MATERIAL MODELING OF PAPER

Effect of delamination on folding characteristics of multilayered paperboard – A Numerical Modeling Study

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ABSTRACT

When paperboard is scored and folded during converting operations, it is subject to large stresses causing plastic deformation and delamination. Controlled delamination can be tolerated but if it is excessive can weaken the products and hence needs to be prevented. In order to better design paper products we need to understand the mechanics of scoring and folding operations. Delamination occurs during the folding of paperboard due to large plastic stresses. Scoring and folding operations present an interesting case of material deformation where plasticity, loading and unloading occur in different regions and at different times. Numerical simulation of such processes must include sufficiently sophisticated material models which are capable of tracking paper behavior during all of these processes. Paper is particularly anisotropic with material properties in the thickness dimension which are radically different from the in-plane ones.

We present results of a finite element simulation study of the scoring and folding process of a multi-ply carton board to provide an understanding of the mechanics of scoring and folding operations. Our material model accounted for plasticity and sheet anisotropy in the in-plane and ZD dimensions. Different ZD stress-strain curves were used during loading and unloading. During scoring, different layers of the board undergo large plastic deformation. Delamination of the layers occurred in regions of significant shear strain. We used our model to study the bending moment on the paperboard during the folding operation. The model predictions were confirmed by experimental observation of the local strain fields using visual microscopy and linear image strain analysis (LISA). We also conducted a parametric study of the effect of the important material properties.

Since paper is an inhomogeneous material due to uneven distributions of fibers and poor formation, local material properties are likely to vary significantly. Variation in local properties and its effect on scoring and folding was also studied.

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