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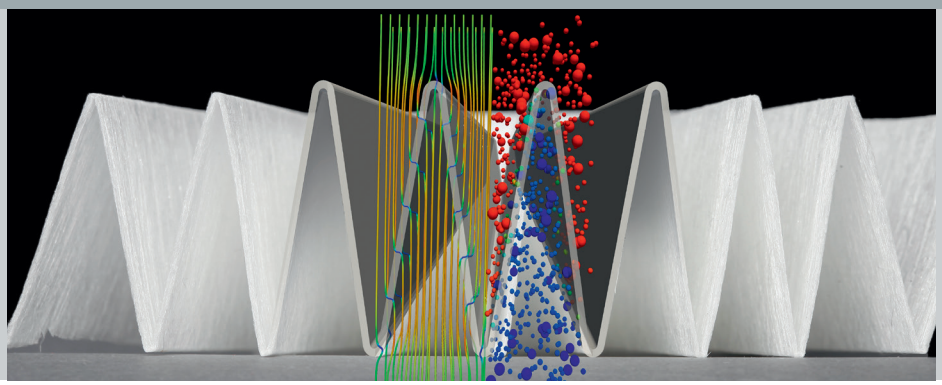

COMPUTER-AIDED OPTIMIZATION OF FILTER PLEATS

Pleated filters are a widely used and intensively studied design concept in filtration.

Even in situations of confined construction spaces and other constraints, many degrees of freedom remain for the design such as the length, the geometric shaping and the packing density (or width of) of the filter pleats.

A purely experimental approach for the identification of an optimal design for a given application can become very time-consuming and costly. In order to accelerate the process, Fraunhofer ITWM develops models and simulation methods for the computer-aided optimization of filter pleats.

Clean flow regime

For the identification of the pleat design with smallest initial differential pressure, both analytical methods and CFD (Computational Fluid Dynamics) are available. The approach based on computer simulations offers the additional feature to find the pleat shape with small initial differential pressure drop and highest degree of uniformity of the fluid flow at the media surface.

Optimization of filtration properties

In terms of filter performance, the pleat shape should ensure a long lifetime and high dust holding capacity (DHC).

For the computer-aided prediction of these properties, we develop

- efficiency models for the numerical simulation of the loading of the pleat (depth and cake filtration),
- permeability models to account for the change of the flow resistivity during simulation and therefore, the evolution of the differential pressure.

Fraunhofer-Institut für Techno- und Wirtschaftsmathematik ITWM

Fraunhofer-Platz 1
67663 Kaiserslautern
Germany

Contact
Dr. Ralf Kirsch
Phone +49 631 31600-4695
ralf.kirsch@itwm.fraunhofer.de

www.itwm.fraunhofer.de

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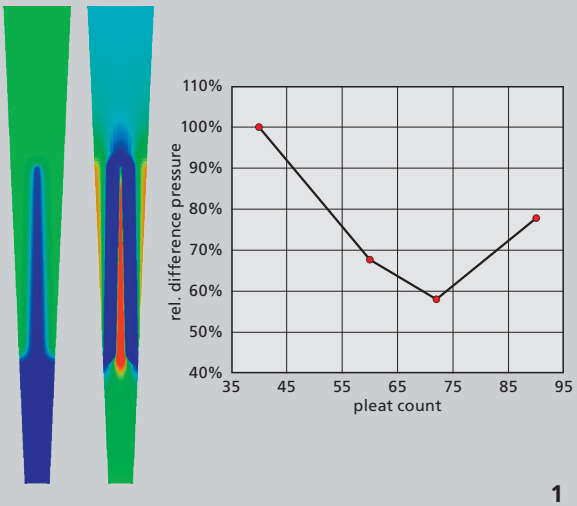

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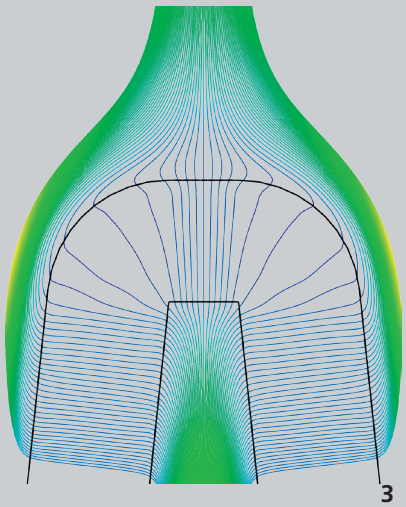

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1 *Optimal pleat count for clean pleated filter. Left: Computed distributions of fluid pressure and flow speed. Right: Differential pressure for different pleat counts*

2 *Reconstruction of CT image of pleat tip with embossing*

3 *Streamline representation of computed flow speed in pleat tip with embossing*

The model parameters can be deduced from flat sheet measurements performed for the filter media used in the pleated filter. In particular, by performing computational what-if studies for multi-layered media, optimal choices for the selection of filtering materials are possible without the need for real-world prototypes.

Influence of pleating process on filter performance

In most cases, the pleating process causes deformations of the filter material, especially in the tip and the bottom of the pleat. This leads to local variations of flow resistance and filtering efficiency. Due to this heterogeneity, a pleated filter and a flat sheet of the same area can differ a lot in terms of DHC and lifetime.

Based on the material distribution in real-word filter pleats, Fraunhofer ITWM develops models and simulation workflows to account for manufacturing effects. A major aspect is the relationship between the variation of the filter material fraction and the corresponding distribution of permeability and efficiency properties.

Using these enhanced models in efficiency simulations for pleated filters leads to more realistic and reliable predictions of filter lifetime. In addition, the influence of local material compression on the filter performance can give hints on the improvement of the pleating process itself.

We offer

Modeling and simulation:

- Specialized simulation software for flow and filtration
- Analytical and numerical modeling of pressure loss depending on pleat length and spacing
- Simulation studies as a service
- Consulting for the establishment of in-house simulation of filter pleats and integration in the workflow of the product development

Experimental services and quality control:

- Computerized tomography of filter pleats and/or specific regions of interest
- Taylor-made online quality control of pleat shapes based on image processing