Textile composite forming simulations using a specific shell approach

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Composite draping simulations have been proposed based on kinematic pin-joint (also called fishnet algorithms) and membrane finite elements. Nevertheless, recent works have shown that the bending stiffness of the fibrous reinforcement, although weak, plays an important role particularly in the wrinkle development simulation . Consequently, the reinforcement is modeled by shell finite elements in most forming simulations. Given the fibrous nature of the reinforcement, some local slippage between the fibers may occur. This makes the mechanical behavior very specific and different of those of a continuous material (such as metals). In particular the bending behavior is specific and must be decoupled from tensile behavior. Moreover, the classical shell kinematics are not valid. The bending behavior is much modified by the possible slippage between fibers [1]. The kinematics of deformation, in particular the rotations of the normal, are mainly driven by the quasi-inextensibility of the fibers. The bending stiffness of the fibers also plays an important role. The present work aims to propose a modeling of the deformation of fibrous reinforcements by a specific Ahmad shell element. This approach concerns both thin and thick reinforcements. In the latter case the kinematics of the deformation in the thickness is particularly interesting.

After presenting the proposed fibrous shell element, the simulation of the bending deformation of several fibrous reinforcements will be compared to experiments [2]. An example is shown below in Fig.1. It will be shown that friction can have an important role and that it can be taken into account by integrating it into the bending stiffness of the fiber. An important objective of this work consists in the simulation of the deformation of thick interlock reinforcements. They are used in aeronautical applications such as motor fan blades. It will be shown that the proposed approached allows to model their deformation with a very low number of degree of freedom.

Keywords: Fabrics/textiles, Process Simulation Finite element analysis (FEA) E. Forming, Shell.

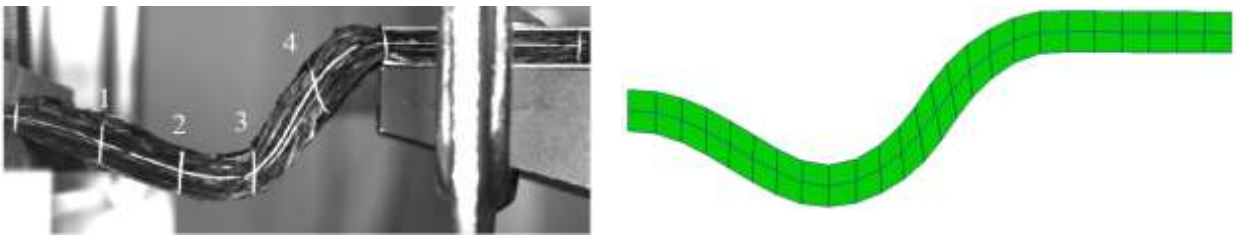

Fig. 1 Bending test on a multilayer reinforcement: Experiment. Simulation.

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