A MULTIPHASE FORMULATION FOR THE MODELING OF GRANULAR FLOW IN THE TRANSVERSE PLANE OF A ROTARY DRUM

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ABSTRACT

Granular flows are widespread across various fields, from geophysical and natural phenomena to industrial applications, yet they lack a unified theoretical framework for characterization and modeling. This challenge stems from fundamental characteristics of granular materials, including grain size and shape distribution, highly dissipative interactions, and the lack of clear separation between microscopic particle and macroscopic flow scales. A notable example of complex granular flow occurs inside a partially filled rotary drum. The movement of solids in such a drum can be decomposed into axial flow due to cylinder inclination and transverse flow due to rotation, with the latter governing critical processes like heat and mass transfer and particle mixing efficiency [1]. This study employs a continuum approach based on the μ(I)-constitutive model to delve into the rheological behaviour and provide an intricate depiction of 2D dense granular flows within a rotating drum. This model, resembling viscoplastic behaviour, uniquely features pressure-dependent yield criterion and viscosity, reflecting the frictional characteristics of the system [2]. Regarding the numerical schemes, for the capturing of the interface we implement the Cahn-Hilliard equation, a phase-field approach for the simulation of immiscible multiphase flows [3]. The governing equations are solved using our Finite Element inhouse code with stabilization techniques for the momentum, the continuity, and the phase field equations [4]. We investigate the dynamics of the flow for various parameters, and we can see a remarkable agreement with experimental results. We notice that as the drum rotates, most of the grains lay in a non-shearing plug flow which follows a solid-body rotation (passive layer), whereas close to the interface in the sheared region, a thin layer of active particles is formed, and the grains are rapidly transported downslope (active layer).

KEYWORDS: Dense Granular flows, Viscoplastic Flows, Rotary Drum, Finite Element Method, Phase Field Method

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