Experimental and CFD numerical study of hopper discharges.

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In this work, we numerically examine granular flows in silos and hoppers using Computational Fluid Dynamics (CFD). In particular, we use constitutive models implemented in a commercial software package (ANSYS Fluent[9]) and employ them to simulate the discharge process. The analysis is focused on the velocity and density fields at the silo exit, and the numerical protocol is validated, comparing with experimental data of mass flow rates. In addition, we test the results inside of them at different heights to check if we obtain Gaussian profiles.

Accurate correlations predicting the mass flow rate in granular hoppers and silos have been introduced accounting the discrete nature of the flowing material [1, 2, 8]. On the contrary, R & D factories and technical offices use continuous models to analyze the most used hopper and silo devices. Such algorithms seem to work very well if a wide series of control parameter are tuning adequately, so they require an extensive experimental calibration.

We use a continuous model based in the KTGF theory [4, 5, 6], including a specific procedure to describe densely packed systems, i.e., taking into account the frictional behavior [7] of the material. By means of this tool we analyze the relationship between the hopper angle and the discharge mass flow rate in conical hoppers. Adjusting the simulation parameters feed-backing the code with experimental results, we develop an accurate calibration procedure, which can be employed in both, simplified lab conditions and industrially relevant systems.

Furthermore, we also explore the role of the outlet aperture. We find that the former numerical approach captures the main features of the granular flux through orifices, such as the velocity and density profiles. Importantly, the results show as the systems dynamics near the hopper exit determines the discharge rate.

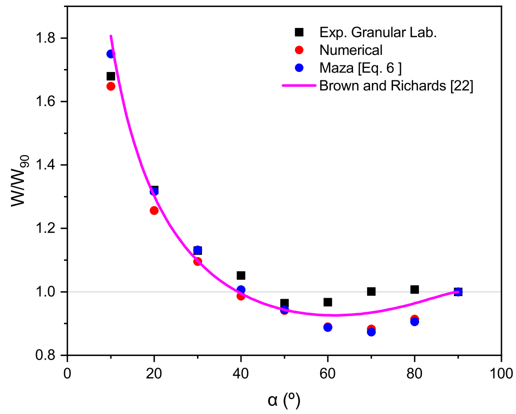

Fig. 1. Comparative Evolution of normalized mass flow rate, $\frac{W}{W_{\alpha=90}}$,Brown and Richards theory and experimental results, for different hopper angles, α.

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