Dynamic Stress Analysis of the Freeman FT4 Powder Rheometer by DEM

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ABSTRACT

Unreliable and inadequate flow of powders is a problem in many powder handling industries, such as pharmaceuticals, food and fast-moving consumer goods. The initiation of powder flow in quasi-static processes, e.g. discharge from hoppers, has been extensively studied and can be suitably characterised by commercial devices, such as shear cells, to ensure suitable process design. However for applications such as tabletting, conveying and packaging the characterisation of powder flow under dynamic conditions is required. The Couette device of Tardos *et al.* [1] aimed to achieve this but suffers from a number of shortcomings requiring further development, such as inadequate wall grip, requiring large quantities of powders, and not being commercially available. The Freeman FT4 Powder Rheometer is the only commercially available device to operate in the transitional and dynamic regimes outlined by [1]. This device measures the translational and rotational work required to drive a rotating impeller into a powder bed at a given speed for a defined distance. Until now this '*Flow Energy*' has not been related to the stresses experienced by the powder and the bulk mechanical properties of the powders, such as cohesion.

In this work we simulate the FT4 experiment using DEM for cohesive, spherical glass beads, with surface energies controlled by silanisation. The DEM results agree well with experiments, which show an increase in flow energy with surface energy. They show that the shear stress within the powder bed is constant along the length of the blade, and increases as the blade descends. DEM strain rate analysis shows that the standard FT4 test operates in the transitional regime for these powder beds. The shear stress is shown to be constant at operational speeds within the quasi-static regime and to increase with strain rate in the transitional and dynamic regime. The increase in shear stress correlates well with the increase in flow energy. These findings will lead to a much improved understanding of dynamic powder flowability and ultimately enhance the capability for reliable design of dynamic processes.

REFERENCES

[1] G.I. Tardos, S. McNamara and I. Talu, "Slow and intermediate flow of a frictional bulk powder in the Couette geometry", *Powder Technology*, **131**, 23-39 (2003).