Effect of Restitution Coefficient on CFD Simulation of Slurry Transport by Pipelines

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ABSTRACT

The research for the effect of the restitution coefficient (RC) between particles on slurry CFD simulation is limited. In this study, using the Eulerian multiphase model based on the kinetic theory of granular flow, a steady state 3D multiphase hydrodynamic model was established to investigate the effect of the RC on sand slurry transported by horizontal pipelines. Six groups of simulations were conducted with particle sizes ranging from 0.29 to 0.55 mm, pipe diameters ranging from 53.2 to 263 mm and efflux solid volume concentrations ranging from 15% to 34%. In each group, different values of RC were investigated to see their effect on the distributions of solid concentration. The result shows the RC has a significant effect on the coarse sand with high concentration in the small diameter pipe.

KEY WORDS: Restitution coefficient; pipeline transport; deep-sea mining; slurry; Eulerian multiphase model.

NOMENCLATURE

C: Lift coefficient
Cωm: Virtual mass coefficient
Cω: User-modifiable constant
Cc: Local solid volume concentration
Cc′: Efflux solid volume concentration
Cwl: Wall lubrication coefficient
D: Diameter of pipe
dp: Diameter of particle
eic: Restitution coefficient for particle collisions
F: Lift force
Fwl: Wall lubrication force
Fvm: Virtual mass force
Ftd: Turbulent dispersion force
Fe: External body force
g: Gravitational constant
gq: Radial distribution function
h: Interphase enthalpy
h⁰: Specific enthalpy of phase q
I₂D: Second invariant of the deviatoric stress tensor
Kpq: Interphase momentum exchange coefficient
k₆q: Diffusion coefficient for granular energy of phase q
L: Length of pipeline simulation model
m: Mass transfer from phase p to phase q
μw: Unit normal pointing away from the wall
p: Pressure shared by all phases
pa: Solids pressure of phase q
Q: Heat exchange between the pth and qth phases
q: Heat flux
R: Interphase force
S: Sources of enthalpy
uₑ: Fluctuating solids velocity of phase q
v: Slurry velocity
vq: Velocity of phase q
y: Distance from the pipe bottom
y: Height of the first layer from the wall
y′: Dimensionless position along the pipe’s vertical axis
Θq: Granular temperature of phase q
αq: Volume fractions of phase q
αq,max: Packing limit of phase q
αq,s: Solid volume concentration
γΘq: Collisional dissipation of energy of phase q
λq: Bulk viscosity of phase q
μq: Shear viscosity of phase q
μq, col: Collisional viscosity
μq, fr: Frictional viscosity
μq, kin: Kinetic viscosity
ρq: Physical density of phase q
ρq: Reference density of phase q
φpq: Energy exchange between phase p and phase q

INTRODUCTION

Compared with the other solid transport methods, pipeline is more efficient and can be easily controlled automatically. Because the material transported is isolated from the external environment, pipeline...