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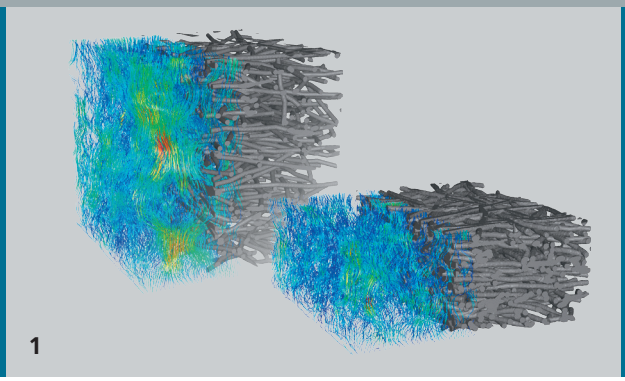
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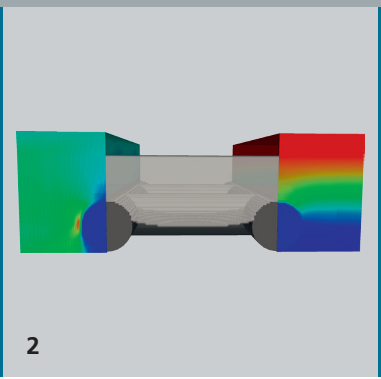
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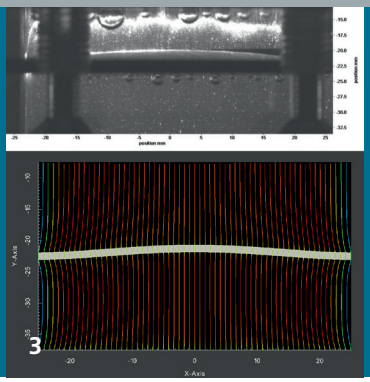
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FiltEST

FeelMath

COUPLING OF FLUID AND STRUCTURAL MECHANICS FOR FILTER MEDIA AND ELEMENTS

Today's quality demands on innovative filtering media and filter elements involve more than the classical criteria like low differential pressure, high filtration efficiency and dirt holding capacity. In more and more application areas, the mechanical stability of the medium and the influence of deformations on the filtration process cannot be neglected any longer. Furthermore, permanent deformations are created during the manufacturing process (e. g. compaction and stretching when filter media are pleated). There are applications where deformations of the housing can become relevant, too.

A lot of research and development activities at Fraunhofer ITWM are dedicated to a better understanding, appropriate modeling and realistic numerical simulation of the deformation of porous materials. By taking into account deformations of the filter media, computer simulations are able to cover a much wider range of real-world scenarios.

The main benefit for designers and media manufacturers is the reduction of developmental time, in particular:

- Identification of suitable filtering materials for more stable filtering media.
- Identification of optimal binder material and favourable distribution.
- A priori study of effects like pleat crowding and pleat collapse.
- Computer-aided design and arrangement of supporting structures such as meshes and ribs.
- Optimization of the design of the housing with respect to both stability and flow resistivity.

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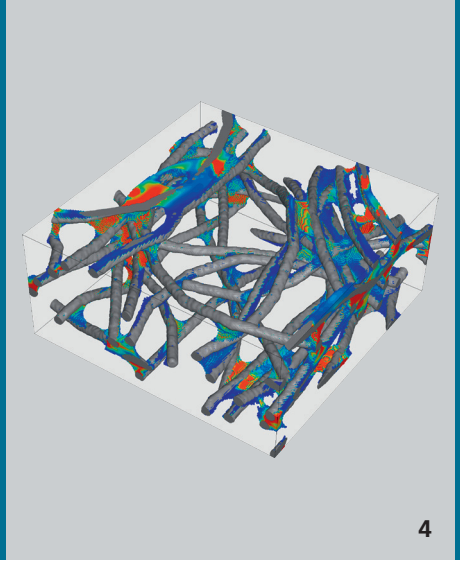

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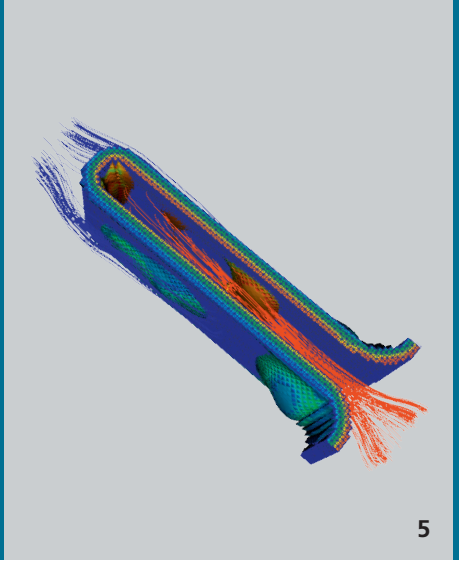

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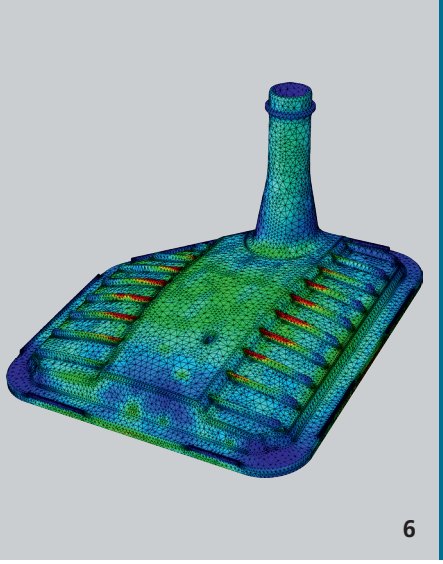

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Modeling and simulation of Fluid-Porous-Structure Interaction (FPSI)

Having chosen suitable media, filter element designers are confronted with the challenge to find a favorable way to fixate and stabilize the filtering media in the element's housing and/or choosing an optimal pleat count. One of the major goals is to identify an optimal trade-off between low flow resistance, large filtration area and high mechanical robustness of the design.

In order to assist filter element designers in this difficult task, the interaction of the deformable porous/mesh with the fluid can be simulated using specialized mathematical models and numerical algorithms.

The research related to this matter such as experimental investigation, mathematical modeling and development of numerical algorithms has been done in collaboration with renowned research institutes.

These joint efforts form the scientific basis for the development of effective and precise simulation tools for dealing with FPSI.

Combined approach for the simulation of flow, efficiency and robustness of filtering devices

Fraunhofer ITWM offers the following services for an integrated computer-aided optimization of filter elements and/or their components:

- Computation of effective mechanical properties of filtering media
- Robust computation of large deformations. Simulation of local damage
- Computation of effective permeabilities of filter media in both initial and deformed state
- Import of CAD geometries or generation of filter pleat shapes, entire panels or cartridges. Import of CAD geometries of filter element housings
- Simulation of the fluid flow through housing and filtering media with filtration efficiency
- Fluid-Porous-Structure Interaction (FPSI) simulations for advanced studies of the flow-induced deformation of the filtering media
- Stress-strain analysis of the filter element's housing based on the flow-induced pressure distribution
- Visualization of the results and export to worksheet formats for post-processing

1 *Streamlines of fluid flow through a filter medium in initial (left) and deformed (right) state*

2 *Flow speed (left) and pressure distribution (right) for a compressed nonwoven filter material with support mesh*

3 *Comparison of real and simulated deformation of a flat medium in a channel flow (Experiment by LFMA, Lyon)*

4 *Visualization of the distribution of the von Mises stress in the binder for a nonwoven under mechanical load*

5 *Fluid-Porous-Structure Interaction (FPSI): Flow pressure-induced deformation of a filter pleat*

6 *Stresses induced by fluid pressure on a filter housing (Geometry example courtesy of IBS FILTRAN).*