8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

NUMERICAL MODELLING OF THERMALLY BONDED BI-COMPONENT FIBRE NONWOVENS

***Emrah Demirci[1], Memiş Acar[2], Behnam Pourdeyhimi[3] and Vadim V. Silberschmidt[4]**

[1]Wolfson School of Mechanical and Manufacturing Engineering
Loughborough University
Loughborough, Leics. LE11 3TU, UK
E-mail: E.Demirci@lboro.ac.uk
www.lboro.ac.uk/departments/mm/mm/research/mechanics-advmaterials/staffpage/Emrah.htm

[2]The Nonwovens Institute
College of Textiles, North Carolina State University, Raleigh, NC 27511, USA
E-mail: Behnam_Pourdeyhimi@ncsu.edu
http://www.tx.ncsu.edu/faculty_center/directory/detail.cfm?id=94

[3]Wolfson School of Mechanical and Manufacturing Engineering
Loughborough University
Loughborough, Leics. LE11 3TU, UK
E-mail: m.acar@lboro.ac.uk
http://www.lboro.ac.uk/departments/mm/staff/acar.html

[4]Wolfson School of Mechanical and Manufacturing Engineering
Loughborough University
Loughborough, Leics. LE11 3TU, UK
E-mail: v.silberschmidt@lboro.ac.uk
http://www.lboro.ac.uk/departments/mm/staff/silberschmidt.html

Key Words*:* *Finite Element Analysis, Bi-component Nonwoven, Bond Spots, Fibre Matrix, Orientation Distribution Function, Anisotropy.*

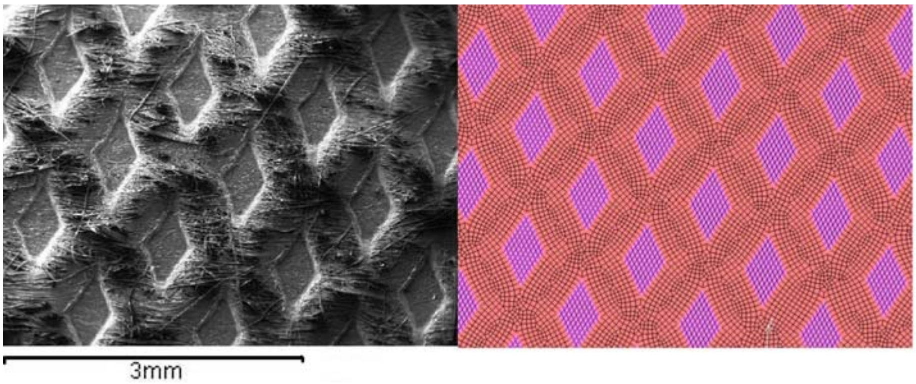
ABSTRACT

Nonwoven fabrics are web structures of randomly oriented fibres, which are bonded by mechanical, thermal or chemical techniques. This paper focuses on thermally bonded nonwoven materials with bi-component fibres. These fibres have a sheath/core structure, with external layer – sheath – having a lower melting temperature than that of the core. During the thermal bonding of such fibres, as the hot calender with an engraved pattern contacts the fibre web, bond spots are formed by melting of the sheath material. In the formed nonwoven, the melted sheath material acts as an adhesive while the core part remains fully intact. The shape and pattern of the bond spots are shown in Figure 1a obtained by scanning electron microscopy.

In this paper a mechanical response of sheath/core bi-component nonwoven materials is simulated with finite elements (FE) by means of the user-defined material subroutine. This subroutine calculates the material's mechanical properties as a function of the fibre characteristics and manufacturing parameters such as the sheath/core cross-sectional area ratio, fibre diameter, fibre orientations, fabric density etc.

The FE model simulates two types of regions: fibre matrix and bond spots. Fibre matrix is composed of sheath/core fibres with random orientations. Since the mechanical properties of the matrix are based on the orientations of individual fibres, their

randomness is introduced in terms of the orientation distribution function. Unlike the previous models [1, 2], which treat the fibre matrix as a symmetric truss system, in the developed approach (Fig. 1b) the matrix is modelled with anisotropic shell elements. In some nonwoven models [1, 2] the bond spots are assumed as isotropic elastic bodies or rigid body links between fibre segments. This approximation can be considered suitable for nonwovens with mono-material fibres, but it is not adequate for sheath/core ones. Our model treats the areas of bond spots as a deformable bi-component composite material composed of the sheath material as matrix and the core material as fibres.



(a) (b)

Figure 1. (a) SEM picture of the bi-component nonwoven material. (b) FE model of the material.

Finally, the specimens of nonwoven materials with different dimensions are subjected to tensile tests along different loading directions with respect to the machine direction of the material. The force-displacement curves obtained in these tensile tests are compared with results of FE simulation.

REFERENCES

[1] S. Limem and S.B. Warner, "Adhesive point-bonded spunbond fabrics", *Textile Res. J.*, Vol. **75(1)**, pp. 63−72, (2005).

[2] D.H. Mueller and M. Kochmann, "Numerical modeling of thermobonded nonwovens," *Intern. Nonwovens J.*, Vol. **13(1)**, pp. 56-62, (2004)