Basic Preexaminations of Inline Measurements of Droplet Size Distributions by Statistical Extinction Method

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There is a need for inline sensors for the monitoring of process sprays, which are able to measure the size of droplets or solids, their concentration, and their spatial distribution inline in process plants. The knowledge of these characteristic spray values are of particular importance in many spray processes, e.g. drying processes. The mass transport and thermodynamic characteristics of the droplet phase are depend to a large extend on the droplet size. These characteristic spray values define the proceeding processes in process sprays. Optical methods for particle analysis work contactless and almost do not influence the running processes.

Measurement techniques which are able to monitor process sprays inline in process plants provide a better inline control of drying processes and may improve the understanding of spray drying.
An inline process control allows improving the quality of drying products and facilitates a reduction of degraded material and costs. Therefore, only temporal modifications of the process sprays have to be detected. Thus, there is a need for easy measurement devices which can measure a mean droplet size and a droplet concentration reliably for a long term of time.
A better understanding of drying processes may simplify the design of new process plants for drying processes. Therefore, especially the knowledge of the relationship between characteristic spray parameters (droplet size distribution, droplet concentration, propagation speed) and the generated particles (size distribution, structure) is necessary. Thus, a measurement device which provides information about the characteristic spray parameters and the generated particles at different positions in drying processes is necessary.

Based on statistical extinction method two different measurement devices have been developed. A basic system determines the mean droplet size and the droplet concentration of sprays. Therefore a collimated laser beam with a diameter of about 3 mm crosses the spray. A pinhole with a diameter of 600 µm positioned behind the measuring volume limits the measurement beam cross section to a well defined value. A photodiode detects the fluctuating luminous intensity signal, which is extincted by the droplets of the spray. The transmission of light and its root mean square deviation can be calculated from these values. The statistical extinction method uses the transmission and their the root mean square deviation to calculate the mean droplet size. Bigger droplets which are entering or leaving the measurement volume cause larger root mean square deviations than smaller droplets. The droplet concentration is calculated from the mean value of the transmission and the mean droplet size.
A big advantage of this measuring principle is the simple optical construction which allows a lance-shaped realization of the sensor for the insertion in spray towers. For the measurement in one plane, only one incision with a diameter of about 50 mm in the outer wall of the tower is necessary to insert the lance into the tower. Measurements at very high droplet concentrations and at different positions in the spray tower are possible, if axially displaceable sheaths are used, which shield the laser beam from spray influence for a variable length. This is neither possible with scattered light measuring systems, nor with imaging techniques.
A second measurement system has been constructed to examine if the statistical extinction method is qualified for measuring droplet size distributions of sprays. A collimated laser beam with a diameter of 20 mm crosses the measuring volume. A pinhole with nine holes with different diameters from 10 µm up to 1000 µm is positioned behind the measuring volume. It generates nine laser beams with nine different cross sections. Behind each pinhole a photodiode is positioned which measures the extincted luminous intensity signal. The additional information is caused by the fact that droplets whose diameter is larger than the diameter of one laser beams cannot extinct a cross section which is larger than the laser beam. Thus, these droplets are measured too small. In a larger laser beam these droplets can extinct a cross section which is larger.

In the paper the statistical extinction method and the extension of this measurement principle to measure droplet size distributions are discussed. The construction of both measurement devices and some measurement results are displayed. The ability of the statistical extinction method is discussed by comparing droplet size distributions measured with a laser diffraction system with measurement results of the new sensor.

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