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PARTICLE METHODS IN MULTI-FLUID PROBLEMS

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Abstract. Over the last twenty years, computer simulation of incompressible fluid flow has been based on the Eulerian formulation of the fluid mechanics equations on continuous domains. However, it is still difficult to analyze problems in which the shape of the free surfaces or internal interfaces changes continuously or in fluid-structure interactions where complicated contact problems are involved.

More recently, Particle Methods in which each fluid particle is followed in a Lagrangian manner have been used. The first ideas on this approach were proposed by Monaghan for the treatment of astrophysical hydrodynamic problems with the so called Smooth Particle Hydrodynamics Method (SPH).

This method was later generalized to fluid mechanic problems. Kernel approximations are used in the SPH method to interpolate the unknowns. More particle methods have been developed based on similar ideas and applied to multi-phase flows [6-8 and references therein] It must be noted that particle methods may be used with both: mesh or meshless shape functions. The only practical limitation is that the connectivity in meshless methods or the mesh generation in methods with mesh needs to be evaluated at each time step. For these reason the evaluation of the connectivity must not consume much computing time.

The Particle Finite Element Method –PFEM- (Idelsohn et al. 2004) combines the particle precept with the finite element shape functions using an auxiliary finite element mesh that is quickly built at each time step. PFEM has been successfully used to solve the Navier-Stokes equations for multi-fluid flows, fluid-structure interactions (Idelsohn et al. 2006), fire spread, combustion with melting and dripping and erosion or sedimentation problems (Oñate et. al. 2008).

During this presentation the advantages of PFEM to solve fluid mechanics problems including immiscible heterogeneous flows will be illustrated with several examples.

Finally, the way to achieve Real Time Computational Mechanics taking advantage of the possibility to integrate explicitly with large time steps the Lagrangian formulation will be shown.

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