84d A Method for Predicting Hopper Flow Characteristics of Unconfined Cohesive Powders

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Hoppers are commonly used device in the handling and storage of granular materials. Despite their common use and deceptively simple design, hoppers have a number of problems associated with them which include funnel flows, bridging, and flooding. Hoppers of varying sizes and shapes are used in all kinds of industrial processes involving a wide variety of powders having different properties. Hopper flow can vary from funnel flow to mass flow determined by hopper design, and powder properties. In the case of value-added industries, e.g. pharmaceuticals, due to small batches and often changing product lines, it is impractical to build and design geometric mass flow hoppers. It is well know that most cohesive powders have poor flowability, which makes the discharge from hoppers highly unreliable. In spite of the presence of predictive models and techniques to improve flow of materials through hoppers, there lacks a direct comparison of hopper flow to a tool that can quantify flow properties of powders.

In this study, we investigate the flow properties of cohesive powders in a gravitational displacement Rheometer (GDR) and correlate the properties to flow through hopper. As most industrial applications involve discharge from a drum into a hopper, we have followed similar conditions to maintain the properties of the material. Such a quantification method allows us to define a flow index for materials that can be directly correlated to hopper flow. As the powder cohesion increases, it becomes increasingly difficult for the powder to flow through the hopper, which corresponds to the higher flow index for the GDR. The technique was further expanded to compare bed expansion (dilation) for powders of varying cohesion. This not only allowed us to quantify the flow through hoppers based on cohesion, but also enabled us to determine the discharge density to the hopper. However, the method is only indicative to bench scale hoppers and does not take into account the scale effect. Nevertheless, the method helps in conveniently analyzing the flow properties of cohesive powders and any changes that need to be made to improve flowability, which in turn can help to gain a better understanding of flow, mixing, and segregation dynamics for powdered and granular materials.