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Application of the Concept of Virtual Material for the Design of Additive Manufacturing Processes of Open Cell Foams

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ABSTRACT

The subject of the presented paper is the model based on a digital microstructure called also virtual material, in particular open cell foams characterised with the skeleton formed of convex or re-entrant cells. The study is based on the following hypothesis: Computed Tomography analysis of polyurethane foam with convex or re-entrant cells provides an adequate basis for the computational reconstruction of a “virtual cellular material.” It enables one to simulate numerically the thermomechanical processes for assumed properties of the skeleton material. The hypothesis is based on visible similarity in the structure of convex or re-entrant cells of the observed polyurethane and metallic cellular materials that are reported in many papers discussed in [1]. The virtual foam structure is derived from the real polyurethane foam specimens produced and studied in [2] with use of computed tomography images implementing the procedures described in [1]. The additive manufacturing (AM) methods used for metallic materials mostly require numerical models composed of large sets of 2-D slices of the 3-D structural model. The necessary steps of computational design and pre-processing of additive manufacturing of open cell foams are discussed, including voxel-based and smoothed geometry generation algorithms, positioning and supporting in the working volume of the AM system, slicing, and post-processing. To demonstrate the feasibility of the study, the open-cell multifunctional structures were manufactured, which can be used as e.g., crush-resistant heat exchangers, heat capacitors, etc. The structures were produced using selective laser melting process in the powder bed fusion technology using aluminium and maraging steel powders. References 1. R.B. Pecherski, M. Nowak, Z. Nowak, Virtual metallic foams. Application for dynamic crushing analysis, International Journal for Multiscale Computational Engineering, 15, 431-442, 2017. 2. A. Strek, Production and study of polyether auxetic foam, Mech. Control, 29,78–87, 2010.