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Original Research Paper

Powder deposition in three parallel-oriented dies of cylindrical and E shapes

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ABSTRACT

The second generation pressure deposition tester (PDT-II) was used to evaluate the die filling process in multiple dies. Three parallel-oriented dies of cylinder and E-shape were filled with an alumina powder at different feed shoe speeds. The results indicated that for cylindrical dies at lower feed shoe speed, the center area had the highest pressures; at higher speed, pressure distribution was irregular, complicated, and varied more. One reason for this was relatively low bulk density and small particle size of the powder, which led to relatively poor flowability. For E-shaped dies, due to wider opening of the middle leg, its pressures were higher than those of the other legs. Compared to another powder (BPM) with denser, bigger, and less spherical particles, the alumina powder had the highest final pressures closer to the middle leg, instead of being closer to the back as for the BPM. This was basically due to its physical properties (such as particle size and shape). This research demonstrated that powder physical properties, such as particle size and shape, had pronounced effect on powder deposition. Also, die shape complexity could affect the pattern of powder flow and deposition.

1. Introduction

Die deposition and the achievement of uniform fill, while seemingly simple, are deceptively complex processes that are far from being sufficiently understood [1]. During the process of die filling with a feed shoe to produce tablets or compacts, inhomogeneity might be created, due to nonuniform bulk density distribution at different locations. This nonuniform deposition may cause many problems for the product, such as laminations, cracks, and nonuniform shrinkage on sintering. Understanding the deposition process is an important and necessary step to avoid these problems and ensure a uniform and high density pre-compaction. In order to study the deposition process and uniformity of simultaneous powder fill in multiple dies, the second generation pressure deposition tester, or PDT-II [2–4] was developed and used to simulate and evaluate the die filling process. PDT-II could generate real-time pressure distribution at the bottom of dies during the powder filling process. The data collected could be used to study the effects of various filling-related parameters (such as die shape and feed shoe speed) on the deposition process and final pressure distribution [3]. In this study, PDT-II was used to fill an alumina powder in three parallel-oriented dies. Based on industrial importance, two die shapes, cylindrical and E-shaped, were tested.

2. Research methodology

An alumina powder was used as the test material (Fig. 1). It was a dense white powder with mild ammoniacal odor and stable under ambient conditions. Its particle density and bulk density were 3.33 and 0.83 g/cm^3, respectively. The median size (d_{50}) was 87 μm, obtained by using Malvern Mastersizer S (Malvern Instruments Ltd., UK).

Cylindrical die configuration and the dimension of the feed shoe are shown in Fig. 2(a). Fig. 2(b) shows a 3-dimensional drawing of dies and the feed shoe. The depth of the dies was 19.1 mm. The feed shoe (158.7 mm in inner diameter inclined at 45°) cross-section in contact with the feed shoe table was an ellipse. The movement direction of the feed shoe was parallel to the long axis of the ellipse. The three parallel cylindrical dies were symmetrical about the long axis of the ellipse. As shown in Fig. 2(c), a pressure sensor strip was oriented in four separate directions, i.e., 0–180°, 45–225°, 90–270°, and 135–315°, with respect to the feed shoe movement direction to record pressure change at multiple locations [3]. For each direction, nine sensor elements were exposed to record pressure increase profiles. Data were collected for all the four directions.

The dimensions of the three E-shaped dies are shown in Fig. 3. The depth of the E-shaped dies was also 19.1 mm. The interval between adjacent E-shaped dies was 8 mm. The pressure sensor strip was placed at four locations for each die. For E-shaped dies, the feed shoe approached from the back side, since this direction

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