

LIST OF SYMBOLS

Abbreviation	Term
A	coefficient (equal to $\kappa \rho l$)
A_{∞}	initial value of upward acceleration of a particle
C	fluctuating velocity of particle
C_D	drag coefficient
c_Y	mean particles velocity
D_o	diameter of an orifice
d_b	bubble diameter
d_k	characteristic diameter of particulate phase k
e	coefficient of restitution
Fr	Froude number
f()	frequency
G()	solid compressive stress modulus
g	gravity
g_o	radial distribution function
h	bubble height
I	intensity of transmitted radiation
I_o	intensity of incident radiation
[I]	unit tensor
L	shear layer thickness
l	path length
n	rotation rate
p	pressure
q	flux vector of fluctuating energy
R	spindle radius
Re	Reynolds number
Re_k	Reynolds number of phase k

Abbreviation	Term
t	time
U_r	relative velocity between the colliding bubble and particle
u	velocity in x -direction
v	velocity in y -direction
\mathbf{v}	velocity vector
v_Y	mean particles velocity fluctuation
X_k	reduced volume fraction $\varepsilon_k / (\varepsilon_k + \varepsilon_m)$
x	x-direction in cartesian coordinate
y	y-direction in cartesian coordinate

Greek letters

α	coefficient in particle-particle drag coefficient equation
β_{km}	interphase momentum transfer between phase k and phase m
γ	collision energy dissipation; shear rate
ε	volume fraction
ζ	vorticity
$3/2\theta_s$	fluctuating energy
κ	conductivity of fluctuating energy; attenuation coefficient
μ	viscosity
μ_s	(shear viscosity x volume fraction) of solids
ξ_{ss}	(bulk viscosity x volume fraction) of solids
ξ	bulk viscosity
ρ	density; density of material
σ	surface tension of liquid; standard deviation of velocity fluctuations
τ	shear stress
τ_0	yield stress
Φ_s	viscous energy dissipation
Ψ_s	particle sphericity

Abbreviation	Term
ω	angular velocity;
<i>Subscripts</i>	
a	apparent
bed	effective bed
dil	dilute phase
g	gas phase
k	phase k
l	liquid phase
m	phase m
max	maximum
mf	minimum fluidization
p	particle
s	solid phase
X	x-ray
x	x-direction in cartesian coordinate
y	y-direction in cartesian coordinate
z	z-direction in cartesian coordinate
γ	γ -ray

Superscripts

T	transpose
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