Condenser Bundle Coefficient: Vertical In-Tube or Horizontal (Kern)

Film condensing coefficient for a vertical in-tube condenser (laminar, wavy or turbulent film) or a horizontal shell-side bundle by Kern's loading method.

Input parameters

Unit system: SI

Parameter	Value	Unit
Condensate flow	10,800	kg/h
Condenser type	Vertical, condensing inside the tubes	
Number of tubes	40.000	
Tube length	6.0000	m
Tube inside diameter	22.000	mm
Tube outside diameter	25.000	mm
Condensate density	965.00	kg/m³
Vapour density	0.31000	kg/m³
Condensate viscosity	0.32000	mPa·s
Condensate thermal conductivity	0.67000	W/(m·K)
Condensate specific heat	4.2000	kJ/(kg·K)
Latent heat	2,305.0	kJ/kg

Calculated results

Parameter	Value	Unit
Condensate loading	1.0851	kg/m
Film Reynolds number 4Γ/μ_L	13,564	
Film regime (1 laminar, 2 wavy, 3 turbulent; 0 horizontal bundle)	3.0000	
Condensing coefficient	8,142.6	W/(m²·K)
Condensing surface	16.588	m²
Film temperature drop	51.197	K
Condensate Prandtl number	2.0060	
Jakob number c_pΔT/λ	0.093288	
Subcooling correction (Sadasivan–Lienhard)	1.0130	
Coefficient with subcooling correction	8,248.6	W/(m²·K)

Notes for this case

- Nusselt (Re ≤ 30), Kutateladze-type wavy (30–1600) and Labuntsov-type turbulent (> 1600) correlations for the whole film, as given by after Butterworth.
- Properties at the film temperature T_f = 0.75 T_w + 0.25 T_sat; repeat with properties at the new T_w until it settles. Interfacial shear and vapour superheat are not included.

Formula and method

$$\text{vertical}: \ \Gamma = \frac{W}{n_t \pi D_i},\ Re = \frac{4\Gamma}{\mu_L},\ h = \frac{Re\,K}{1.08 Re^{1.22} - 5.2}\ (30 < Re \le 1600), \quad K = \left[\frac{k_L^3 \rho_L (\rho_L - \rho_V) g}{\mu_L^2}\right]^{1/3}$$

$$\text{horizontal}: \; h = 1.52\left[\frac{k_L^3\rho_L(\rho_L-\rho_V)g}{4\mu_L\Gamma^*}\right]^{1/3}, \quad \Gamma^* = \frac{W}{Ln_t^{2/3}}, \quad \frac{h}{h_{Nu}} = \left[1+\left(0.683-\frac{0.228}{Pr_L}\right)\zeta\right]^{1/4}$$

Variables

W	Condensate flow	kg/s
bundle	Condenser type	-
n_t	Number of tubes	-
L	Tube length	m
D_i	Tube inside diameter	m
D_o	Tube outside diameter	m
ρ_L	Condensate density	kg/m³
ρ_V	Vapour density	kg/m³
μ_L	Condensate viscosity	Pa·s
k_L	Condensate thermal conductivity	W/(m·K)
$c_{p,L}$	Condensate specific heat	J/(kg·K)
λ	Latent heat	J/kg
Γ	Condensate loading	kg/m
Re_f	Film Reynolds number 4Γ/μ_L	-
regime	Film regime (1 laminar, 2 wavy, 3 turbulent; 0 horizontal bundle)	-
h	Condensing coefficient	W/(m²·K)
A	Condensing surface	m²
$T_{sat}-T_w$	Film temperature drop	K
Pr_L	Condensate Prandtl number	-
ζ	Jakob number c_pΔT/λ	-
h/h_{Nu}	Subcooling correction (Sadasivan–Lienhard)	-
h_c	Coefficient with subcooling correction	W/(m²·K)

Method and standards

Nusselt film condensation with wavy and turbulent film corrections and Kern's bundle drainage allowance.

Assumptions and limits

- Pure saturated vapours, gravity-controlled films.

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/chemical/process-heat-exchangers/condensing-coefficient-tube-bundle

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.