Carbon Diffusion Profile in Steel (Carburising or Decarburising)

Carbon content at a depth after carburising or decarburising from surface and initial carbon, temperature and time by Fick's second law, and depth to a carbon level.

Method: Fick's second law; constant surface concentration

Input parameters

Unit system: SI

Parameter	Value	Unit
Surface carbon (wt %)	1.0000	
Initial carbon (wt %)	0.20000	
Diffusion pre-exponential	23.000	mm²/s
Activation energy	148.00	kJ/mol
Temperature	950.00	°C
Time	10.000	h
Depth of interest	0.50000	mm
Carbon level for the depth output (wt %)	0.40000	

Calculated results

Parameter	Value	Unit
Diffusion coefficient	1.1003e-05	mm²/s
Diffusion length	1.2587	mm
Carbon at the depth (wt %)	0.65942	
Depth to the carbon level	1.0239	mm

Notes for this case

• Semi-infinite solid with constant surface carbon: C = C_s − (C_s − C₀)·erf(x/2√(Dt)), D = D₀e^(−Q/RT). For decarburising enter a surface carbon below the initial. The defaults are textbook values for carbon in austenite.

Formula and method

$$C(x) = C_s - (C_s - C_0)\,\mathrm{erf}\frac{x}{2\sqrt{Dt}}, \quad D = D_0 e^{-Q/RT}$$

Variables

C_s	Surface carbon (wt %)	-
C_0	Initial carbon (wt %)	-
D_0	Diffusion pre-exponential	m²/s
Q	Activation energy	J/mol
T	Temperature	K
t	Time	s
x	Depth of interest	m
C_x	Carbon level for the depth output (wt %)	-
D	Diffusion coefficient	m²/s
$2\sqrt{Dt}$	Diffusion length	m
$C(x)$	Carbon at the depth (wt %)	-

x_C	Depth to the carbon level	m

Method and standards

Fick profile.

Assumptions and limits

- Semi-infinite plate; constant D and surface carbon.

References

Fick's second law, constant surface concentration

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/carbon-diffusion-profile-fick

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.