Study on Bending of Laminar Packaging Material from Tetra Pak

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Abstract

Tetra Pak is the largest food packaging company in the world and develops filling machines capable of producing 40,000 milk cartons per hour. To predict and control the behavior of the packaging materials, Tetra Pak utilizes digital 3D models for modeling and simulation purposes. Carton packages for liquid food products are made of laminar material consisting of clay coated paperboard, polymers and aluminum foil. Tetra Pak constantly strives to increase capacity of the filling machines and quality of the packages. In order to do this, the folding and forming sequence in packaging machines need to be flawless. Package forming and appearance is important from an aesthetic perspective, to signal high quality and attract consumers purchase. In addition, it is also a matter of packages fitting into secondary packaging and transport solutions. When a package is formed in the filling machines, the material is folded according to the crease lines. The crease lines in the packaging material needs to activate and aid the process correctly, every time. Therefore, in-depth study of the folding behaviour of the paperboard and the lamination layers helps Tetra Pak verify the simulation models of machine/material interaction.

To obtain reliable virtual models, it is important to know the exact geometry of the products, but also the geometrical changes the products undergo during production. In this project, we have developed a method to deduce information on how the packaging material behaves when being bent at different angles.

In order to carry out this study, we have used four different samples of packaging material. The material was characterized using micro X-ray computed tomography scans with voxel size 2.4 μm at the 3D Imaging Center at DTU. Each samples was imaged four times in different bending angles that are 0°, 45°, 90° and 180°. A set of holders and support tools were developed which allow the same position of the material to be studied. To prevent the material from over-bending, and to allow for geometrical flexibility during bending, support tools were fabricated for 45° and 90° bending angles.

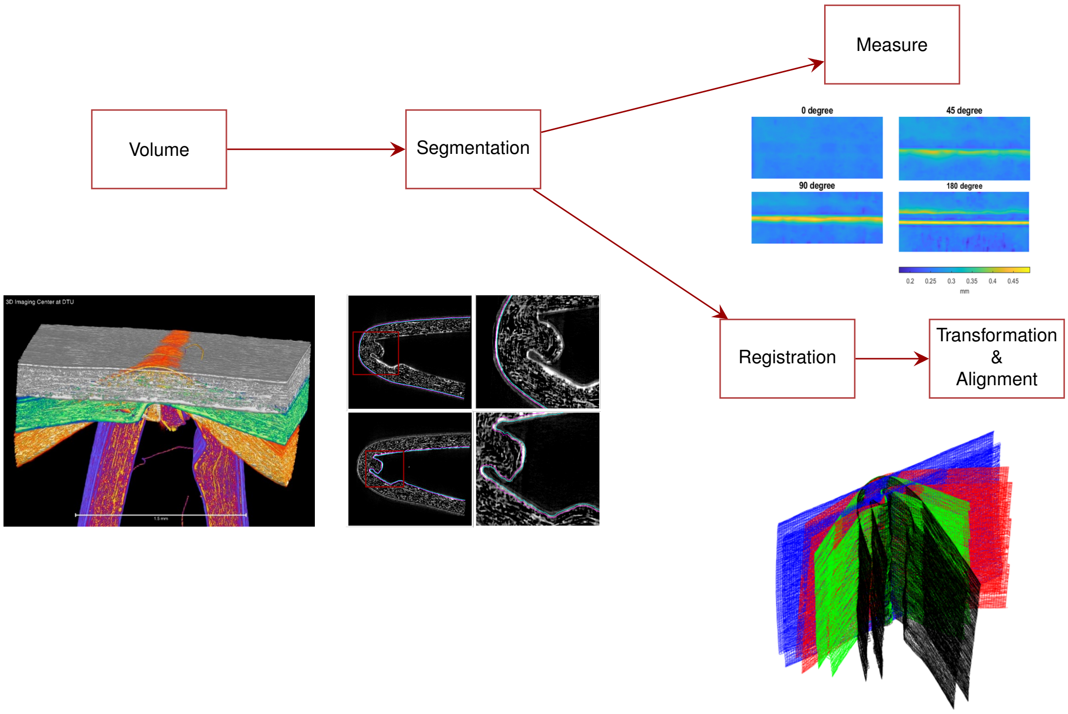

Figure 1: Developed pipeline to study how the layered material behaves when being bent at different angles.

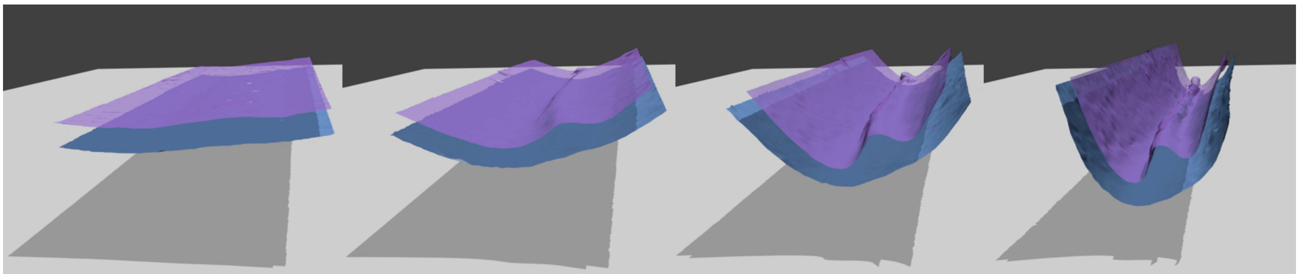

Figure 2: Resulting segmentation of the inner and outer mesh in different bending angles. From left to right, 0°, 45°, 90° and 180°, respectively.

The goal of this study is to measure properties of laminar material when they are bent, segmenting different layers and study the transformation of laminar material for simulation process.

We developed a semi automatic pipeline to analyze the laminar material during bending. The pipeline contains different phases: 1) Annotation of the approximate position of the layers and unwrapping the bent material, segmentation of the layers in the material and obtaining meshes, 2) Measuring the bending properties of laminar material, 3) Registration of the meshes, 4) Transformation and alignment of the bent meshes among different angles, 5) Interpolation of the meshes between different angles. Figure 1 illustrate the developed pipeline together with results from different phases.

In the pipeline, we utilized laminar material layered structure to obtain the true geometry of packaging material. We used geometrical transformation to unwrap bent laminar material to stretched surfaces and used a graph-cut based search to find the surfaces throughout the whole

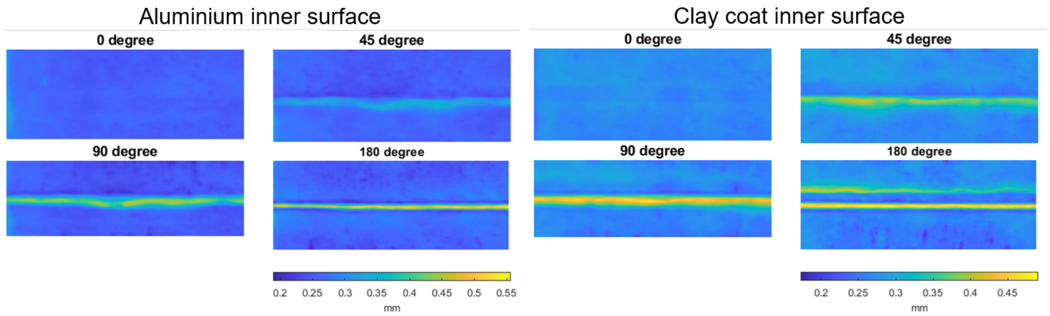

Figure 3: Measure that indicates the behaviour of inner surface in material when bent. Left image shows the measure when aluminium is inner surface with one peak in the middle of the crease line and right shows the measure when clay coat is inner surface with two peaks close to the edges of the crease line.

volume. We detected two surfaces, one close to inside layer of the packaging material (we call it inner surface), see figure 2, and one close to the outside (outer surface). The reason for using layer surface detection method is that the conventional thresholding methods for segmentation might work for brighter layers with higher contrast compare to the rest of material such as aluminium but they do not work for segmenting other layers. Using the segmented surfaces, we measured the bending properties of materials by finding the distance between inner and outer surfaces. The measure indicated when aluminum is the inner surface in bending; it created one peak in the middle of crease line in the distribution of the measured distance while clay coat created two peaks around the edges of the crease line, see figure 3.

In addition, we extracted the intensity information along the surfaces into paperboard layer to register the material in different bending angles using the paperboard texture. This resulted in voxel to voxel correspondence of the layers. Finally, using geometrical and bijection transformation among different bending angles, we obtained information to align all the meshes and transform each bending mesh to another one. Furthermore, the bijection transformation allows us to interpolate between consecutive angles, such that we can create an image sequence with arbitrary many intermediate angles (see the video on `https://video.dtu.dk/media/Bending+animation/0_gna4b9r6`).

In conclusion, we have developed a pipeline which segment laminar material, measure a property of the bending in laminar material and finally extract deformation information of the bent layers.

Acknowledgement

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[1] `www.qim.dk`