DAMAGE AND FRACTURE OF LAYERED STRUCTURES WITH AUXETIC METAMATERIALS UNDER DYNAMIC LOADING*

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The results of fracture creation numerical study in the layered structures of with an internal layer of re-entrant auxetic metamaterials under dynamic impacts are presented. The purpose of the study was to establish the influence of the effective strain rate and temperature on the damage formation and fracture of elements layered structures. The response of layered systems to dynamic loads was studied at strain rates from 100 to 1000 s^{-1} and initial temperatures from 153 to 473 K.

Numerical simulation of mechanical response to dynamic loading of model 3D volumes of layered structures consisting of upper and base plates, between which a layer of re-entrant auxetic metamaterial was placed, having rigid contact of the outer frame elements with the plates, was performed using by the Autodyn, LS Dyna software including in WB ANSYS 15.2.

The normal displacement velocity of the loading plate surface under an impulse loading was determined using by loading function $v_z(t)$. Under harmonic loading it was analyzed frequencies of $v_z(t)$ which is satisfy the condition: $f_{cycl} > 0.25\, v_z^{(amp)/[}H - m/(\rho_c F)]$, where H is the thickness of metamaterial interlayer, m is the mass of metamaterial interlayer, ρ_c is the mass density of material of metamaterial frame element, F if the square of metamaterial volume projection onto the base plate.

Layered structures based on aluminum alloy 1530 (AMg2) and also titanium alloy Ti-5Al-2.5 Sn (Ti Grade 6), which can be produced by welding, soldering or selective laser sintering, are considered. Damping layered structures with a layer of 3D re-entrant auxetic metamaterial, which have the ability to effectively absorb and dissipate the energy of impulse effects, are considered [1, 2]. To describe the mechanical behavior of structural elements from alloys belonging to different isomechanical groups of materials, constitutive equations and fracture models were used based on the evolution of damage to the alloys during deformation at high strain rates [3, 4].

The results of numerical modeling showed a change in the dissipative properties of three-layer structures made of light aluminum alloys with a layer of re- entrant auxetic metamaterial under dynamic loading, which is caused by damage and fracture of the frame elements of the metamaterial. The research results displayed that with an increase in the strain rate and temperature for the same duration of dynamic impacts, not only the equivalent plastic deformation in the metamaterial frame elements increases, but also the temperature increment in the plastic deformation zone increases. As a result, the growth of damage to the material of frame elements in zones of development of plastic deformations slows down, and the dependence of the growth of the damage parameter becomes nonlinear.

It is shown that the damage of the considered layered systems under dynamic conditions does not occur simultaneously. Fracture under the influence of impulse forces normal to the surface begins in the zones of connection of the frame elements of the re-entrant auxetic metamaterial with the plate experiencing the load.

The results obtained confirm the prospects of using the considered three-layer structures as dampers of pulsed mechanical loads in temperature range from 153 to 473 K.

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