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多相流和计算流体力学

用单元胞模型数值模拟气泡群中气泡的运动

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摘要 用数值方法模拟了气泡群中Reynolds数为50的气泡的运动，以单元胞模型体现气泡群中气泡间的相互作用。数学模型用完全的流体力学方程、以流函数-涡度为变量来描述变形气泡周围的液体流动，控制方程在贴体正交坐标系中、以有限差分法离散后数值求解。模拟结果表明，气含率对气泡阻力系数和气泡偏心率有很大的影响，与理论分析较符合。但单元胞模型预测的阻力系数与基于爬流中球形气泡的理论值相比，在数值上偏高很多。采用无剪切为外边界条件比用无涡度为外边界条件的模型预测更接近理论公式。预计单元胞模型经进一步改进后可成为处理气泡群的有效工具。

关键词 单元胞模型 变形气泡 阻力系数 数值模拟 气泡群

分类号

Cell model approach to motion of bubbles in swarm

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Abstract

To account for the interaction between bubbles in a swarm, cell models were applied to simulating numerically the bubble motion in a swarm of deformable gas bubbles with a Reynolds number of 50.Simulations were based on the full Navier-Stokes equation of liquid flow in a spherical cell.The stream function and vorticity of the axi-symmetrical flow field were solved in a boundary-fitted orthogonal reference frame.Numerical results suggested significant effects of gas holdup on the drag coefficient and deformation of bubbles in a swarm, but the drag coefficient predicted by the model was much higher than that from theoretical equations based on spherical bubbles in creeping flow.The cell model with zero shear stress as the outer cell boundary condition seemed to behave better than that with zero vorticity condition.It is suggested that the cell model is a potentially reliable approach to resolve the bubble behavior in a dense swarm.

Key words cell model deformable bubble drag coefficient numerical simulation bubble swarm

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