A FFT Based Mesoscopic Approach for the Compression and Recovery Simulation of Structured Nonwovens

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ABSTRACT

In the work at hand a three-dimensional mesoscopic model for the compression and recovery simulation of structured nonwovens is presented. Starting point of the developed material model is the one-dimensional (macroscopic) power-law as already proposed by van Wyk [1]. Furthermore, the strain rate dependency of fibrous materials, see e.g. [2], is considered via a viscoelastic extension of the van Wyk model. In order to take into account the recovery behavior, see e.g. [3], the developed material model is completed by plastic deformations.

The local structuring of the nonwovens is taken into account by considering the local fiber volume fractions (FVF). To this end, a detailed microscopic geometry containing the single fibers is considered, either obtained from a µCT image or a three-dimensional virtual material model generated with GeoDict [4]. This detailed geometry is transformed into a mesoscopic geometry model that is completely described by the locally varying FVF.

The mesoscopic compression and recovery simulations of the structured nonwovens with the elasto-visco-plastic material model including the local FVFs are carried out within the solver FeelMath which is developed at Fraunhofer ITWM. This solver is based on the Fast Fourier Transfomation (FFT) of the Lippmann-Schwinger (LS) integral equations in elasticity, for details see [5] and [6]. The LS-FFT method allows a fast and efficient simulation of complex structures. The influence of different structuring patterns of nonwovens is studied particularly with regard to the recovery behavior.

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