Microstructure Simulation of Virtual Woven Filter Media

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Introduction

aim: understand the interplay of geometrical, flow and filtration properties of woven filter media

$\Rightarrow$ optimization of the product

method: reveal the interplay by means of computer simulation

- generate / characterize filter media with GeoDict
- generation of woven structures with WeaveGeo
- simulation of porosity / flow / filtration processes

$\Rightarrow$ shorten the optimization process / reduce its cost.

examples: metal wire meshes and protective clothing

- use tomography / measured parameters to generate a model
- compare simulations / measurements

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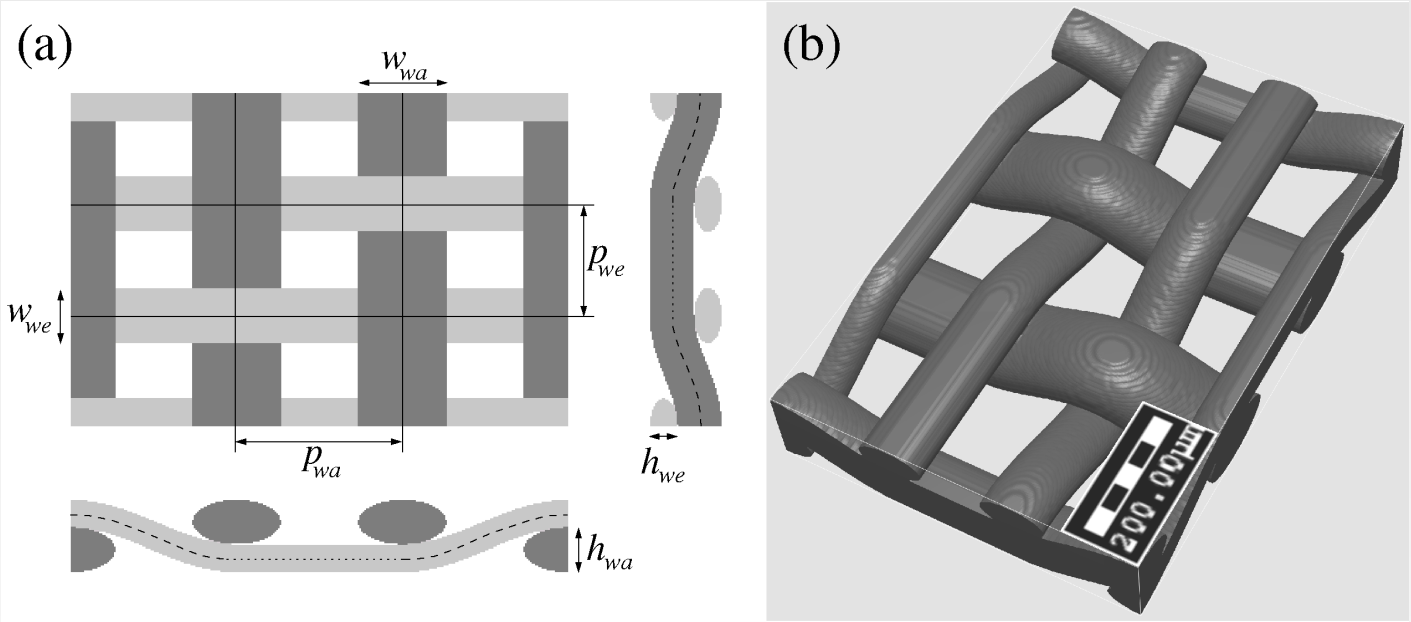
Generation of Virtual Woven Filter Media - 1



- weave diagram: plain weave, twill weave, satin weave ...
- weave parameters: pitch p, thread width w and height h

  $\Rightarrow$ virtual 3D model of the weave geometry

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Generation of Virtual Woven Filter Media - 2

shape variations:

- broadening of the threads at the float intervals
- lateral deformation of the threads
- different bending of warp / weft threads (crank factor)
- stiffness of the threads
- reduction of the amplitude of the vertical thread oscillation

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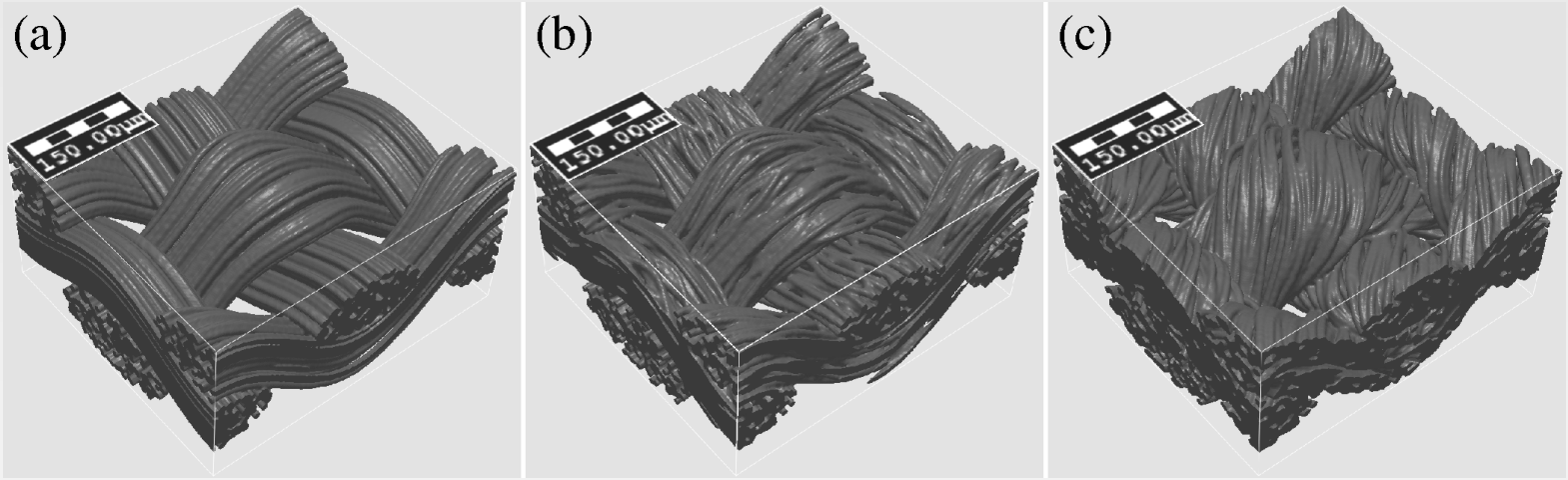
Generation of Virtual Woven Filter Media - 3



multifilament weaves:

- filaments are randomly distributed over the wire cross-section
- filaments are packed as dense as possible without overlap
- random change of the filament positions in the threads
- the filaments of multifilament weaves may be twisted

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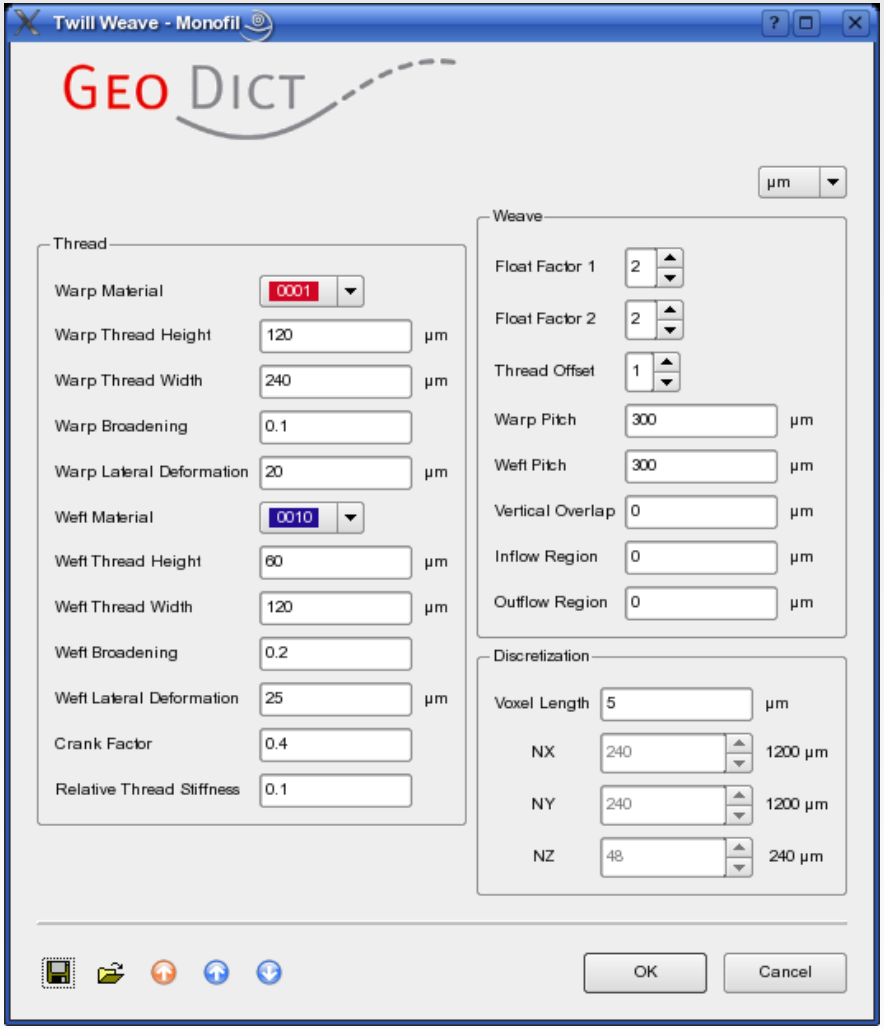
Generation of Virtual Woven Filter Media - 4



GeoDict module WeaveGeo:

- generates plain, twill and satin weaves
- generates mono- and multifil weaves
- generates dutch weaves

GeoDict:

- creates voxel geometries
- provides tools to simulate material properties
- Flow-, Filter-, PoroDict, ...

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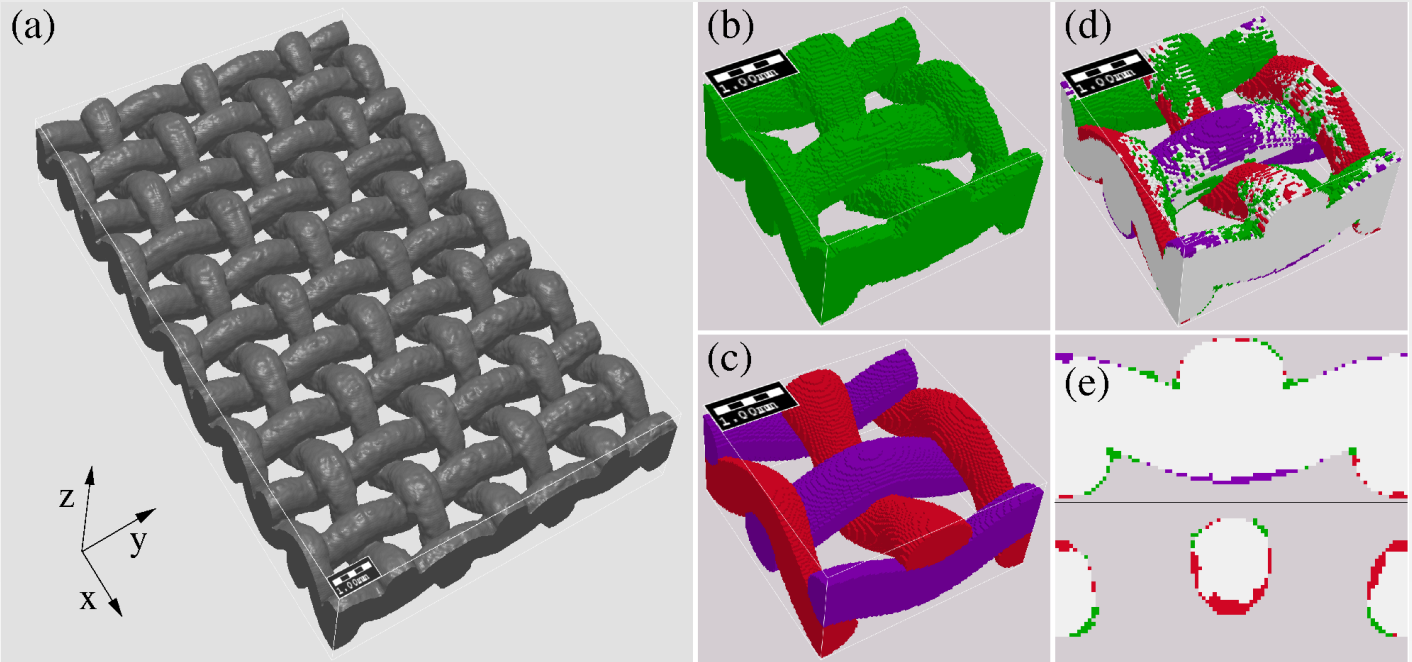
Metal Wire Meshes - 1



- binarize a mesh tomography (GKD - Gebr. Kufferath AG)
- find the mesh parameters
- generate a virtual mesh model
- generate a difference image

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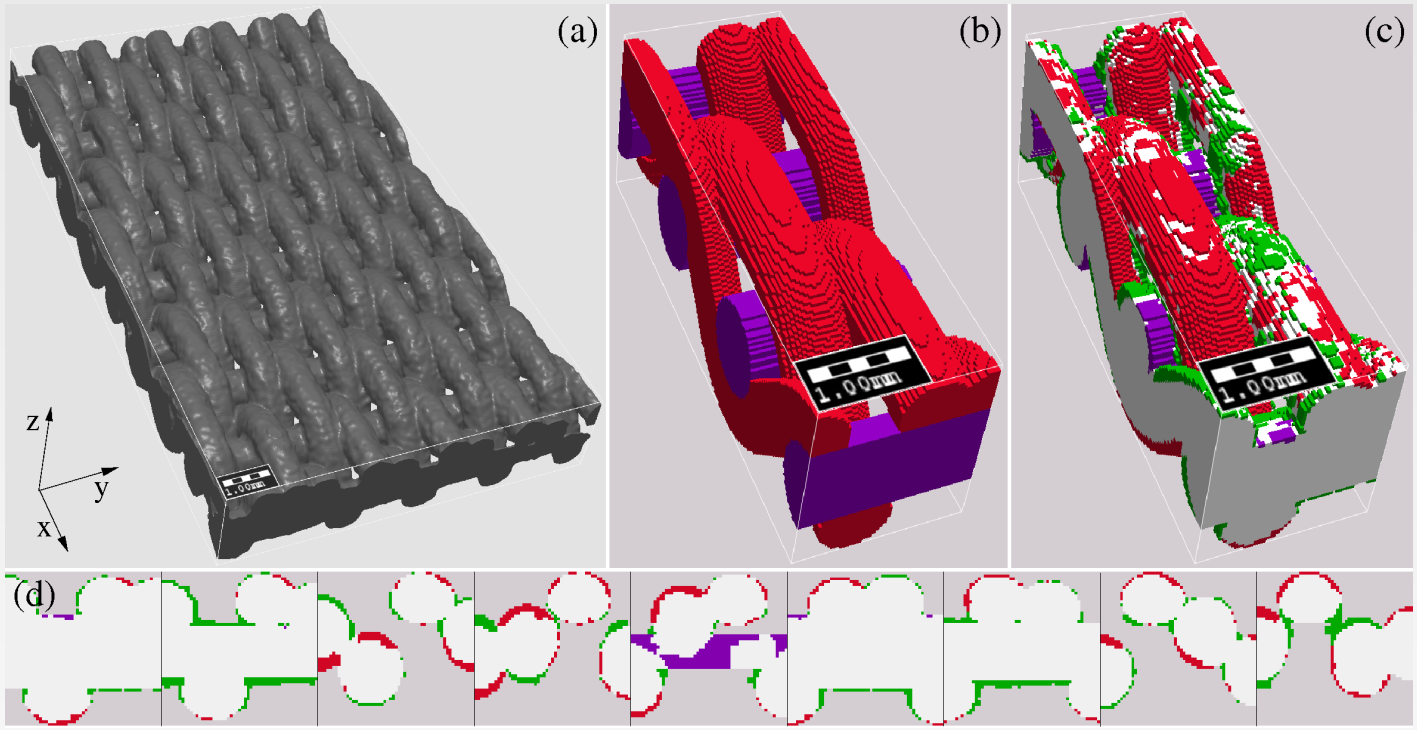
Metal Wire Meshes - 2



comparison tomography / model (done for 12 meshes):

- good agreement between the geometries ($\approx 10\%$)
- good agreement of the simulations (largest particle, flow, ...)

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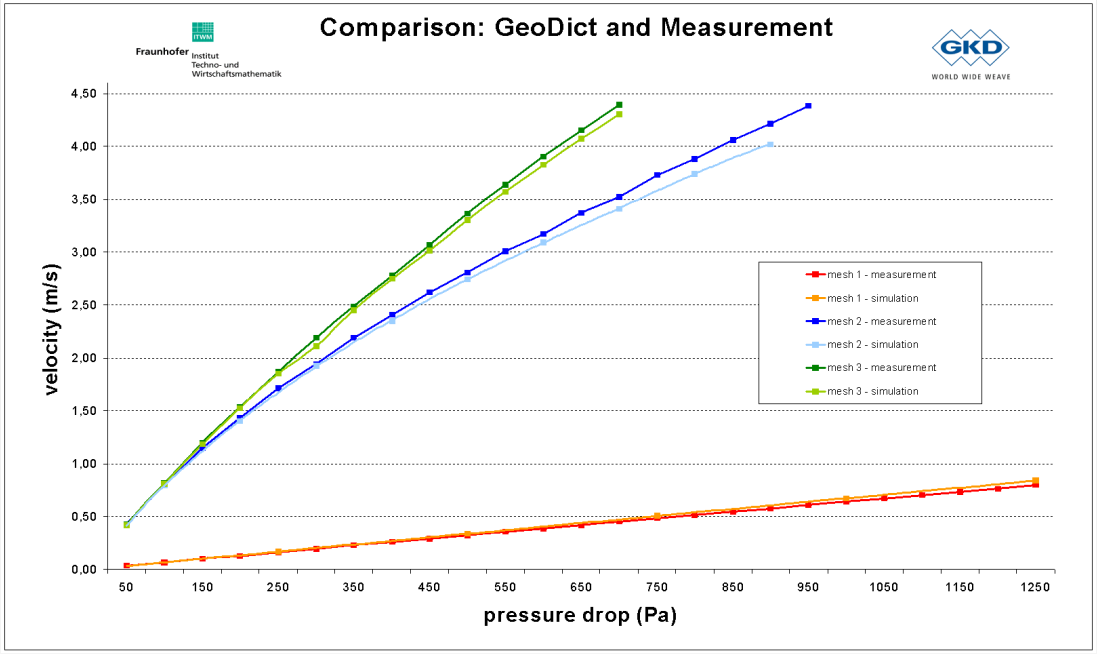
Metal Wire Meshes - 3



velocity dependent pressure drop for perfusion with air, comparison between experiment and simulation:

- models generated with easy to measure parameters
- the difference experiment / simulation $< 4\%$

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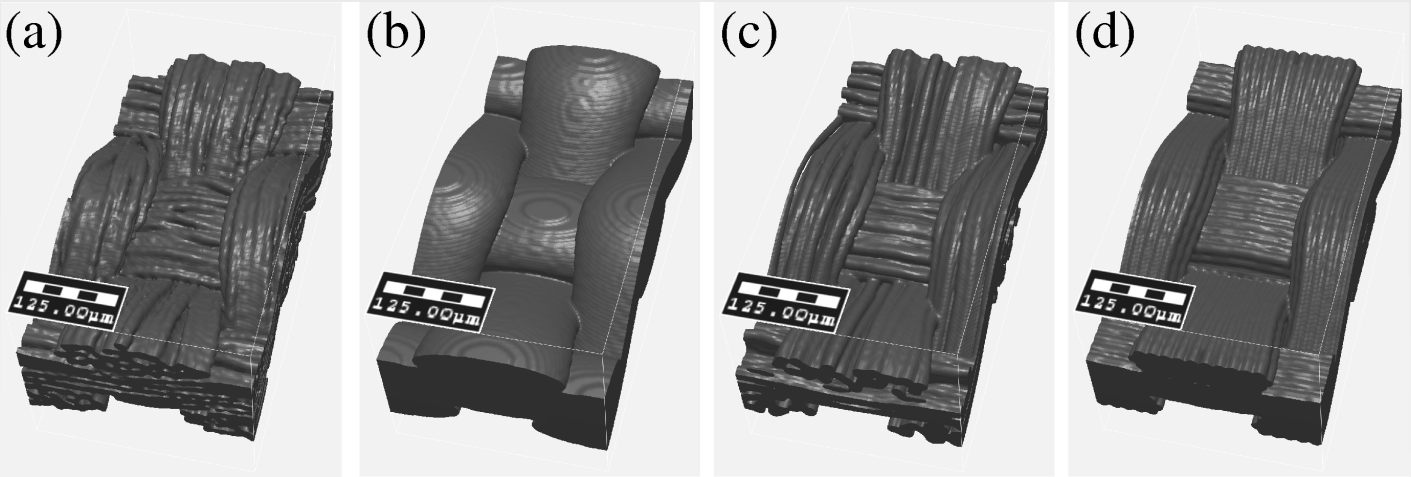
Protective Clothing - 1



the clothing is a very dense plain weave (Institut für Textil- und Bekleidungstechnik)

generate weave models:

- model 1: monofilament weave, only the form of the threads
- model 2: random multifilament weave
- model 3: regular multifilament weave, filaments packed dense

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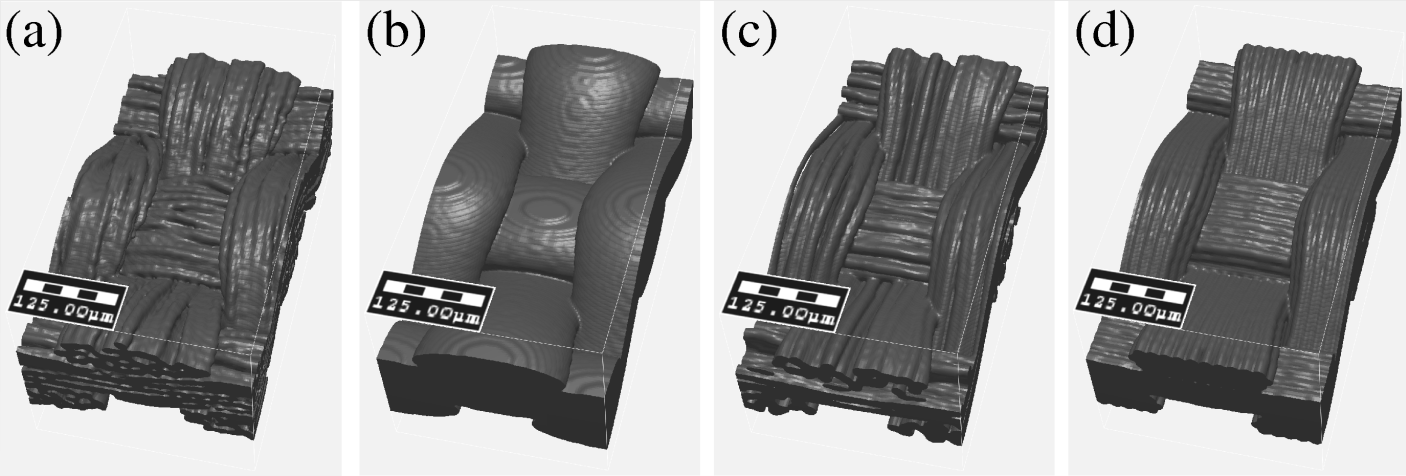
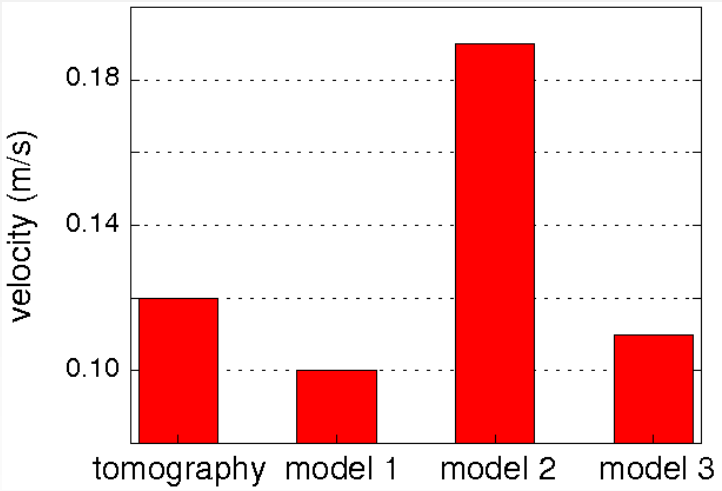
Protective Clothing - 2





air perfusion with $\Delta p = 200Pa$

- small part of the flow through the threads (permeability of the threads)
- model 3 is a good approx. (add small random filament movement)

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Conclusions

- virtual monofilament / multifilamant models are in very good agreement with real metal wire meshes / protective clothing
- simulations of pressure drop / largest penetrating particle on the geometry models are in good agreement with simulations on corresponding tomographies
- simulations on the geometry models are in very good agreement with measurements (monofilament)

the advantages of the use of GeoDict:

- easy and precise generation of meshes / prediction of mesh parameters
- visualization of complex meshes / simulation results

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E. Glatt, S. Rief, A. Wiegmann, M. Knefel and E. Wegenke. Struktur und Druckverlust realer und virtueller Drahtgewebe, F&S 23(2): 61-65 (2009)

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