PENTAMODE METAMATERIALS UNDER DYNAMIC LOADING *

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Metamaterials currently are of interest for a wide variety of applications including damping systems. This work aimed to evaluate dissipative effect of pentamode metamaterials subjected to dynamic loading. The results of numerical modelling of the mechanical behavior of pentamode metamaterials from alpha titanium alloys were received and compared with available experimental data. The model of inelastic deformation and ductile damage criterion were used to describe the ductility of the framework of metamaterials in a wide range of strain rates, temperature and stress triaxiality [1, 2]. A method is presented for predicting energy dissipation during inelastic deformation of metamaterials at high strain rates. The numerical simulation of the mechanical response of a pentamode metamaterial from the Ti-5Al-2.5Sn titanium alloy was carried out during dynamic compression at 100 m/s.

The evolution of the framework structure is the cause of different values of the dissipated work and coefficient of energy dissipation. Fig. 1 shows calculated values of the specific mechanical energy W over time (curves 1 and 3) and the specific internal energy W_{int} (curves 2 and 4) over time.

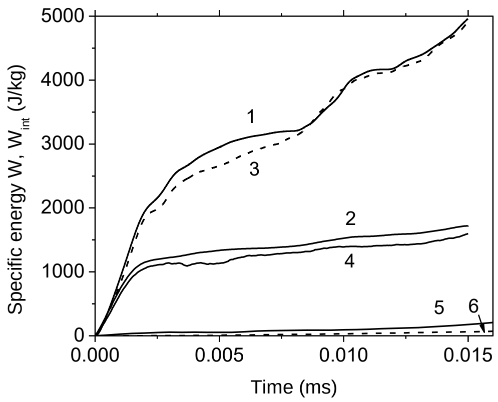

Fig.1. Specific internal energy of deformed framework elements under compression at the velocity of 100 m/s. Curves 1, 2 correspond to W (t), and curves 3,4 correspond to W_{int} (t)), respectively.

Curves 5 and 6 indicate the change in W and W_{int} during high-speed deformation of the bulk titanium alloy Ti-5Al-2.5 Sn at a strain rate of 100 s^{-1}. Calculated normalized Young modulus $\langle E\rangle/E_s$ and value of the normalized effective yield stress σ_y/σ_{ys} agree with experimental data obtained by Hedayati and coworkers [3]. A methodology to analyze the energy dissipation due to inelastic deformation of structured materials at high strain rates was presented for metamaterials. The values of the energy dissipation coefficient were determined for uniaxial compression of the pentamode metamaterial with the relative mass density of 3.145% at strain rates of ~20.8 10^3 s^{-1} and initial temperatures of 300 K and 900 K. The values of the energy dissipation coefficient during uniaxial dynamic compression of the pentamode metamaterial are 1.5 times higher than for the bulk alloy counterpart. The energy dissipation coefficient under uniaxial compression decreases by a factor of 1.5 - 2 with an increase in the initial temperature from 300 K to 900 K.

It was shown that the values of the energy dissipation coefficient during uniaxial dynamic compression of the pentamode metamaterial are 1.5 times higher than for the bulk alloy counterpart.

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