Two-Phase Void Fraction and Density: Homogeneous, L-M, Chisholm, CISE

Void fraction and two-phase density of a gas–liquid or steam–water flow by the homogeneous, Lockhart–Martinelli, Chisholm and CISE methods, with Xtt.

Input parameters

Unit system: SI

Parameter	Value	Unit
Vapour mass fraction (quality)	10.000	%
Liquid density	739.70	kg/m³
Vapour density	36.500	kg/m³
Liquid viscosity	0.091000	mPa·s
Vapour viscosity	0.019000	mPa·s
Total mass flux	1,000.0	kg/(m²·s)
Pipe inside diameter	50.000	mm
Surface tension	17.600	mN/m

Calculated results

Parameter	Value	Unit
Lockhart–Martinelli parameter (turbulent–turbulent)	1.8770	
Two-phase multiplier	11.939	
Void fraction, homogeneous	69.247	%
Density, homogeneous	252.75	kg/m³
Void fraction, Lockhart–Martinelli	71.059	%
Density, Lockhart–Martinelli	240.01	kg/m³
Slip ratio, Chisholm	1.7107	
Void fraction, Chisholm	56.827	%
Density, Chisholm	340.09	kg/m³
Slip ratio, CISE	1.3569	
Void fraction, CISE	62.398	%
Density, CISE	300.92	kg/m³

Notes for this case

• Void fractions from the methods usually agree within about 10 %, but two-phase densities can differ by a factor of two or more; for hydrostatic head in thermosyphon and natural-circulation loops use a slip model (Chisholm or CISE), not the homogeneous density.

Formula and method

$$\alpha = \frac{x}{x + S(1-x)\rho_V/\rho_L}, \quad \rho_{tp} = \alpha\rho_V + (1-\alpha)\rho_L, \quad X_{tt} = \left(\frac{1-x}{x}\right)^{0.9}\left(\frac{\rho_V}{\rho_L}\right)^{0.5}\left(\frac{\mu_L}{\mu_V}\right)^{0.1}$$

$$\alpha_{LM} = \frac{\phi_L - 1}{\phi_L}, \quad \phi_L^2 = 1 + \frac{20}{X_{tt}} + \frac{1}{X_{tt}^2}, \quad S_{Ch} = (\rho_L/\rho_V)^{1/4}\ (X \le 1), \quad S_{CISE} = 1 + E_1\left(\frac{y}{1+yE_2} + yE_2\right)^{1/2}$$

Variables

x	Vapour mass fraction (quality)	-
ρ_L	Liquid density	kg/m³
ρ_V	Vapour density	kg/m³
μ_L	Liquid viscosity	Pa·s
μ_V	Vapour viscosity	Pa·s
G	Total mass flux	kg/(m²·s)
D	Pipe inside diameter	m
σ	Surface tension	N/m
X_{tt}	Lockhart–Martinelli parameter (turbulent–turbulent)	-
ϕ_L^2	Two-phase multiplier	-
α_{hom}	Void fraction, homogeneous	-
ρ_{hom}	Density, homogeneous	kg/m³
α_{LM}	Void fraction, Lockhart–Martinelli	-
ρ_{LM}	Density, Lockhart–Martinelli	kg/m³
S_{Ch}	Slip ratio, Chisholm	-
α_{Ch}	Void fraction, Chisholm	-
ρ_{Ch}	Density, Chisholm	kg/m³
S_{CISE}	Slip ratio, CISE	-
α_{CISE}	Void fraction, CISE	-
ρ_{CISE}	Density, CISE	kg/m³

Method and standards

Slip-ratio and separated-flow void fraction models.

Assumptions and limits

- Adiabatic, steady two-phase flow; turbulent–turbulent Lockhart–Martinelli.

Report details

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