Friction in Forming of UD Composites

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The aerospace and automotive industry show an increasing interest in thermoforming processes of unidirectionally (UD) reinforced thermoplastic laminates. Especially, hot stamp forming provides a fast automated process, which allows tailored and complex products. In order to develop a simulation tool for predicting failure like wrinkling or tearing of the product, a thorough understanding of the underlying deformation mechanisms is required.
One of these deformation mechanisms is inter–ply or tool/ply friction. A constitutive model that assumes hydrodynamic lubrication (HL) for fabric reinforced thermoplastics was introduced by Akkerman et al [1]. This model is essentially based on the fabric weave geometry and assumes HL on a meso–mechanical level. However, this model is not easily applicable to UD geometries. Despite the lack of a physical model for UD laminate friction, the frictional behaviour is assumed to be HL. This is indicated by own experimental data and is also assumed by Murtagh [2]. The actual film thickness is unknown, however.
An HL model can also be derived on a macro-mechanical level by assuming not perfectly parallel surfaces that can tilt with respect to each other. This is commonly known from the Michael/Kingsbury tilting pad [3]. This model shows that very small misalignments which are difficult to control will influence the friction significantly.
A friction test set-up was developed at the University of Twente [4], in which a laminate is pulled at constant velocity, while clamped by two blocks at processing temperature. The set–up operates in a standard mechanical test–system. The blocks are self–aligning and the spacing between the blocks is measured at four corners with micrometer accuracy. During the experiments we observed a tilt angle that changes significantly during the friction test. On the basis of a parameter study we will present the significance of these variations on the friction. We will compare the influence of the misalignment for UD and fabric weave geometries. A new constitutive model will be derived that is based on a macro– and meso–mechanical level.

References

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