Quasi-Static Fluid-Structure Interactions Based on a Geometric Description of Fluids

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Abstract

Regarding an efficient computation of quasi-static fluid-structure interaction problems all relevant properties of the fluid, such as density, pressure or fluid level, are captured using only the geometry of the surrounding wetted structure. This allows an analytical and thus meshfree description of the fluid, with its strain energy implemented in a deformation-dependent energetic equivalent loading acting on the structure. Hence, for the description of the interaction of the structure and the fluid only the structural geometry is necessary, see [1], [3] and [2].

A special focus of this work is therefore on the geometric capturing of all energetic terms describing the state of equilibrium only in terms of the surrounding wetted structure. After a consistent linearization of the equations and their discretization with finite element mapping functions, several solution schemes for this kind of equations are discussed. Further more, the influence of such volume-dependent pressure loadings on the structural stability is investigated.

Some practical examples covering the fields of hydraulic engineering and metal sheet forming, but also a benchmark featuring large rotations show both the advantages and the disadvantages of the meshfree fluid formulation.

Although a reduction of the fluid, where the inner state variables are generally field quantities, to a single phase system with position-invariant state variables restricts the consideration to quasi-static applications, however, in the last numerical example the transition to acoustics is presented, in order to expand the applicability of the algorithms derived in this work.

References

[1] J. Bonet, R.D. Wood, J. Mahaney, and P. Heywood. Finite element analysis of air supported membrane structures. *Computer Methods in Applied Mechanics and Engineering*, 190:579–595, 2000.

[2] M. Haßler and K. Schweizerhof. On the static interaction of fluid and gas loaded multi-chamber systems in a large deformation finite element analysis. *Computer Methods in Applied Mechanics and Engineering*, 197:1725–1749, 2008.

[3] T. Rumpel. *Effiziente Diskretisierung von statischen Fluid-Struktur-Problemen bei großen Deformationen*. PhD thesis, Institut für Mechanik der Universität Karlsruhe (TH), 2003.