Finite element simulation of interaction of flow and an airfoil with three degrees of freedom

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The subject of the contribution is the numerical solution of the two-dimensional incompressible viscous flow and a vibrating airfoil. In our model the airfoil is represented by a structure, which can perform vertical and torsional vibrations and its flap flutters. Mathematical model of flow is formed by the system of two dimensional non-stationary Navier-Stokes equations and continuity equation, coupled by initial condition and mixed boundary conditions. Stabilized finite element method is used to get the numerical solution. With regard to the moving airfoil, the computational domain is time dependent. This involvement requires to use suitable technique for the simulation on moving computational grids. To solve this we apply the Arbitrary Lagrangian-Eulerian method. The numerical simulation consists of the coupling procedure of the computation of flow with the system of ordinary differential equations describing the airfoil motion. The ordinary differential equations for the airfoil are solved by an appropriate solver. In our case we employ the Runge-Kutta method. The finite elements method leads to a large discrete system of nonlinear algebraic equations. We solve nonlinearity by implementing the Oseen iterations. This method splits nonlinearity into a sequence of linear problems with solutions converging to the solution of the nonlinear Navier-Stokes problem. High Reynolds numbers up to 10^6 require the application of a suitable stabilization of the finite element discretization. Numerical tests prove that the developed method is sufficiently accurate and robust.

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