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EXPERIMENTAL APPROBATION OF THE ACCELERATED FATIGUE TEST METHOD ON VARIOUS METALLIC MATERIALS

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Keywords: operation, steel, surface hardening, fatigue characteristics, surface roughness, microhardness, temperature, time.
Abstract. The use of high-frequency cyclic loading is shown to determine the nature of the change in the fatigue properties of an aluminum alloy AK8M3 with laser hardening. The loading of the samples was carried out on a specially designed research facility, which operated with a resonant oscillation frequency f_{res} = 18 kHz. The samples vibrated according to the second eigenmode of oscillation. The influence of the composition of graphitized steels on the change in fatigue

ЭКСПЕРИМЕНТАЛЬНАЯ АПРОБАЦИЯ МЕТОДИКИ УСКОРЕННЫХ УСТАЛОСТНЫХ ИСПЫТАНИЙ НА РАЗЛИЧНЫХ МЕТАЛЛИЧЕСКИХ МАТЕРИАЛАХ

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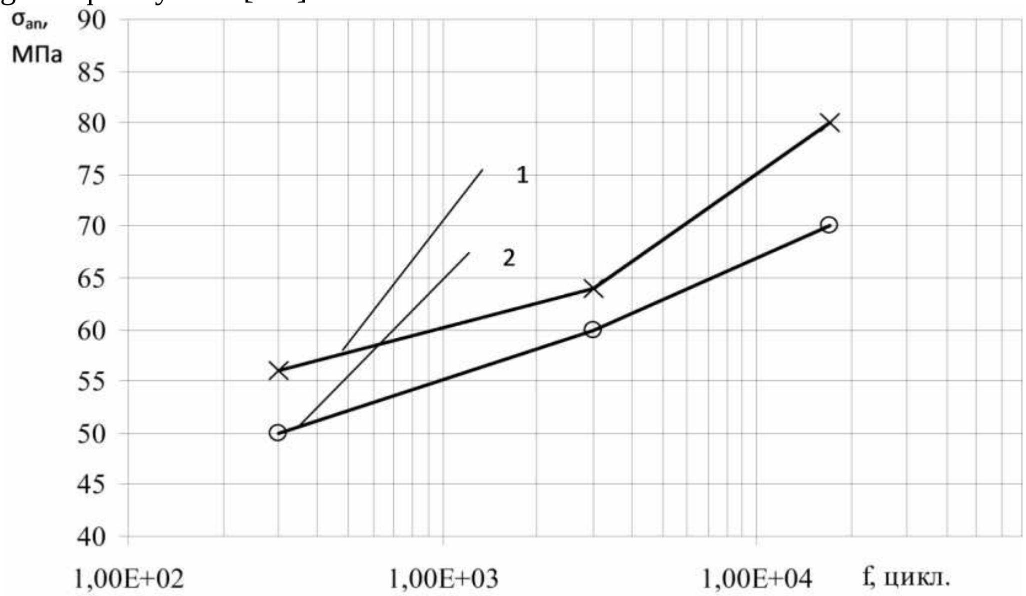
Ключевые слова: эксплуатация, сталь, поверхностное упрочнение, усталостные характеристики, шероховатость поверхности, микротвердость, температура, время.
Аннотация. Показано использование высокочастотного циклического нагружения для определения характера изменения усталостных свойств алюминиевого сплава АК8М3 с лазерным упрочнением. Нагружение образцов производилось на специально разработанной исследовательской установке, работавшей с резонансной частотой колебаний $f_{рез}$ = 18 кГц. Образцы колебались по второй собственной форме колебаний. Установлено влияние состава графитизированных сталей на изменение усталостных

Theoretical analysis and especially mathematical modeling of the kinetics of fatigue failure, which combines the impact of a number of physical, mechanical and structural factors, as well as the processes of accumulation of damage to materials and the development of crack formation, is very complex. Based on the analysis of the law of motion of a fixed dislocation segment, which takes into account the inertia and viscosity of the medium, the determination of the critical stresses for the start of operation of the Frank–Read source at an alternating voltage was performed. For experimental verification of critical stress values, comparison of fatigue characteristics determined at different test frequencies, it is proposed to use the value of threshold values of cyclic loads corresponding to stresses below which there is no irreversible fatigue damage with unlimited test bases.

Threshold stresses were determined by the methods of microhardness, X-ray diffraction and microstructural analyses, electrical resistance upon reaching the level of cyclic stresses, below which changes in the parameters of these physical and mechanical properties were not recorded by the instruments. It should also be noted that there is a good correlation between the experimentally determined threshold stresses and the critical stresses of the beginning of the fatigue failure process found theoretically (Fig. 1) .Comparison of curves of frequency dependences of threshold stresses and endurance limits of materials determined in the studied frequency range showed their equidistance, which was observed at normal and elevated temperatures for various test bases using both longitudinal and bending vibrations. Thus, the difference between the limited endurance limits and the magnitude of the threshold stresses for each material in the studied frequency range is a constant value. Due to the fact that the threshold stresses are determined quite simply, for example, by changing the microhardness, it becomes possible to predict the characteristics of low-frequency fatigue strength using the results of high-frequency tests [1-2].



1 – threshold voltages, 2 – critical voltages

Fig. 1. Threshold and critical stresses of steel 25 KhGT

From the results obtained on the effect of amplitude-frequency and temporal loading parameters on the kinetics of the dislocation density of the studied materials, it can be seen that the most intensive changes in the structure-sensitive characteristics for the selected levels of alternating stresses occur at the beginning of cyclic loading. The fine structure of the studied materials is characterized by the most dramatic change in the dislocation density during the first loading cycles. In the future, with the cycles running, saturation occurs, which is replaced at the stage of microcrack development by a gradual transition through the extremum (Fig. 2). The observed effects of the kinetics of a number of structurally sensitive properties of the materials under study, depending on the amplitude-frequency and temporal factors of influence and determined mainly by the nature of the distribution and interaction of defects in the crystal lattice, can be explained from the standpoint of modern dislocation-vacancy concepts.

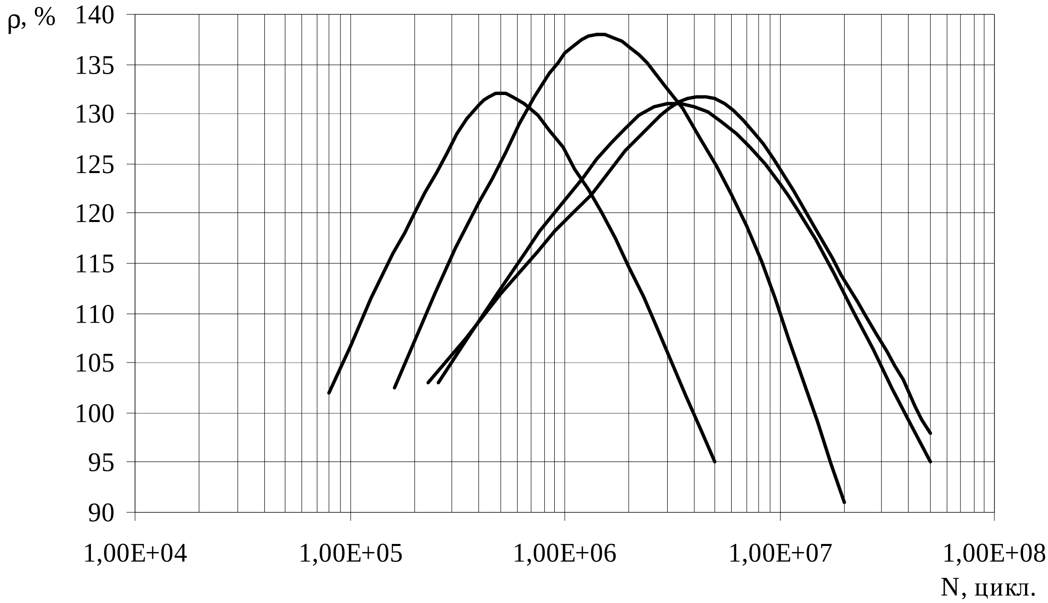


Fig. 2. Influence of the frequency of alternating bending on the kinetics of dislocation density of steel 25 KhGT

The dislocation density at the first stage of testing increases at all studied frequencies, which indicates the beginning of the process of material hardening. In the initial stage of loading, only oscillatory movement of segments of pinned dislocations around the equilibrium position takes place. The subsequent imposition of alternating stresses with a high frequency of the half-cycle of oscillations leads to the activation of dislocations present in the material, their rise from energy wells, helps them overcome potential barriers and move through obstacles, thereby causing plastic deformation [3].

The continuation of cyclic loading causes the appearance of new defects due to the action of dislocation sources activated in the first loading cycles, as well as sources arising due to the interaction of dislocations located in adjacent parallel slip planes. As a result, the density of dislocations and point defects (interstitial atoms and vacancies) increases significantly. At a certain concentration of defects, both dislocations and vacancies, their mass breakdown from obstacles occurs, causing a violation of interatomic bonds. The determining factor in this case is an increase in the dislocation density with an increase in the number of loading cycles, which is confirmed by the X-ray diffraction studies (Fig. 2). The cessation of the increase in the density of dislocations is associated with the deceleration of the action of the source of their multiplication by stresses from previously emitted dislocations.

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