

## FiltEST

## FILTER ELEMENT SIMULATION TOOLBOX

The optimization of filter element designs is a challenging task due to increasing requirements concerning the filtration efficiency, dirt holding capacity and service life. In more and more application areas, purely empirical product development based on the testing of real-world prototypes is recognized as very time-consuming and costly.

- simulation of the fluid flow through the housing and the filtering media,
- simulation of the transport of particles and their deposition,
- and the computation of the evolution of the permeability distribution and the total differential pressure caused by the loading.

### More than a decade of expertise in modeling and simulation of filtration

In order to accelerate the development phase and to assist engineers in finding an optimal design, Fraunhofer ITWM develops the Filter Element Simulation Toolbox (FiltEST). More than a decade of expertise and experience in modeling and simulation of filtration processes are combined in this simulation software.

FiltEST uses specialized models and numerical methods for the

The filtration models used in FiltEST are able to cover a range of dynamical efficiency behavior such as clogging of the media and release (reemission, reentrainment) of captured particles. The model parameters for filtration and permeability evolution can be obtained from standard test procedures for the filter media. In many cases, no additional experimental effort is necessary for the setup of the models.

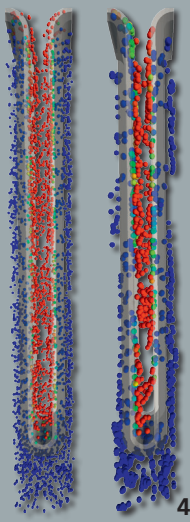
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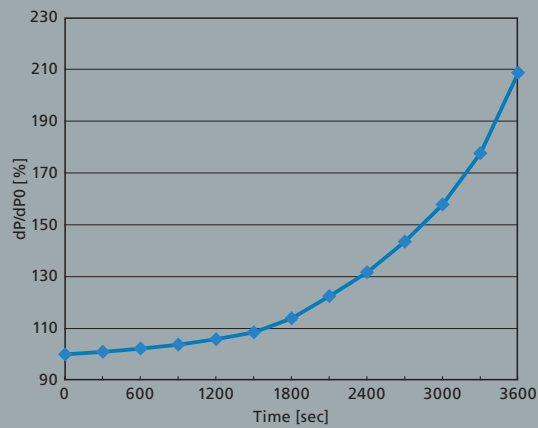
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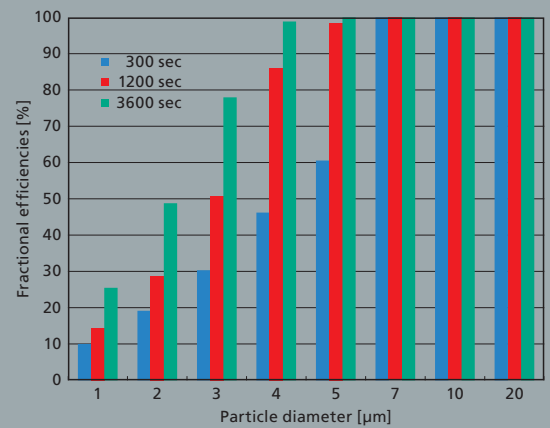
[www.itwm.fraunhofer.de/filttest](http://www.itwm.fraunhofer.de/filttest)



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## Optimization of filter element designs by what-if simulation studies

FiltEST provides flexible “virtual” test stands for both single-pass and multi-pass tests. Thanks to the generic implementation of these virtual test stands, the simulation toolbox is able to cover a broad range of standardized efficiency tests. Furthermore, the test dust in the simulation can consist of several particle sizes (“channels”) in order to compute fractional filtration efficiencies.

These features bring the simulation closer to reality and simplify the comparison of measured filter performance with the computed results.

Equipped with these possibilities, product developers can benefit from the variation of various design parameters in order to find their optimal combination. FiltEST allows for the study of the effects of such variations that would require substantial efforts when applied to real-world prototypes. Amongst others, this includes the variation of

- geometrical features of the filter element housing, shaping of supporting structures (e.g. ribs),
- the geometry of the filter media (e.g. pleat packing density, pleat shape),
- the filtering materials themselves, combinations of them and in case of multi-layered media, the thickness of individual layers.

To sum up, FiltEST enables product developers to evaluate and compare different filter designs before the prototyping stage.

## Integration in the CAE workflow and visualization of results

FiltEST currently supports the import of CAD data in STL format as input for the built-in grid generator. The results of efficiency simulations are stored in text-based tables which can be easily imported by any common worksheet software (e.g. MS Excel®, OpenOffice, LibreOffice) for further post-processing (e.g. creation of data charts).

The visualization data are stored in the open VTK format and can be viewed either using the built-in viewer tool or open-source software (e.g. Paraview, VisIt).

The 3D visualization of the velocity field, the distribution of pressure, particle concentrations and retentions puts the user in a position to “look inside” the filter element during operation, giving additional information for further improvement of the design.

## Coupling with structural mechanics code for porous materials

FiltEST simulations can be coupled with FeelMath, a very efficient simulation software for the structural mechanics of composite and porous materials, developed at Fraunhofer ITWM. The coupled simulations deliver further insight into the complex interplay between flow properties (e.g. permeability) and mechanical loads (e.g. compression) of filter media.

**1** Cylindrical housing with round pleated filter medium, side inlet (red) and central outlet at the bottom (green)

**2** Numerical simulation of the flow through the filter element: Streamline representation of the fluid flow speed

**3** Efficiency simulation: Visualization of the local particle concentration

**4** Filter pleat with two different media layers: Concentration distribution of small (left) and large (right) particles. Red indicates high local concentration, blue stands for low concentration.

**5** Relative pressure drop vs. time during loading (chart created from simulation results)

**6** Evolution of fractional efficiencies (bar chart created from simulation results)