Thick-Walled Sphere under Internal Pressure (Lamé)

Radial and hoop stresses in a thick-walled sphere under internal pressure by the Lamé solution, at the inner and outer surfaces, compared with the thin-wall result.

Method: Lamé solution for a thick sphere (Timoshenko and Goodier, Theory of Elasticity)

Input parameters

Unit system: SI

Parameter	Value	Unit
Internal pressure	50.000	MPa
Inner radius	100.00	mm
Outer radius	150.00	mm

Calculated results

Parameter	Value	Unit
Hoop stress at the inner surface	56.579	MPa
Hoop stress at the outer surface	31.579	MPa
Radial stress at the inner surface (−p)	-50.000	MPa
Thin-wall hoop stress p r_i/(2t)	50.000	MPa
Stress intensity at the inner surface (Tresca)	106.58	MPa

Notes for this case

- Elastic Lamé solution; compare the stress intensity with the material's yield or the code's allowable. Design of pressure vessels follows the applicable code.

Formula and method

$$\sigma_t(r) = \frac{p\, r_i^3 (r_o^3 + 2r^3)}{2r^3 (r_o^3 - r_i^3)}, \quad \sigma_r(r) = -\frac{p\, r_i^3 (r_o^3 - r^3)}{r^3 (r_o^3 - r_i^3)}$$

Variables

p	Internal pressure	Pa
r_i	Inner radius	m
r_o	Outer radius	m
$\sigma_{t,i}$	Hoop stress at the inner surface	Pa
$\sigma_{t,o}$	Hoop stress at the outer surface	Pa
$\sigma_{r,i}$	Radial stress at the inner surface (−p)	Pa
σ_{thin}	Thin-wall hoop stress p r_i/(2t)	Pa
$\sigma_{t,i} - \sigma_{r,i}$	Stress intensity at the inner surface (Tresca)	Pa

Method and standards

Lamé solution for spherical symmetry.

Assumptions and limits

- The stress intensity σ_t − σ_r at the inner surface is the Tresca equivalent stress; no yield or code check is made.
- Elastic, internal pressure only.

References

- Lamé solution for a thick sphere (Timoshenko and Goodier, Theory of Elasticity)

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-sphere-stress

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Reopens the calculator with the inputs of this report.