Homogenisation Annealing Time for Dendritic Segregation

Annealing time to reduce dendritic segregation to a target fraction of its amplitude, from dendrite arm spacing and an Arrhenius diffusivity.

Method: Decay of sinusoidal segregation by diffusion

Input parameters

Unit system: SI

Parameter	Value	Unit
Dendrite arm spacing (segregation wavelength)	100.00	µm
Diffusivity pre-exponential	1.6000	cm²/s
Activation energy	270.00	kJ/mol
Annealing temperature	1,200.0	°C
Residual segregation fraction	1.0000	%

Calculated results

Parameter	Value	Unit
Diffusivity at temperature	4.2727e-10	cm²/s
Relaxation time	1.6468	h
Annealing time	7.5837	h

Notes for this case

• A sinusoidal concentration profile of wavelength λ decays as e^(−t/τ), τ = λ²/(4π²D) (Fick's second law). Halving the arm spacing (faster solidification) cuts the time fourfold. Substitutional elements such as Mn, Cr and Ni diffuse slowly in austenite, so full homogenisation of coarse castings is rarely practical.

Formula and method

$$\frac{\beta}{\beta_0} = e^{-t/\tau}, \quad \tau = \frac{\lambda^2}{4\pi^2 D}, \quad D = D_0 e^{-Q/RT}$$

Variables

λ	Dendrite arm spacing (segregation wavelength)	m
D_0	Diffusivity pre-exponential	m²/s
Q	Activation energy	J/mol
T	Annealing temperature	K
β/β_0	Residual segregation fraction	-
D	Diffusivity at temperature	m²/s
τ	Relaxation time	s
t	Annealing time	s

Method and standards

Homogenisation.

Assumptions and limits

- Sinusoidal profile; constant D; no second phases.

References

Decay of sinusoidal segregation by diffusion

Report details

Report reference	FCC-XHX0-AYPR (the same inputs always give the same reference)
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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/homogenisation-annealing-time

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.