

## A Case Study of Realistic Two-Scale Modeling of Water Permeability in Fibrous Media

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**Abstract:** There are several 3-D analytical models available for predicting the permeability of fibrous media. These models are developed based on the assumption that the medium is homogeneous with fibers oriented either in one specific direction, randomly oriented in the plane of the material, or isotropically oriented in a 3-D space. Unlike the homogeneous geometries normally considered for modeling, real media have a rather inhomogeneous Solid Volume Fraction (SVF), fiber orientations, and/or diameters. The presence of such non-uniformities in a real medium renders the models' predictions inaccurate. Sectioning-imaging, MRI imaging, or tomographic methods are often used to obtain a 3-D image of the real media for the purpose of calculating the permeability. These techniques, however, require extensive computational resources making the simulations limited to very small sub-domains. To circumvent this problem (required computational memory), a two-scale modeling approach is proposed that allowed modeling the entire thickness of a typical hydroentangled fabric on a personal computer. In particular, the micro-scale water permeability of a carded, hydroentangled nonwoven is computed via a finite difference CFD code, GeoDict, by using 3-D reconstructed microstructures obtained from Digital Volumetric Imaging (DVI). The resulting permeability tensors are then used in a lumped porous media model developed by Fluent Inc. for simulating water flow through the entire thickness of the material and the calculation of effective permeability. The modeling strategy presented in this study, is not limited to the case considered here and can be applied to different porous materials.

**Keywords:** CFD simulation, 3-D imaging, Permeability, Fibrous materials, Fiber, Nonwovens

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