

GRANULAR FLOW THROUGH A "LIVE WALL" HOPPER

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by

Shun Gao

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ABSTRACT

Hoppers are a common device used in the handling and storage of granular materials. Ensuring efficient flow in these devices is critical due to their prevalence in industrial operations. One of the more common flow problems in hoppers is funnel flow where regions of stagnant material exist close to the hopper walls. One method often employed to prevent funnel flows is to vibrate the walls of the hopper by attaching unbalanced motors or pneumatic vibrators. Hoppers employing vibration to induce granular flow are called "live wall" hoppers.

This thesis presents the results from an experimental study of the mass discharge rate and velocity field from a discharging "live wall" hopper. A quasi two-dimensional hopper was constructed and filled with 3mm diameter glass spheres. Attached to one of the flexible inclined walls of the hopper is an electromagnetic shaker which oscillates the wall sinusoidally with variable amplitude and frequency. Measurements of the mass discharge rate from the hopper were made as a function of the oscillation parameters. In addition, a video particle tracking system was used to determine the velocity field of granular material within the hopper during the discharge process.

The experimental measurements indicate that the mass discharge rate from the hopper is insensitive to the vibration parameters over a range of oscillation frequencies from 10 to 30 Hz and acceleration amplitudes between 0 and $3g$ where g is the acceleration due to gravity. The velocity field within the hopper, however, is significantly affected by the oscillations. Against the oscillating wall the granular material readily flows while near the non-vibrating wall the flow remains stagnant. Velocity profiles at various locations in the hopper are presented and are used to determine the degree of influence of the wall vibration. The stagnant area in the hopper is also reduced significantly with vibration. When the vibration frequency is 15 Hz and the vibration acceleration amplitude is $0.75g$ and $1.5g$, the corresponding stagnant area is reduced to approximately 70% and 40%, respectively, of the stagnant area in the hopper without vibration. It is proposed that the insensitivity of the discharge rate to the vibration is the result of the small scale particle motion near the hopper exit, and the reduction of the stagnant area is primarily due to the decreased effective friction factor of the particles caused by the localized vibration.