ROLE OF ENERGY OF DEFECT OF PACKING IN RESISTANCE TO PASSING OF THE LOCALIZED PLASTIC DEFORMATION ON THE CYCLIC STRENGTH AND DURABILITY OF METALS

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Researched cylindrical samples with a diameter of 2 and 5 mm from metals with different type of a crystalline structure and energy of defect of package (γ) on fatigue in a broad range of frequencies of loading (ω) according to the diagram of a console bend with rotation. Damage of a surface was estimated on change of a microstructure of material under the influence of cyclic tension. The evaluation characteristic was served by the sliding bands arising on a sample shlifa from a zone of the largest tension [1]. The quantitative assessment of resistance of fatigue was the inclination of the left branch of curve fatigue to an axis of cycles (tg α_w).

The damage to the active layer and the surface proper is described by an expression of the form:

$$U_{\text{пс}} = \frac{\tau B_{\text{ду}} - U_{\text{п}} K_j}{K_j}\left[\frac{\tau B_{\text{ду}}}{\tau B_{\text{ду}} - U_{\text{п}} K_j} - e^{-K_{Ay} K_j j}\right], \qquad (1)$$

where $U_{\text{п.с}}$ – the parameter of the damage of the active layer of the surface; τ – is the voltage acting on the dislocation loop; $B_{\text{д.у}}$ – is the area of the defect in the package; $U_{\text{п}}$ – energy threshold of damage to the surface layer; K_j – is the parameter related to the inverse relationship with the transverse dimension (thickness) of the surface layer j; K_{Ay} – is a parameter that determines the resistance of the medium to the passage of the physical process of plastic deformation, the parameter of hardening of the material of the surface layer.

The smaller ω, the smaller the strain rate and the lower the resistance of the medium passage of the process of softening (smaller parameter K_{Ay}), that is, the softening is easier than hardening. The nature of the broad bands associated with the transverse slide [2-4], the energy of activation which is the reverse of the energy of defect packaging (γ). The lower γ, the more the material is able to strain hardening, the resistance of the medium undergo a physical process of plastic deformation becomes higher.

Therefore, $K_{Ay\gamma_1} > K_{Ay\gamma_2}$ if $\gamma_1 < \gamma_2$. The magnitude of the energy defect of the packaging determines the rate of cross slip, which leads to accumulation of fatigue damage in the slip bands. This fact reduces the parameters of fatigue resistance of material in the form of increasing the slope of the curve of fatigue, leading to a decrease in the number of cycles to failure.

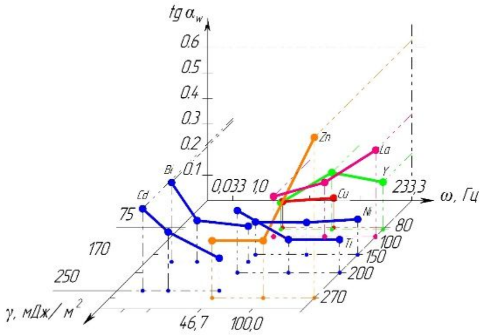

Fig. 1. Relationship between fatigue resistance index (tgαw) and frequency of loading cycles (ω), taking into account the energy of the packing defect (γ)

Conclusions:

The higher the energy of the defect in the packing, the more advanced the cross slide in the zone of localization of plastic deformation and the steeper the slope of the fatigue curves, and, consequently, lower cyclic strength and durability of metals. The materials with high energy of packing defect is observed a decrease in the slope of fatigue curves with increasing frequency of loading, with the exception of zinc, a material with low energy show the opposite pattern. The increase in fatigue strength with decreasing or increasing frequency of loading leads almost always to a reduction of the angle of inclination of fatigue curve to the axis of the number of cycles.

References:

1. Mylnikov V.V., Shetulov D.I., Chernyshov E.A. Investigation into the Surface Damage of Pure Metals Allowing for the Cyclic Loading Frequency // Russ. J. Non-Ferr. Met. 2013. Vol. 54. P. 229–233.

2. Shetulov D.I., Kravchenko V.N., Myl'nikov V.V. Predicting the Strength and Life of Auto Parts on the Basis of Fatigue Strength // Russian Engineering Research. 2015. Vol. 35. P. 580–583.

3. Shetulov D.I., Andreev V.V, Myasnikov A.M. Dislocation Model of Nucleation and Development of Slip Bands and Their Effect on Service Life of Structural Materials Subject to Cyclic Loading // Physics of atomic nuclei. 2015. Vol. 78. P. 1374-1381.

4. Mylnikov V.V., Shetulov D.I., Chernyshov E.A. Speed Effect upon Varying the Cyclic Loading Frequency for Certain Pure Metals // Russ. J. Non-Ferr. Met. 2015. Vol. 56. No. 6. P. 627–632.

5. Mylnikov V.V., Shetulov D.I., Chernyshov E.A. Variation in faktors of fatigue resistance for som pure metals as a function of the freguensy of loading sycles // Russ. J. Non-Ferr. Met. 2010. Vol. 51. P. 237–242.