Splitting solver with immersed boundary extension for the analysis of backward-facing step flow

Zamani Ngali[a]*; Kahar Osman*[b]*; Nasrul Hadi Johari*[c]
[a]Faculty of Mechanical and Manufacturing Engineering Universiti Tun Hussein Onn Malaysia, 86400 Batu Pahat, Johor, Malaysia
[b]Faculty of Mechanical Engineering Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia
[c]Faculty of Mechanical Engineering, Universiti Malaysia Pahang, Lebuhraya Tun Razak, 26300 Kuantan, Pahang, Malaysia

ABSTRACT
Flow analysis of backward-facing step is claimed to be a necessity when it comes to Computational Fluid Dynamics solver validation. The turbulence development with both separation and reattachment passing through the step has become the practical challenge for solver developers ever since the numerical computation revolution started. In-line with the trend, this work is predestined to further validate the use of Splitting velocity-pressure coupling method with immersed boundary extension for unsteady Navier-Stokes flow solver. The comparison is launched with steady numerical results via established software for commonly used benchmark backward-facing step construction. Flow parameters in both solvers are set equivalent to Reynolds number of 1000. The assessment is carried out when the flow has reached steady flow condition. The streamwise velocity profiles are well-matched where the maximum error is within 4%. The reattachment distance measured from the developed solver is also in good agreement with the reference results with only 1.84% difference recorded. The comparison proves that the solver developed in this work could become a very handy alternative especially when we look at the solver simplicity and the number of nodes it consumes to obtain comparable results.

KEYWORDS:
backward-facing step;Immersed Boundary;Splitting

REFERENCES

1. Karniadakis, G.E., Israeli, M., Orszag, S.A. High-order splitting methods for the incompressible Navier-Stokes equations. (1991) *Journal of Computational Physics*, 97 (2), pp. 414-443

2. Keyak, J.H., Meagher, J.M., Skinner, H.B., Mote Jr., C.D. Automated three-dimensional finite element modelling of bone: a new method. (1990) *Journal of Biomedical Engineering*, 12 (5), pp. 389-397.

3. Kalitzin, G., Iaccarino, G. (2002) *Turbulence Modeling in An Immersed Boundary RANS Method*, pp. 415-426.

4. Peng, H., Ruan, Z., Long, F., Simpson, J.H., Myers, E.W. V3D enables real-time 3D visualization and quantitative analysis of large-scale biological image data sets. (2010) *Nature Biotechnology*, 28 (4), pp. 348-353.

5. Pereira, J.C.F., SchöNung, B. Experimental and theoretical investigation of backward-facing step flow. (1983) *Journal of Fluid Mechanics*, 127, pp. 473-496.