

Wrinkling in packaging material: Experiments and thermo-mechanical stochastic modeling

Whether a combination of a deterministic and stochastic modeling approach can be used to capture microstructural phenomena, is investigated in this thesis. This is achieved by mimicking the laws of physics using appropriate software in combination with physical experiments, as well as X-ray computed tomography.

By using software implementing the *finite element method (FEM)*, the virtual model constructed in this thesis has been able to capture microstructural changes in packaging material, that are observed during physical experiments. The physical experiments consisted of warming up packaging material with a *heat gun*. The physical phenomena involved were investigated using X-ray computed tomography, to try to determine which parameters were important during virtual reconstruction. The physical phenomenon known as *buckling* and the increase in volume of the aluminum foil layer in response to heat, were considered to cause the *wrinkles* that were observed both physically and virtually.

The virtual model used in this thesis was different from models usually used in this modeling context in that it implemented a more realistic appearance. Instead of creating the paperboard part of the packaging material as flat and smooth, it was modeled as irregular. More specifically, the surface of the paperboard was scanned using a scanning microscope and the result was exported and used in the virtual model. This virtual FE-model was then able to capture the wrinkling process in the packaging material, which a model without geometrical irregularities was not. The results in the virtual experiments seemed to have characteristics similar to those observed in the physical experiments, suggesting a valid virtual representation.

Hopefully this thesis will act as a starting point for virtual models adopting even more *realistic* aspects to further increase the adequacy of their results. Future works within this specific area could include a more thorough investigation regarding the impact different parameters have on wrinkling, e.g. moisture content in the paperboard.