Image-based finite element method applied to in-situ X-ray tomography compression tests of open cell polymeric foams

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Abstract

Polymeric foams are widely used in different industries such as automotive, aviation and military due to their wide density range, high specific strength, strong ability to absorb impact loads, and good thermal insulation properties [1-2]. In this study, taking advantage of 3D imaging technology based on X-ray computed tomography (CT), in-situ compression tests were carried out to explore the global and local deformation behaviour of open cell polyurethane foams. Different strain levels were recorded and relevant images reconstructed from x-ray CT during the in-situ tests. To better understand the deformation behaviour of the interior structure of foams under uniaxial loading, an advanced CT image-based finite element model was used, providing a non-destructive and non-invasive way to study the real internal structure of the foam for different loading stages [3]. The finite element models of the foam microstructure for each strain level were generated from images obtained by X-ray CT by applying level set method (LSM) and Delaunay triangulation (DT). Moreover, in order to improve the mesh quality of the FE models and calculation accuracy, Taubin smoothing algorithm was utilized. Then, numerical simulations on the smoothed mesh were implemented to compare with the experimental tests and understand deformation process occurring during compression. Good agreement was observed between the deformations obtained by simulations and in-situ compression experiments at different strain levels. Morphological features of deformed models at different strain level were identified. Three main features were analysed in this study, namely: strut length, strut thickness and strut orientation. The comparison of these features for different deformation stages was carried out. The results suggest that large amounts of cells collapse during the compression process. Under uniaxial stress, the open-cell foam deforms by struts bending followed, at sufficiently large loads, by nonlinear deformation within the struts. The deformation behaviour of the interior structure strongly depends on the initial orientation and thickness of struts.

References:

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