Measurement of Particle Size Distribution in Fluidized Beds

The process of particle size enlargement can change the properties of granular materials significantly. By agglomeration fine-sized primary particles are transformed into free-flowing and dustless consumer products. Usually this is achieved by the addition of an aqueous binder forming liquid bridges between the primary particles. To solidify the binder bridges the solvent needs to be removed by a drying process. The fluid bed technology is one possibility to combine both agglomeration and drying in a single apparatus. This technology can be used either for batch operation or in continuous operation mode, depending on the product specification, throughput or production costs. For the design of production plants fundamental knowledge of the relationship between governing process parameters and the resulting product properties is desired. Such knowledge can be implemented in simulation models, providing a framework to support the plant design.

In literature, many attempts have been made to describe the process of agglomeration in fluidized beds in terms of the continuous population balance approach. Population balance equations (PBE) describe the temporal change of particle property distributions. As a result, one obtains the temporal change of the particle number distribution with respect to selected particle properties, which are called the internal coordinates. The most demanding part of applying PBE to agglomeration is the choice of the kinetics in terms of an agglomeration kernel. For the one-dimensional PBE, where the particle volume $v$ represents the internal coordinate, the kernel is given as the product of the agglomeration efficiency and a size-dependent expression.

For two materials, highly porous alumina oxide and non porous glass beads (fig. 1), the influence of process conditions such as flow rate of gas, temperature and binder concentration on the kinetics of spray agglomeration process was investigated. Therefore a lab scale fluidized bed (fig. 5) was utilized. A sample port was attached to the chamber to withdraw particles from the fluidized bed. The temporal evolution of particle size distribution was measured offline by means of the Camsizer of Retsch Technology (fig. 2).

The measuring principle of the particle sizer is based on the evaluation of particle shadow projections which are generated by dryly dispersed particles falling down in front of a light source. The projections are recorded by a two-camera-system and are then evaluated by digital image analysis. The wide measuring range of the instrument allows to analyze particles in a range from 30 µm to 30 mm so that extensive growth progressions during the agglomeration process can be clearly displayed. The instrument uses two high-resolution CCD cameras for the simultaneous analysis of particle size and particle shape. During the measurement, each camera has a different task. The basic camera (CCD-B) analyses every large particle in the sample, whereas the Zoom camera (CCD-Z) registers the small particles with higher resolution. The contact-free optical measurement is carried out in real time and provides all required information about particle size and shape simultaneously, as well as the number of particles, the specific surface area, and average sample density. The samples are fed to the measurement chamber via a vibratory chute (width 60 mm). To avoid the mechanical destruction of the fragile fluidized bed agglomerates during the feeding, the amplitude of the chute was reduced to a minimum.

The analysis of the experimental data in terms of dynamic evolution of particle size dis-
The provided data are directly used to determine the kinetics of the growth process. It is demonstrated that some size-dependent kernels such as shear-kernel or EKE-kernel do not preserve the temporal evolution of the size distribution. On the contrary, an empirical kernel of Kapur (1972) predicts the experimental data with high accuracy (fig. 4).

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