Comparison of the finite volume method with Lagrangian vortex method for 2D flow simulation around airfoils at intermediate Reynolds number

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ABSTRACT

The study is focused on the comparison of mesh and mesh-free methods of computational fluid dynamics for 2D simulation of the viscous incompressible flow at intermediate Reynolds numbers (Re = 1000). We consider the finite volume method implemented in widely known software package OpenFOAM. As the meshfree method, the vortex method, precisely, viscous vortex domain method (VVD) [1] is considered. Algorithm of the VVD method is implemented in the open source code VM2D [2] developed by the authors.

As the model problems, a series of problems of the flow simulation around two circular airfoils is considered with different mutual positions (Fig. 1). The angle α varies from 0° to 180°, as in [3, 4], where numerical and experimental results for such problems are presented.

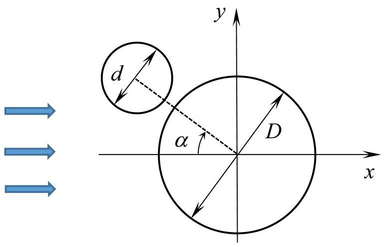

Figure 1. Mutual position of two circular cylinders with different diameters

For simulation in OpenFOAM, meshes with different number of cells were used: 450 000 cells, 150 000 cells, 50 000 cells. Numerical experiments were performed using 12…24 CPU cores. Computations in VM2D were performed with different discretization: the large circle were discretized by 250, 500 and 1000 elements, which corresponds to approximately 10000, 25000 and 100000 vortex elements in the vortex wake. To speed up calculations, in VM2D Nvidia CUDA technology usage is implemented (as well as OpenMP and MPI technologies), that allows achieving high acceleration (up to hundreds times) due to the fact that the VVD method refers to a class of particle methods.

The following characteristics were investigated: drag coefficient, lift coefficient (average values and RMS amplitudes) and amplitude spectra of the lift coefficient. Numerical experiments show that the meshfree vortex method give the results with acceptable accuracy at much lower computational time and lower computational burden in comparison with the finite volume method.

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