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Original Research Paper

The best screw shape for fine zinc oxide particles feeding

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ABSTRACT

One of the most important requirements of particles feeding is a very homogeneous mass flow of fine particles. Screw feeders are among equipment used to feed particles in many industries. In this study, the performance of four single screw feeders with different pitch and blade shape screws has been studied experimentally for steady and stable feeding of fine zinc oxide particles at flow rates corresponding to laboratory scale range (under 10 g/min). The following results were obtained from this investigation: (I) the sticking problem of fine particles in angular pitch screw was solved by changing the pitch shape to circular; (II) the distribution of the fluctuations and their intensity in mass flow rates also lessen by using the circular pitch and a thin blade screw in place of the circular pitch and a thick blade screw. Also for both feeders, the feeding was often interrupted in low flow rates, but it will be disappeared by increasing the flow rate. Furthermore, the results of experiments show that the performance of the circular pitch and a thin blade screw feeder was better than other screw feeders and able to both swirl and mix the particles with different characteristics and reduce the mean aggregate size of the particle size distribution (PSD) when transmitting the zinc oxide particles.

1. Introduction

Fine particles feeding are widely used, especially in polymer, chemical and food industries [1–3]. One of the most important applications is feeding of zinc oxide particles to a solar reactor for decomposition to zinc as an energy carrier and hydrogen producer by water splitting method [4–6].

In recent years there were considerable efforts to provide the uniform fine particles feeding to gas–solid two phase flow reactor [2,7]. On laboratory scale, it is particularly difficult to achieve steady and stable feeding because the fine particles are very compressible. Therefore, weighing and transmitting (metering and handling) in low flow rates is difficult [8,9]. The fine (less than 1 μm) ZnO particles are very cohesive and sticking, and classified as Geldart group C particles [10–13]. Group C particles tend to cling to each other as a consequence of the interparticle forces and form agglomerates [2,11,13]. Therefore, it was expected that we have coarse agglomerations in the initial ZnO powder. Furthermore, the fine particles feeding are very sensitive because a small variation in the gas–solid two phase flow will change the reaction process.

There are many types of feeders available for feeding of particles in the literature. The screw feeders are among the most widely used types of volumetric feeders to particles feeding. They are a popular choice for many applications because of that can easily be modified to fit the type of particles and process involved [10,14,15]. Some advantages of screw feeders include particles transmitting, stirring, mixing [3,14,16,17], and reliable to low and high feeding rates [10,14].

The drawbacks of screw feeders are as follows:

- Interlocking or cohesive arch of particles forming above the screw in the hopper [10,14].
- 'Clogging' takes place when particles stick to the root corners of the screw flight. 'Logging' is a term used when the total volume of the screw is filled and rotates [14].
- Instantaneous fluctuations of mass flow rate [18,19].
- Promote the aggregation of particles that then drop off the end of the screw as particle aggregates [2].

In critical process-control applications, time intervals for sampling should be no longer than residence time in the actual process. This can be a problem with processes that have short residence times, particularly gas–solid reactors [10]. Complete conversion of gas–solid reactions may be achieved by increasing the operating temperature and residence time [20]. However, the residence time of gas–solid reactions is usually in the order of several seconds [21–23].

The novelty of the present work is using of a circular pitch and a thin blade screw for improving the performance of a screw feeder with respect to the above mentioned problems for steady and

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