Dynamic simulation of spherical particle settling in quiescent water

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\textbf{Abstract}

An examination of the behaviour of free settling particles in Newtonian fluids is important in designing multiphase systems for widespread applications in industrial water treatment processes. Through transient three-dimensional simulations based on the arbitrary Lagrangian–Eulerian (ALE) moving mesh technique, the present study evaluates the behaviour of a rigid sphere settling or falling freely in water, a Newtonian fluid at rest under the influence of gravity. Simulations were carried out for sphere-to-fluid density ratios between 1.3 and 1.92; wall effect was reduced by setting up blockage ratio as 0.01 and corresponding moderate particle Reynolds numbers ($Re_p$) ranging from 131 to 1,097. This paper presents linear velocity, trajectory, transient drag coefficient, angular velocity and lift coefficient of a spherical particle settling freely in quiescent water. Data from the study was validated by comparing with published research literature results. Findings revealed that firstly, when a sphere descends from its initial position, its trajectory is defined by the onset of its rotation and lift force. Secondly, the effect of sphere rotation on transient drag coefficient is reported. It is also observed that for the entire range of $Re_p$ studied, ALE is one of the powerful tools to capture accurate behaviour of solid–fluid interaction systems. However, it requires frequent re-meshing and fine mesh around the solid–fluid interface.

\textbf{Keywords}: Settling velocity; CFD simulation; Drag coefficient; Angular velocity; Lift coefficient