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

A Finite Element Approach for Hydroelastic Vibrations of Fluid Filled Tanks Around a Pre-Stressed State

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Keywords: *hydroelasticity, follower forces, geometrically non-linearity, finite element method, reduced order models*

This study deals with the finite element (FE) computation of hydroelastic vibrations for pre-stressed elastic tanks with free-surface fluid. The prediction of fluid-structure dynamic behavior is a critical step in aerospace engineering for the design of launchers with liquid propellant or tanks of satellites [1, 2]. The use of flexible structures, such as hyperelastic membranes or very thin walls, induces the need of numerical models taken into account the pre-stressed state due to geometrical non-linearities. The main objective of this work is to estimate the influence of the pre-stressed state in the dynamic behavior of the fluid-structure system. The proposed approach consists (i) in solving the quasi-static non-linear FE problem of the filled tank submitted to hydrostatic follower forces [3], and then (ii) to evaluate the hydroelastic vibrations around the pre-stressed state. For the dynamic solution, a reduced order model is developed considering a modal basis evaluated around the pre-stressed state and including the added mass effect of the incompressible fluid. Some numerical examples are proposed (i) to validate the model by comparison with experimental results from the literature [4] and (ii) to show the efficiency of the approach. The competition between the added-mass and pre-stressed effects of the tank for various fluid height is highlighted through parametric studies.

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