Film Condensation on Horizontal Tubes (Nusselt)

Condensing coefficient of steam on a horizontal tube and a vertical row of N tubes by Nusselt's film theory, with IF97 liquid properties.

Method: Nusselt film theory for a horizontal cylinder; h = 0.729 [g ρ_l(ρ_l − ρ_v) h′_fg k³/(μ ΔT D)]^¼; …

Input parameters

Unit system: SI

Parameter	Value	Unit
Steam pressure (absolute)	2.0000	bar
T_sat − T_wall	8.0000	K
Tube outside diameter	25.000	mm
Tubes in a vertical row	10.000	

Calculated results

Parameter	Value	Unit
Coefficient, single tube	13,917	W/(m²·K)
Mean coefficient, row of N tubes (N^−1/4)	7,826.4	W/(m²·K)
Heat flux, single tube	111.34	kW/m²

Notes for this case

• Liquid properties at saturation; non-condensable gas sharply lowers the coefficient. Kern's N^−1/6 is a less conservative row correction.

Formula and method

$$h_1 = 0.729 \left[\frac{g \rho_l (\rho_l - \rho_v) h'_{fg} k_l^3}{\mu_l \Delta T D} \right]^{1/4}, \quad h_N = h_1 N^{-1/4}$$

Variables

p	Steam pressure (absolute)	Pa
ΔT	T_sat − T_wall	K
D	Tube outside diameter	m
N	Tubes in a vertical row	-
h_1	Coefficient, single tube	W/(m²·K)
h_N	Mean coefficient, row of N tubes (N^−1/4)	W/(m²·K)
q	Heat flux, single tube	W/m²

Method and standards

Nusselt.

Assumptions and limits

- Laminar film, pure vapour.
- Liquid properties at saturation. Incropera (and the vertical-surface calculator here) take them at the film temperature (T_sat + T_wall)/2; for large ΔT the two differ by a few per cent.

References

- Nusselt film theory for a horizontal cylinder
- h = 0.729 [g ρ_l(ρ_l − ρ_v) h′_fg k³/(μ ΔT D)]^¼
- h′_fg = h_fg + 0.68 c_p ΔT
- row of N tubes × N^−¼ (Incropera); properties from IAPWS-IF97

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/mechanical/heat-transfer/condensation-horizontal-tube

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.