NUMERICAL MODELLING OF FOAM METAL AND HONEYCOMB STRUCTURES FOR APPLICATION IN EXOSKELETON DEVICES

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1. Introduction

Foamed metals, also called metal plans are pure metals or alloys that have in their structure a significant amount of intentionally introduced gas bubbles. Another group of material concerns honeycomb structures which use biological analogues. Both materials can be used as a core in the sandwich structures. Sandwich structure consisting of a core and cladding has been used in various industries such as aerospace, shipbuilding, automotive industry. The core layer in most cases is thicker than the outer layer. Such a structure greatly vary its properties of conventional construction, inter alia, due to the anisotropy of stiffness. Both materials are in themselves strong and rigid, but the composite formed from them has much rigidity and strength. It has several important features that are important in designing and developing in these industries.

The aim of our investigation is to prepare the material (structure) that can be used as supporting elements and safety (protection) in the exoskeleton, with particular emphasis on lower limb. In the paper modeling and numerical analysis of mechanical parameters of foam metal and honeycomb structures are presented for application in sandwich structures. Parametrical model of honeycomb structures was built and next numerical simulations for different configuration and cell size were performed. In the next part multi-scale modeling of the foamed metal structures using numerical homogenization algorithm was performed [1,2]. The first, numerical model of heterogeneous porous simplified structures of typical foamed metal, based on the FEM was built. Next, a micro RVE model representing elementary volume of macroscopic model was constructed. Material parameters of the considered structure were determined with use of numerical homogenization algorithm. In the work the different RVE models of structure were created and their properties were compared at different relative density, different numbers and the size and structure of the arrangement of voids.

2. Numerical research

Using FEM the simplified models of foam metal structures were prepared. Here, the MSC.Software system was used. In RVE elements the size of voids, the number of voids (density) and position were changed. As a basic material assumed pure aluminium (Young modulus E = 69 GPa, Poisson ratio ν = 0.33). Each RVE element was modelled as a cube measuring 5x5x5 mm. The simplest element had one void with a radius of 2.25 mm centrally positioned. For each model were carried out six analyzes corresponding to the six types of boundary conditions. This allows us to determine the average value of strain and stress. Finally, the elasticity matrix of defined materials can be determined. Figures 1a and 1b show the selected regular and irregular RVE elements respectively. Table 1 presents coefficients of elasticity matrix for regular RVE model.

In case of honeycomb structures results obtained from previous investigations were the base to prepare a new numerical model [3,4]. Here assumed that the parametric model of geometry would be a good solution in the next tests. The premise was to design a geometric model to create the honeycomb structure which had a size of about 10 to 80 mm and the size of the single cell was varied in the range of 1 to 5 mm. In a few steps, a surface model was transformed into a spatial model while simultaneously multiplying the number of cells and layers. With a 2D sketch 3D solids were created. Figures 1c and 1d present parametric models consist of one layer and three layers.

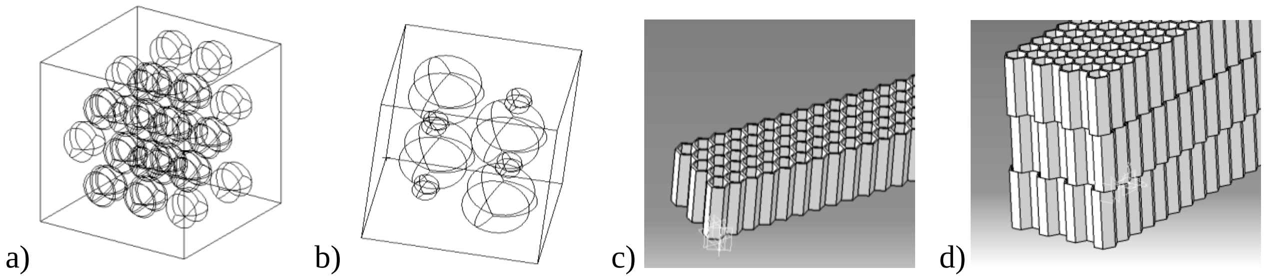

Fig. 1. RVE models regular (a), irregular (b) and parametric models consist of one layer (c) and three layers (d).

	X	Y	Z	YZ	XZ	XY
X	78224.5	39229.7	39229.7	-0.0	-0.0	-0.1
Y	39229.7	78224.5	39229.7	-0.0	-0.1	-0.0
Z	39229.7	39229.7	78224.5	-0.0	-0.1	-0.1
YZ	0.0	-0.0	0.0	38994.8	0.0	-0.0
XZ	-51.5	-26.6	-24.5	577.1	38993.3	-0.0
XY	0.0	0.0	-0.0	0.0	0.0	38994.8

Table 1. Coefficients of elasticity matrix for regular RVE model

3. Conclusions

In this study developed 3D model of RVE elements and the coefficients of elasticity matrix were determined for different number and size of voids and their various positions. It means that influence of geometrical features on material parameters was tested.

It can be observed that if the inclusions grid is regular then density primarily influence on coefficient of elasticity matrix. However changing the size of inclusions in some plane or direction we have impact on the form of matrix, which gives us to understand that if we will skillfully control the composite geometry we will be able to model its mechanical parameters.

In further studies, the results (material constants) will be used to develop and stress analysis of complex systems containing elements made of foamed metal type structures. This should result in significantly shorten the time of calculation.

Prepared models of honeycomb structure are ready to used in sandwich structures. Models consist of one layer were tested and obtained results can be considered as satisfactory. Models consist of two and more layers need further studies. Selected models are ready to used but not all of them meet the requirements.

In further studies, the planning is to create some structure models (3D printing) and to carry out stress tests (compression test and a three-point bending test). This will verify experimentally the results of numerical simulations.

4. References

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