Numerical Investigation on Flow Pattern over Backward-Facing Step for Various Step Angles and Reynolds numbers

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Abstract

Investigating Backward-Facing Step(BFS) flow is important in that it is a representative case for separation flows in various engineering flow systems. There have been a wide range of experimental, theoretical, and numerical studies to investigate the flow characteristics over BFS, such as flow separation, reattachment length and recirculation zone. However, most of such previous studies were concentrated only on the perpendicular step angle. In this study, several numerical investigations on the flow pattern over BFS with various step angles (10° ~ 90°) and expansion ratios (1.48, 2 and 3.27) under different Reynolds numbers (5000 ~ 64000) were carried out, mainly focused on the reattachment length. The numerical simulations were performed using an open source 3D CFD software, OpenFOAM, in which the velocity profiles and turbulence intensities are calculated by RANS (Reynolds Averaged Navier-Stokes equation) and 3D LES (Large Eddy Simulation) turbulence models. Overall, it shows a good agreement between simulations and the experimental data by Ruck and Makiola (1993).

In comparison with the results obtained from RANS and 3D LES, it was shown that 3D LES model can capture much better and more details on the velocity profiles, turbulence intensities, and reattachment length behind the step for relatively low Reynolds number(Re < 11000) cases. However, the simulation results by both of RANS and 3D LES showed very good agreement with the experimental data for the high Reynolds number cases(Re > 11000). For Re > 11000, the reattachment length is no longer dependent on the Reynolds number, and it tends to be nearly constant for the step angles larger than 30^{o}.) Based on the calibrated and validated numerical simulations, several additional numerical simulations were also conducted with higher Reynolds number and another expansion ratio which were not considered in the experiments by Ruck and Makiola (1993).

Keywords : Backward facing step, Numerical simulation, OpenFOAM, Reattachment length

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