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A Study of Segregation Behaviour with Rotation Speed in a Double-Walled Rotating Drum

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Extended Abstract

Granular mixing is an essential industrial and household process described by the attainment of a proper mixture of different granular raw materials so as to ensure the high quality of a product or a semi-product. Such process is very crucial in the manufacture of pharmaceuticals, where concoction and segregation of drugs and medicinal ingredients need to be executed precisely. In line with this, industrial engineers and academic researchers have been dually investigating the fundamental mechanisms of mixing/segregation in powder or granular materials [1, 2].

In the past few years, rotating drums have been widely used for the investigation of the mechanics of granular flow and mixing/segregation, partly because the flow field in such drums is relatively simple [3-5]. In this study, experiments were performed to investigate the revolution and behavior of size-induced particle segregation in a quasi-two-dimensional double-walled rotating drum of different rotation speeds and filling degree conditions. A quasi-2D double-walled rotating drum whose axial length as well as outside and inside wall diameters are 15, 300, and 180 mm, respectively. The rear surface of the drum was an aluminum plate that reduces electrostatic effects. It was adhered with a black paper to minimize optical noise effect in the digital images. A clear acrylic front plate was placed for flow visualization. Owing to the wall friction effect, the concentration profiles near the walls may differ from those in the bulk material. Thus, the front and rear walls of the drum were cleaned prior to each test to ensure that they were smooth and to reduce wall friction effect between the wall and the granular flows. A high speed camera with a speed of 30 frames per second (fps) and a spatial resolution of 1,280 × 1,024 pixels was used to record flow images during the segregation process. Moreover, a digital video recorder was used to capture color images for better image processing. For segregation analysis, the color images were converted to grayscale at a digitized grayscale level range of 0-255, which is appropriate for differentiating between the black (4 mm) and white (2 mm) particles. These images were digitally stored in computer files.

The results show that both rotational speeds and filling degree importantly influence the segregation behavior. The results demonstrate that three different segregation flow patterns (Brazil-nut effect state, mixing state and reverse Brazil-nut effect state) will occur under different rotation speed. At the same time, the speed at which these segregation flow patterns occur will vary with the filling degree. The results of this study for different radial segregation behavior of particles in the rotating drum can be used in many industries. For example, it can be applied to separate rice from their husks or impurities in the food industry as well as the size grading of sand or segregation between sand and garbage in the sand and gravel industry. Moreover, it also can be used to manufacture functionally graded material of different structural types.

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