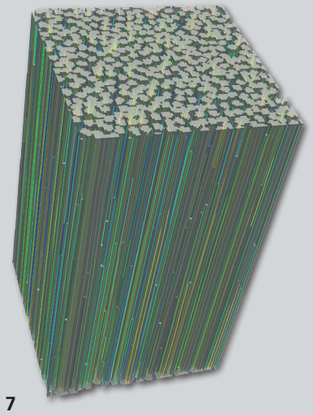

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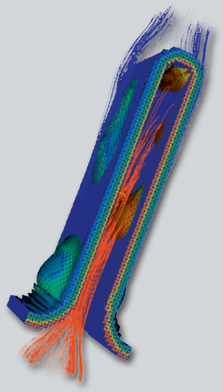

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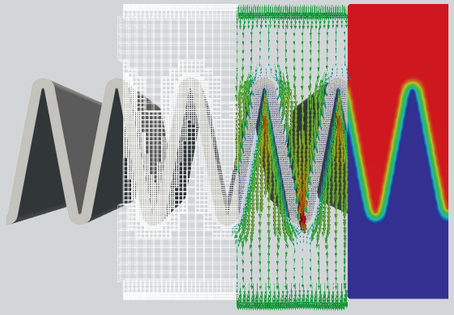

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7 Flow through the channels ("fingers") of an microfiltration membrane

8 Flow-induced deformation of a filter pleat

9 Geometry, adaptive grid, computed velocity field and pressure for a pleated panel

Modelling and simulation of filters at various scales

Modern filters have to meet highest quality standards and therefore, their design is both challenging and costly. Computer simulations can assist to reduce both the duration of the design period and the testing phase of prototypes. The simulation of filters is also a challenge, since filtration involves processes at length scales that often differ by several orders of magnitude (ranging from the scale of the particles/fibers up the housing dimensions).

On all these scales, appropriate mathematical models are required to describe
- the capturing of particles,
- the fluid flow through the medium and
- the flow in the filter housing.

Furthermore, in order to get the full picture of the filtration process, the models valid for each scale are combined in a coupled simulation approach. Finally, efficient and robust solution methods have to be implemented to give reliable results.

Our competencies

For more than 10 years, Fraunhofer ITWM has developed models, methods and software tools for the simulation of filtration. Parts of this work have been done in close collaboration with internationally renowned experts in the field and partners from the industry.

Based on our expertise and experience, we can offer
- Mathematical modeling of filtration and separation processes on both the microscopic and macroscopic scale and the coupling of different scales
- Virtual design of filter media with simulation of the material's filtration properties
- Optimization methods for the geometry of filter media and elements
- Modeling and simulation of deformation of filtering media, especially Fluid-Porous-Structure Interaction
- Simulation of the performance of entire filter elements incl. standardized efficiency tests
- User-friendly software solutions for flow and filtration simulation, effective visualization of the results

Our partner

Math2Market GmbH is a 2011 spin-off from Fraunhofer ITWM. Math2Market owns, markets, and develops GeoDict for generation of micro-scale geometric material models and property prediction in close cooperation with ITWM.

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sms_flyer_filtration tools from nano to macro_EN

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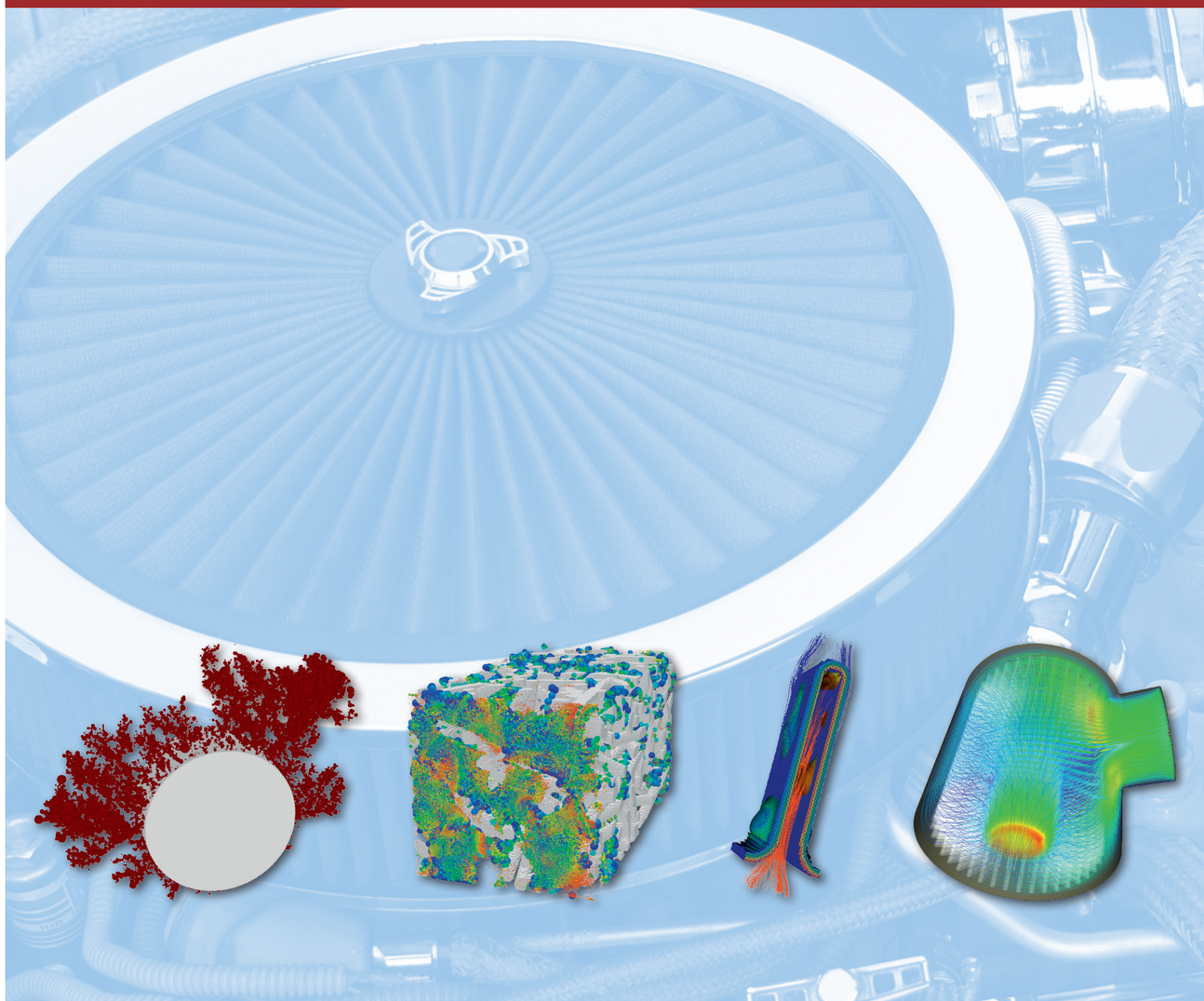
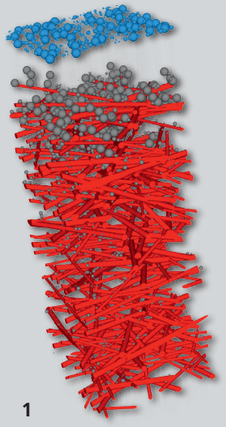
FROM NANO TO MACRO FILTRATION SIMULATION TOOLS





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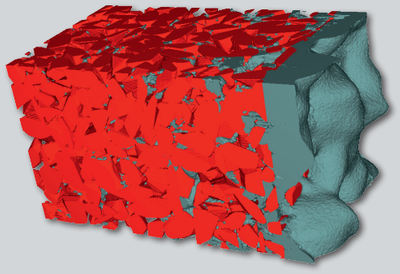

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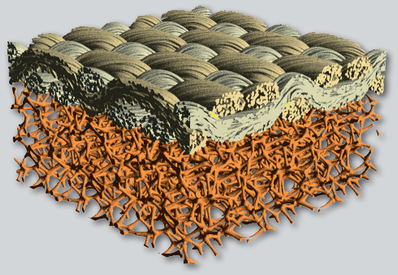

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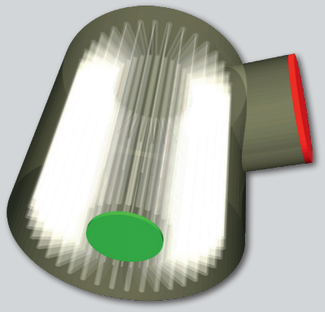
FILTER DICT
Innovation in Filtration



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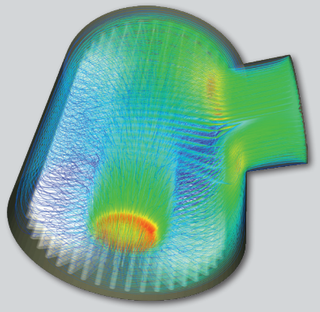

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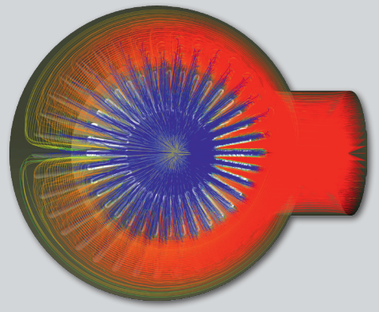

6

FiltEST

1 *Filtration in oil filter (FiberGeo, FilterDict)*

2 *Soot filtration simulation*

3 *Two-layered micro-scale filter media*

Understanding the filtration process in filter media and single pleats

Pressure drop in filters, filter efficiency and filter life time depend on the interaction of filter media, fluid, and particles. The geometry generating modules of the GeoDict software in combination with its FilterDict module are essential to improve filters by detailed 3d modeling of the filtration process:

- Import and modeling of the detailed geometry of filter media and pleats
- Modeling of motion and deposition of particles in filter media and pleats
- Modeling of depth filtration, cake filtration, and the transition in filter media and pleats

The powerful modeling capabilities of GeoDict reveal the geometry and properties of existing filters and explore hypothetical filtration scenarios. Fast and cost-effective modeling experiments, run in the computer, guide you to innovative real prototypes that can be manufactured and tried out.

Filter media can be

- modeled nonwoven and papers
- modeled ceramics and sintered metal
- modeled woven
- modeled open-cell foams
- imported micro-CT models

Customers' uses of GeoDict and its modules include

- Diesel particulate filters
- Automotive air, oil and fuel filters
- Membranes
- Fuel cells
- Sludge filtration
- Oil production

Results of micro-scale simulations can be the input parameters in filter-scale simulations.

Simulation of filter elements

The key challenge in designing complete filter elements is to find a good compromise between the interacting performance factors:

- Pressure drop
- Filtration efficiency
- Dirt-hold capacity

Simulations with an efficient CFD solver and appropriate models for the filtration process enable engineers to determine

- Flow velocity field
- Pressure distribution
- Filtration efficiency

Based on this information, a reliable assessment of the quality of a filter element design is already possible at a very early stage of the development.

An example for such software is FiltEST (Filter Element Simulation Toolbox) which is developed by Fraunhofer ITWM. This software collection covers almost all of the developmental process of an element, incl. the import of CAD geometries and the export of the simulation results for effective visualization and further post-processing.

The simulation of pleated cartridge filters is a special challenge due to the complexity of the shape of the medium, and due to the possible deflection of the pleats. Fraunhofer ITWM offers services and tools that assist engineers in

- Determining the optimal number and size the of pleats for clean regimes
- Determining optimal number and size of pleats for the loading stage
- Determining optimal number and size of pleats with respect to possible pleat deflection and crowding for clean regimes
- Studying the deflection of the filtering medium under different loadings
- Optimal shaping and sizing of the filter element housing

4 *A round pleated cartridge element with inlet pipe*

5 *FiltEST flow simulation: Streamline visualization of the velocity field*

6 *FiltEST efficiency simulation: Streamline visualization of the concentration of the dissolved particles*