Induction Bar Heating Line: Heat Time, Coil Length and Frequency

Ballpark minimum heat time, coil line length, lowest efficient frequency and power for through-heating steel bars to forging temperature by induction.

Input parameters

Unit system: SI

Parameter	Value	Unit
Bar diameter	50.000	mm
Production rate	2,000.0	kg/h
Resistivity of the hot steel (above the Curie point)	1.2000	Ω·mm²/m
Relative permeability (1 above the Curie point)	1.0000	
Required ratio of diameter to reference depth	4.0000	
Mean specific heat, ambient to final	670.00	J/(kg·K)
Initial temperature	20.000	°C
Final temperature	1,250.0	°C
Overall coil efficiency	65.000	%

Calculated results

Parameter	Value	Unit
Minimum heat time	96.875	s
Minimum coil line length	3.3598	m
Lowest frequency for the D/δ ratio	1.9454	kHz
Reference depth at that frequency	12.500	mm
Power into the steel	457.83	kW
Power at the coil terminals	704.36	kW

Notes for this case

• Ballpark formulas for carbon steel bars heated from ambient to forging temperature: heat time 25D² s and coil length 0.03 in per lb/h. Eddy currents do not cancel when D/δ exceeds about 4, so the frequency should not fall below f_min; much higher frequencies overheat the surface and lengthen the soak.

Formula and method

$$t_{min} = 25D^2 \ [\mathrm{s},\ \mathrm{in}], \quad l_{min} = 0.03\,\dot{m} \ [\mathrm{in},\ \mathrm{lb/h}], \quad f_{min} = \frac{\rho}{\pi \mu_0 \mu_r (D/k)^2}, \quad P_w = \dot{m} c (T_f - T_{in})$$

Variables

D	Bar diameter	m
$\dot{m}$	Production rate	kg/s
ρ	Resistivity of the hot steel (above the Curie point)	Ω·m
μ_r	Relative permeability (1 above the Curie point)	-
D/δ	Required ratio of diameter to reference depth	-
c	Mean specific heat, ambient to final	J/(kg·K)
T_{in}	Initial temperature	K
T_f	Final temperature	K

η	Overall coil efficiency	-
t_{min}	Minimum heat time	s
l_{min}	Minimum coil line length	m
f_{min}	Lowest frequency for the D/δ ratio	1/s
δ	Reference depth at that frequency	m
P_w	Power into the steel	W
P_c	Power at the coil terminals	W

Method and standards

The ballpark relations for inline bar heating.

Assumptions and limits

- Carbon steel; ambient to forging temperature; continuous feed.

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/steelmaking-foundry/induction-bar-heating-line

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Reopens the calculator with the inputs of this report.