

# Modeling of screw feeder performance

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## Abstract

Screw feeders or conveyors are widely employed in industry for the bulk transport of particulate materials. Several studies have attempted to relate the discharge rate with the rotation speed of the screw via experiments and particle dynamics simulations. However, a detailed mechanics-based model that would assist in optimal design of screw feeders has not been attempted. In this work we consider a single-screw feeder, as the first step to modeling powder flow in a twin-screw feeder that is widely used in industry. We first construct a mechanics-based model by enforcing the balances of linear and angular momentum on a suitably chosen continuum element. With the simplifying assumptions that the granular medium moves as a rigid body that slips along the surfaces of the screw and barrel, and neglecting the effect of gravity, we show that under certain limiting conditions the discharge rate for a given angular velocity and screw geometry can be obtained. Further, we show that the discharge can be maximized by setting the ratio of the pitch to barrel radius to a specific value.

We then study the detailed flow within the conveyor by particle dynamics simulations using the Discrete Element Method. Our simulations show that a significant fraction of the material does indeed exhibit solid body motion, in agreement with the assumption of the simple model. We assess the effect of relaxing the limiting conditions employed in the model, thereby determining the connection between the friction at the walls and the kinematics. The variation of the volumetric flow rate with the ratio of pitch to barrel radius in the presence of gravity is finally compared with that from our model and simulations in the absence of gravity. We observe that both exhibit the same qualitative trends, indicating that the dependence of the volumetric discharge rate on the geometry of the conveyor is not altered by the introduction of gravity.

Our study thus provides useful information for the design of screw feeders, and provides insight into the mechanics of the flow of the powder in a screw conveyor. Moreover it lays the foundation for a more thorough analysis that is to follow, where we will use a robust constitutive relation for the stress to determine the flow and stresses developed in single and twin screw conveyors.