In-plane fracture analysis of paperboard using x-ray tomography

By Daniel Andersson and Olof Hedberg

Abstract

Paperboard undergoes changes in its mechanical properties when subjected to loading. To increase the knowledge about the mechanisms active during loading, it is of interest to understand how the internal structure of paperboard evolves. It was found that neither sample geometry nor delamination within the paperboard affect the cohesive failure. One observed mechanism during tensile loading was a thickness increase immediately after load was applied. The thickness increase continued during the experiment, and resulted in delamination close to failure. In addition, when analysing the normal strain-field in the loading direction, localisation of zones with higher strains were observed.

Introduction

During manufacturing and usage of paperboard-based packages, paperboard is subjected to different types of external perturbations. It is therefore of importance to know how the package behaves when subjected to different loading scenarios. The paperboard gives the package its structure and geometry, and is therefore highly relevant when analysing how the package reacts to load.

Tensile experiments were performed to study the paperboard when subjected to in-plane loading. To also analyse the internal structure of the paperboard, x-ray tomography in combination with the image analysing tool *digital volume correlation* was used.

Method

Tensile experiments on paperboard samples with different geometries were performed to analyse how this affect the material response. The same type of tensile experiments were also performed on pre-delaminated specimens to study the impact of delamination on the material response.

X-ray tomography was used to get 3D-images of the sample during tensile loading. The images were then analysed to study the change in thickness of the tested sample. The images were also analysed using digital volume correlation, which allowed the strain fields in the sample due to deformation to be analysed.

Results

From the tensile experiments, it were found that neither the sample geometry nor delamination affect the cohesive failure of the paperboard. The thickness increase was measured at six different amounts of displacement, denoted as holding points, and the result is shown in Figure 1.

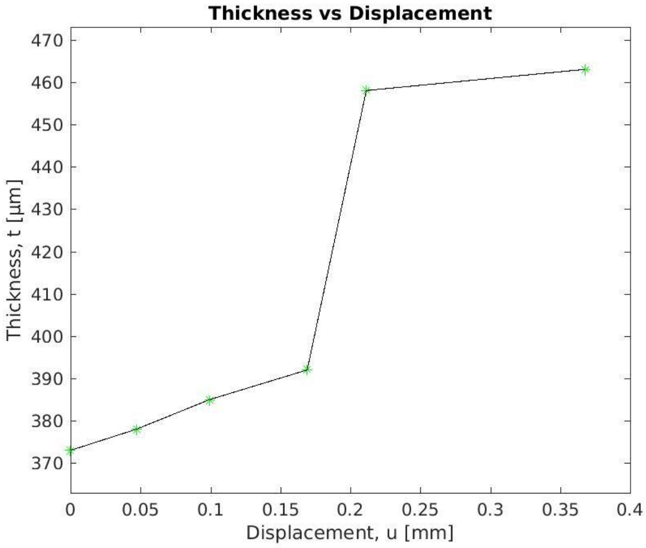

Figure 1. Thickness as a function of displacement during tensile loading of paperboard. The green dots corresponds to the holding points.

From the digital volume correlation, it was found that the strains in the loading direction localised in zones of higher strains. In Figure 2 the strains in the loading direction right before- and after failure are shown. A, B and C corresponds to different views of the sample. It appears that the failure seen in the right image follows one of the zones with higher strain seen in the left image.

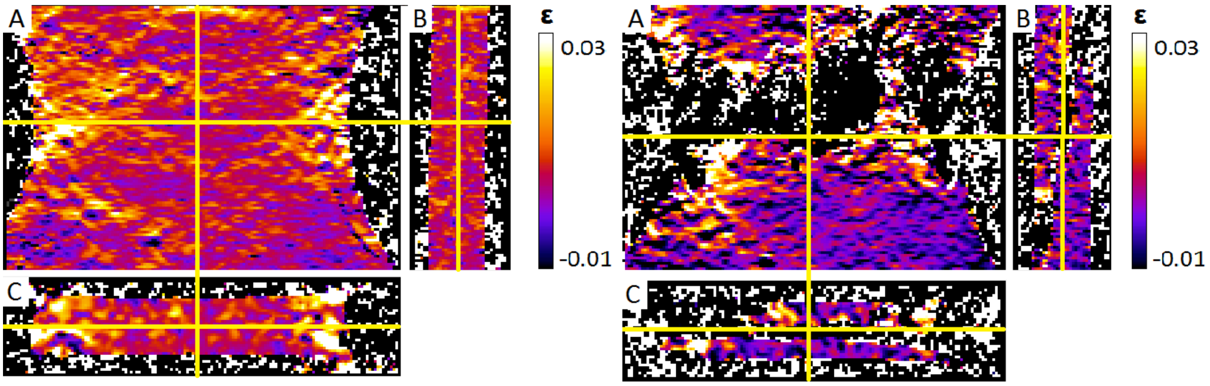

Figure 2. Normal strains in the loading direction of the test sample right before failure (left) and right after failure (right).

Conclusions

The conclusions were the following:

- neither sample geometry nor delamination affect the material response during tensile loading;
- digital volume correlation is an image analysing tool that can be used when analysing paperboard;
- the localisation of the normal strains in the loading direction probably cause the failure of the sample;