6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

ON PARTITIONED AND MONOLITHIC COUPLING STRATEGIES IN LAGRANGIAN VORTEX METHODS FOR 2D FSI PROBLEMS

K.S. Kuzmina, I.K. Marchevsky and E.P. Ryatina*

Bauman Moscow State Technical University, 105005,
Ivannikov Institute for System Programming of the RAS, 109004
kuz-ksen-serg@yandex.ru, iliamarchevsky@mail.ru, evgeniya.ryatina@yandex.ru

Keywords: *Vortex Methods, Viscous Incompressible Media, Boundary Integral Equation, Fluid-Structure Interaction, VM2D Code*

Lagrangian vortex methods are powerful tool for numerical simulation in CFD and coupled fluid-structure interaction (FSI) problems. They are especially efficient for external flows simulation because of exact satisfaction of the continuity equation and perturbation decay condition on infinity. The main feature of vortex methods is vorticity considering as a primary computed variable, while velocity and pressure distributions can be reconstructed by using the Biot — Savart law and the Cauchy — Lagrange integral analogue. Advantages of vortex methods include the possibility to "concentrate" computational resources in the domain with non-zero vorticity and to simulate arbitrary large displacements of the airfoils in the flow. Moreover, in contrast to mesh methods, computational cost of such simulation just a little higher than for flow simulation around immovable airfoil.

There are two approaches to coupling strategy implementation in FSI-problems: partitioned and monolithic ones. According to the partitioned strategy, each time step should be split into two substeps: hydrodynamic and mechanical ones. At the first substep we simulate the flow around the airfoil moving with known velocity and compute hydrodynamic loads acting it. At the mechanical substep hydrodynamic forces are assumed to be known from the previous substep and dynamics equations for the mechanical system are solved. The main advantage of such strategy is the possibility of independent solvers usage, interacting only through the interfaces, so it is easy to develop new methods and algorithms, improve existing ones or even use some "outer" solvers.

However, this strategy can't be applied if the density of the airfoil is comparable with the flow density. In this case the described numerical algorithm becomes unstable. The second strategy (monolithic) is based on simultaneous solution of two sub-problems. It is possible due to linear expression of the integral forces through parameters of the vortex sheet being generated on the airfoil surface. The main advantage of this method is high accuracy and stability, however in the framework of this approach it's impossible to split the code into different modules.

Both strategies are implemented in the VM2D open source code developed by the authors; their efficiency and applicability are estimated for the test problem of wind resonance simulation for the circular cylinder.

The research is supported by the RFBR (proj. 17-08-01468 and 18-31-00245).