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多相流

# 提升管内气固两相双组分颗粒流动的离散颗粒硬球模型的模拟

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摘要 基于离散颗粒(DPM)硬球模型，数值模拟提升管内双组分颗粒气固两相湍流流动行为。应用Vreman的亚格子尺度（SGS）模型模拟气体湍流，建立考虑不同颗粒加速度效应的两颗粒碰撞最小时间计算模型。数值模拟预测了大颗粒和小颗粒的速度和浓度分布。研究结果表明小颗粒具有高的轴向速度和脉动速度，而大颗粒具有低的轴向速度和脉动速度。在床中心区域，小颗粒轴向速度分布出现3个峰值，对于大颗粒轴向速度仅出现两个峰值。在壁面区域大颗粒和小颗粒速度均出现两个峰值。沿床径向方向呈现床中心颗粒浓度低、壁面区域颗粒浓度高的环核流动结果。随着表观气速的增大，颗粒浓度沿径向和床高分布趋于均匀。在床中心区域模拟计算轴向颗粒速度、颗粒浓度和RMS速度与文献实验结果相吻合。在提升管内气体湍流对小颗粒流动具有一定的影响，颗粒间碰撞作用对颗粒相流动的影响大于气相湍流的影响。

关键词 离散颗粒模型 大涡模拟 双组分 提升管

分类号



# Numerical simulation of flow behavior of gas-solid binary of particles in riser with hard-sphere discrete particle model

**Abstract**

Numerical simulation was performed on the turbulent flow of gas-solid with a binary mixture of particles in a riser.The particle motion was dealt with a hard-sphere discrete particle model (DPM).The Navier-Stokes equation was used to model gas phase flow with the large eddy simulation (LES) method.Vreman's SGS model was used to model gas turbulence.A model of the collision time between two particles experiencing different accelerations was proposed. A binary mixture of particles with different diameters was used in the simulation and layer inversion was observed. Numerical results indicated that the flotsam of small particles had a high axial velocity and a high root-mean-square velocity, while the jetsam of large particles had a low axial velocity and a low root-mean-square velocity. At the center of the riser,triple peaks of particle velocity were found from the probability of particle velocity.However, twin peaks existed near the wall.The core-annular flow structure was observed from simulation.With the increase of superficial gas velocity,more uniform distribution of concentration and particle velocity was observed along radial and axial directions in the riser.The average particle velocity and concentration for the flotsam and the jetsam were unequal in the radial and axial directions. Numerical results were compared with the experimental and numerical results using the two-fluid model of literature. The predicted particle velocity, concentration and root-mean square velocity were in agreement with experiments at the center,but higher than the experimental values, near the wall.Gas turbulence affected the motion of small particles.The particle collisions dominated the flow behavior of particle phase in the riser.

**Key words** discrete particle simulation large eddy simulation binary mixture riser

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