FORCES ACTING ON PARTICLES IN A SEPARATED WALL-BOUNDED SHEAR FLOW

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Trajectories of solid particles in laminar and turbulent flow over a backward-facing step have been numerically computed by integrating the equation of motion for particles. The various forces acting on the particles [1] have been calculated for a variety of flow Reynolds numbers and for different particle characteristics such as the Stokes number and the particle-to-fluid density ratio. Semi-empirical corrections for certain terms were incorporated into the equation to suit a higher range of parameters.

The particles were released at different initial inlet positions and were assumed not to affect the fluid flow (one-way coupling). The wall-particle interactions were carefully modeled. The governing equations for the fluid flow are solved using a spectral element method [2]. The fluid velocity at the particle position was assessed using full spectral interpolation.

In the main flow regime the drag and gravity were found to be the most significant forces, provided that the density of the particles is larger than that of the fluid. The history force and lift were in most cases two orders of magnitude smaller. Neutrally buoyant particles are strongly affected by the pressure force. The virtual mass effect was very small for the majority of cases. Further, the most important parameters are found to be Reynolds and Stokes numbers. Influence of the density ratio is weak.

In the separation region drag and gravity dominate also, but the lift and history forces become more significant. Dependence of the forces on Stokes number and is weak.

In the near-wall region the drag force increases due to the wall effects. Lift force closes up to drag and exceeds gravity in importance; the history term becomes essential in some instances, too. On the other hand, parameter variation is not important here.

[1] Maxey, M.R. and Riley, J.J.: Equation of motion for a small rigid sphere in nonuniform flow. J. Fluid Mech., Vol. 26, 883--889, 1983.

[2] Wilhelm, D., Haertel, C. and Kleiser, L.: Computational analysis of the two-dimensional--three-dimensional transition in forward-facing step flow. J. Fluid Mech., Vol. 489, 1--27, 2003.