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多相流和计算流体力学

流化床密相区颗粒扩散系数的CFD数值预测

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摘要

应用离散颗粒模型直观获得颗粒运动情况，并从单个颗粒和气泡作用的角度分析颗粒运动和混合，证实气泡在床层中上升、在床层表面爆破以及气泡上升引起的乳化相下沉运动对颗粒混合起关键作用。应用基于颗粒动理学的双流体模型系统地对床宽分别为0.2、0.4、0.8 m的二维流化床在鼓泡区和湍动区的气固两相流动行为进行数值模拟。受离散颗粒模型启发，在双流体模型计算结果基础上，引入理想示踪粒子技术计算床内平均颗粒扩散系数。计算结果表明，颗粒横向扩散系数(D_x)总体上随流化风速增大而增大，但受床体尺寸影响较大;颗粒轴向扩散系数随流化风速增大而增大，受床体尺寸影响较弱。文献报道的密相区颗粒横向扩散系数分布在10^{-4}～10^{-1} $m^2 \cdot s^{-1}$数量级。本文提出的计算方法在数量级上与文献实验结果吻合，表明在大尺寸流化床且高流化风速下，颗粒横向扩散系数远大于小尺寸鼓泡流化床，为不同研究者实验结果的分歧提供了理论依据，也为预测大型流化床内颗粒扩散速率提供了放大策略。

关键词

流化床 颗粒混合 气泡运动 颗粒横向扩散系数

分类号

Prediction of solids dispersion coefficient in fluidized bed dense zone using CFD simulation

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Abstract

The dynamic processes of solids mixing were obtained from the CFD-DEM simulations for two cases at different fluidizing velocities.The mechanisms of solids mixing in view of the particle and bubble scales were examined, and it was established that bubble movement through the bed, bubble burst at the bed surface and emulsion flowing downward induced by bubble rise played crucial roles in solids mixing.The kinetic theory based two-fluid model was used to simulate 2-dimensional fluidized beds with the width of 0.2 m, 0.4 m and 0.8 m,respectively, covering regimes from bubbling to turbulent fluidization.Based on the simulation results from the two-fluid model, ideal tracing particles were used to track the solids phase movement, then according to these trajectories the average solids dispersion coefficients were computed.The results indicated that the lateral dispersion coefficient (D_x) increased with the increase of gas velocity, but it was greatly limited by the bed size.The axial dispersion coefficient also increased with the increase of gas velocity, yet was weakly limited by the bed size.The computational results agreed in the same order of magnitude with the values of D_x reported by different authors in the range of 10^{-4}—10^{-1} $m^2 \cdot s^{-1}$ orders.The prediction established that the values of D_x in larger fluidized beds at a higher fluidizing velocity was much larger than that in small bubbling beds, which explained the discrepancy between the experimental values of D_x in the literature and the methodology for scaling-up solids dispersion rate in industrial fluidized beds.

Key words

fluidized bed solids mixing bubble dynamic lateral dispersion coefficient of solids

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