Water and Steam Heat Transfer Coefficient in Tubes

Inside heat transfer coefficient of water or superheated steam flowing in a tube by the Gnielinski and Dittus–Boelter correlations, with IAPWS properties.

Method: V. Gnielinski (1976) with Petukhov friction factor; Dittus–Boelter (1930); ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Flow through one tube	2,880.0	kg/h
Tube inside diameter	38.000	mm
Pressure (absolute)	66.000	bar
Bulk temperature (single phase: water or superheated steam)	450.00	°C

Calculated results

Parameter	Value	Unit
Heat transfer coefficient, Gnielinski	2,549.0	W/(m²·K)
Heat transfer coefficient, Dittus–Boelter	2,559.5	W/(m²·K)
Reynolds number	1,006,443	
Prandtl number	0.98306	
Velocity	33.219	m/s

Formula and method

$$Re = \frac{\dot{m}\, d_i}{A\, \mu} \qquad f = (0.79 \ln Re - 1.64)^{-2} \qquad Nu_G = \frac{(f/8)(Re - 1000)\, Pr}{1 + 12.7\sqrt{f/8}\,(Pr^{2/3} - 1)} \qquad h_G = \frac{Nu_G\, k}{d_i}$$

$$h_{DB} = 0.023\, Re^{0.8}\, Pr^{0.4}\, \frac{k}{d_i} \qquad v = \frac{\dot{m}}{\rho A}$$

Variables

$\dot{m}$	flow through one tube	kg/s
d_i	tube inside diameter	m
p	pressure, absolute	Pa
T	bulk temperature	K
h_G	coefficient by Gnielinski	W/(m²·K)
h_{DB}	coefficient by Dittus–Boelter	W/(m²·K)
Re	Reynolds number	–
Pr	Prandtl number	–
v	velocity	m/s
f	Darcy friction factor (Petukhov)	–
Nu_G	Nusselt number	–
μ	dynamic viscosity	Pa·s
k	thermal conductivity	W/(m·K)
ρ	density	kg/m³
A	flow area	m²

Method and standards

Gnielinski's correlation with Petukhov's smooth-tube friction factor, and Dittus–Boelter for comparison; properties from FireCAD's

IAPWS-IF97 with IAPWS 2008 viscosity and 2011 conductivity at the bulk temperature. The conductivity omits the 2011 release's critical-enhancement term, as its industrial use allows; this makes h about 0.1–0.2 % low for hot water and medium-pressure steam, more near the critical point.

Assumptions and limits

- Fully developed turbulent single-phase flow in smooth tubes; no entrance effect or property-variation correction.
- Dittus–Boelter is evaluated with Pr^0.4, the exponent for a fluid being heated; for a fluid being cooled the exponent is 0.3. It is shown for comparison only; use the Gnielinski value.

References

• V. Gnielinski (1976) with Petukhov friction factor
• Dittus–Boelter (1930)
• IAPWS R7-97 IF97
• IAPWS 2008 viscosity
• IAPWS 2011 conductivity

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/mechanical/heat-transfer/steam-side-coefficient

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Reopens the calculator with the inputs of this report.