On coupling of incompressible fluid and structure models in an aeroelastic application

Petr Sváček[1]

In this paper the numerical approximation of a two dimensional aeroelastic problem is addressed. The mutual interaction of fluids and structure can be met in many different situations, cf. [1]. The main objectives of the engineering problems is to determine the critical velocity for loose of the system stability. In many cases simplifications of the aeroelastic model are used, e.g. linearized models, etc.

Here, the fully coupled formulation of incompressible viscous fluid flow over a structure is used. For the flow model we use the incompressible system of Navier-Stokes equations with large values of the Reynolds number $10^4 - 10^6$. The Navier-Stokes equations are spatially discretized by the FE method and stabilized with a modification of the Galerkin Least Squares (GLS) method; cf. [3].

The motion of the computational domain is treated with the aid of Arbitrary Lagrangian Eulerian(ALE) method. The GLS stabilizing terms are modified in a consistent way with the weak formulation of the ALE method.

The structure model is considered as a solid body with two/three degrees of freedom (bending, torsion and torsion of the control section). The motion is described with the aid of a system of nonlinear differential equations. The construction of the ALE mapping is based on the solution of an elastic problem.

The method is applied onto several benchmark problems, where several technical parameters are compared with reference values. The nonlinear behaviour of the coupled system is shown for the nearby critical velocity.

References:

[1] Dowel E. H., "A Modern Course in Aeroelasticity", Kluwer Academic Publishers, Dodrecht, 1995.

[2] Gelhard T., Lube G. and Olshanskii M.A., "Stabilized finite element schemes with LBB-stable elements for incompressible flows". Journal of Computational and Applied Mathematics, 177:243-267, 2005.

[1]Czech Technical University in Prague, Faculty of Mechanichal Engineering, Department of technical mathematics, Karlovo nam. 13, Praha 2, 12135 Praha 2, Czech Republic, Petr.Svacek@fs.cvut.cz