In-Depth DEM Analysis of a Continuous Mixing Device

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ABSTRACT

The pharmaceutical industry is undergoing a transformation from batch production to continuous manufacturing. Key advantages of continuous manufacturing over batch production include reduced downtimes, smaller footprints and better control of product quality. The minimal set-up for continuous production of tables is direct compression and includes only three unit operations: feeding of raw material, mixing the components to a homogenous blend, and finally the tablet press.

In this work, a mixing device dubbed CMT (Continuous Mixing Technology) has been analysed with DEM (Discrete Element Method) simulations. The CMT follows a vertical design: powder is continuously fed at the top, passes a de-lumping screen agitated by an impeller at the top, and falls then into the conical mixing zone with a second impeller. The hold-up mass in the system is kept constant by a dynamic valve that restricts the outlet flow. The advantage of the CMT over the traditional horizontal and inclined devices is that hold-up mass (and thus mean residence time) can be independently controlled from the impeller speeds (and thus shear rates acting on the powder).

The DEM simulations have been carried out with the GPU-based code XPS (Extended Particle System) developed at RCPE. Details regarding contact model, calibration, CMT geometry and experimental validation with RTD (Residence Time Distribution) data are described in [1]. The previous work focused on exploring the design space and quantifying the mixing quality at different operating points with the help of RTDs. The goal of this work is to understand why certain operating conditions work better than others.

The first step is the analysis of the powder bed shape in the mixing zone. This helps to build some intuition for the flow dynamics that occur inside the CMT, e.g. a possible short-circuit path from the de-lumping screen to the exit valve. However, the DEM simulations generate much more data: the current position and velocity as well as residence time and travel distance since creation is tracked for each particle. The data establishes a link between different distributions (RTD, travel distance and velocity distribution) and particle trajectories. In particular, undesirable early peaks in the RTD have been connected to typical trajectories.

This analysis does not only create insight to the mixing process, but also lays the groundwork for future design optimizations of the CMT.

REFERENCES

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