
$\sigma_{r,o}$	Radial stress at the outside	Pa
σ_l	Longitudinal stress (closed ends)	Pa
$\sigma_{\theta,i} - \sigma_{r,i}$	Stress intensity at the bore (Tresca)	Pa
A, B	Lamé constants	Pa, N

Method and standards

Lamé's elastic solution for a long cylinder under internal and external pressure; the longitudinal stress is for closed ends.

Assumptions and limits

- The longitudinal stress A is for closed ends carrying the end thrust; with open ends (a tube whose thrust is taken elsewhere, a press-fitted sleeve) it is zero. Hoop and radial stresses are the same either way.
- No yield check: compare the stress intensity at the bore (Tresca) with the allowable stress of the code or the material's yield strength.
- Elastic, homogeneous, far from ends.
- Tensile positive.

References

- G. Lamé (1852); Timoshenko
- Strength of Materials Part II

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/mechanical/strength-of-materials/thick-cylinder-lame-stress

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