

Multiscale modelling of mechanical and flow performance of nonwovens

Understanding of mechanical behaviour of nonwoven filter mediums is quite challenging due to their complex microstructure composed of randomly distributed, curved and polymer-based fibres. During the design process of nonwoven products, numerical tools, such as, Finite Element Analysis and Computational Fluid Dynamics were facilitated to predict their mechanical and flow performances under service conditions.

A novel parametric 3D finite element model was developed using Python®, generating randomly distributed fibre-networks with microscopic properties, such as, various fibre cross-sections (circular, trilobal) basis weight, etc. This novel model incorporates fibre curvatures along with fibre to fibre interactions such frictional contact, fibre bonds and it enables to model nonwoven filtration medium.

Furthermore, single fibres extracted from fabric were tested at micro tensile tester to obtain elastic, plastic and viscous properties. Selected nonwoven samples were scanned with micro CT and their microstructural properties were quantified. Using this data, novel computational models were prepared. The mechanical response was simulated and flow properties were calculated. In addition, various case studies were conducted to predict the contribution of modelling parameters to both the mechanical and flow performances. Consequently, the model was found as superior to the existing FE and CFD models since it could account for the complex mechanisms, such as, fibre-to-fibre interactions. In the light of our findings, it is anticipated that our computational model, our numerical analyses will help researchers and filter industry to improve their existing products and to design novel nonwovens for highly competitive market.