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Unified approach of hydrodynamic modeling and numerical simulation of dilute and dense granular flows for industrial applications

Dariusz Niedziela[1], Sebastian Schmidt[1], Konrad Steiner[1]*, Clément Zemerli[1]

[1] Fraunhofer Institute for Industrial Mathematics, Fraunhofer-Platz 1, D 67663 Kaiserslautern,
Konrad.steiner@itwm.fraunhofer.de , www.itwm.fraunhofer.de/sms

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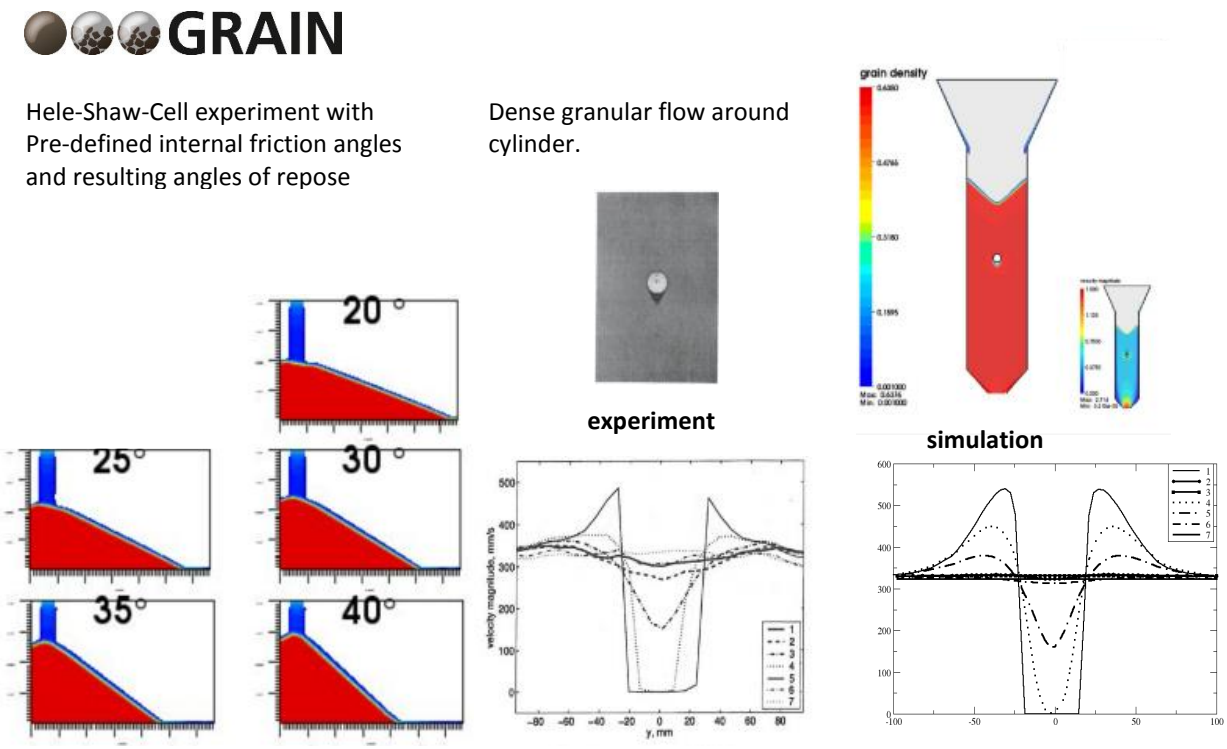
SUMMARY

In the talk we describe the hydrodynamic approach developed in recent years ([1-3]) to model powder and granular flow behavior physically consistent in both the dilute and the densely packed regimes. Recent analytical work has underlined that the employed model recovers a wide range of complex effects and behaviour like Bagnold scaling, slow visco-plastic motion or critical state plasticity [3]. Hence, this is a powerful approach to model complex industrial processes where several of the abovementioned regimes can occur at the same time. Additionally, numerical experiments have underlined that our approach reproduces typical behaviour of granular systems like the formation of sand piles with the pressure dip effect or core and mass flow in silos [3,4]. All these effects are a direct consequence of the hydrodynamic modelling, without the need to include them explicitly into the constitutive equations. This greatly simplifies the model calibration procedure during which only a few physical material parameters must be included. Additionally, in the general approach followed here, the model is not tuned for one flow configuration but can be applied to different kind of processes.
Extending this single-phase granular model to multiple phases, both the flow of concentrated suspensions [4] as well as air assisted powder transport [5] can be treated consistently. The numerical and implemental challenges arising in complex multi-phase fluid simulation will be explained and we describe our concept of a finite volume solver framework which contains linear and nonlinear discretization and solving techniques as well as pre- and post-processing facilities [6]. We show how typical material characterization techniques and adequate numerical solution techniques make this approach suitable for simulation of complex industrial design questions involving powder or granular material. The industrial examples like granular flows in silos and mixers, suspension flows in ball mills and pneumatic transport will show the broad applications range of the hydrodynamic granular model.



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