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The Fluid Compressible Effect on Particle Dynamics in Turbulent Vertical Channel Flow

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Extended Abstract

Incompressible dispersed multiphase turbulent flows have been fully investigated in the past decades and lots of valuable findings have been put forward[1-3]. However, when it comes to compressible situation, we still know little. In this paper, the resuspension and motions of spheroidal particles in three-dimensional compressible turbulent channel flow were simulated by an Eulerian-Lagrangian point particle approach. Particles with different inertia (Stokes number St=5, 30, 50, 100) were dispersed in a downward or an upward channel flow and therefore the downward gravity was agreed with or opposite to the flow directions. The results were compared with particles without gravity in downward channel flow. Research has found that contrary to expectations, particles with greater inertia are more easily carried away from the wall by the fluid, leading to their re-suspension[4]. The strength of compressibility also influences the ease with which particles of different gravitational configurations are carried away from the wall. In a compressible fluid with weak compressibility at Ma=0.5, particles moving against gravity are the most difficult to be carried away from the wall. Conversely, in a compressible fluid with strong compressibility at Ma=1.5, particles without gravity are the most difficult to be carried away from the wall. However, regardless of the strength of compressibility, particles moving in the same direction as gravity are the easiest to be carried away from the wall, possibly due to their higher flow velocity[5]. Further subdividing the near-wall region into four distinct microzones to investigate the transport characteristics of particles in different microzones. It was found that the probability density function of particle flow velocity exhibits two peaks in the logarithmic layer, suggesting the existence of two different transport mechanisms. The normal velocity of particles is a key parameter indicating their movement away from or toward the wall. The probability density function of the normal velocity of gravity-free particles exhibits a significant positive shift in the buffer layer and logarithmic layer, indicating that particles are primarily entrained by the fluid and ejected from the wall in these layers. Further microscopic analysis reveals that particles only exhibit a phenomenon where the negative average normal velocity exceeds the positive average normal velocity when they reach the Bulk flow region, indicating that particle migration towards the wall mainly occurs in the Bulk flow region. This is also the reason why there is a net trend of particle migration towards the wall after a certain period of particle initiation.

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