11th. World Congress on Computational Mechanics (WCCM XI)
5th. European Conference on Computational Mechanics (ECCM V)
6th. European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

APPLICATION OF THE LS-STAG IMMERSED BOUNDARY METHOD FOR NUMERICAL SIMULATION IN COUPLED AEROELASTIC PROBLEMS

Ilia K. Marchevsky[1] **and Valeria V. Puzikova**[1*]

[1] Applied Mathematics dep., Bauman Moscow State Technical University, Russia,
105005 Moscow, 2nd Baumanskaya, 5, IliaMarchevsky@mail.ru, Valeria.Puzikova@gmail.com

Key words: *Immersed Boundary Methods, The LS-STAG Method, Coupled Aeroelastic Problems, The Spalart-Allmaras RANS Model, Multigrid Methods.*

Immersed boundary methods [1] are useful for numerical simulation in coupled aeroelastic problems, since they do not require a coincidence of cell edges and the computational domain boundaries, and they allow to solve problems when the domain shape is irregular or it changes in the simulation process due to aeroelastic body motion. The main advantage of these methods is that we don't need mesh reconstruction at each time step. In the present study, the Cartesian grid and the LS-STAG method [2] are used in coupled aeroelastic problems.

We proposed extension of the LS-STAG discretization for Reynolds-averaged Navier-Stokes (RANS) equation. The Spalart-Allmaras model [3] is used for turbulent viscosity.

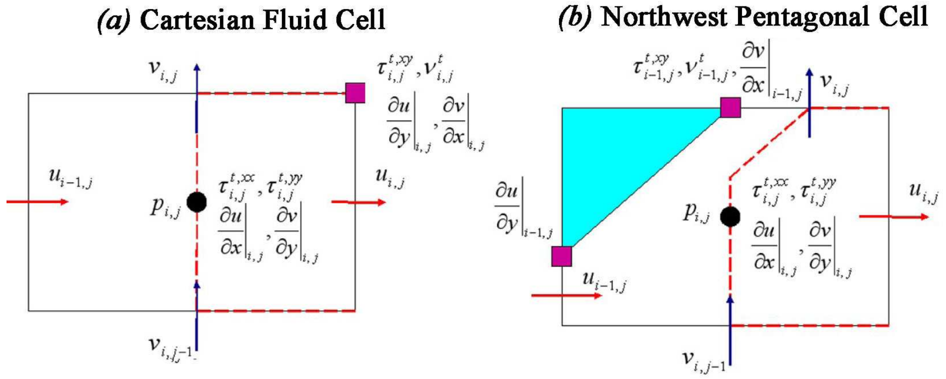

Figure 1: Location of discretization points for pressure (p), velocities (u, v), turbulent eddy viscosity (ν^t), normal and shear stresses on fluid cell *(a)* and northwest pentagonal cell *(b)* of the LS-STAG mesh.

Computations show that inappropriate choice of multigrid preconditioner parameters leads to a significant increase of simulation time. The original algorithm of solver optimal parameters choice is proposed: firstly amplification mode factors are computed using the discrete Fourier transform technique, then the smoothing factor and solver cost-coefficient are computed through the amplitudes of smooth and rough components of the iteration error. It is shown that the smoothing factor and solver cost-coefficient are close to be independent on the mesh size. Therefore they can be computed on the coarse grid.

As an example, computational results for the circular airfoil wind resonance at $\mathrm{Re} = 1000$ shown below. To simulate wind resonance phenomenon we considered the motion of the circular airfoil of diameter D across the stream with one degree of freedom. Computational results are in good agreement with the previous studies [4]. Maximum amplitude (fig. 2) is about $0.4D$ and it occures when the natural frequency of the system St_ω is close to the Strouhal number, calculated for a fixed airfoil $\mathrm{St} \approx 0.24$ [2, 5].

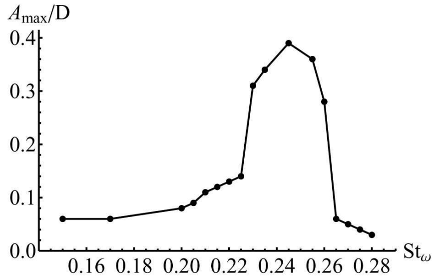

Figure 2: Maximum amplitude of the circular airfoil oscillations at $\mathrm{Re} = 1000$.

The work was partially supported by Russian Federation President Grant for young scientists [proj. MK-6618.2013.08]

REFERENCES

[1] R. Mittal and G. Iaccarino. Immersed boundary methods. *Annu. Rev. Fluid Mech.*, Vol. **37**, pp. 239–261, 2005.

[2] Y. Cheny and O. Botella. The LS-STAG method: A new immersed boundary / level-set method for the computation of incompressible viscous flows in complex moving geometries with good conservation properties. *J. Comput. Phys.*, Vol. **229**, pp. 1043–1076, 2010.

[3] M. L. Shur, M. K. Strelets, A. K. Travin and P. R. Spalart. Turbulence Modeling in Rotating and Curved Channels: Assessing the Spalart-Shur Correction. *AIAA Journal*, Vol. **38**, No. 5, pp. 784–792, 2000.

[4] J. T. Klamo, A. Leonard and A. Roshko. On the maximum amplitude for a freely vibrating cylinder in cross flow. *J. of Fluids and Struct.*, Vol. 21, pp. 429–434, 2005.

[5] J. W. He, R. Glovinski, R. Metcalfe, A. Nordlander and J. P. Triaux. Active control and drag optimization for flow past a circular cylinder. Part I: Oscillatory cylinder rotation. *J. Comput. Phys.*, Vol. **163**, pp. 87–117, 2000.