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Influence of granule porosity during fluidized bed spray granulation

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Abstract

Fluidized bed spray granulation is an important process for the transformation of liquids into solid materials. Especially product properties like final particle size and structure of the granules are important. These properties are closely related to the selected process parameters such as temperature and spraying rate. By knowing the relationship between the thermal process conditions and resulting particle structure, the final product can be designed according to the wishes of the consumers. In the presented work, a correlation between the thermal process conditions and the achieved shell porosity, which is relevant for the particle structure, is revealed. Therefore two experimental series with different materials (non-porous glass particles and porous alumina) were performed in a lab-scale fluidized bed spray granulator. The lab-plant allows the precise measurement of the inlet and outlet temperatures and moisture contents of the gas. All process parameters were kept constant except the inlet gas temperature and the spraying rate. Although the amount of initial material as well as the amount of injected solution was the same for all experiments, the final particle size distribution and the structure of the formed shell were clearly different. The obtained experimental results were compared with a process model including a new expression for the growth kinetics, which takes into account an acceleration of the growth velocity due to the formation of a porous structure. The used model also considers the separation of the fluidized bed into two different zones, namely the spraying zone and the drying zone. With the given initial process conditions, the model calculates the time evolution of the particle size distribution, the theoretical outlet temperature and the moisture content of the gas. The introduction of the shell porosity into the growth kinetics reduces the underestimation of the particle size in the model, which occurs if the formed layer on the particle surface is assumed to be compact.
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1. Introduction

Approximately 60% of all industrially goods are particulate solids [1] because the handling, storing and further processing is often easier than for liquid substances. One fundamental process for the fabrication of granular products is fluidized bed spray layering granulation (FBSG), especially in food and pharmaceutical industries. Depending on the large variety of application very different particles are needed. The process of FBSG offers the advantage of a selective control of product properties such as particle size, moisture content, solubility or composition by forming it out of, e.g., suspensions, solutions, emulsions or melts. Furthermore the porosity or rather the structure of the granules can be influenced by the chosen process conditions.

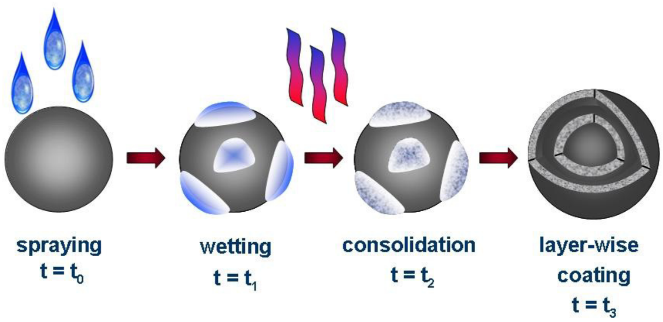

Fig. 1.Granulation scheme.

The following cases should provide a short overview. If an active substance should have a fast release then a porous surface is preferred. But also the opposite case of a compact and smooth surface is possible. These coated particles were used e. g. to protect the core from outer influences for a certain time. Often very narrow particle size distributions are preferred by the costumer but in some cases wide distributions offer more benefits. To that reason the FBSG-user has to know which process parameter to choose to handle the process in the right way and to push the product quality in the favored direction. For a better understanding, a closer look on the micro-phenomena is necessary. The primary particles which are used as seeds during the granulation can consist out of filling material or even the active component itself from an industrial point of view. These seeds are streamed by hot gas to fluidize them. Out of a nozzle, which can be positioned on the bottom, side or top of the process chamber, droplets are sprayed on the particles. The differences in deposition, spreading, penetration and drying of the droplets will affect the process development and yield to different particle properties. The challenge is to predict all these phenomena (Fig. 1) in detail. So a fundamental understanding, of how it is possible to produce such different product properties with the same material and the same apparatus, is needed. The investigation of how the process conditions influence the particle porosity is done experimental. Macroscopic population balance equations (PBE) are enhanced and tested with the derived influences from the experimental investigations. The modeling of such a complex granulation process is split in two main parts. The first one is the description of the temporal evolution of the particle size distribution. For the case of describing only one characteristic parameter, namely the particle size x, the layering process can be described by a one-dimensional PBE. The second part is the description of the drying conditions. The dependency of the achieved granule porosity on the thermal process conditions is expressed by an empirical correlation which is established from experiments. Results for both are presented and discussed in section 4.

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