An immersed boundary method for compressible flows at low Mach numbers on engineering applications using massive parallelization systems

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ABSTRACT

Low Mach numbers, compressible flows play an important role in engineering applications such as engines, vehicle aeroacoustics or turbine flow. Use of computational fluid dynamics (CFD) to gain an understanding of these complex flow phenomena for design and analysis is a promising option. However, how to treat the complex geometry and generate mesh efficiently are always troublesome. In recently years, immersed boundary methods (IBM) have gained a lot of attention because it can solve the above issue by using Cartesian gird to represent arbitrarily complex geometries. Hence, an immersed boundary method for compressible flows at low Mach numbers on a hierarchical grid structure: Building Cube Method [1] for the massive parallelization systems is developed.

An all speed compressible solver, i.e., low Mach fix for Roe (LMRoe) developed by Rieper [2] with high order reconstruction is adopted to achieve high accuracy and cure the problem of excessive dissipation when using compressible solvers at low Mach numbers directly. A robust interpolation and novel strategy are proposed to make our IBM available for the objects with no thickness walls. More importantly, the present method can also address the most common problem of IBM with a moving object, which is the fresh cell without any special treatment.

The result of the compression and expansion processes inside an engine with a moving piston shows that the new method is conservative. Besides, the flow-induced noise problem is conducted to validate the accuracy of our IBM. Finally, the flow around a vehicle is simulated using a raw CAD data which demonstrates the capability for the extremely complex geometry and engineer applications.

REFERENCES

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