Taylor Dislocation Strengthening (Work Hardening)

Flow stress increase from dislocation density by the Taylor relation, with the mean dislocation spacing and the total yield strength over a friction stress.

Method: Taylor relation for forest hardening

Input parameters

Unit system: SI

Parameter	Value	Unit
Dislocation density (m^{-2})	1.0000e+14	
Shear modulus	26.000	GPa
Burgers vector	0.28600	nm
Taylor constant	0.30000	
Taylor factor (3.06 fcc, 2.75 bcc)	3.0600	
Friction (lattice and solute) stress	20.000	MPa

Calculated results

Parameter	Value	Unit
Shear stress increase	22.308	MPa
Tensile flow stress increase	68.262	MPa
Total flow stress	88.262	MPa
Mean dislocation spacing 1/√ρ	100.00	nm

Notes for this case

• A moving dislocation must pass the stress fields of the forest dislocations it cuts, so the shear stress needed grows with the square root of their density: Δτ = αGb√ρ, α ≈ 0.2–0.5. The Taylor factor M converts resolved shear to tensile stress for a polycrystal. Annealed metals have ρ ≈ 10^{10}–10^{12} m^{-2}, heavily cold-worked ones 10^{14}–10^{16} m^{-2}. Strengthening contributions from grain size, solutes and precipitates add to this (often in quadrature for similar obstacles).

Formula and method

$$\Delta\tau = \alpha G b\sqrt{\rho_d}, \quad \sigma_y = \sigma_0 + M\alpha G b\sqrt{\rho_d}$$

Variables

ρ_d	Dislocation density (m^{-2})	-
G	Shear modulus	Pa
b	Burgers vector	m
α	Taylor constant	-
M	Taylor factor (3.06 fcc, 2.75 bcc)	-
σ_0	Friction (lattice and solute) stress	Pa
$\Delta\tau$	Shear stress increase	Pa
$\Delta\sigma$	Tensile flow stress increase	Pa
σ_y	Total flow stress	Pa
ℓ	Mean dislocation spacing 1/√ρ	m

Method and standards

Taylor hardening.

Assumptions and limits

- Homogeneous forest; constant α; room-temperature deformation.

References

Taylor relation for forest hardening

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/materials/properties/taylor-dislocation-strengthening

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.