Damage of titanium alloys under tensile at high strain rates

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In this work, a damaged medium model was proposed to describe the dynamic fracture of titanium alloys VT1-0, VT5-1 and VT6. The proposed model allows to describe both spall fracture and tensile fracture at high strain rates under conditions of a complex stress state. The elastoplastic response of titanium alloys is described by a constitutive equation taking into account the dependence of the flow stress from cumulative plastic deformation, homologous temperature, and the logarithm of the normalized equivalent strain rate [1].

The kinetics of damage was describing by parameter D as a result of nucleation, growth and coalescence of voids: $\mathrm{d}D/\mathrm{d}t = \mathrm{d}D_1/\mathrm{d}t + \mathrm{d}D_2/\mathrm{d}t$, where D is the damage parameter, D_1 is the constituent of D associated with damages caused by negative pressure, D_2 is the constituent of damages caused by voids evolution under repeated loading, $\mathrm{d}D_1/\mathrm{d}t = \alpha_1 \min[0, \mathrm{d}p/\mathrm{d}t]H(-p + p_c)$, where $H(\cdot)$ is the Heaviside function, p is the pressure, α_1, and $p_c < 0$ are constants of the material, $\mathrm{d}D_2/\mathrm{d}t = [1/(\gamma_1 A\sqrt{2\pi})]\exp[-(\ln(A)/\gamma_1\sqrt{2})^2]$, where $A = \int_0^t W^e[\beta_1 \exp(-\beta_2 W^p)(1-D)]^{-1}(\mathrm{d}W^p/\mathrm{d}t)\mathrm{d}t$, β_1, β_2, γ_1, are constants of the material, W^e, and W^p are the specific internal energy, and the specific dissipated energy, respectively. Obtained results of numerical simulation are in agreement with the available experimental data on a spall and dynamical fracture of titanium alloys. It was shown that in spall zone there are meso-volumes in which the alloy has undergone severe inelastic deformation. These inelastic strains occur during repeated loading of the alloy in reflected loading and unloading waves. The work is supported by the Russian Science Foundation (grant No. 20-79-00102).

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