MECHANICAL BEHAVIOR OF ALSI10MG ALLOY OBTAINED BY 3D PRINTING UNDER COMPRESSION AT HIGH STRAIN RATES *

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The expanding use of additive manufacturing technologies (AM) including 3D printing by selective laser melting (SLM) for creation of structural elements from light alloys with high specific strength characteristics places increased demands on the accuracy and adequacy of computer engineering predictions, both materials and structures.

Currently, the AlSi10Mg alloy is widely used for 3D printing by SLM of light and reliable structural elements with complex topology. [1, 2].

An urgent problem is the development of models that make it possible to adequately predict the mechanical behavior including damaging and fracture of Al-Si-Mg alloys obtained by the SLM method under dynamic influences. During the operation of aerospace technique and land and sea transport systems structures under the influence of dynamic loads, a complex stress state arises in printed from AlSi10Mg constructional elements, and plastic deformations can develop, adiabatic shear bands can form, leading to damage to the material and destruction of structures.

This paper presents the results of an experimental study and numerical simulation of the mechanical behavior of AlSi10Mg alloy samples obtained by selective laser sintering under quasi-static and dynamic uniaxial compression.

Compression tests at a constant strain rate were carried out using an Instron VHS 40/50-20 high-speed test bench (Instron Corporation, High Wycombe, UK) with a 50 kN load cell. The tests were performed in the speed control mode at the initial values of the compression velocity of 0.002 ± 0.00001, 2 ± 0.01, and 10 ± 0.02 m/s.

Numerical simulation of mechanical response to dynamic loading of model 3D volumes of AlSi10M alloy was performed using by the Autodyn, LS DYNA software including in WB ANSYS 15.2.

The results of the study showed that in samples of the alloy obtained by the SLM method, compressive deformation is accompanied by the formation of plastic deformation localization bands, which transform with increasing strain rate into adiabatic shear bands.

Taking into account strain hardening, thermal softening in plastic deformation localization bands, dilatancy effects due to the nucleation and growth of pores, as well as degradation of elastic moduli as a result of damage accumulation, leads to the need to solve a system of nonlinear equations.

When performing numerical modeling, we took into account the anisotropy of the resistance to plastic flow of the AlSi10Mg alloy, caused by the texture and bimodal grain size distribution, which are formed when printing a body using the SLM method [3, 4].

The results of a numerical analysis of the deformation of samples under high-speed uniaxial compression indicate the staged nature of the evolution of damage. In the process of damage formation, microdamage nucleates in localization bands, clusters of microdamage form, clusters transform into a mesoscopic crack, interaction of mesoscopic cracks system and creation of the macroscopic fracture zone.

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