CHARACTERIZATION OF INPUT PARAMETERS FOR NUMERICAL MODELING OF NONWOVEN MATERIALS

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Various textile and filtration products in many sectors, such as, hygiene, health care, civil engineering and automotive are partially or thoroughly made up of nonwovens. Understanding and characterization of mechanical behavior of nonwoven materials is challenging due to their complex microstructure composed of polymer based randomly distributed fibers bonded together with thermal, mechanical or chemical methods. During the design process of nonwoven products, strong and reliable numerical tools, such as, Finite Element Method can be facilitated to simulate their real-life performance under service conditions [1]. There are two main numerical modeling strategies employed in the analysis of mechanical behavior of nonwoven materials using finite element analysis based on continuous and discontinuous techniques [1].

This study focuses on determination and characterization of input parameters for the development of numerical models for the simulation of mechanical response of nonwovens using continuous or discontinuous modeling techniques. Initially, tensile and relaxation tests are performed on single fibers (extracted from nonwoven fabrics) to obtain elastic, plastic, damage and time-dependent mechanical response of fibers. Fiber curl can be characterized using SEM or X-ray micro CT images and implemented either implicitly using the elastic portion of the tensile curve in the continuous model or explicitly using a sinusoidal function in the discontinuous model. Random orientation of individual fibers is characterized in terms of the orientation distribution function (ODF). An algorithm, based on the Hough transform, was developed [2] to compute the ODF and calculate the structure's anisotropy based on SEM or X-ray micro CT image of fiber matrix. The nonwoven fabric can modele as an assembly of two regions, namely, bond points and a fiber matrix, having distinct mechanical properties. Bond points are treated as a deformable composite material in both continuous and discontinuous modeling strategies. On the other hand, the fiber matrix is treated as a composite membrane structure having low stiffness in thickness direction in continuous modeling technique and explicit fiber-by-fiber modeling in discontinuous modeling technique. A second algorithm was developed to calculate the anisotropic material properties of these regions based on these input parameters and manufacturing parameters. The algorithms can be used in numerical modeling as well as product development and optimization of nonwovens.

Keywords: Fibrous materials, Nonwovens, Model Parameters, Characterization, Orientation Distribution Function, Relaxation, Tensile Test, Fiber Curl, Hough Transform

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