S3.5.1 MICRO-SCALE MODELING OF FLOW BEHAVIOR THROUGH NONWOVENS: COUPLED FLUID-STRUCTURE INTERACTION

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Design process of nonwoven materials in the light of their ultimate use is troublesome and quite challenging due to their complex microstructure composed of randomly distributed and curved fibers. Within the design process, numerical tools, such as Finite Element Analysis and Computational Fluid Dynamics, are facilitated to predict their mechanical performance under service conditions before manufacturing them. This paper presents a computational and experimental framework to calculate flow properties of some selected nonwovens with various microstructural control parameters in compression and free stress state, i.e. no compression.

Randomly distributed fiber-networks with microscopic properties such as fibre curvature were generated through a novel parametric 3D finite element model. This novel model was implemented for through-air bonded nonwovens in this research and fiber-to-fiber interactions were incorporated.

The source of compression might be an external load or flow field itself, i.e. direct coupling of flow behavior and nonwoven structure. For the first case, to compute the effect of microstructural changes due to compression on flow properties such as pressure drop and air permeability, the nonwoven networks were compressed within the framework of finite element. Subsequently, the flow properties of their compressed and stress free forms were calculated through CFD simulations. For the second case, the flow stress field around the fibers and deformation on fibers were exchanged at every time increment. Computational model was validated through permeability test results in good correlations. Furthermore, the novel parametric model enabled to investigate the influence of isotropic/anisotropic fiber diameter distributions and imperfections on fiber cross-sections.