Nucleate Boiling of Binary Mixtures: Schlünder, Thome–Shakir, Palen

Nucleate boiling coefficient of a binary mixture from the pure-component values, phase compositions or boiling range, and Palen's Mostinski correction.

Method: Schlünder and Thome–Shakir mixture corrections to the ideal coefficient; Palen's Mostinski factor

Input parameters

Unit system: SI

Parameter	Value	Unit
Liquid mole fraction of the lighter component	40.000	%
Vapour mole fraction of the lighter component	62.000	%
Boiling point of the lighter component at the pressure	68.750	°C
Boiling point of the heavier component at the pressure	110.65	°C
Pure-component coefficient, lighter	4,500.0	W/(m²·K)
Pure-component coefficient, heavier	3,800.0	W/(m²·K)
Heat flux	30.000	kW/m²
Liquid molar density	8.0000	kmol/m³
Latent heat of the mixture	31.000	kJ/mol
Boiling range T_dew − T_bubble	12.000	K
Pressure	101.33	kPa
Critical pressure, lighter	3,030.0	kPa
Critical pressure, heavier	2,740.0	kPa

Calculated results

Parameter	Value	Unit
Ideal mixture coefficient (x_i/h_i)⁻¹	4,052.1	W/(m²·K)
Schlünder	2,589.1	W/(m²·K)
Thome–Shakir	2,634.9	W/(m²·K)
Pseudo-reduced pressure	0.035478	
Pressure factor (Palen)	0.86512	
Mixture factor (Palen)	0.58958	
Mostinski with Palen's mixture factor	701.80	W/(m²·K)

Notes for this case

- Schlünder needs the equilibrium vapour composition; Thome–Shakir uses the boiling range instead (mass transfer coefficients 0.0002 and 0.0003 m/s). Palen's factor applies only with the Mostinski correlation and is deliberately conservative.

Formula and method

$$h_{nb} = h_{ideal}\left\{1 + \frac{h_{ideal}}{\widehat{q}}\left[1 - \exp\left(\frac{-\widehat{q}}{\rho_L \lambda \beta}\right)\right](T_{sat,2} - T_{sat,1})(y_1 - x_1)\right\}^{-1}$$

$$h_{TS} = h_{ideal}\left\{1 + \frac{BR\,h_{ideal}}{\widehat{q}}\left[1 - \exp\left(\frac{-\widehat{q}}{\rho_L \lambda \beta}\right)\right]\right\}^{-1}, \quad F_m = \left(1 + 0.023\widehat{q^{0.15}}BR^{0.75}\right)^{-1}$$

Variables

x_1	Liquid mole fraction of the lighter component	-
y_1	Vapour mole fraction of the lighter component	-
$T_{sat,1}$	Boiling point of the lighter component at the pressure	K
$T_{sat,2}$	Boiling point of the heavier component at the pressure	K
$h_{nb,1}$	Pure-component coefficient, lighter	W/(m²·K)
$h_{nb,2}$	Pure-component coefficient, heavier	W/(m²·K)
$\widehat{q}$	Heat flux	W/m²
ρ_L	Liquid molar density	mol/m³
λ	Latent heat of the mixture	J/mol
BR	Boiling range T_dew − T_bubble	K
P	Pressure	Pa
$P_{c,1}$	Critical pressure, lighter	Pa
$P_{c,2}$	Critical pressure, heavier	Pa
h_{ideal}	Ideal mixture coefficient (x_i/h_i)$^{-1}$	W/(m²·K)
h_{Schl}	Schlünder	W/(m²·K)
h_{TS}	Thome–Shakir	W/(m²·K)
P_{pr}	Pseudo-reduced pressure	-
F_P	Pressure factor (Palen)	-
F_m	Mixture factor (Palen)	-
h_{Palen}	Mostinski with Palen's mixture factor	W/(m²·K)

Method and standards

Mixture corrections to nucleate pool boiling coefficients.

Assumptions and limits

- Binary mixtures (Schlünder); pool boiling.

References

Schlünder and Thome–Shakir mixture corrections to the ideal coefficient; Palen's Mostinski factor

Report details

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