# The modified numerical scheme for 2D flow-structure interaction simulation using meshless vortex element method

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## ABSTRACT

The modification of the meshless Vortex Element Method based on the Viscous Vortex Domain Method [1] and non-classical approach to boundary conditions satisfaction [2, 3] is developed for numerical simulation in 2D FSI-problems for incompressible flows. The developed approach preserves all advantages of meshless lagrangian vortex methods, however the accuracy of vortex layer computation is much higher than in 'classical' realizations of vortex methods. No-slip boundary condition is satisfied through limit value of tangential velocity vanishing at the airfoil surface while in 'classical' approach normal components of velocity is used. These approaches lead to solving of Fredholm-type integral equation of the second kind (with bounded kernel) and Hilbert-type singular integral equation of the first kind correspondingly.

The developed method allows to simulate flow around fixed, movable and deformable airfoils while the computational cost of the algorithm remains nearly the same. The discretization scheme is constructed in such a way that it provides exactly the same results in direct and inversed motion of the airfoil (i.e. when the rigid airfoil moves translationally in still media and when the airfoil is fixed in the unbounded incident flow).

But the further accuracy improvement is restricted to the accuracy of the airfoil approximation. In the present research we don't assume the solution to be continuous along the airfoil – it is important for correct flow simulation around airfoils with angle points and sharp edges. The algorithm is developed and the corresponding quadrature formulae are derived which allows to take into account the curvature of the airfoil. This approach allows to consider the solution to be piecewise-linear or even piecewise-quadratic along every curvilinear part of the airfoil whereas in traditional approaches the solution assumed to be piecewise-constant along straight airfoil's panels.

In order to reduce time of computations number of approaches and technologies are implemented such as parallel computational algorithms, fast multipole methods for *N*-body-type problems [4] etc.

In the present research the well-known two-way coupled problem of vortex induced vibrations and wind resonance phenomenon simulation is considered. The obtained dependency of the oscillations amplitude on the eigenfrequency of linear visco-elastic mechanical system (including hysteresis phenomenon) is in good agreement with experimental data and other known numerical simulations [5].

It is shown that meshless vortex method as opposed to mesh methods allows to provide numerical simulation in such problems with sufficiently small requirements to memory and computational time and small numerical viscosity.

## REFERENCES

[1] P.R. Andronov, S.V. Guvernyuk and G.Ya. Dynnikova, *Vortex methods of unsteady hydrodynamic loads calculation*, Moscow State University, 2006.

[2] S.N. Kempka, M.W. Glass, J.S. Peery and J.H. Strickland "Accuracy considerations for implementing velocity boundary conditions in vorticity formulations", *SANDIA REPORT. SAND96-0583, UC-700*, 1996.

[3] I.K. Marchevsky and V.S. Moreva, "*Vortex Element Method for 2D Flow Simulation with Tangent Velocity Components on Airfoil Surface*", Proceedings of ECCOMAS-2012 Congress, Vienna, (2012).

[4] G.Ya. Dynnikova "Fast technique for solving the N-body problem in flow simulation by vortex methods", *Computational Mathematics and Mathematical Physics*, Vol. 49, Is. 8, pp. 1389-1396, (2009).

[5] J.T. Klamo, A. Leonard and A. Roshko, "*On the Maximum Amplitude for a freely vibrating cylinder in cross flow*", Journal of Fluid and Structures, Vol. 21, pp. 429-434, (2005).