Fatigue-resistance characteristics of Ti–6Al–4V alloy synthesized by the simplest powder metallurgy method involving the processes of pressing and sintering of blended elemental titanium hydride-based powders were studied. Powder materials have a relatively fine-grain β-phase, which despite the presence of residual pores, makes for quite a high fatigue limit (500 MPa) comparable to that of the corresponding cast alloys. Fatigue cracks in the powder alloys are initiated from such stress raisers as major pores open to the surface of the specimen gauge length. Along with a significant decrease in the production costs of titanium alloys and articles of them, the use of this method provides obtaining materials with satisfactory static and dynamic mechanical characteristics suitable for practical applications.

**Keywords**: fatigue, fatigue limit, powder metallurgy, microstructure, structural parameter, titanium alloys.

**Introduction.** Possessing a unique combination of high strength characteristics and corrosion resistance, titanium alloys are used as structural materials in aerospace engineering. The wider application of titanium alloy products is limited by the high cost of the material and its treatment, which is why manufacturing methods providing a reduction of the final cost are needed. One of such methods is the powder metallurgy (PM) technology, specifically the blended elemental powder metallurgy approach (BEPM), the gist of which is that alloying elements in the form of elemental powders or master alloy powders are added to titanium-based powder [1-4]. Along with a reduction of the cost of products manufactured using this method, a decrease in their mechanical characteristics occurs mainly due to residual porosity. The fatigue-resistance characteristics are most sensitive to the presence of residual pores in materials. Thus, at a porosity of 1–2% they decrease by 10–30%, while the static mechanical characteristics, in this case, do not decrease so markedly [1]. To lower the level of residual porosity and improve the mechanical characteristics, a complicated and costly hot isostatic pressing technology is often applied, but even the use of this technology does not always lead to a complete “recovery” from pores, particularly where titanium powders with a high chloride content are concerned [4, 5]. As a result, the fatigue resistance of PM titanium alloy products is lower than that of the products made of cast and especially hot deformed alloys.

In [6–9] the authors show that the use of titanium hydride as a basis for powder mixtures when producing titanium alloys via the BEPM has a positive impact on their final density and chemical and microstructural homogeneity. Ti–6Al–4V alloy obtained from a mixture of titanium hydride and master alloy powders by the simplest technique of pressing and further sintering in vacuum possessed high relative density (up to 99%). Its tensile testing revealed that the mechanical characteristics of such material, owing to its homogeneous fine-grain microstructure and a low impurity content, almost match those of a monolithic material having the same composition. However, the issue of the fatigue-resistance characteristics, specifically the fatigue limit, which, in many cases, serves as a criterion for the applicability of structural materials, remained unexplored.

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The object of the present work is to determine the cyclic strength of Ti–6Al–4V powder alloy obtained from the mixture of titanium hydride and master alloy powders using the simplest form of the BEPM method involving only the pressing and sintering operations, identify a structural parameter responsible for the fatigue crack nucleation, and determine a quantitative relationship between this parameter and the fatigue limit.

**Materials and Investigation Methods.** As a basis of the powder mixtures, we used titanium hydride powder (the particle size is 100 µm, the chemical purity 99%, and the hydrogen content 3 mass %). To obtain the Ti–6Al–4V composition, the corresponding amounts of alloying elements in the form of 65Ti–35Al and 25Al–75V master alloy powders with a particle size of 65 µm and a purity of 99% were added. The powders were mixed for 6 h and the mixture was pressed at room temperature to form prismatic compacts of dimensions 55 × 10 × 10 mm under a pressure of 700 MPa. Sintering was carried out in vacuum at 1350°C. After sintering, the density of the alloy was determined through hydrostatic weighing and the microstructure was examined by light microscopy.

Mechanical tensile tests were conducted by the conventional procedure on cylindrical specimens (the diameter of the gauge length 3 mm) turned from prismatic billets. Experimental investigations of the fatigue-resistance characteristics were performed using the method detailed earlier in [10, 11]. Smooth cantilevered specimens of thickness 3 mm and width 7 mm in the working section were tested in lateral bending in an electrodynamic shaker (VÉDS-400A) under conditions of resonance transverse vibrations. As a criterion for the fracture of the specimens, we took a 1% drop in the resonance frequency as compared to its initial value, this drop corresponding to the occurrence of a surface macrocrack of depth up to 1 mm in the specimen working section (Fig. 1). Before testing, the specimen surface was mechanically polished and the sharp edges were rounded (r = 0.5 mm) to remove stress raisers. To determine the effect of the stress raisers on fatigue resistance, some specimens with non-rounded edges were tested. Fractographic examinations of the fatigue fracture surfaces were carried out with the use of a JSX-840 (JEOL) scanning electron microscope.

**Results and Discussion.** The initial compacts had quite a low density (70 to 75% of the theoretical one). However, in heating and isothermal holding at 1350°C their density grew rather quickly and reached 4.394 g/cm³, which corresponds to a relative density of 98.3%. The density of titanium hydride is lower than that of titanium free of hydrogen, so the density increase in heating is related not only to the sintering of the powder particles, but also to the decomposition of titanium hydride and its dehydrogenation. Thermodynamic calculations suggest that hydrogen released in the decomposition of titanium hydride, if it is in an atomic state, is capable of restoring oxides of aluminum and, possibly, titanium [6]. The analysis performed revealed that after sintering, the contents of oxygen (0.26%) and nitrogen (0.047%) are below the limit values, which can cause embrittlement, and the hydrogen content is 0.0018%, which indicates that it almost completely left the material during sintering in vacuum. The chemical composition practically corresponded to the design one: Ti–5.8Al–4.0V.