

Solution of nonlinear coupled problems of flow induced vibrations of an elastic structure

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We shall focus on mathematical modelling of nonlinear coupled problems of fluid-structure interactions and particularly on description of a numerical method based on finite element method for solution of such problems in 2D. The coupled problems describing the interactions of fluid flow with elastic structure motion (e.g. aeroelasticity/hydroelasticity) are of great importance in many fields of physical and technical sciences and scientific applications (e.g. in civil engineering – stability of bridges, in mechanical engineering – bladed machines, aircraft design and safety, etc). In the technical practice the linearized aerodynamics approach is used based on solution of only special problems of aeronautical aeroelasticity in the linear domain. The critical fluid flow velocity can be determined, but nonlinear phenomena cannot be captured. In order to address the nonlinear effects we shall consider the coupled solution of partial differential equations describing the flow problem coupled with the solution of motion equations for the structure.

The main attention will be paid to the description of the numerical method. First, the approximation in moving domains and the time discretization will be treated with the aid of Arbitrary Lagrangian-Eulerian method and higher order implicit backward difference formula. The weak formulation of a simplified problem will be introduced and the use of various boundary conditions will be discussed. Further, the energy transfers between fluid and structure for a simplified problem will be discussed. Further, the weak formulation of the problem will be spatially discretized with the aid of a stabilized finite element method. Moreover, the solution of the nonlinear coupled problem will be treated. The performance of the numerical method will be demonstrated on number of examples either on nonlinear aeroelastic problems or by an application from biomechanics.