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PROBLEMS OF VIRTUAL CELLULAR MATERIALS: REPRESENTATIVE VOLUME ELEMENT AND ENERGY-BASED ASSESSMENT OF FAILURE STRENGTH

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Abstract

Three kinds of cellular materials are considered. Depending on geometry and physical properties of the skeleton, these are metallic cellular materials with convex or reentrant open cell structure. To the third group belong alumina foams produced by gel casting method. The study of such materials is based on the following hypothesis:
*Computed Tomography analysis of polyurethane foam with convex or reentrant cells provides an adequate basis for the computational reconstruction of a „**virtual cellular material**". It enables to simulate numerically the thermomechanical processes for assumed properties of the skeleton material: (Young modulus, Poisson's ratio and elastic limit or heat conductivity etc.).*
Finite element computations are used to analyse mechanical properties of a material volume. Such an analysis is usually related with big computational costs. Therefore, it is important to keep the size of the considered cellular material volume as small as possible. On the other hand, the validity of the continuum model requires the proper size of the RVE. The aim of the study is to estimate the sufficient size of representative volume element (RVE) in order to assess the validity of the elastic model of the considered cellular material. An array of cubes of virtual cellular material is used to compute the particular deformation modes providing elastic moduli, Young modulus E, shear modulus G and bulk modulus K as well as the resulting Poisson's ratio [1], [2], [3].

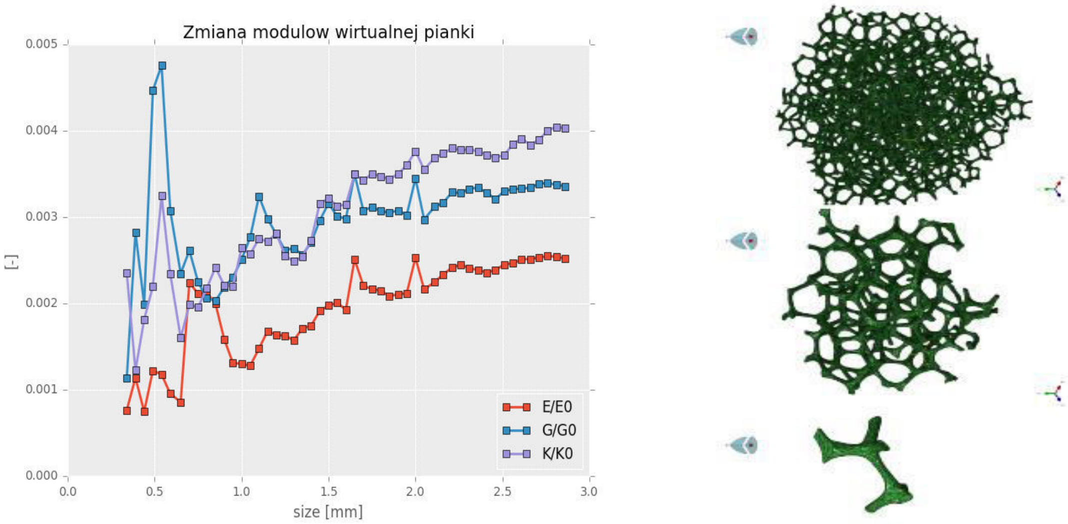

Fig. 2. Effect of the RVE size on Young modulus, shear modulus and bulk modulus & the elements of a convex cellular structure of the size: 2.87 mm, 1.51 mm and 0.35 mm.

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Also the results of the microtomography of alumina foams are used to create the *„**virtual cellular material**”* i.e. the numerical model reconstructing the structure of real foam skeleton. The numerical simulations of compression test are performed. The results are compared with experimental data of elastic moduli and failure strength. The numerical simulations of failure strength under compression for alumina foams are performed. The calculations with use of the numerical model are time consuming. Therefore, the simplified method of the assessment of failure strength is proposed. It is based on the energy-based hypothesis on the equivalence of of elastic moduli and the resulting equivalence of the values of failure strength of real alumina foam and the cellular material with regular structure (e.g. *fcc* type). The justification of the hypothesis based on experimental data of compression of alumina foam are discussed and the range of validity as regards porosity values is studied [1], [4].

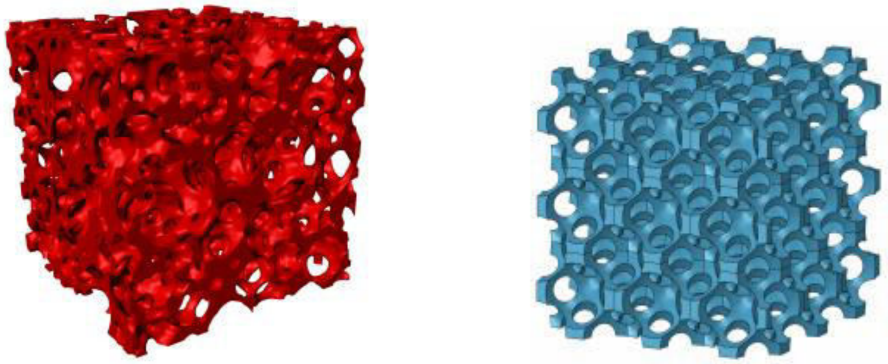

Fig. 1. The three-dimensional numerical model of real alumina foam and periodic foam structure based on *fcc* unit cell.

References:

[1] Z. Nowak, M. Nowak, R.B. Pecherski, M. Potoczek, R.E. Sliwa, Numerical simulations of mechanical properties of alumina foams based on computed tomography, Journal of Mechanics of Materials and Structures, 12, 1, 107-121, 2017.

[2] R. B. Pecherski, M. Nowak, Z. Nowak, K. J. Natonik, Application of the concept of virtual cellular material for modelling of open cell structures. Part I. Numerical simulations of deformation processes in cellular copper, 2017 – under preparation for publication.

[3] K.J. Natonik, Application of the concept of virtual cellular material for modelling of open cell structures. Part II. Numerical assessment of the RVE size, 2017 – under preparation for publication (based on the BEng thesis, 2016).

[4] M. Nowak, Z. Nowak, R.B. Pecherski, M. Potoczek, R.E. Sliwa, Assessment of failure strength of real alumina foams with use of the periodic structure model – submitted to Archives of Metallurgy and Materials, 2017.

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