Towards the Simulation of Deformable Sloshing Tanks with Spline-Based Solution Methods

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ABSTRACT

The structural design of liquid storage tanks is sufficient for conventional load cases. Nevertheless, extraordinary loads like seismic excitations and in combination with minor material defects can lead to a complete failure of the structure [1].

The challenges of numerical simulation of seismic effects on sloshing fluids in flexible tanks can be summarized as follows: An accurate consideration of the interaction between fluid and surface of the structure is essential; on the structural side, the numerical representation of curved shell structured has to be geometrically exact; and finally, a suitable consideration of the free-surface flow is needed, including its influence on load changes on the structure.

For the solution of the surface-coupled problem in the presented work a staggered approach is applied, successively calling the single-field solvers XNS and FEAFA. The in-house code XNS is a finite element code based on the Deforming Spatial Domain/Stabilized Space-Time (DSD/SST) [2] procedure, taking the unsteady character of the problem as well as the deformable computational domain resulting from the free-surface motion and the deforming structure into account. The in-house finite element code FEAFA solves the elastodynamic problem. Expecting minor and homogeneous surface motion, an approach following the idea of Interface-Tracking is applied to compute the free-surface flow [3]. The Elastic Mesh Update Method transfers the resulting surface displacements of both structural deformation and free-surface motion to the CFD grid.

The stability analysis of tank structures is extremely sensitive to the geometrical approximation, especially if shell elements are used. To counteract this sensitivity, spline-based methods such as the isogeometric analysis can be used [4]. Following this strategy, spline-based methods are integrated into the existing partitioned approach to reduce inaccuracies in the overall analysis. The extensions include modifications not only in the solution strategies for structural and fluid mechanics as well as the free-surface problem, but also in the projection routines.

Current developments and results are presented.

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