An hybrid multiscale model for immersed granular flows

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ABSTRACT

Flows mixing grains and fluid, called *immersed granular flows*, are of huge interests in a lot of industrial domains. There exists many ways to simulate such flows and in most of the cases the physical and numerical models depend on the scale at which the fluid has to be represented [1]. This submission is devoted to an hybrid multiscale model to represent immersed granular flows. On one hand, the fluid flow between the grains is deduced from Navier-Stokes equations for incompressible flows taking into account the porosity of the mix and computed using the *finite element method* at a greater scale than the grains scale. On the other hand, the grains are considered as discrete elements in a Lagrangian way. All the contacts happening during a time step are solved by a *nonsmooth discrete elements method* and the resolution of the trajectories is based on Newton dynamics. The interaction force between grains and fluid is used as a closure relation for the model and are applied on the fluid as ponctual forces.

This kind of model is able to represent highly inhomogeneous immersed granular flows going from pure fluid to porous media. Furthermore, it is able to represent the interactions between grains and complex geometries accuratly thanks to the discrete elements method that are of huge interest for extrusion processes for example. Then, we obtain accurate results for fluid and grains dynamics with a reduced computational time due to the representation of the fluid at a large scale.

First results are promising. We have simulated in two dimensions the behaviour of a drop made up of grains falling in a viscous fluid and compared the results with experiments found in [2]. The viscous effects force the drop to exhibit particular shapes during the fall. At each step, we have compared the macroscopic behaviour of the drop and found that it corresponds to a vertical slice of the experiments. At the beginning of the fall some particles leak at the rear of the motion forming a tail. Later, for a sufficiently high number of grains forming the drop, a circulating velocity field splits it when there is no longer enough grains in its centre. This process is recurent for each of the new droplets until there is no longer enough grains forming the droplets.

The method used for these simulations will be analysed to prove the convergence and other results involving free surfaces flows will be shown. We will focus on the transport of sediments during a dam burst. Imposing a inflow upstream, we will observe the discharge of the fluid mixing sediments composing of grains with different sizes and shapes to study their influence on the leakage rate. Simulations of such a situation are of huge interests to evaluate the possible damages on cities in the near region of a dam.

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