Direct Numerical Simulations of Two-dimensional Viscoelastic Flow over a Circular Cylinder

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Abstract

It is believed that polymer has important applications in reducing the drag of ship and submarine hulls to achieve a higher speed and reduced energy cost. However, there isn't any numerical research on flow over bluff body at high Reynolds number to the author's knowledge. This is the motivation for this paper, which investigates the flow behaviors at a broad range of both Reynolds number and Weissenberg number by direct numerical simulation to understand the effect of viscoelasticity on the flow past a circular cylinder and get the drag reduction map. The models used for Newtonian fluid or dilute polymer in solution are respectively Navier-Stokes and Oldroyd-B. The approximation is performed by means of finite differences on the one hand for velocity and pressure and on the other hand for the elastic stress tensor. The obstacles are taken into account using the volume penalization method in both cases. The artificial boundary condition without any reflections is imposed on the outlet of the channel. The results show that the lift force decreases, the drag first decreases then increases with the increasing of the Weissenberg number. The drag reduction up to 50% can be obtained at the suitable Weissenberg number.

Keywords: direct numerical simulation, penalization method, Oldroyd-B model, flow over a circular cylinder