

MACROSCOPIC THEORY OF AEROSOL NANOPARTICLES FILTRATION IN POLYDISPERSE FIBROUS FILTERS

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Classical theory of aerosol filtration is clearly formulated in the idealized case of a monodisperse filter, i.e., composed of fibers with the same diameter, but majority of real fibrous filters is significantly polydisperse and fine fibers are mixed together with thicker ones. The aim of this work is to extend the theory of depth filtration for such polydisperse filters. For this purpose two limiting macroscopic model were formulated first, namely, the Fully Segregated Flow Model (FSFM), in order to estimate an upper limit of aerosol penetration, and the Perfectly Mixed Flow Model (PMFM) – to calculate a lower limit of aerosol penetration through a filter. These two models were solved (PMFM – analytically, and FSFM – numerically) in the case of aerosol nanoparticles filtration in polydisperse fibrous filters having log-normal fiber diameter distribution. Then, the most general, Partially Segregated Flow Model (PSFM) was proposed as a linear combination of the two limiting models. Results of calculations obtained using the newly formulated models are compared with the ones predicted in a common way, based on a mean fiber diameter. Consequences of utilization of a mean fiber diameter only in designing polydisperse fibrous filters for removal of nanoparticles are discussed.

KEYWORDS: aerosol, fibrous filter, modeling, nanoparticles, penetration, polydispersity

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Preferred presentation format: oral