DYNAMIC AND SHOCK-WAVE PROPERTIES OF AK6 AL ALLOY MESH PRODUCTS OBTAINED BY ADDITIVE TECHNOLOGY

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The aim of the research is to study and compare the dynamic and shock-wave properties of volume-structured samples (barriers) with different topologies – cubic (FCC, BCC) and TPPME (gyroid type), as well as to identify the best structural design of mesh structures to improve the performance characteristics of the Al-Cu-Mg-Si alloy.The purpose of these studies is to study the effect of the geometry of the construction of samples relative to the AlSi10Mg alloy substrate on their structure, defects and mechanical properties.

The objects of the study were samples of AK6 alloy (analogous to A1360), synthesized on a Realizer-SLM100 3D metal printer. To study the deformation behavior of the AK6 alloy under quasi-static deformation, sets of mesh samples with different pore channel topology and different densities were loaded using the Hopkinson–Kolsky method. The gyroids differed not only in density, but also in geometric characteristics – cell period and wall thickness. The attenuation of plane shock waves depending on the topology of the mesh structures was studied on an experimental setup under conditions of one-dimensional loading with an HMX-based explosive charge. Information on the stress state of the products under impact loading was obtained by continuously measuring mechanical stresses using pressure sensors. Based on the dynamic diagrams obtained when loading samples using the Hopkinson–Kolsky method in the strain rate range of $5.0 \cdot 10^2$–$5.7 \cdot 10^3$ s^{-1}, the values of the conditional yield strength and ultimate strength were determined. The strain rate dependences of the strength characteristics of samples with different mesh structures were constructed, and it was shown that the mechanical properties remain constant in the studied strain rate range. A comparison of the mechanical properties of samples with different cubic mesh structures was carried out. It was found that the properties of samples with an FCC structure (ρ = 1.27 g/cm^3) are higher than the properties of samples with a BCC structure (ρ = 1.15 g/cm^3) by about 7%. A decrease in the density of samples with a BCC structure to ρ = 0.4 g/cm^3 sharply, by 8–10 times, worsens the properties of the material. Reduction of the cell period from 3 to 1 mm and the density from 0.7 to 1.8 g/cm^3 leads to an increase in the conditional yield strength of gyroids by 2.4 times. Comparison of the properties of the SLS alloy AK6 and foam aluminum showed that σ_B of gyroids with a density of ρ = 0.7 exceeds the strength of foam aluminum (ρ = 0.5) by ~1.5 times. It was determined that the best properties are exhibited by gyroids with a cell size of 1 mm and a wall thickness of 0.2 mm. Dependences of the shock wave attenuation coefficient depending on the thickness of the obstacles – gyroids (9, 12, 18, 21 mm) are constructed. It is shown that for obstacles (<12 mm) the influence of the geometric parameters of gyroids is insignificant. For example, for obstacles 9 mm thick, an increase in the cell parameter from 1 to 3 mm increases the coefficient from 1.25 to 1.4. With a greater barrier thickness, the shock wave attenuation effect depends on the gyroid cell parameter. In particular, it was found that gyroids with a cell of 2 mm have a higher shock wave absorption capacity (K = 4), whose mechanical characteristics $\sigma_{0.2}$ = 28 MPa, σ_B = 52 MPa are comparable with the properties of annealed aluminum obtained by traditional casting technology. Comparison of the strength and shock wave characteristics of samples with different mesh structures shows the advantage of gyroids as a promising design for improving the properties of volumetrically structured products.

Structural studies were performed at the M. N. Mikheev Institute of Metal Physics, Ural Branch of the Russian Academy of Sciences.