Modelling Simul. Mater. Sci. Eng. **15** (2007) 855–868 doi:10.1088/0965-0393/15/8/003

Simulating through-plane permeability of fibrous materials with different fiber lengths

Q Wang[1], **B Maze**[1], **H Vahedi Tafreshi**[2,3] **and B Pourdeyhimi**[1]

[1] Nonwovens Cooperative Research Center NC State University, Raleigh, NC 27695-8301, USA
[2] Mechanical Engineering Department, Virginia Commonwealth University, Richmond, VA 23284-3015, USA

E-mail: htafreshi@vcu.edu

Received 1 May 2007, in final form 2 September 2007
Published 20 November 2007
Online at stacks.iop.org/MSMSE/15/855

Abstract

Assuming that fibers can be represented as straight cylinders, an algorithm for generating virtual 3D layered fibrous media made up of fibers having identical diameters but different lengths is presented. It is shown that for a given basis weight and computational box (sample size), reducing the fiber length causes the solid volume fraction (SVF) to increase as the fibers pack next to one another more efficiently. The air permeability of these media is numerically simulated and discussed in detail with respect to the available 2D and 3D studies in the literature. Our permeability calculations show an excellent agreement with the predictions of the empirical equation of Davies [1] as well as the analytical model of Spielman and Goren [2]. Such an agreement indicates that, within the range of dimensions considered, the fiber length has no significant influence on the materials' through-plane permeability as long as the SVF remains constant. While this concept has been empirically observed in the past, our work is the first numerical simulation devised to confirm it.

1. Introduction

Nonwoven fibrous materials such as filters, papers, wipes and insulators have copious industrial applications. For many applications, nonwovens' through-plane permeability is an important property. Nonwovens are made by assembling short or infinitely long fibers (continuous filaments) on top of one another and bonding the same by mechanical, thermal, or chemical means. Manufacturing nonwovens typically consists of three major steps; fiber production, fiber-web (fiber assembly) formation, and fiber bonding. The fiber-web structure has a major

[3] Author to whom any correspondence should be addressed.

