Biaxial Rotary Mixer to encounter Granular Segregation

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Abstract

Mixing is an important but poorly understood aspect in petrochemical, food, ceramics, fertilizer and pharmaceutical processing and manufacturing. Segregation and mixing phenomenon occur in most systems of powdered or granular solids and have a significant influence on their behavior. Deliberate mixing of granular solids is an essential operation in the production of industrial powder products usually constituted from different ingredients. The knowledge of particle flow and mixing in a blender is critical to optimize the design and operation. Since performance of the final product depends on reliable granular flow and blend homogeneity, the consequence of variability can be detrimental. A common approach to powder mixing is to use a tumbling blender, which is essentially a hollow vessel horizontally attached to a rotating shaft. This single axis rotary blender is one of the most common batch mixers among in industry, and finds use in myriad of application as dryers, kilns, coaters, mills and granulators. In most of the rotary mixers, the radial convection is faster than axial dispersion transport. This slow dispersive process hinders mixing performance in many blending, drying and coating applications. A double cone mixer is designed and fabricated which rotates around two orthogonal axes, causing axial mixing competitive to its radial counterpart. Glass beads (1mm & 3mm) and art sand (250 μm) of different colors are used for mixing experiments. Discrete Element Method (DEM) based numerical model is developed to simulate the granular flow within the mixer. Digitally recorded mixing states from experiments are used to fine-tune the numerical model. Moreover, discrete pocket samplers are also used in the experiments to quantify the characteristics of mixing of glass beads of two different colors. In each experiments, at definite time intervals, the rotary movement is temporarily stopped to open up the top half of the cone , place the sampling template on the top surface of the granular bed, and then to draw samples using discrete pocket sampler (GlobalPharma, NJ) from the same area of the bed through the holes of the sampling template. The mixing states are quantified in each batch run, by hand counting the number of glass beads of different colors present in each sample to be a function of space and time. As hand counting is impossible for smaller particles, Matlab based digital image analysis technique is used to characterize the mixing states in the experiments with art sand. A parametric study of the effect of vessel speeds, relative rotational speed (between two axes of rotation), particle size and vessel fill level on the granular mixing is investigated by experiments and numerical simulation. Incorporation of dual axis rotation enhances axial mixing by 60 to 85% in comparison to single axis rotation. Increase in the rotational vessel speed enhances mixing till a optimum value above which mixing does not improve for centrifuging effects. Particle size and fill level has nominal impact on granular mixing.

keywords: Granular Mixing, Discrete Element Method, Axial Segregation, Rotary Blenders, Image Analysis.

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