Modelling Dynamic Behaviour of Thermally Bonded Bicomponent Fibre Nonwovens

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Summary

Nonwovens are polymer-based engineered textiles having randomly distributed fibres bonded together with mechanical, thermal or chemical techniques. This paper focuses on thermally bonded nonwoven fabrics manufactured with bicomponent fibres. Such fibres have a core/sheath structure, with a material of the inner region - core - having a higher melting temperature than that of the surface region (sheath). During the bonding of these fibres, a hot calender with an engraved pattern contacts a fibre web causing the sheath part of fibres to melt; the latter acts as an adhesive while the fibres' core part remains fully intact. As a result of the bonding process, two distinct regions, namely bond points and the fibre matrix, possessing different characteristics, form the nonwoven fabric. The structure of the resulting thermally bonded bi-component fibre nonwoven is shown in Fig. 1 obtained with scanning electron microscopy (SEM).

In this paper a dynamic response of core/sheath type thermally bonded bicomponent fibre nonwoven textiles is simulated in finite element (FE) environment. The simulated nonwoven fabric is treated as an assembly of two regions with distinct mechanical properties. One region - the fibre matrix - is composed of randomly oriented core/sheath fibres acting as link between bond points. Random orientation of individual fibres is introduced into the model in terms of the orientation distribution function in order to calculate the structure's anisotropy. A code based on digital image processing techniques is developed to analyse the ODF of fibres and the mechanical anisotropy of the fabric using micro-scale images of fibre matrix obtained with SEM or X-ray micro computed tomography. Another region - bond points - is treated as a deformable bicomponent composite material composed of the sheath material as its matrix and the core material as reinforcing fibres with random orientations. A second code is developed to assess the time-dependent anisotropic mechanical properties of these regions based on fibre characteristics and manufacturing parameters such as the planar density, core/sheath ratio, fibre diameter etc. Having distinct anisotropic mechanical properties for two regions, the fabric is modelled with shell elements with thicknesses identical to those of the bond points and fibre matrix.

The developed model is used to simulate a dynamic interaction of a falling ball with the nonwoven fabric, resulting in several rebounds. Finally, results of the FE

simulations and respective experiments are compared to evaluate efficiency of the proposed numerical modelling approach.