Aerosol Concentration vs. Loading Rate as the Determining Parameter for the Pressure Drop of Oil Mist Filters

H.E. Kolb, J. Meyer and G. Kasper

Institut für Mechanische Verfahrenstechnik und Mechanik, Karlsruher Institut für Technologie, 76131 Karlsruhe, Germany
Keywords: filtration, coalescence filter, oil mist, pressure drop.
Presenting author email: eckhard.kolb@kit.edu

Submicron oil aerosols ("oil mist") are generated by a wide range of processes, such as metal cutting, engine crankcase ventilation, or the compression of gases. An efficient and commonly practiced way of capturing and removing oil mist is by fibrous filters media. During steady-state operation of a mist filter, captured aerosol is driven by the airflow toward the rear surface of the media, where it drains as a thin film through which the air has to break through. Maintaining this steady-state flow of coalesced liquid requires an additional "wet Δp" above and beyond the "dry Δp" of the media, which is composed of an internal contribution ("channel-Δp") required to "pump" liquid through the media – typically in distinct channel-like structures – plus a final steep "jump-Δp" required to overcome capillary retention forces and maintain the liquid drainage film on the surface. These mechanisms were first described in the Jump-and-Channel Model by Kampa et al (2014). For an illustration see Figure 1.

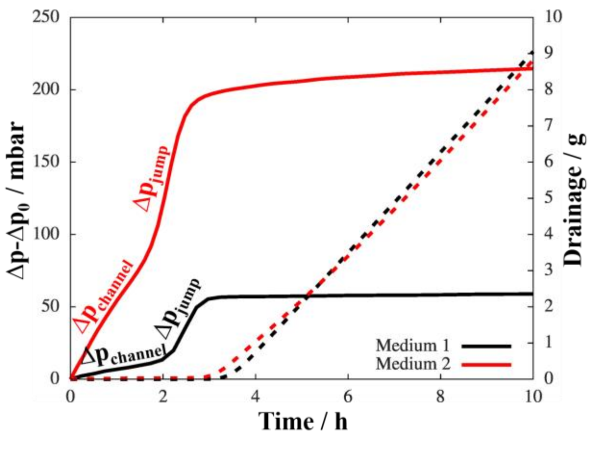

Fig. 1- Typical contributions of channel-Δp and jump-Δp to the pressure drop of an oil mist filter in operation.

While the jump-Δp is determined mostly by the structural properties of the filter media (Kampa, 2015; Kolb et al., 2015), the channel-Δp shows an additional strong dependence on operating parameters such as air flow velocity v, aerosol concentration c, and liquid loading rate c·v. Understanding and optimizing these parameters is key to minimizing the wet Δp.

The dependence of channel-Δp on these operating parameters is rather complex for liquid aerosol filtration, because v, c, and c·v each affect the internal liquid distribution (the channel structure) in their own ways, which are not generally understood yet. For example, a constant loading rate c·v can be achieved by an infinite set of combinations of v and c. Past investigations were based either on a fixed flow velocity v and variable concentration c (Contal et al., 2004), or on a fixed oil loading rate c·v (Kampa et al., 2015). Incidentally, the results do not agree with regard to effect of these parameters on the total Δp. A more detailed study on the effect of flow velocity v is still missing.

The present work concentrates on the effects of aerosol concentration c and oil loading rate on Δp for flow velocities ranging from 10 cm/s to 70 cm/s. Numerous experiments were carried out with multiple layers of wettable glass fiber media, which were loaded with submicron oil aerosol until well past steady-state. At the end of each experiment the global saturation per layer was measured. Also the individual layers were photographed and the local oil distribution (i.e. number and diameter of oil channels) was determined as a function operation conditions. The results show a significant effect of flow velocity on global and local saturation. The best correlation of channel-Δp with operating parameters was found for the oil loading rate.

Contal, P., J. Simao, D. Thomas, T. Frising, S. Callé, J.C. Appert-Collin & D. Bémer (2004). Aerosol Science, 35, 263-278.

Kampa, D., S. Wurster, J. Buzengeiger, J. Meyer, & Kasper, G. (2014). Int. J. Multiphase Flow, 58, 313-324.

Kampa, D., S. Wurster, J. Meyer, & Kasper, G. (2015). Chemical Engineering Science, 122, 150-160.

Kolb, H.E., S. Wurster, J. Meyer, & Kasper, G. (2015). *Aerosol Technology Conference*, Tampere, Finland.