Particle Collision in Viscoelastic Fluids

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Abstract
Particle-particle and particle-wall collision occurs in many natural and industrial applications such as sedimentation, crystal growth, suspension rheology, and microfluidic devices such as those used in mechanical cell lysis. To accurately predict the behavior of particulate flows, fundamental knowledge of the mechanisms of single collision is required. Whereas several experimental studies have been conducted on the influence of the Newtonian fluid on the collision process, few numerical studies address this issue and the effect of viscoelasticity of the liquid yet to be discovered. In this work, particle-wall collision in Newtonian and viscoelastic fluids is numerically and experimentally studied. The effect of Stokes number, surface roughness, and Deborah number on the rebound velocity of a colliding spherical particle on a wall is considered. The experimental study of particle-wall collision in poly(ethylene-oxide) mixed with water shows that the results for the coefficient of restitution in polymeric liquids can be collapsed together with the Newtonian fluid behavior if one defines the Stokes number based on the local strain rate. Our theoretical analysis for a sphere moving normal to a wall in a second-order fluid shows that the contribution of the second-order fluid to the overall force applied to the particle is an attraction force towards the wall.

Interaction of two circular particles in a Newtonian fluid at Re 470. Left) vorticity contours and stream lines Right) normal force

Collision of a sphere onto a wall. Vorticity contours are shown. Reynolds number is 850 and roughness height is 9.8 µm.

Coefficient of restitution normalized by that for dry collision as a function of St where roughness height is 0.7 µm. The present numerical results are compared with the experimental results by Gondret et al.

Collision of a sphere onto a wall in poly(ethylene-oxide). Coefficient of restitution normalized by that for dry collision as a function of St where roughness height is 0.5 µm. Left) shear rate is defined using the particle impact velocity and diameter. Right) using local shear rate.

References