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On effect of shear-tension coupling in forming simulation of woven fabric reinforcements

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Abstract:

Optimization of forming process of fabric reinforced composites requires a multifaceted characterization of the reinforcement material and its implementation in customized simulations. This manuscript investigates the effect of inclusion of 'shear-tension coupling' (interaction) in woven fabric models on the ensuing predictions of forming simulations. To this end, a constitutive model estimating the shear stiffness as a function of axial tension along warp and weft in a typical glass plain weave has been selected. The model was implemented into the Abaqus numerical package using a customized fabric element, capable of simulating the non-orthogonal behaviour of the fabric as well as its tension-shear interaction. Subsequently, the model was employed for studying forming processes with three different punch geometries including hemisphere, double-dome, and tetrahedral shapes. In each case, comparisons were made between the model with the effect of shear-tension interaction and the conventional model assuming the shear stiffness to be merely a function of shear angle (i.e., with no interaction). Results revealed that although the conventional models may be acceptable in predicting the general shear deformation pattern of the fabric (in particular in the presence of sufficient blank holder forces), the forming models that included the shear-tension interaction had lower formation of local wrinkles as well as notably higher residual stresses in all simulation cases, especially in critical sharp corners of the parts and the fabric free regions.

Keywords: A. Fabrics/textiles; B. Mechanical properties; C. Finite element analysis (FEA), E. Forming; Shear-tension interaction