On Finite Element Method Application in Aeroelasticity

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In this paper the main interest is paid to the numerical approximation of the fluid and structural models in aeroelastic simulations as well as to the coupling of both models. First, the fluid motion is described by the incompressible Navier-Stokes equations (INSE). In this case for the numerical approximation, several sources of instabilities have to be treated. First, the couple of finite elements for velocity and pressure needs to satisfy Babuška-Brezzi (BB) condition in order to guarantee the stability of the scheme. Furthermore, high Reynolds numbers require the application of a suitable stabilization. Although there is a number of stabilization procedures used in many applications, the proper choice of stabilization parameters remains an open problem for Reynolds numbers in the range $10^4 - 10^6$. In the paper the stabilization procedure based on Galerkin-Least squares method adapted for the case of higher-order finite elements will be given. Nevertheless, the higher values of Reynolds number causes the fluid flow to be turbulent. The comparison of laminar and turbulent aeroelastic simulations will be given.
In the presented paper two different structural models motivated by technical applications will be considered. The structural motion can be either modelled using two degrees of freedom (e.g., flexibly supported airfoil which can vertically oscillate and rotate around its elastic axis) or as an elastic body. The motion of elastic body is then described by Lamé's equations and solved with the aid of Finite Element Method.
Last, the coupling of the fluid and structural models will be discussed. The fluid approximation on moving meshes will be treated with the aid of the Arbitrary Lagrangian-Eulerian (ALE) method. The weak, strong, and monolithic approaches to the coupling of the models will be discussed. The numerical results will be validated with NASTRAN computations and with experimental data.