

## Continuum damage modeling of delamination in paperboard for creasing and folding

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Paperboard is a material that is widely used in the packaging industry. A reason for this is that the material is suitable for converting. This master thesis concerns the creasing and folding operations of a continuum paperboard material model developed by Erik Borgqvist. The material model has been proven to be able to predict many material behaviours. However, not all operations are predicted accurately. One such operation is the folding of creased paperboard. This issue is considered in this work by the incorporation of damage.

The scope of this work is to investigate if the folding of creased paperboard can be predicted more accurately by including damage in the material model. The creasing and folding operations are simulated by using the commercial engineering software LS-Dyna, which is an advanced general-purpose simulation software. The introduction of damage is made as an add-on feature to the continuum material model via an LS-Dyna built-in software called eGISSMO. Damage is thus introduced on top of the existing material model.

### Methods

The method was to first simulate the creasing and folding of creased and uncreased paperboard without any introduction of damage. After this, the damage was introduced in the material model. Two different approaches were considered. In the first approach, the out-of-plane plastic shear strain was chosen to drive the evolution of damage, whereas in the second approach the damage was driven by the out-of-plane plastic tension strain.

### Results

The results in this thesis show that, by introducing damage in LS-Dyna, it is possible to accurately predict the folding of MD creased paperboard. Considering the two approaches for incorporating damage, it was noted that it is

easier to calibrate the response by using the out-of-plane plastic shear strain to drive the damage. Moreover, the agreement with the measured data is much better in this case.

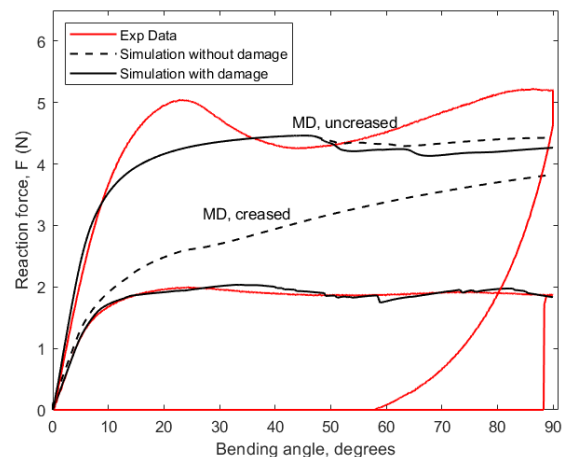


Figure 1: Simulation of the folding of creased and uncreased paperboard with and without damage.

Considering the deformed responses, it was observed that using the shear strain to drive the damage, the micro-cracks near the clamps were captured, whereas using the tension strain, the delamination in the out-of-plane direction was predicted.

The conclusion is that the out-of-plane shear strain seems to have a larger impact on the folding of creased paperboard in the MD-direction than the out-of-plane tension strain.