PORE-SCALE MODELING OF THE SINTERED POROUS 316L DEFORMATION PROCESS USING MICRO COMPUTED TOMOGRAPHY

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1. Introduction

Recent research into porous materials has been using models mapping the realistic shapes of pores. The most common method of obtaining cross sections is X-ray computed microtomography (micro-CT). For optimal quality of tomographic images it is necessary to have an suitable configuration of the micro-CT imaging parameters for the specific material [1]. In recent years the finite element modeling of mechanical properties concerning various cellular materials based on microtomography images has been developed. The most frequently were investigated metallic cellular materials [2, 3].

Micro-CT device has limited measurement accuracy. This results in a lack of information about the geometric shape of details smaller than the pixel size obtained during the measurement. In the case of the sintered 316L these are fissures and small pores resulting from the manufacturing process. No mapping of the geometric details results in overestimation of nominal (average) stress, obtained by numerical computations [4]. The paper describes a complex method to compensate of micro-CT inaccuracy used for numerical modeling. The proposed methodology enables the modeling of porous materials deformation taking into account their heterogeneous structure. The research allows to determine the impact of porous structure on the deformation process.

2. Materials and methods

Raw materials used for research were 316L powders. For the preparation of porous materials was used sintering method based on powder metallurgy [5]:

- annealing of the powder in vacuum in order to remove oxide layers from the surface of the particles;
- cold pressing in a special die using an EDZ-1000 universal uniaxial test machine;
- sintering at high temperature.

By using three different pressing pressures 200, 400 and 600 MPa were obtained sinters with porosity of 41%, 33% and 26% respectively.

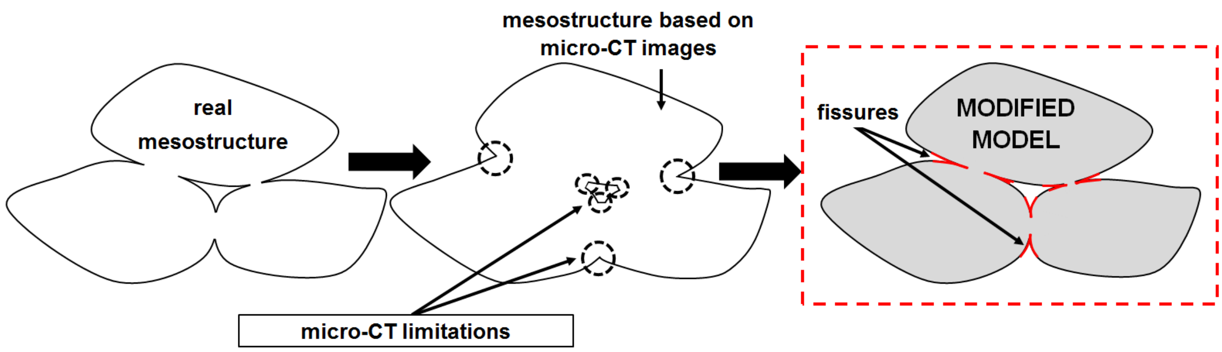

Fig. 1. Schematic representation of the essence of the Model III.

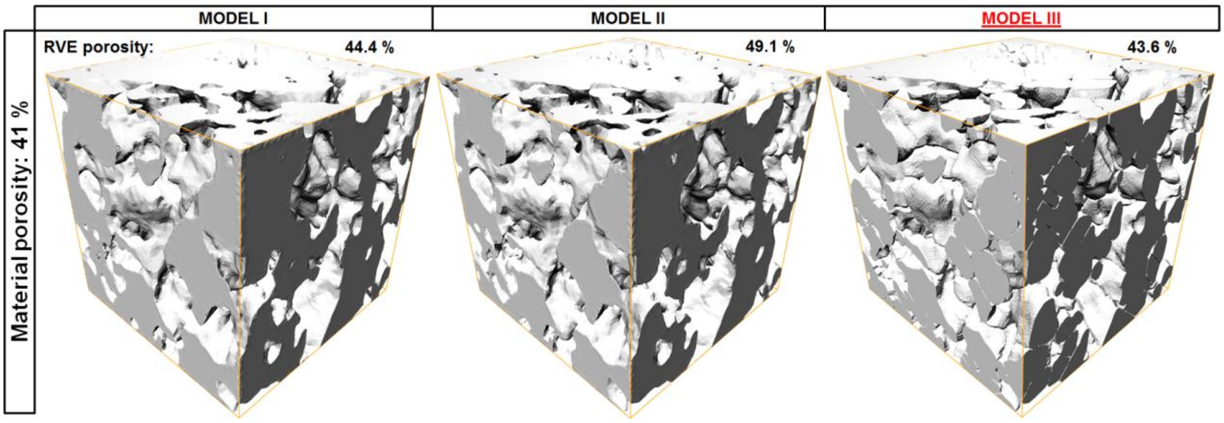

Fig. 2. Example representative volume elements obtained for material with 41% of porosity.

The microtomography were conducted with accuracy of 2.9 μm (pixel size). In the work Doroszko and Seweryn (2015b) described that the accuracy of the micro-CT is insufficient for mapping the geometry such as small pores and fissures in size less than the size of the received pixels. The lack of mapping of these geometric details in models cause overestimated values of macroscopic nominal stress in the deformed sintered materials [6]. For compensate of micro-CT inaccuracy were used three numerical models:

1. Model I involves artificial understatement of Young's modulus and yield strength to approximate the value of macroscopic nominal stress obtained by computation and experiment [3].

2. Model II describes a simplified method for mapping inaccuracy compensation in the numerical calculations. It consisted of increasing the porosity of the separated models by changing the grayscale threshold representing the porous material [6].

3. Model III it is comprehensive approach that take into account the geometric elements i.e. fissures and small pores in the numerical calculations, without overestimation the porosity of models. The essence of the method it is the appropriate modification of shapes separated from received tomographic images (fig. 1). Figure 2 shows example representative volume elements obtained for material with 41% of porosity.

3. References

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