Micromechanical Simulation of the Resilience of Nonwovens

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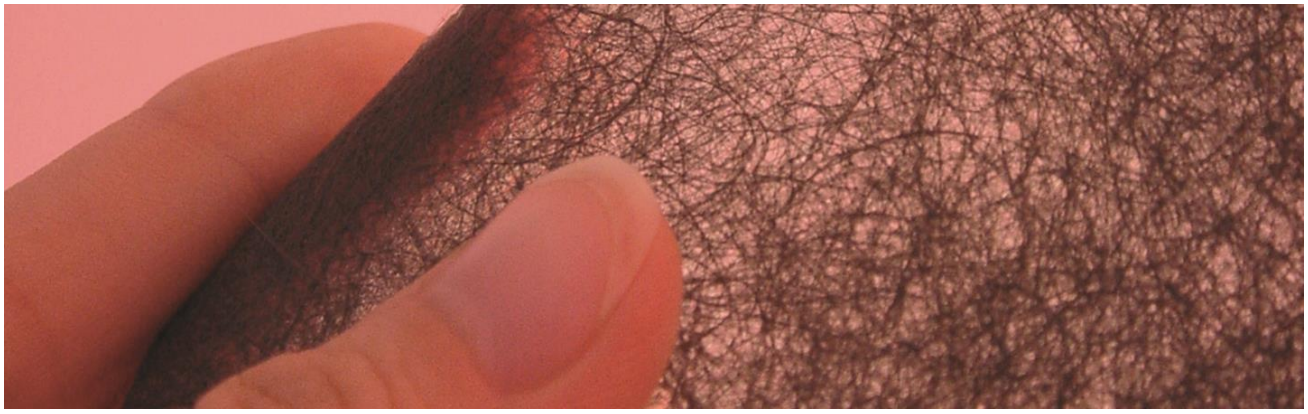
Nonwovens are an important component of different products of several uses, e.g. transport of humidity in sanitary products, insulation materials or filters. Nonwovens are usually produced on large engineering facilities. For this, experimental studies of design with regard to the optimization of these nonwoven-structures prove to be very difficult.



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Influence Design Parameters

There are so many parameters of design, as for example fibers, surface weight or type of nonwoven bonding and finishing that are affecting the properties of nonwovens. For the change of one single parameter, e.g. the material of fiber, it is necessary to adapt the whole process of fabrication from the spinning of the fibers via their stacking to the nonwoven hardening.

Following the production of such a prototype a time consuming and cost-intensive characterization of the properties of nonwovens carried out experimentally has to be done. Therefore, for this reason detailed studies considering several parameters of design are uneconomic..

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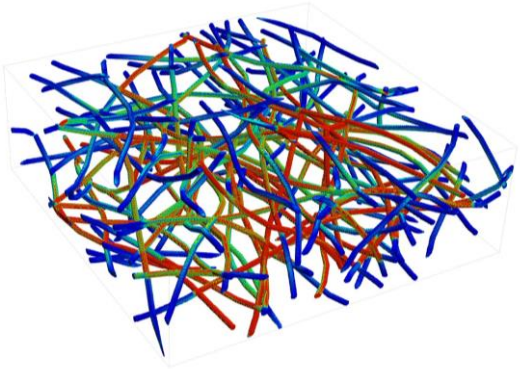
Computer generated microstructure model of a nonwoven fabric with a typical anisotropic fiber direction distribution.



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Calculated local voltages in the fibers (red: high voltage, blue: low voltage) when the nonwoven is pressed together. These stresses substantially influence the non-woven properties.

Thus, micromechanical models of simulation are developed at Fraunhofer ITWM in cooperation with Procter & Gamble Service GmbH (P & G). By means of these models it is possible to forecast numerically the effective properties of nonwovens for diverse parameters of design. To virtually modify and optimize individual parameters in this connection it is only necessary to adapt the corresponding inputs of the model.

Fast Predictions Possible

In this case, the focus of the numerical predictions is primarily lying on the time-dependent behavior of the nonwovens. The dynamic properties can be determined by means of numerical simulation of cyclic measurements. In doing so, a good correspondence of simulation and measurements is obtained.

Compared to experiments the required time of simulation for the behavior in case of low frequencies does not change. Therefore, we can obtain rapid forecasts for the long-term behavior (month till years) and the corresponding resilience of nonwovens using numerical models. A lot of alternatives can be simulated and studied within a few hours.

The fact that not only effective (macroscopic) properties of nonwovens can be computed, but also local physical values such as distribution of tension in binding agents and fibres is a further advantage of this micromechanical approach. So, the simulation contributes to a better understanding of the properties of nonwovens.

Future designs deal with an extension of the models with regard to simulation of the production processes. By this, a fully digitalized layout design of nonwovens, from the manufacturing process till the optimization of functionality is possible..

Source: Fraunhofer Institute for Industrial Mathematics ITWM