Wire Drawing: Ideal Draw Stress, Force and Maximum Reduction

Ideal drawing stress and force for wire or bar from the area reduction and mean flow stress, and the theoretical maximum reduction per pass.

Method: Ideal work: σ_d = σ̄ ln(A₀/A_f); maximum reduction when σ_d = σ̄; r = 1 − 1/e (Kalpakjian; Groover)

Input parameters

Unit system: SI

Parameter	Value	Unit
Entry diameter	6.0000	mm
Exit diameter	5.0000	mm
Mean flow stress	400.00	MPa
Process efficiency (friction and redundant work)	70.000	%

Calculated results

Parameter	Value	Unit
Area reduction	30.556	%
Ideal draw stress σ̄ ln(A₀/A_f)	145.86	MPa
Draw force with efficiency	4.0913	kN
Ideal maximum reduction, frictionless (1 − 1/e)	63.212	%
Maximum reduction at this efficiency (1 − e^{−η})	50.341	%

Formula and method

$$\sigma_d = \bar{\sigma} \ln \frac{A_0}{A_f}, \quad F = \frac{\sigma_d A_f}{\eta}, \quad r_{max} = 1 - e^{-1}, \quad r_{max,\eta} = 1 - e^{-\eta}$$

Variables

d_0	Entry diameter	m
d_f	Exit diameter	m
$\bar{\sigma}$	Mean flow stress	Pa
η	Process efficiency (friction and redundant work)	-
r	Area reduction	-
σ_d	Ideal draw stress σ̄ ln(A₀/A_f)	Pa
F	Draw force with efficiency	N
r_{max}	Ideal maximum reduction, frictionless (1 − 1/e)	-
$r_{max,\eta}$	Maximum reduction at this efficiency (1 − e^{−η})	-

Method and standards

Ideal work.

Assumptions and limits

- The breakage check compares the actual draw stress σ_d/η with the mean flow stress σ̄; work-hardened wire leaves the die with a higher flow stress, so the check is conservative.
- r_max = 63.2 % is the frictionless limit. With the efficiency η the limit is 1 − e^(−η) (50 % at η = 0.7); practical passes are smaller still (about 30–45 %) for die life and safety.
- Uniform deformation.

References

- Ideal work: $\sigma_d = \bar{\sigma} \ln(A_0/A_f)$; maximum reduction when $\sigma_d = \bar{\sigma}$
- $r = 1 - 1/e$ (Kalpakjian; Groover)

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/manufacturing/wire-drawing-force

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Reopens the calculator with the inputs of this report.