11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

# ASSESSMENT OF COMPLEX WAVE-STRUCTURE INTERACTION USING A STABILIZED EDGE-BASED FINITE ELEMENT APPROACH

**José L.D. Alves[1], Carlos E. Silva[1], Bruno Correa [1], Renato N. Elias, Alvaro L.G.A. Coutinho, Milton A. Gonçalves Jr., Adriano M. A. Cortês[2] , Fernando A. Rochinha, Gabriel M.G. Bernadá[3] and Daniel F.C. Silva[4]**

[1] LAMCE/COPPE/UFRJ Caixa Postal 68552, 21941-972 Rio de Janeiro, RJ, Brazil,
{jalves, kadu}@lamce.coppe.ufrj.br, bruno_correa@poli.ufrj.br
[2] NACAD/COPPE/UFRJ P.O.Box 68506, 21941-972 Rio de Janeiro, RJ, Brazil,
{renato, alvaro}@nacad.ufrj.br, milton.a.g.j.@gmail.com, adrimacortes@gmail.com
[3] PEM/COPPE/UFRJ P.O.Box 68506, 21941-972 Rio de Janeiro, RJ, Brazil,
faro@mecanica.coppe.ufrj.br, olimarenho@gmail.com
[4] PETROBRAS S.A, Research Center. danielfc@petrobras.com.br

**Key Words:** *ALE formulation, Volume-Of-Fluid method, Rigid body dynamics, Fluid-Structure interaction*

Complex flows involving waves and free-surfaces occur in several problems in hydrodynamics, such as fuel or water sloshing in tanks, waves breaking in ships, offshore platforms motions, wave action on harbours and coastal areas. The computation of such highly nonlinear flows is challenging since waves and free-surfaces commonly present merging, fragmentation and cusps, leading to the use of interface capturing Arbitrary Lagrangian-Eulerian (ALE) approaches. In such methods the interface between the two fluids is captured by the use of a marking function that is transported in a flow field. In this work we simulate these problems with a 3D incompressible SUPG/PSPG parallel edge-based finite element flow solver associated to the Volume-of-Fluid (VOF) method. The hyperbolic equation for the transport of the marking function is also solved by a fully implicit parallel edge-based SUPG finite element formulation. Global mass conservation is enforced adding or removing mass proportionally to the absolute value of the normal velocity at the interface. All those techniques were successfully implemented in a computational code, which has been suitably used to carry out several studies. The performance and accuracy of the proposed solution method is tested in the simulation of waves and in the interaction between waves and a floating body resembling a typical FPSO (floating production storage and offloading) unit. Results count on the establishment of a relaxation zone close to the domain outflow, which partially absorbs incoming waves, avoiding their reflection.

## REFERENCES

[1] Elias, R. N. and Coutinho, A. L. G. A., 2007, “Stabilized Edge-Based Finite Element Simulation of Free-Surface Flows”, Int. J. Numer. Meth. Fluids, 54, pp. 965–993.

[2] Esperança, P. T. T., Coutinho, A. L. G. A., Gonçalves Jr, M. A., Elias, R. N., Ferreira, M. D. A. da Silva; Martins, M. A. D., 2009, “Progressive Wave Simulation Using Stabilized Edge-Based Finite Element Methods”. Proceedings of the ASME 28th International Conference on Offshore Mechanics and Arctic Engineering - OMAE, Honolulu, Hawaii, USA.

[3] Galeão, A. C, do Carmo, E. G. D, 1988, “A Consistent Approximate Upwind Petrov-Galerkin Method for Convection-Dominated Problems” Computer Methods in Applied Mechanics and Engineering; 68, pp. 83-95.
[4] Brooks, A. N. and Hughes, T. J. R., 1982, “Streamline-upwind/Petrov-Galerkin Formulations for Convection Dominated Flows with Particular Emphasis on the Incompressible Navier-Stokes Equation”, Comput. Methods Appl. Mech. Engrg; 32, pp. 199-259.
[5] Bazilevs, Y., Calo, V. M., Tezduyar, T. E., Hughes, T. J. R., 2007, “ Discontinuity Capturing for Advection-Dominated Processes with Application to Arterial Drug Delivery”, International Journal for Numerical Methods in Fluids, 54, pp. 593-608.
[6] Hirt, C. W. and Nichols, B. D. 1981, “Volume of Fluid (VOF) Methods for the Dynamics of Free Boundaries”, Journal of Computational Physics; 39, pp. 201-225
[7] Martins, M. A. D., Elias, R. N. and Coutinho, A. L. G. A., 2007, “Edgepack: A Parallel Vertex and Node Reordering Package for Optimizing Edge-Based Computations in Unstructured Grids”. Lecture Notes in Computer Science; 4395, pp. 292-304.