Advances in the Particle Finite Element Method (PFEM) for Analysis of Particulate Flows in Engineering

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ABSTRACT

We present recent developments in the Particle Finite Element Method (PFEM, www.cimne.com/pfem) for analysis of complex particulate flow problems in engineering. These type of flows are typical of fluid-soil-structure interaction situations [1] , environmental flows [2], biological flow, melting and burning of objects in fire[3] and some industrial forming processes, among others.

The PFEM uses an updated Lagrangian description to model the motion of nodes (particles) in both the fluid and the solid/structure domains which are modelled as a single continuum (SC). Nodes are viewed as material points which can freely move and even separate from the main analysis domain representing, for instance, the effect of physical particles or water drops. A mesh connects the nodes defining the discretized domain where the governing equations for the SC problem are solved as in the standard FEM. The necessary stabilization for dealing with the incompressibility of the fluid is introduced via the finite calculus (FIC) method. An incremental iterative scheme for the solution of the non linear transient coupled problem in the SC is used. Advances in the PFEM to allow for frictional contact conditions and surface erosion at fluid-solid and solid-solid interfaces via mesh generation are described. A new technique to model the motion of particles of different sizes in a fluid is described.

We present examples of application of the PFEM to a number of particulate flow problems such as the erosion of earth dams in overtopping situations, the motion of mud particles and floating/submerged bodies in tsunami flows, the impact of slurry flows on structures , the erosion due to water streams in river beds and slopes, wall erosion and particle transport in excavation and drilling problems in the construction and oil/gas industries, melting and dripping of polymer objects due to fire and simulation of industrial forming problems involving particulate flows ,among others.

REFERENCES

[1] E. Oñate, M.A. Celigueta, S.R. Idelsohn , F. Salazar and B. Suárez B**, "**Possibilities of the particle finite element method for fluid–soil–structure interaction problems", *Comput Mech* (2011) 48:307–318

[2] E.Oñate, S.R. Idelsohn, M.A. Celigueta, R. Rossi (2008), "Advances in the particle finite element method for the analysis of fluid–multibody interaction and bed erosion in free surface flows". *Comput Methods Appl Mech Eng* 197(19–20):1777–1800

[3] E.Oñate, R. Rossi, S.R. Idelsohn, K. Butler (2010), "Melting and spread of polymers in fire with the particle finite element method". *Int J Numer Methods Eng* 81(8):1046–1072