First South-East European Conference on Computational Mechanics
SEECCM-06, *June 28-30, 2006, Kragujevac, Serbia and Montenegro*

Advances in the particle finite element method for fluid-structure interaction problems

E. Oñate, S.R. Idelsohn, M.A. Celigueta, R. Rossi

International Center for Numerical Methods in Engineering (CIMNE)
Universidad Politecnica de Cataluña
Campus Norte UPC, 08034 Barcelona, Spain
e-mail: onate@cimne.upc.edu

Abstract

We present a general formulation for analysis of fluid-structure interaction problems using the particle finite element method (PFEM). The key feature of the PFEM is the use of a Lagrangian description to model the motion of nodes (particles) in both the fluid and the structure domains. Examples of application of the PFEM to solve a number of fluid-structure interaction problems involving large motions of the free surface and splashing of waves are presented.

Key words: particle finite element, fluid-structure, interaction problems

1. Introduction

There is an increasing interest in the development of robust and efficient numerical methods for analysis of engineering problems involving the interaction of fluids and structures accounting for large motions of the fluid free surface and the existence of fully or partially submerged bodies. Examples of this kind are common in ship hydrodynamics, off-shore structures, spill-ways in dams, free surface channel flows, liquid containers, stirring reactors, mould filling processes, etc.

Typical difficulties of FSI analysis using the FEM with both the Eulerian and ALE formulation [2,3] include the treatment of the convective terms and the incompressibility constraint in the fluid equations, the modelling and tracking of the free surface in the fluid, the transfer of information between the fluid and solid domains via the contact interfaces, the modelling of wave splashing, the possibility to deal with large rigid body motions of the structure within the fluid domain, the efficient updating of the finite element meshes for both the structure and the fluid, etc.

Most of these problems disappear if a *Lagrangian description* is used to formulate the governing equations of both the solid and the fluid domain. In the Lagrangian formulation the motion of the individual particles are followed and, consequently, nodes in a finite element mesh can be viewed as moving "particles". Hence, the motion of the mesh discretizing the total domain (including both the fluid and solid parts) is followed during the transient solution.

In this paper we present an overview of a particular class of Lagrangian formulation developed by the authors to solve problems involving the interaction between fluids and solids in a