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EFFECT OF STRAIN UNDER CONDITIONS OF UNIFORM COMPRESSION ON THE PHYSICAL AND MECHANICAL PROPERTIES OF TITANIUM IN THE TEMPERATURE RANGE OF 77–800 K

The effect of deformation by quasihydroextrusion with counter-pressure (QHEC), creating conditions of hydrostatic compression to 22 kbar at 77 K and 12 kbar at 300 K, on characteristics of macro- and microyielding of titanium VT1-0 was studied.

In the temperature range of 77–800 K, control of physical and mechanical properties of titanium in the initial state and after QHEC to 25% at 77 and 300 K was carried out by measuring the temperature dependences of the mechanical properties, shear modulus, the relative resistivity (ρ_{77}/ρ_{300}) and assessment of energy and structural states of the dislocation structure by measuring the amplitude dependence of internal friction $\delta(\gamma)$ and electron microscopy.

It was shown that VT1-0 in the initial state was characterized by a sharp increase in the strength and ductility in the area of 130–77 K, the presence of thermally activated dependence of the strength within the range of 77–600 K and athermal dependence at 600–800 K. High strength and ductility of VT1-0 in the initial state at 77 K was provided by active development of twinning.

QHEC enhanced strength properties in the range of 100–700 K, suppressed sharp rise at 77 K and held thermally activated nature of the dependence of proportional limit, yield strength and tensile strength in the entire temperature range studied (77–800 K), that indicated a decrease in the stacking fault energy of titanium after QHEC at 77 and 300 K.

It was found that at 300 K, QHEC reduced ductility of titanium by 38% in the case of extension at 77 K compared to the initial state and after QHEC at 77 K, the ductility was reduced threefold, probably due to the suppression of twinning after QHEC.

Electron microscopy studies confirmed that QHEC significantly reduced the tendency to twinning in the subsequent low-temperature deformation.

By measuring $\delta(\gamma)$ it was found that 25% QHEC at 77 and 300 K increased microyielding parameters (voltage of separation of dislocations from pinning points and start of Frank–Read sources) compared with the initial VT1-0, as well as macroscopic characteristics of strength (σ_{pr}, $\sigma_{0.2}$ and σ_b).

It was found that the model of Granato–Lücke could not be used within a wide temperature range in the course of the analysis of the temperature dependence of internal friction of titanium after deformation under hydrostatic compression.

Keywords: titanium, deformation, hydrostatic compression, strength, plasticity, parameters of microplasticity, relative electrical resistance

Fig. 1. The structure of the titanium in the initial state

Fig. 2. Microstructure of the titanium after QHEC at 300 (*a*) and 77 K (*б*)

Fig. 3. The temperature dependence of the proportional limit stress σ_{pr} (*a*), yield strength $\sigma_{0.2}$ (*б*) and ultimate strength σ_b (*в*) of the titanium in the initial state (■) and after QHEC at 77 (▲) and 300 K (●)

Fig. 4. The temperature dependence of the relative elongation of the titanium in the initial state (■) and after QHEC at 77 (▲) and 300 K (●)

Fig. 5. Temperature dependence of the stress of dislocation breakaway from pinning points τ_{br} (*a*) and of the stress of the start of work of Frank–Read sources τ_{start} (*б*) in the titanium in the initial state (■) and after QHEC at 77 (▲) and 300 K (●)