Simulation of lanimar flows over a backward-facing step using an ALE particle method

Fangyuan Hu*, Tasuku Tamai† and Seiichi Koshizuka†

* Department of Systems Innovation, Graduate School of Engineering
the University of Tokyo
7-3-1, Hongo, Bunkyo-ku, Tokyo, Japan
e-mail: hfy8373@mps.q.t.u-tokyo.ac.jp

† Department of Systems Innovation, Graduate School of Engineering
the University of Tokyo
7-3-1, Hongo, Bunkyo-ku, Tokyo, Japan

ABSTRACT

The backward-facing step flow is a frequently employed benchmark problem for its geometrical simplicity. It has been viewed as a prototype for flows with separation and reattachment and has been studied in various experimental and theoretical work. Particularly, the problem has been used as a benchmark problem for the verification of various inlet/outlet boundary conditions [1].

In this research, lanimar flows with Reynolds numbers from 100 to 600 over a backward-facing step are simulated using an arbitrary-Lagrangian-Eulerian (ALE) particle method [2]. The ALE particle method first moves particle in a Lagrangian way. Then a modification to the particle position is performed to maintain the regularity of the particle distribution. An upwind interpolation is used to account for the convection which happens when particles are arbitrarily moved. A least squares moving particle semi-implicit method (LSMPS) [3] is used to solve the Navier-Stokes equations.

Since the backward-facing step flow is an open boundary problem, inflow and outflow boundary conditions are necessary. We propose simple and consistent open boundary conditions for viscous incompressible laminar flow calculation using Lagrangian particle methods. At the inlet of the calculation domain, a velocity specified condition is applied. At the outlet of the domain, a fully-developed flow condition is applied.

The calculation results are compared with experimental data and numerical results by finite volume method. The reattachment point position, the circulation position and the velocity field are compared.

REFERENCES

[1] D. Gartling, *A test problem for outflow boundary conditions – flow over a backward-facing step*, International Journal for Numerical Methods in Fluids, Vol. 11, 953-967, 1990.

[2] F. Hu, T. Matsunaga, T. Tamai and S. Koshizuka. *An ALE particle method using upwind interpolation*. Computers and Fluids, Vol. 145, 21-36, 2017.

[3] Tasuku Tamai and Seiichi Koshizuka. *Least squares moving particle semi-implicit method.* Computational Particle. Mechanics, Vol. 1, 441, 2014.