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Modification of the Mechanical Properties of the Sheet Two-Phase High-Strength Titanium Alloy VT 23 Due to Impulse Introduction of Energy

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Abstract

This study shows the effect of the specific impact-oscillatory loading (dynamic non-equilibrium processes) on the variation of the mechanical properties of the sheet two-phase high-strength titanium alloy VT 23. The results of fractographic research are used for interpreting the results of mechanical tests.

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1. Introduction

Aircraft construction requires the use of materials that can withstand the severe pressures of flight at high altitudes. Titanium alloys for industrial use are widely used for aircraft as a material having light weight (density being 60% that of steel), high strength, and excellent corrosion resistance. The authors are actively developing a new line of research in the mechanics of deformable solids, which is associated with the dynamic non-equilibrium processes (DNP) on the variation of the initial mechanical properties of structural materials. A simple and effective method of the DNP implementation is developed, which consists in a high-speed stretching of the material with the superimposition of a high frequency vibration process (several kilohertz) [1–3]. This mode of loading is achieved on a specially modified test setup that consists of two circuits – the external (a load frame of the test setup) and the internal ones. The internal circuit is the simplest statically undefined structure, which consists of three parallel elements loaded simultaneously, i.e. the central specimen and two symmetrical satellite specimens (“brittle samples”) of different cross-section made of hardened steels 65G or U8-U12. When this structure is loaded, satellite specimens are destroyed (for a given load or strain), and extra energy is introduced into the material of the test specimen under the implementation of the above loading process. The analysis of the results obtained on the materials of different classes has shown that transients modes of loading, which are implemented under short pulses of the force uploading characterized by the mass transfer without any dissipation of energy in the classical sense (i.e. conversion of the mechanical energy into heat), allow for the self-organization of new dissipative structures in structural materials, whose physical and mechanical properties are significantly different from those of the original structure [3–5]. In case of loading with a short impulse at a short distance from the surface of the impact, slow diffusion mechanisms of the momentum and energy transfer are still undeveloped. Therefore, the energy of the power pulse is transferred from the macroscopic level to some intermediate mesoscopic level, at which the energy left in the medium is spent on the formation of new dissipative structures. The objective of the paper is to study the effect of the impulse introduction of energy into the sheet two-phase high-strength titanium alloy VT 23 on the variation of its mechanical properties under further static tensioning, and to interpret the results of mechanical tests based on the results of fractographic research.

2. Research technique

The developed and repeatedly tested methods of the DNP implementation under impact – oscillatory loading [1–3] were used in this study to perform tests on specimens from the sheet two-phase high-strength alloy VT 23 with the thickness of 3 mm (Fig. 1).

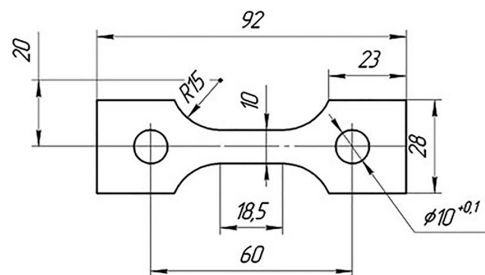


Fig. 1. Test specimen.

The chemical composition of the alloy under study are given in the Table 1.

Table 1. The chemical composition of the titanium alloy VT 23, (%).

Fe	Cr	Mo	V	Ti	Al
0.4–0.8	0.8–1.4	1.5–2.5	4.0–5.0	84.0–89.3	4.0–6.3

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