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Elastic modelling of polymeric foams using a Representative Volume Element approach

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Non-destructive, high-precision imaging techniques provide a wealth of information on the internal structure of materials used for a variety of applications, ranging from structural composites to biomedical devices. The main issue to deal with is the large amount of generated data, and the numerical resources required to process it. In this work high-resolution X-ray computed tomography is chosen to investigate a closed-cell polyethylene terephthalate (PET) foam available in four different densities, typically used for composite sandwiches. The resulting set of images is used for both morpho-structural and finite element analyses. The material spatial distribution is computed by exploiting the Mean Intercept Length (MIL) algorithm, as proposed by Moreno [1]. Other macroscopic structural parameters are extracted, such as solid volume fraction and mean structure thickness, with the aim of identifying a relationship with macroscopic mechanical properties. Since the reconstruction of the entire inspected volume would result into a prohibitive number of finite elements, a 2D statistical approach is developed. The sets of images are divided into smaller subdomains for which individual morpho-structural properties are computed. The density and the material spatial distribution are represented by a synthetic parameter called degree of anisotropy (DA): a 2D frequency statistics is derived and for each sample the most frequent domain is detected and then converted into a finite element mesh, by exploiting the marching cube algorithm. For each domain finite element analyses are run under elementary loading conditions [2] and the macroscopic stress and strain tensors evaluated through Gurson's homogenization algorithm; the homogenized compliance matrix is assembled to obtain a set of orthotropic elastic constants. The approach is validated with uniaxial compression data; then, all the sub-domains are considered as valid samples to be reconstructed and simulated to broaden the range of investigated structural and mechanical properties. This larger dataset allows the identification of global macroscopic relationships between structural parameters and elastic constants.

REFERENCES

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