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Hydrodynamics of airlift reactor with internal circulation loop: Experiment vs. CFD simulation

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Abstract

Effect of geometrical parameters on two phase hydrodynamics of airlift reactor is the main topic of present paper. Laboratory scale apparatus with internal circulation loop consists of concentric draft tube, in which a gas bubbles rising. Setup of draft tube inside of reactor is important geometry parameter and has big influence on two phase hydrodynamics. In experiment was studied influence of changes diameter of draft tube to hydrodynamics in airlift reactor. Results of experiments (liquid velocity and gas hold-up) were compared with the simple CFD simulations performed in COMSOL Multiphysics 3.5a. For each point of gas volumetric flow in simulation, were determined conditions of bubble diameter and bubble drag coefficient. Although bubble break-up and coalescence were neglected, the results of numerical simulation are in pretty good agreement with experimental data.

Keywords: Bubbles; airlift reactor; draft tube; CFD simulation

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Nomenclature

A_g	cross-section area to gas input (m^2)
C_μ	turbulence modeling constant, C_μ = 0.09 (1)
$C_{\varphi1}$	turbulence modeling constant, $C_{\varphi1}$ = 1.44 (1)
$C_{\varphi2}$	turbulence modeling constant, $C_{\varphi2}$ = 1.92 (1)
C_k	bubble induced turbulence modeling constant, C_k = 0.01 – 1 (1)
C_φ	bubble induced turbulence modeling constant, C_φ = 1 – 1.9 (1)
c_D	drag coefficient (1)
d_b	bubble diameter (m)
F	volume force (interaction force) (N/m^3)
g	gravity acceleration, g = 9.81 (m^2/s)
$\Delta h_{r,d}$	difference of level in reverse U-tube manometer in riser and downcomer (m)
$K_{B,T}$	loss coefficient at the bottom and at the top (1)
M	molecular weight of gas, M_{air} = 0.029 (kg/mol)
N_ρ	gas mass flux ($kg/(m^2 s)$)
Δp	pressure difference (Pa)
p	hydrostatic pressure (Pa)
Q_g	input gas volumetric flow (m^3)
R	universal gas constant, R = 8.314 (J/(mol.K))
S_k	additional source term ($kg/(m^3.s)$)
T	temperature of liquid, T = 288 (K)
u_l	liquid velocity (m/s)
U_l	superficial liquid velocity (m/s)
u_g	gas velocity (m/s)
U_g	superficial gas velocity (m/s)
u_{slip}	slip velocity (m/s)
$\Delta z_{r,d}$	difference of height between delivery point from reverse U-tube manometer in riser and downcomer (m)
φ	dissipation rate of turbulent energy (m/s^3)
ε_g	gas hold-up (1)
$\varepsilon_{gr,gd}$	gas hold-up in riser and downcomer (1)
ε_l	liquid hold-up (1)
η_l	viscosity of liquid (Pa.s)