Reynolds Number for Multiphase Flow @model

@wikipedia

In multiphase flow the Darcy friction factor can be calculated as Darcy friction factor Single-phase @model with specific approximation of Reynolds number:

(1) $$\mathrm{Re} = \frac{\sum_\alpha \rho_\alpha \, u_\alpha^2 \, A_\alpha}{\sum_\alpha \mu_\alpha \, u_\alpha \, \sqrt{A_\alpha}} = \frac{\sum_\alpha \rho_\alpha \, q_\alpha^2 / A_\alpha}{\sum_\alpha \mu_\alpha \, q_\alpha / \sqrt{A_\alpha}} = \frac{1}{\sqrt{A}} \cdot \frac{\sum_\alpha \rho_\alpha \, q_\alpha^2 / s_\alpha}{\sum_\alpha \mu_\alpha \, q_\alpha / \sqrt{s_\alpha}}$$

where

ρ_α	α-phase fluid density	s_α	volume share occupied by α-phase
μ_α	α-phase fluid viscosity	A_α	cross-sectional area occupied by α-phase
u_α	α-phase fluid velocity	A	total cross-sectional area

Reynolds number represent the ration of intertial forces to viscous forces:

$$\mathrm{Re} = \frac{\text{Intertial Forces}}{\text{Viscocus Forces}}$$

Homogeneous Pipe Flow

Homogeneous Pipe Flow is characterized by the same phase velocities: $u_\alpha = u_t, \forall \alpha \in \Gamma$ (no slippage) and the multiphase Reynolds number takes simpler form:

(2) $$\mathrm{Re} = \frac{\sum_\alpha \rho_\alpha \, u_\alpha \, A_\alpha}{\sum_\alpha \mu_\alpha \, \sqrt{A_\alpha}} = \frac{\dot m}{\sum_\alpha \mu_\alpha \, \sqrt{A_\alpha}} = \frac{\dot m}{\sqrt{A}} \cdot \frac{1}{\sum_\alpha \mu_\alpha \, \sqrt{s_\alpha}}$$

2-phase Gas-Liquid flow

$$\mathrm{Re} = \frac{\rho_L \, u_L^2 \, A_L + \rho_g \, u_g^2 \, A_g}{\mu_L \, u_L \, \sqrt{A_L} + \mu_g \, u_g \, \sqrt{A_g}}$$

where

ρ_L	liquid density	ρ_g	gas density
u_L	liquid velocity	u_g	gas velocity
A_L	cross-sectional area occupied by liquid	A_g	cross-sectional area occupied by gas
μ_L	liquid viscosity	μ_g	gas viscosity

See also

Physics / Fluid Dynamics / Pipe Flow Dynamics / Darcy–Weisbach equation / Darcy friction factor

Reference

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Shannak, B. A., 2008, Frictional Pressure Drop of Gas Liquid Two-Phase Flow in Pipes, Nuclear Engineering and Design, Vol. 238, pp. 3277-3284., doi.org/10.1016/j.nucengdes.2008.08.015