Hydrodynamics of a jet impinging on a granular layer

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Abstract

The surface erosion of a cohesive soil by an impinging jet is the principle behind the Jet Erosion Test (JET), a common experimental test which was first introduced by Hanson et al [1] to characterize the resistance against erosion of cohesive soils. In this work, the JET is investigated numerically at the microscale by a coupled fluid-particle flow. The methods chosen for the present simulation are the Lattice Boltzmann Method (LBM) for the fluid phase and the Discrete Element Method (DEM) for describing the motion of the solid particles [2]. Here, we focus specifically on the determination of the flow characteristics of an impinging jet on a fixed granular bed surface in order to assess the suitability and relevance of commonly used empirical estimations based on the free jet self-similar model.

In the present contribution, we firstly introduce a 2D model of a laminar free jet which is validated against well-known theoretical solutions. Then, we present a parametric study of the jet impingement, at first on a solid regular surface and afterwards on a fixed granular layer, while taking into account variations of particle sizes, of distance from the jet origin and of the jet´s Reynolds number. This analysis helps us understand the hydrodynamics phenomenology and quantify the flow characteristics at the bed surface, including maximum velocity, shear stress, pressure and pressure gradient which can be regarded as the main cause of particles detachment under hydrodynamic forces. Finally we show that the results obtained agree overall satisfactorily with the free jet self-similar model by introducing some simple empirical coefficients.

[1] Hanson, G.J. and Cook, K.R. 2004. Apparatus, test procedures and analytical methods to measure soil erodibility in situ. *Engineering in Agriculture, ASAE, 20(4): 455-462.*

[2] Cuéllar, P., Philippe, P., Bonelli, S., Benahmed, N., Brunier-Coulin, F., Ngoma, J., Delenne, J.-Y., Radjai, F. (2015): Micromechanical analysis of the surface erosion of a cohesive soil by means of a coupled LBM-DEM model. *Proc. 4th Int. Conf. on Particle-based Methods, PARTICLES 2015*.