Recrystallisation Kinetics by the JMAK (Avrami) Equation

Fraction recrystallised after a time at temperature by the Johnson–Mehl–Avrami–Kolmogorov equation, with the half time shifted by an activation energy.

Method: Johnson–Mehl–Avrami–Kolmogorov kinetics

Input parameters

Unit system: SI

Parameter	Value	Unit
Half time at the reference temperature	10.000	min
Reference temperature	600.00	°C
Activation energy	200.00	kJ/mol
Annealing temperature	620.00	°C
Avrami exponent	2.0000	
Annealing time	5.0000	min
Target fraction	95.000	%

Calculated results

Parameter	Value	Unit
Half time at the annealing temperature	5.3962	min
Fraction recrystallised	44.850	%
Time for the target fraction	11.218	min

Notes for this case

• X = 1 − exp(−k·tⁿ), k = ln 2/t_{50}^n; t_{50} scales with exp(Q/RT). Fit t_{50} and n to annealing tests on the same cold-worked material; prior strain and grain size change both.

Formula and method

$$X = 1 - \exp(-kt^n), \quad k = \frac{\ln 2}{t_{50}^n}, \quad t_{50} = t_{50,ref} \exp\left[\frac{Q}{R}\left(\frac{1}{T} - \frac{1}{T_{ref}}\right)\right]$$

Variables

$t_{50,ref}$	Half time at the reference temperature	s
T_{ref}	Reference temperature	K
Q	Activation energy	J/mol
T	Annealing temperature	K
n	Avrami exponent	-
t	Annealing time	s
X_t	Target fraction	-
t_{50}	Half time at the annealing temperature	s
X	Fraction recrystallised	-
t_X	Time for the target fraction	s

Method and standards

JMAK kinetics.

Assumptions and limits

- Isothermal annealing; site-saturated or constant nucleation.

References

Johnson–Mehl–Avrami–Kolmogorov kinetics

Report details

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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

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

This calculator online

https://calc.firecad.com/materials/heat-treatment/recrystallisation-jmak-kinetics

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Reopens the calculator with the inputs of this report.