IMMERSED BOUNDARY PENALTY METHOD FOR COMPRESSIBLE FLOWS OVER MOVING OBSTACLES

I.Abalakin[1], T.Kozubskaya[1], L.Kudryavtseva[2] and N.Zhdanova[1]

[1] Keldysh Institute of Applied Mathematics RAS, 4A, Miusskaya Sq., Moscow, 125047, Russia, nat.zhdanova@gmail.com, http://caa.imamod.ru/
[2] Dorodnicyn Computing Centre of FRC CSC RAS, 40, Vavilova str., Moscow, 119333, Russia, liukudr@yandex.ru, http://www.ccas.ru/

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A computational non-boundary-conforming method for unstructured meshes is presented. It is intended for numerical simulation of viscous compressible flows over solid nondeformable moving obstacles. It facilitates to predict loadings on structure and could be used in many engineering applications.

A key point of the method is a fulfillment of proper boundary conditions on the solid-fluid interface using the immersed boundary (IB) approach. We use the Brinkman-penalization method [1] for the Navier-Stokes system for compressible flows. According to it, a solid body is considered as a porous medium with low permeability and its influence on the flow is simulated by adding penalty terms in the governing equations. For the numerical solution of penalized Navier-Stokes equations on unstructured meshes we use the higher-accuracy Edge-Based Reconstruction scheme [2].

An improvement of accuracy of the IB method can be reached by a strong mesh resolution near immersed boundaries. In cases of arbitrarily moving bodies, the mesh elements should be small enough inside a rather large area of possible trajectories, so a number of mesh nodes may increase dramatically. To avoid this problem, we use the dynamic mesh adaptation based on moving mesh nodes which is developed mostly for mesh adaptation to the flow field. The ‘nodes-redistribution’ adaptation combined with the IB method allows to preserve mesh topology and to avoid the solution interpolation. Another important advantage is a possibility to keep the same data structure and to arrange an efficient parallel implementation of this approach.

The workability of the method is demonstrated on the following test cases: flow induced by harmonic oscillations of a cylinder, flow around a transversely oscillating cylinder in a quiescent gas and free stream, flow around a moving airfoil.

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