ACCOUNTING FOR FILTER MATERIAL HETEROGENEITIES IN FILTRATION SIMULATION

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The design of filter media is an important issue to meet the requirements of today's filtration processes. The media have to be optimized in terms of pressure loss, capturing efficiency, and dust holding capacity.

One well-known technique to reach these goals is the design of layered (or graded) filtering media. In order to distribute the dust more evenly over the depth of the medium, such a design usually combines relatively open prefilter material(s) with one or several fine filter layers downstream. However, such a design can lead to undesired effects, e.g. internal cake filtration. This occurs when particles penetrate the upstream layer but cannot enter (part of) the fine filter region downstream because the pores are too small. Thus, on the interface between the two layers, an internal cake is built up.

Another widely used technique to increase dust holding capacity and filter lifetime is the pleating of filter media. However, the manufacturing process can lead to heterogeneities in the filter media. Embossing, for example, leads to locally compressed areas with a higher solid volume fraction. Obviously, this introduces variations of the local flow resistivity in the filter pleat which are expected to influence both fluid flow and particle deposition.

This study is devoted to the handling of such material heterogeneities in filtration simulation on the macroscopic scale. To this end, a multiscale approach is taken for both applications: Simulations on the microstructure of the filter material provide the corresponding permeability and efficiency properties. In the case of the pleated filter, CT-images are used to create a simulation model for the distribution of the filter material which is translated into a permeability distribution. The effective properties obtained from the microstructures are used in the macroscopic simulation to predict the filter lifetime.

It is shown that by accounting for heterogeneities, corresponding simulations are able to provide more realistic results.