Development of a light-sheet device for on-line measurements of large droplets entrained from mist filters

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Mist droplets of sizes in the order of a few hundred nm are generated in large amount by various industrial processes, e.g. by oil lubricated compressors, metal cutting tools or during engine crankcase ventilation. The most common method for removing such particles from an air stream is the use of fibrous filters. As a result of gas flow through the partially saturated filter media, previously collected liquid can be entrained further downstream, decreasing the effectiveness of the filter significantly.

Entrainment drop sizes range over several orders of magnitude. At the coarse end, which contains most of the mass, large blown off drops from several hundred microns up to a millimeter are observed. To detect these drops continuously, a light-sheet device was developed. A laser beam is expanded to form an illuminated plane directly behind the filter. The scattered light of individual drops, which are blown off the filter and hence pass through this light-sheet, is detected via a photomultiplier (PM). The operating principle of the device is shown in Fig.1.

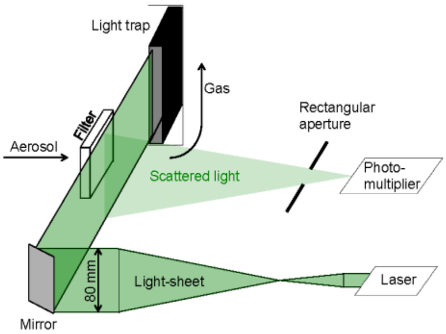

Figure 1: Operating principle of the custom-build light-sheet device.

The measurement volume (80 mm x 80 mm x 2mm) which is limited by the rectangular aperture in front of the photomultiplier, covers the complete 50 mm x 50 mm filter face. By substitution of apertures in the direction of detection, entrainment from selected areas of the filters is analyzed. The light-sheet device operates with a continuous-wave laser and thus is able to detect complete entrainment rates.

The PM signal height corresponds to the drop size. Monodisperse droplets in the range of 300 - 600 µm, generated via vibrating piezoelectric orifice are inserted into the measurement volume for device calibration. For drop sizes detected with the light-sheet device, the scatter signals correlate to drop sizes squared, since the laws of geometric optics are valid. Thus, no ambiguities of signal height and corresponding sizes occur. From the calibration process, a lower detection limit of 170 µm, caused by minimal usable signal to noise ratio, and an upper detection limit of 2300 µm, caused by maximal detectable signal height, has been set.

The measurement of entrained droplet spectra is a very useful tool to study entrainment kinetics, i.e. the rate of formation and size of droplets as a function of air velocity, oil loading rate, filter specific parameters (porosity, fiber diameter) and oil properties (viscosity, surface tension).

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