

# Numerical study of the drag in fluid-grain medium with the MigFlow software

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## ABSTRACT

Multi-grains systems stage solid bodies with fluid like behaviours through large scale interaction network rearrangements, enabling them to flow around large objects. A quantity of interest when it comes to granular flows is the drag force exerted upon such objects. Numerical models are able to give an insight of this momentum transfer, whose knowledge is essential for a lot of applications such as the design of protection devices against avalanches, particle mixers, or ploughers.

The case of dry granular media has already been studied. It has been shown that at low velocities, the drag force is independent from the velocity [1]. The resistance induced by the intergrain contact network does not depend on the velocity. Some researches studied the penetration of spherical projectiles in immersed granular media. This work presents a numerical simulation of immersed grain flow around a sphere to study the resulting drag.

The simulations are performed using MigFlow, an open-source software based on a hybrid, multi-scale model for fluid-grain mixes going from pure fluid to porous media. On the one hand, the Navier-Stokes equations for the fluid phase are solved with a finite element method taking the porosity of the mix into account. On the other hand, the grains are solved at a finer scale, using a Lagrangian approach : each particle is considered as a discrete element. Their motion is derived from Newton's second law of motion and the contacts between them are solved with the Non Smooth Contact Dynamics method. The fluid-grain interaction force is based on an empirical relationship, and is applied as a punctual force on the fluid at the positions of the centres of mass of the particles. From the combination of the two scales, the model is able to represent various flow configurations in complex geometries, with an attractive computational cost.

The model has been validated for the fall of Stokes clouds, with a behaviour corresponding to experiments, and consistency has been shown between 2D results and 3D vertical cuts [2]. The friction between grains has been validated against experimental results in the case of a rotating mill without fluid. The different rotating regimes (rolling, cascading, cataracting and centrifuging) have been observed, with transitions occurring at Froude numbers corresponding to experiments.

## REFERENCES

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