Effects of elasticity, inertia and viscosity ratio on the drag coefficient of a sphere translating through a viscoelastic fluid

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S.A. Faroughi[1,✉], Célio Fernandes[2,✉], Gareth H. McKinley[1,✉] and J. Miguel Nóbrega[2,✉]

[1] Department of Mechanical Engineering, Massachusetts Institute of Technology, USA
[2] i3N/Institute for Polymers and Composites, University of Minho, Portugal

The ability to simulate the behavior of dilute suspensions, considering Eulerian-Lagrangian approaches, requires proper drag models, which should be valid for a wide range of process and material parameters. These drag models allow to calculate the momentum exchange between the continuous and dispersed phases. The currently available drag models are only valid for inelastic constitutive fluid models. This work aims at contributing to the development of drag models appropriate for dilute suspensions, where the continuous phase presents viscoelastic characteristics. To this aim, we parametrize the effects of fluid elasticity, namely, the relaxation and retardation times, as well as inertia on the drag coefficient of a sphere translating through a viscoelastic fluid, described by the Oldroyd-B model. To calculate the drag coefficient we resort to three-dimensional direct numerical simulations of unconfined viscoelastic flows past a stationary sphere, at different Reynolds number, Re, over a wide range of Deborah numbers (< 9), and the polymer viscosity ratios. For low Re (< 1), we identified a non-monotonic trend for the drag coefficient correction (the ratio between the calculated drag coefficient and the one obtained for Stokes-flow). It initially decreases with the increase of De, for low De values (< 1), which is followed by a significant growth, due to the large elastic stresses that are developed on both the surface and wake of the sphere. These behaviors, observed in the inertia less flow regime, are amplified as the polymer viscosity ratio approaches unity. At higher Re (> 1), the drag coefficient correction is found to be always bigger than unity, but smaller than the enhancement calculated in creeping flow limit.

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