Title……………Numerical modeling of fully coupled solid-fluid flows………………

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Abstract

The key objective of this dissertation is to introduce a unified discretisation of rigid solids and fluids, allowing for resolved simulations of fluid-solid phases within a meshless framework. The numerical solution, attained by Smoothed Particle Hydrodynamics (SPH) and a variation of Discrete Element Method (DEM), the Distributed Contact Discrete Element Method (DCDEM) discretisations, is achieved by directly considering solid-solid and solid-fluid interactions. The novelty of the work is centered on the generalization of the coupling of the DEM and SPH methodologies for resolved simulations, allowing for state-of-the-art contact mechanics theories to be used in arbitrary geometries, while fluid to solid and vice versa momentum transfers are accurately described. The methods are introduced, analyzed and discussed.

A series of experimental campaigns are devised to serve as validation points for complex solid-fluid flows simulations and together with analytical and other benchmark numerical solutions, allow for a comprehensive characterization of the model. Unique experiments were performed, such as dam-break flow with movable objects and settling dynamics of macroscopic solid particles. The results show that the model is accurate and is capable of treating highly complex interactions, such as transport of debris or unsteady hydrodynamic actions on structures.

Key-words: Solid-fluid flows, Meshless methods, Smooth Particle Hydrodynamics, Discrete Element Method, Debris flows, Contact laws, Solid transport, High-performance computing, Buoyancy, Validation