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MODELING OF MULTIAXIAL NON-CRIMP FABRICS

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Numerical simulation is an important tool for the optimization of the load-bearing behaviour of composites reinforced with high performance textile structures. Fabrics undergo a high degree of deformation while formed from two-dimensional shape into a complex three-dimensional form. Composites carry the main load in the direction of the fibre orientation. A small difference between the load and fibre orientations decreases this capacity significantly. Because of the high deformations and the anisotropic character of most fabrics the reinforcement orientation in the formed structural part is hardly predictable. Therefore, drapability simulations, based on the finite element method (FEM), are used to predict the fibre orientation and the highly sheared zones and, additionally, to proof the formability of the textile structure itself [1].

Due the low cost and high productivity production non-crimp fabrics (NCFs) are widely used as reinforcement structures. Furthermore, NCFs offer mechanical properties close to unidirectional structures with various orientations of the single layers, e. g. 0°/+45°/-45°/90°. The single layers are stitched together, which mostly influences the shear and thus the draping behaviour of NCFs. Depending on the stitching pattern NCFs show non-symmetrical shear behaviour [2, 3]. For the simulation of the drape behaviour of biaxial non-crimp fabrics different models at meso- and macroscale exist. Creech, for example, presented a meso-modelling approach for biaxial NCFs with tricot stitch which has proven successful for complex draping scenarios [4].

The presentation gives an overview over two modelling approaches for biaxial and multiaxial NCFs developed at the ITM. It provides further information on the implemented material models in LS-DYNA® and the required textile characterisation tests. The first approach is a shell-element based continuum simulation model for biaxial NCFs. To describe the forming behaviour of the shell elements a suitable material model was developed and implemented that represents the nonlinear deformation mechanisms: tension, in-plane shear and bending. For the drape simulation of multilayer NCFs with non-orthogonal reinforcement directions a mesoscale model is used. To represent the complex forming mechanisms the individual reinforcement layers are represented by layered shell elements, linked by coupling elements. This configuration enables a very good representation of the global behaviour of NCFs under complex loading and failure effects of the stitching. The determination of the input parameters for the mesoscale model is more complex than for the macroscale model. Due to the higher resolution of the internal structure further parameters, such as friction and shearing between the layers, are required to describe the material behaviour.

The drape simulation offers new possibilities for the designing of composites. The formability of the NCFs to the intended three-dimensional geometry can be proofed. Furthermore, it becomes possible to predict the fibre orientation and thus weak spots in the component. So the drape simulation could improve time- and cost intensive composite designing processes.

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