8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

CONSISTENT INTERFACE CAPTURING TECHNIQUE FOR FLUID-SHELL INTERACTION PROBLEMS BASED ON DISCONTINUOUS INTERPOLATION AT LEVEL SET INTERFACES

*** Tomohiro Sawada [1a], Shogo Nakasumi [1b], and Akira Tezuka [1c]**

[1] National Institute of Advanced Industrial Science and Technology (AIST).
1-2-1 Namiki, Tsukuba, Ibaraki 305-8564, Japan.
[a)] tomohiro-sawada@aist.go.jp, [b)] nakasumi.shogo@aist.go.jp, [c)] tezuka.akira@aist.go.jp.

Key Words: *Fluid-Shell Interactions (FSI), Interface-Capturing Method, Non-interface-fitted Method, Extended Finite Element Method (X-FEM), Discontinuous Interpolations, Level Set Method.*

ABSTRACT

Finite element simulation technique of fluid-structure interaction (FSI) problems can be classified into different two approaches from the geometrical treatment of fluid mesh [1]; the one is interface-fitted method, and the other is non-interface-fitted method. The interface-fitted method is generally combined with interface-tracking mesh moving techniques [2], and DSD/SST [1,2] or ALE [3-6] methods. It has a consistent discretization of fluid-structure coupling conditions on their interfaces. When the fluid mesh, however, becomes too distorted to track interfaces, troublesome remeshing procedure is required to advance further analysis. Non-interface-fitted aproaches have an essential advantage over the fitted methods to large deformations and complex geometries, because it dose not need mesh updating.

A main objective of the study is to develop a non-interface-fitted mesh method for large deformation fluid-shell interaction analysis that is consistent with two physical conditions at the interface [7]. The one is continuity of velocities and surface forces at the interface, and the other is discontinuity of fluid velocity gradients and pressures across the interface. An extended finite element method (X-FEM) [8-10] which is combined with Lagrange multiplier method [11,12] is introduced to discretize the interface conditions without inconsistency. A level set function is also introduced to construct enrichment functions of the X-FE interpolation. This approach is firstly reported by Legay, et al. [13-15]. It enables us to handle general FSI problems comparably to the interface-fitted method. Fundamental concepts, formulations, and some demonstrational applications, which targets to simulate complex fluid-shell interactions, are presented. And, the relation between the fluid-solid interface locator technique (FSILT) with extended domains [1] will be also discussed at the same time.

REFERENCES

[1] T. E. Tezduyar, Interface-tracking and interface-capturing techniques for finite element computation of moving boundaries and interfaces, *Comput. Methods Appl. Mech. Engrg.*, **195**: 2983-3000, 2006.

[2] K. Stein, T. Tezduyar, R. Benney, Mesh moving techniques for fluid-structure interactions with large displacements, *J. Appl. Mech.*, **70**: 58-63, 2003.

[3] Q. Zhang, T. Hisada, Analysis of fluid-structure interaction problems with structural buckling and large domain changes by ALE finite element method, *Comput. Methods Appl. Mech. Engrg.*, **190**: 6341-6357, 2001.

[4] T. Sawada, T. Hisada, Fluid-structure interaction analysis of the two-dimensional flag-in-wind problem by an interface-tracking ALE finite element method, *Comput. Fluids*, **36**: 136-146, 2007.

[5] T. Sawada, T. Hisada, Overlaying ALE mesh approach to computation of fluid-structure interactions, in CD-R proceedings of *the 5th International Conference on Computation of Shell and Spatial Structures*, IASS IACM, Salzburg, Austria, 2005.

[6] T. Sawada, A. Tezuka, T. Hisada, Overlaying mesh method for large deformation fluid-shell interaction analysis using interface-tracking ALE local mesh and immersed boundary global mesh, *Transactions of JSCES*, **2007**: 20070029, 2007.

[7] T. Sawada, A. Tezuka, T. Hisada, Extended finite element method for the fluid-structure interaction problems based on discontinuous interpolations on level set interfaces, in CD-R proceedings of *the APCOM'07 in conjunction with EPMESC XI*, Kyoto, Japan, December 3-6, 2007.

[8] N. Moës, J. Dolbow, T. Belytschko, A finite element method for crack growth without remeshing, *Int. J. Numer. Meth. Engng.*, **46**: 131-150, 1999.

[9] T. Belytschko, N. Moës, S. Usui, C. Parimi, Arbitrary discontinuities in finite elements, *Int. J. Numer. Meth. Engng.*, **50**: 993-1013, 2001.

[10] G. J. Wagner, N. Moës, W. K. Liu, T. Belytschko, The extended finite element method for rigid particles in Stokes flow, *Int. J. Numer. Meth. Engng.*, **51**: 293-313, 2001.

[11] R. Glowinski, T. W. Pan, J. Périaux, Distributed Lagrange multiplier methods for incompressible viscous flow around moving rigid bodies, *Comput. Methods Appl. Mech. Engrg.*, **151**: 181-194, 1998.

[12] J. de Hart, F. P. T. Baaijens, G. W. M. Peters, P. J. G. Schreurs, A computational fluid-structure interaction analysis of a fiber-reinforced stentless aortic valve, *J. Biomech.*, **36**: 699-712, 2003.

[13] A. Legay, J. Chessa, T. Belytschko, An Eulerian-Lagrangian method for fluid-structure interaction based on level sets, *Comput. Methods Appl. Mech. Engrg.*, **195**: 2070-2087, 2006.

[14] A. Legay, A. Kölke, An enriched space-time finite element method for fluid-structure interaction - part I: prescribed structural displacement, in proceedings of *the III European Conference on Computational Mechanics, Solids, Structures and Coupling Problems in Engineering*, Lisbon, Portugal, 2006.

[15] A. Kölke, A. Legay, An enriched space-time finite element method for fluid-structure interaction - part II: thin flexible structures, in proceedings of *the III European Conference on Computational Mechanics, Solids, Structures and Coupling Problems in Engineering*, Lisbon, Portugal, 2006.