Simulating Permeability of Calendered Fibrous Structures

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A large portion of nonwoven fibrous materials are consolidated by means of hot compaction rolls, i.e., hot calenders. Calendering causes significant increase in the Solid Volume Fraction (SVF) of the media and therefore, affects their permeability. To our knowledge, no systematic work has been dedicated to study the permeability of the calendered materials.

During the past decades, there have been many pioneering works aimed at understanding parameters that influence the permeability of a fibrous material. In all the above studies permeability is calculated for a medium with fixed geometrical properties. Our objective in this paper is to simulate the permeability of the nonwoven materials before and after calendering process. In this study, virtual nonwoven structures are generated and then compressed from top and bottom to resemble hot calendering process. These simulations start with generating uncompressed structures according to the desired dimensionless basis weights. Modeling bending of the fibers at the crossovers is geometrically complicated. The fibers on the outside of the web are pushed toward the inside, bending and moving the fibers in their way. The bending is regulated by a parameter which resembles the stiffness of the fibers. The simulation procedure is highly recursive, propagating the compression from contact point to contact point throughout the web.

Figure 1 shows an example of our virtually calendered spun-bonded nonwoven fabrics. The air flow field throughout these compressed structures is solved using Computational Fluid Dynamics tools and their dimensionless permeability is calculated (see Figure 2).

The dimensionless permeability of the calendered media is computed and reported for different degrees of compression (different SVFs). Results of our simulations are compared with experiment (reported in our previous research note) and a good agreement is observed.

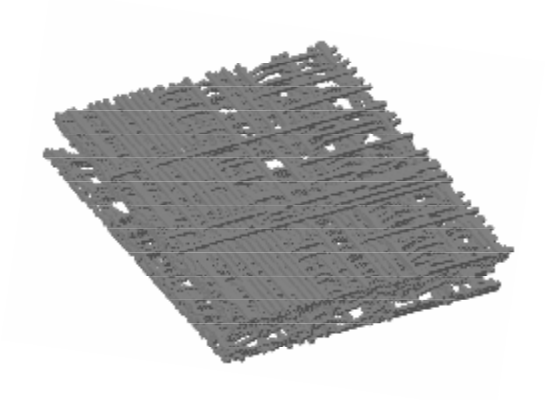

Figure 1: an example of our virtually calendered spun-bonded nonwoven fabrics.

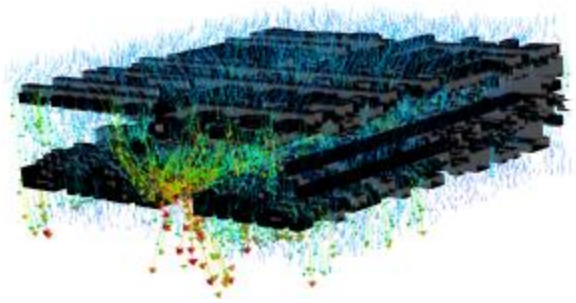

Figure 2: Air flow field through a calendered nonwoven fabric.

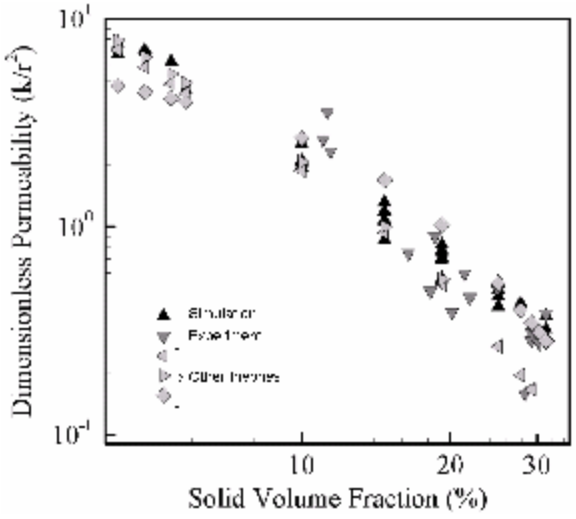

Figure 3: Comparison between our simulations, experiment, and other theories.

To learn more about this research contact us at nonwoven@ncsu.edu