KEY ISSUES OF DESIGN AND NUMERICAL INVESTIGATIONS OF REGULAR CELLULAR STRUCTURES MANUFACTURED ADDITIVELY OF Ti6Al4V

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1. Introduction

Regular cellular structures are a new prospective group of multifunctional materials [1, 2]. Low density, high mechanical strength, as well as thermal, acoustic and vibration insulation make them attractive for many demanding branches of industry [3]. This group of materials is on interest of automotive, aviation, railway, chemical and civil engineering. Moreover, regular cellular structures could be potentially implemented in many military applications, especially in development of passive protective systems. Contemporary, a progress in the area of material science and a growing potential of additive manufacturing methods cause an increasing development of advanced engineering and functional cellular structure materials [4, 5].

The aim of the paper is to present the main issues related to designing and numerical investigation on a deformation process of 2D regular cellular structures produced of Ti6Al4V using LENS (Laser Engineering Net Shaping) additive manufacturing technique.

2. Key issues of numerical simulations of structure deformation process

The main idea of the conducted numerical investigation was directed to define a relationship between structure topology, relative density versus absorption energy. Typical honeycomb and re-entrant honeycomb structure samples made of Ti6Al4V were used during experimental investigations. They were tested under static and dynamic loading boundary conditions. The outcomes of the conducted experimental tests were used to validate a numerical model describing a structure deformation process. Unfortunately, the obtained results of the preliminary computer simulations were in disagreement to the experimental data. Based on the additional attempts to conducted numerical investigations, the authors have found certain key issues which should be included during preparation of numerical models (Fig. 1).

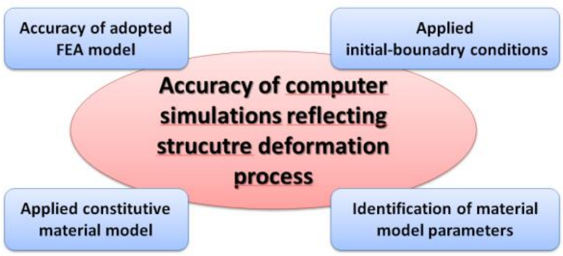

Fig. 1. Main issues influenced accuracy of a computer simulation structure deformation process

Owing to the above mentioned issues it is possible to increase the accuracy of numerical outcomes. The first issue is accuracy of the adopted FE model. Application of LENS system and a contouring procedure in the structure samples manufacturing process require CAD model with a thin wall thickness (0.01 mm). Due to technological limitation of LENS system, the wall thickness of a real structure sample was defined based on a single contour. The authors have noticed a considerable dimensional deviation between the assumed and the real value of the structure wall thickness. Additional measurements (3D scanning, computer tomography) and a quality control procedure must be adopted in order to define the correct value of wall thickness of a structure FE model (Fig. 2).

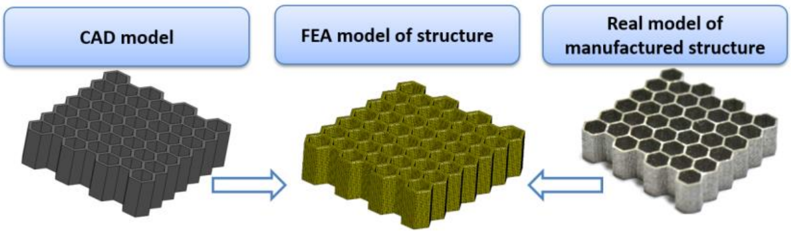

Fig. 2. Scheme of FEA model preparation including dimensional deviation of real structure

The other important issue which should be considered during numerical investigation of the structure deformation process is the applied definition of initial-boundary conditions. The restrain and loading conditions adopted in computer simulations need to be identical as in the experimental tests. Moreover, a contact definition strongly affects the obtained results. A constitutive material model is the further issue necessary to be considered. The authors of the paper have tested a few of the most popular constitutive material models available in LS-DYNA software (PLASTIC_KINEMATIC, PICEWISE LINEAR PLASTICITY, SIMPLIFIED JOHNSON-COOK, JOHNSON-COOK WITH FAILURE CRITERIA). Based on the obtained results it was noticed that material models without failure criteria present different results in comparison to the experimental data. The last point which, in authors' opinion is also crucial is a proper identification of the material model parameters. Structures manufactured additively by LENS indicate sensitivity to technological parameters. The samples used to determine the material model parameters should be produced in the same technological process as the structures. Moreover, they ought to be subjected the same heat treatment operations.

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3. References

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