The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

TOWARDS A BETTER PREDICTION OF AERODYNAMIC COEFFICIENTS IN AN IMMERSED BOUNDARY CONTEXT

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Keywords: *Immersed Boundary Method, Wall Model, Cartesian Mesh, Turbulent Flows*

This paper presents an improved immersed boundary method (IBM) with new wall modeling assumptions for the simulation of compressible flows on Cartesian grids. This method relies on an adaptive positioning of both target and image points, in accordance with the Reynolds number. It primarily ensures that the mesh is fine enough at the first computed cells to correctly capture the strong variations of the tangential velocity in the wall normal direction, and ultimately prevents the appearance of spurious oscillations at the wall. In the present work, we take into consideration normal pressure gradient information, interpolated at a new set of image points positioned farther away from the geometry, in order to extend the validity domain of our wall modeling. This significantly improves the prediction of the skin friction and the skin pressure coefficients, and also results in a better estimation of both the drag and lift coefficients through the near-field integration of all aerodynamic forces at the wall. The latest developments essentially consist in a second-order extraction of the pressure at the wall during the post-processing step and a modification of Musker's algebraic wall function to reconstruct the velocities and friction at the target points at each iteration of the flow solver. This new methodology has been validated through the study of subsonic flow simulations around a NACA0012 profile and a 3.5:1 prolate spheroid, where good agreements between the wall-modeled IBM solutions and the body fitted wall-resolved references have been observed.

REFERENCES

[1] S. Péron, C. Benoit, T. Renaud, I. Mary, An immersed boundary method on Cartesian adaptive grids for the simulation of compressible flows around arbitrary geometries, *Engineering with Computers*, Vol 37, 2020.

[2] B. Constant, S. Péron, H. Beaugendre, C. Benoit, An improved immersed boundary method for turbulent flow simulations on Cartesian grids, *Journal of Computational Physics*, Vol 435, 2021.