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The relationship between material displacement and pressure reduction in a mass flow hopper during initiation of flow

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Abstract

The methods for calculation of material pressures in a mass flow hopper are well researched and documented by multiple authors. The imposed material pressures directly relate to the pull-out tension of a belt feeder or apron feeder, or a shutoff gate.

It is well documented that the initial filling condition imposes a high ‘initial’ pressure on the feeder, and after commencement of a small amount of material withdrawal, the pressure state reduces to a ‘flow’ condition.

Very little research has been presented to demonstrate the amount of material displacement that is required to achieve this change in pressure state, although it is generally understood that the transition takes place rapidly, after only a small amount of material movement.

A laboratory scale test programme was performed to measure the initial and flow pressures and record the relationship between material displacement and actual pressure at the hopper bottom.

The tests were repeated with a variety of material types and hopper configurations, which assisted in understanding the observed effects in terms of a wider range of production scale applications. Parameters that were varied were hopper half-angle, outlet opening width, height of bin filling, differing bulk materials and wall materials. Additional tests were performed to demonstrate the effects of inertial compaction during filling, and a test was performed to gain insight into the time response during slow withdrawal of material

The required displacement for all cases was substantially lower than originally expected prior to performing the test programme.

The results give insight into the design of feeder and hopper interfaces and sizing of mechanical components of feeders. They also provide some guidelines to the requirements of possible load relieving mechanisms.