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Coupled PFEM-DEM-FEM formulations for analysis of particulate flows and their interaction with structures

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ABSTRACT

The aim of this talk is to present the last advances in the development of a multi-coupled method for fluid-particles-structures interaction. Many practical cases are affected by this phenomenon, spanning from natural hazards, as tsunami and debris flows, to industrial applications, as manufacturing processes, oil drilling and pharmaceutical industry.

The so-called Particle Finite Element Method (PFEM, www.cimne.com/pfem [1]) is used for the fluid dynamics solution. The PFEM has been proven to be a powerful strategy for the simulation of free-surface fluids. Thanks to the Lagrangian description of motion and an efficient remeshing algorithm, the PFEM allows for the accurate solution of complex fluid dynamics problems involving large changes of topology of the fluid bodies.

The PFEM is extremely versatile and it enables a natural coupling with other numerical methods, as the Finite Element Method (FEM) and the Discrete Element Method (DEM). The DEM [2] is here used for modeling spherical and not spherical rigid particles dragged by the fluid motion, while the FEM is employed for the solid structures solution. A coupled FEM-DEM formulation has been presented in a recent work [5]. On the other hand, several examples of PFEM-FEM strategies can be found in the literature. In this work, PFEM and FEM are coupled monolithically by using the so-called Unified formulation ([3], [4]) to model the fluid-structure interaction. The method also allows to account for the thermal effect and to model phase change problems.

This talk wants to give an overview of these coupled strategies, that have all been implemented in the open-source platform Kratos Multiphysics (http://www.cimne.com/kratos).

REFERENCES

[1] S.R. Idelsohn, E. Oñate, and F. Del Pin. The particle finite element method: a powerful tool for incompressible flows with free-surface and breaking waves. *Int. J. Numer. Methods Eng.*, **61**:964-89, 2004.

[2] E. Oñate, M.A. Celigueta, S.R. Idelsohn, F. Salazar, B. Suárez. Possibilities of the particle finite element method for fluid–soil–structure interaction problems. *Comput. Mech.*, **48**: 307-318, 2012.

[3] S.R. Idelsohn, J. Marti, A. Limache, and E. Oñate. Unified Lagrangian formulation for elastic solids and incompressible fluids: Applications to fluid-structure interaction problems via the pfem. *CMAME*, **197**:1762-1776, 2008.

[4] A. Franci, E. Oñate, and J. M. Carbonell. Unified Lagrangian formulation for solid and fluid mechanics and FSI problems. *CMAME*, **298**:520-547, 2016.

[5] M. Santasusana, J. Irazábal, E. Oñate, J.M. Carbonell. The Double Hierarchy Method. A parallel 3D contact method for the interaction of spherical particles with rigid FE boundaries using the DEM. *Comput. Part. Mech.*, **3 (3)**, 407-428, 2016.