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MECHANICAL RESPONSE OF ADDITIVELY MANUFACTURED 2D REGULAR CELLULAR STRUCTURES MADE OF MS1 STEEL POWDER SUBJECTED TO UNIAXIAL LOADING TESTS

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Introduction

Contemporary progress in the area of material science and growing potential of additive manufacturing methods cause an increasing development of advanced engineering and functional cellular structure materials [2, 3, 8]. One of the significant features which they demonstrate are high mechanical properties with respect to low density. This group of materials has begun to be used in many demanding branches of industry such as automotive, aviation, railway, chemical, and civil engineering [5, 9]. Moreover, regular cellular structures could be potentially implemented in military applications, especially in the development of passive protective systems.

The purpose of the paper is to present results of experimental and numerical investigations of a mechanical response of additively manufactured regular cellular structures subjected to uniaxial loading tests.

Research methodology

The main idea of the conducted investigation was directed to define a relationship between the structure topology, a relative density versus an absorption energy. This work is a continuation of studies where FDM 3D printing method and polymer material were used [5]. Conducted evaluation of the structure deformation process under uniaxial loading boundary conditions was realized following to scheme presented in Fig. 1.

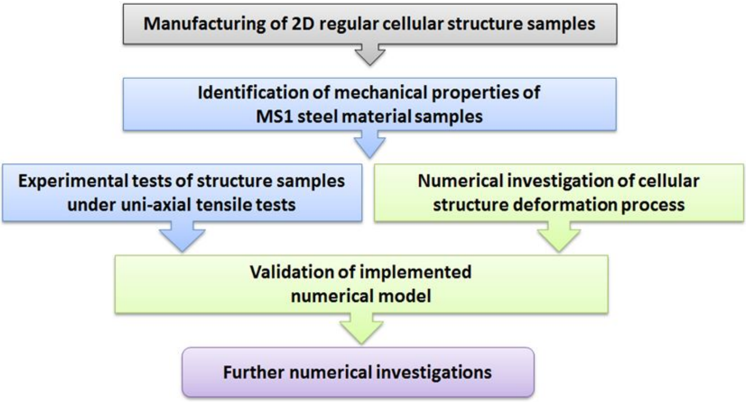

Figure 1. Scheme of main stages of conducted investigations

The method of direct, selective laser melting of metallic powders was used to manufacture the regular cellular structures as well as dog-bone tensile test samples and cylindrical samples for Taylor tests. The manufacturing was performed using the powder bed fusion technology with the EOS M280 DMLS system and MS1 maraging steel powder. The MS1 steel has a chemical composition corresponding to European 1.2709 alloys and provides high hardness (> 33HRC) and yield stress of approx. 1100MPa. The cuboid samples of cellular structures (dimensions $36 \times 36 \times 10$ mm) were sintered using the standard laser exposition parameters, solid-material supports and were not subjected to a postprocessing (machining, shot-penning and heat treatment).

Typical honeycomb and re-entrant honeycomb structure samples made of MS1 maraging steel were used during experimental investigations, where samples were subjected to quasi-static, uniaxial compression tests. The evolution of loading force and absorbed energy versus displacements are presented in Fig. 2 and Fig. 3 respectively. The results provide high repeatability even in the range of severe plastic deformation. The outcomes of the conducted experimental tests are the basis for further numerical modelling describing the deformation process and performing model validation.

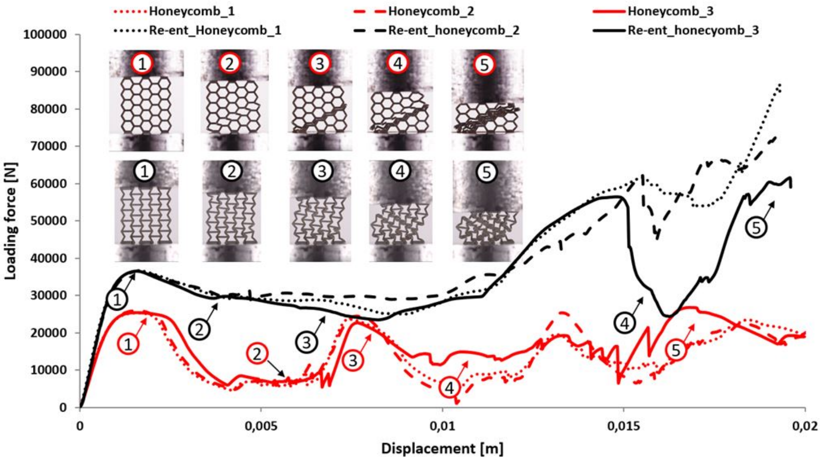

Figure 2. Deformation process of honeycomb and re-entrant honeycomb structure samples

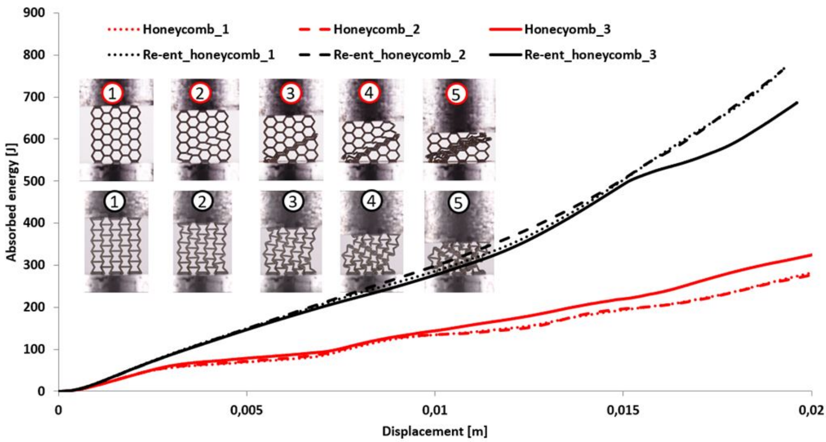

Figure 3. Absorbed energy during deformation process of honeycomb and re-entrant honeycomb structures

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