Generation Of Open-Foam RVEs With Strut Variations Using Distance Fields And Level Sets

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Abstract

A methodology to generate Representative Volume Elements (RVEs) for open-foam cellular materials based on distance and level set functions is explained. The main focus of this work is to properly represent the geometry of the foam struts of the RVEs that are resultants of the solidification phase during manufacturing.

The distance functions are defined based on the work of Sonon [1], where an arbitrary shape packing generation algorithm is introduced based on distance functions. Combinations of these functions are used to generate tessellations and extract an open-foam RVE structure with variations in the strut morphology according to the physical foams the RVE is being compared with. The shape of cross-sections of the struts and their variation along the axis of the struts are some such morphological parameters which are compared. Real foam samples from existing literature are used to verify statistically the morphological properties like face-to-cell ratio, edge-to-face ratio and strut length distribution among others. The correlation of these properties on the initial conditions like sphere packing fraction, sphere volume distribution and periodicity of the RVEs have also been studied and are found to be in good match.

Steep discontinuities in the distance functions derivatives result in the generation of jagged sharp edges, due to the use of discrete level set functions. Thus, a modification in this extraction was deemed necessary and a procedure to extract geometries from multiple level set functions to reproduce such sharp edges of the struts has been incorporated in the current work (Figs. 1 and 2).

The individual cells are extracted as inclusion surfaces based on said combination of the distance functions and their modifications. The sharp edges are computed from the intersection of these inclusion surfaces. The resulting geometry can then be meshed using size functions based on curvature and narrowness and a mesh optimization inspired from [2]. The methodology to produce high quality meshes based on [3] will be outlined. The resulting FE models are easily exported for a multi-scale study to understand the effects of a elastic-plastic test by upscaling to assess the practical applications of these models by comparing with experimental data of physical samples.

Keywords: **Cellular Materials, Open-cell foams, Representative Volume Elements**

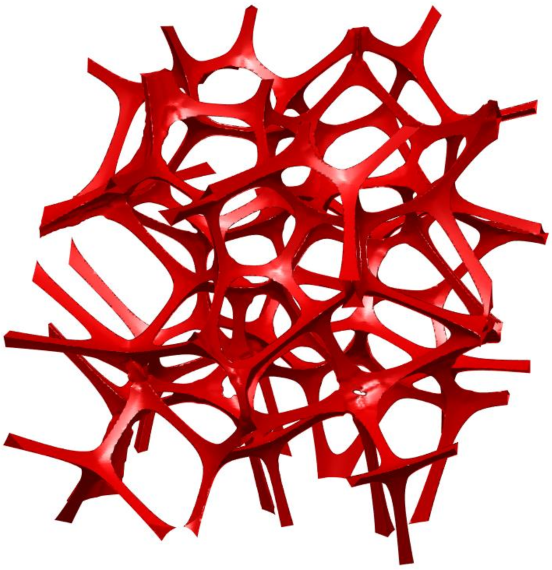

Figure 1. Open foam morphology extracted with refined sharp edges of strut matching morphological variations as seen in real foams.

Figure 2. A sample strut from the resulting morphology.

References

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