

1.9.17. STRUCTURAL ANALYSIS OF POLYMERIC FOAMS BY SUB- μm X-RAY COMPUTED TOMOGRAPHY

Kastner J., Kickingner R., Salaberger D.,
Upper Austria University of Applied Sciences, Austria

Introduction. Due to the light weight, excellent strength/weight ratio, superior thermal and acoustic insulation properties polymeric foams are the material of choice for many applications. They can be found in many products of daily life like cars and mattresses. The main fields of applications are packaging, automotive industry, leisure- and furniture industry as well as construction. Foams can be classified in closed and open cell materials. Within this paper we have investigated different kinds of polymeric foams and in particular a foam with embedded cellulose particles – a new material for special mattresses. These materials were characterized by cone beam high resolution X-ray computed tomography (CT) with resolutions below one micrometer. In order to get enough contrast the CT-measurements were performed with tube voltages below 50 kV. The CT-data were processed by various algorithmic steps (thresholding, segmentation, watershed transformation) to get the open or closed cell structure in 3 dimensions. Finally, characteristic data like the overall porosity, volume, size, position and form factor of all cells as well as wall thicknesses were determined.

Results. The CT-investigations were performed by a Nanotom device using a Nano-focus tube with a molybdenum-target and tube energies in the range between 25 and 50 kV. The voxel sizes were between 0.5 μm and 4 μm . Figure 1 shows a cross-sectional CT picture of a polypropylene foam granule. As figure 1 clearly shows it is a closed cell foam. With the high CT-resolution all the individual walls are clearly visible, which have thicknesses in the range between 8 and 15 μm .

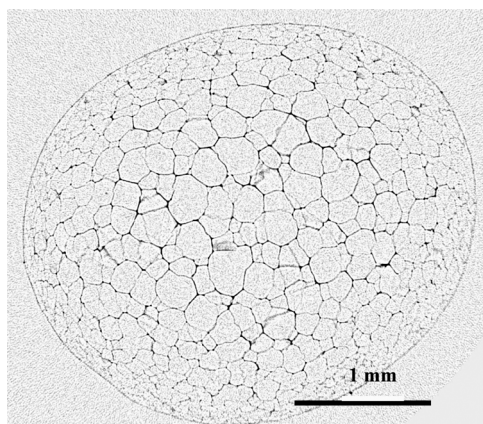


Fig. 1. Cross-sectional CT-picture of polypropylene foam showing the closed cell structure. For presentation the X-ray absorbing polymer is represented in black in the air in white

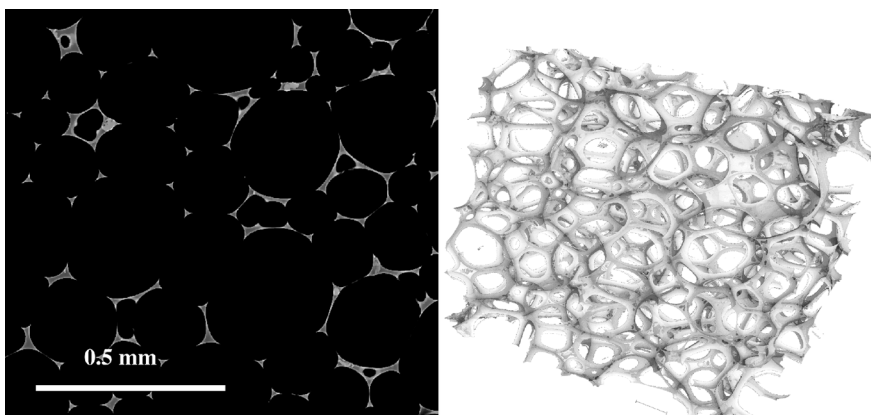


Fig. 2. Cross-sectional CT-picture of a polymeric foam with cellulose particles (left picture). 3-dimensional picture of CT-data of the polymeric foam with cellulose particles visualised by surface rendering (right picture). Both pictures show the open foam structure and the cellulose particles within the polymeric walls

Figure 2 shows a cross-section and a 3D-picture of the CT-results of polymeric foam with cellulose particles. The 3D-structure of this open cell foam as well as the individual cellulose particles embedded within the polymeric walls are clearly visible. As figure 2, shows the cellulose particles are mostly embedded at the wall crossings.

The CT-data were further processed by various image processing methods like thresholding, segmentation, and watershed transformation. In this way characteristic data of both open and closed cell structures could be determined. These data are the overall porosity and the individual volume, size, position and form factor of all cells as well as wall thicknesses. Material data derived from different kinds of foams are compared and discussed.

Summary. We have used high-resolution CT with voxel sizes between $0.5\ \mu\text{m}$ and $5\ \mu\text{m}$ for the characterisation of different polymeric foams with open and closed cell structures as well for an open cell material with cellulose particles embedded within the walls.

CT is very useful to get high resolution 3-dimensional information about the various foams. The CT-data were analysed by 3D-image processing methods so that characteristic data like porosity, pore volumes, sizes, positions, orientations as well as wall thickness and the like could be derived.

For the polymeric foam with cellulose particles the individual cellulose particles within the polymeric walls could be segmented and analysed.

Structural analysis of foams by high-resolution CT is very useful. It enables polymer companies and research institutes to optimise the foam products and the production processes.