6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11 – 15 June 2018, Glasgow, UK

NUMERICAL SIMULATION OF A PARTICLE TRANSPORT IN THE FLAT CHANNEL

D. Kuranakov, D. Esipov, V. Lapin and L. Anisyutin

Institute of Computational Technologies SB RAS,
6 Academician M.A. Lavrentiev avenue, Novosibirsk, 630090, Russia,
kuranakov@ict.sbras.ru

Key Words: *Immersed Boundary Method, fluid-particle interaction, Segre-Silberberg effect.*

The problem of the proppant transport, sedimentation and jamming in the hydraulic fracture is of current scientific and technological interest. For fully resolved simulations of these processes a new model of incompressible viscous fluid flow with the immersed solid particles is presented. The fluid-particle interaction is modeled using the Immersed Boundary Method (IBM) [1, 2] that uses the fixed uniform staggered Eulerian grid for the fluid flow and the Lagrangian grid attached to the particles and moving with them. A regularized delta function is used to interpolate the variables from one grid to another. The Navier-Stokes equations are solved by the SIMPLE iterative method in which the correction of the pressure and velocity is applied until the needed accuracy is reached at each time step. The special force is incorporated into the Navier-Stokes equations that corrects the velocity in the solid-fluid interface in such a way to fulfill the no-slip boundary condition. For better approximation of the no-slip boundary condition the multidirect forcing scheme [3] is applied that consists in iterative correction of the applied force. Particle transfer and rotation are simulated using the Newton-Euler equations. The main feature of the proposed model is fully coupling of the fluid velocity and the particle velocity using iterations.

The proposed model was verified using the benchmark problems: cavity flow problem, flow around the cylinder, the transfer and rotation of a single particle in Poisseuille flow (Segre-Silberberg effect [4]). The problem was solved for various Reynolds numbers, particle sizes, densities, starting positions and shapes. The model is planned further to be used for simulations of many (>100) particles transport and its jamming.

The authors acknowledge the financial support of this research by the Russian Science Foundation (grant No. 17-71-20139).

REFERENCES

[1] M. Uhlmann, An immersed boundary method with direct forcing for the simulation of particulate flows. *J. Comput. Phys.*, Vol. **209**(2), pp. 448–476, 2005.

[2] W.-P. Breugem, A second-order accurate immersed boundary method for fully resolved simulations of particle-laden flows. *J. of Comput. Phys.*, Vol. **231**(13), pp. 4469–4498, 2012.

[3] K. Luo, Z. Wang, J. Fan, K. Cen, Full-scale solutions to particle-laden flows: Multidirect forcing and immersed boundary method. *Physical Review E*, Vol. **76**(6), 2007.

[4] G. Segre, A. Silberberg, Behavior of macroscopic rigid spheres in Poiseuille flow. *J. Fluid Mech.*, Vol. **14**, pp. 136–157, 1962.