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FRETTING-FATIGUE COATINGS OF DISCRETE-ORIENTED STRUCTURE

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The results of tests on the fatigue and fretting-fatigue specimens of steel coated 30KhGSA with discrete-oriented structure have been analyzed. It is shown that the best characteristics of fatigue resistance in fretting have digital coverage in the grid holes reinforced by ion nitriding.

General statement of the problem and its connection with scientific and practical tasks. Current researches in the field of tribology and contact mechanics destruction of parts and vehicles components under varying loading conditions represent a new direction. It determines a significant part of operational failures in technical objects for various purposes. If you wear leads to large financial losses, the fatigue damage can lead to a sudden failure of responsible units, mechanisms and structures that besides damage can be more disastrous.

Review of publications and analysis of unresolved issues. An important direction in improving repair of parts of technical objects is a science-based search of modern, innovative low-cost recovery of parts and components of vehicles, which determines the modeling of friction units, establishing the influence of external factors on their performance, the study of the processes that develop on the friction surfaces.

Among many methods of generating discrete surfaces to increase wear resistances is actively used mechanical method of discrete surfaces formation, the essence of which is the dynamic action of the indenter to the surface and create micropitting (holes) at the expense of surface plastic deformation. Micropitting improve the lubricating properties of the surface, increase the resistance setting and corrosion, reduce the break-in period. Selection of the optimal location micropitting allows the design surface with high performance, improve the tribological characteristics, reduce the stress state of the surface [1-4].

The purpose of research. Study the effect of coatings discrete oriented structure formed by mechanical fatigue and fretting-fatigue are 30KhGSA.

Research methods. The samples for study characteristics of fatigue resistance and fretting-fatigue were made of stainless steel 30KhGSA, heat treated - hardening: 910°C heating up and cooling in oil, and leave at 500°C for 1 hour.

Experimental characterization of fatigue resistance and fretting-fatigue carried out on the SLD (based on an electrodynamic shaker, certification number UA6.001.N.313) mode resonant vibrations under normal laboratory conditions. Cantilevered flat corset type samples tested in symmetric lateral bending. Failure criterion for taking samples falling natural frequency of 1%, compared to the original value of the resonance, which corresponds to the birth of the "dangerous" section of sample surface semielliptical macrocrack depth of 0,1 mm. Frequency resonant oscillations of test specimens for fatigue was ~ 130 Hz, fretting-fatigue ~ 75 Hz.

The force with which the rider clung to the surface sample was calculated assuming that the nominal contact pressure should be 140 MPa. With this contact stress, according to the literature [5], provides favorable conditions for fretting.

The tests before starting were conducted on samples of the dynamic calibration method developed by the Central Institute of Aviation Motors (CIAM, Moscow) and recommended for dynamic calibration on aviation industry [6]. Appearance of the specimen and the amplitude envelope stresses in arbitrary units in the load curve shown in fig.1. During the tests given amplitude control voltage was carried out using an optical microscope MBS-2, supporting the corresponding constant amplitude control 2λ at the free end of the sample.

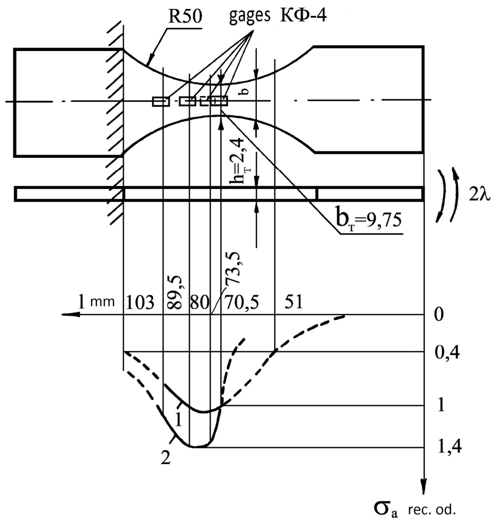

Fig. 1. Drawing a sample, outline of its load and stress amplitude envelope: 1 - fatigue test, 2 - fretting-fatigue test (with an attached sample torque ring)

After fixing the number of cycles to failure samples were adjusted to the final destruction (split in two) in order to accurately determines the location of fatigue crack initiation and subsequent microscopic examination, and determines the actual value of the stress fracture amplitude in for the i^{th} sample. Since the samples were different thickness h_i in the work area and destroyed at different locations along the length l_i, formula for calculating the actual voltage has been derived.

$$\sigma_a = \sigma_a^T \frac{h_i \cdot b_T \cdot l_i}{h_T \cdot b_i \cdot l_T},$$

where σ_a^T - the amplitude of the voltage in a small section of the sample, which was performed calibration; h_T, b_T, l_T - thickness, width, and the distance from the free end of the calibrated model; h_i, b_i, l_i - section dimensions and distance to the site of the destroyed i^{th} sample.

It should also be noted that prior testing sharp edges round out the working part of the sample to 0,5 mm in order to eliminate stress concentrations. This guaranteed the fatigue crack initiation in the middle of the surface, except for its appearance on the sharp edges of the sample.

Results and analysis. In chart 1 has been shown the results of testing fatigue and fretting-fatigue specimens of steel 30KhGSA. The results indicate that the discrete cover holes in the grid significantly reduce the fatigue resistance characteristics of the samples were compared with 30KhGSA smooth samples (endurance limit decreased to ~ 1,84 times). These are because the holes are stress concentrators and, in addition, in the process of application holes in its neighborhood at the sample surface are initiated residual tensile stress [4]. However, reducing resistance characteristics of fretting-fatigue specimens with holes in relation to the characteristics of a "pure" fatigue significantly less (endurance limits differ ~ 1,22 times) than those for the reduction of smooth specimens (endurance limits differ ~ 1,91 times) shows some positive effect mesh holes in relation to the characteristics of fatigue resistance in fretting.

Chart 1. Endurance limits of the tested samples of 30KhGSA

Type of test	The fatigue limit of samples with different surface treatments, σ_{-1}, MPa		
	Uncoated polishing	Mesh holes	Ion nitriding grid holes
Fatigue	718	390	520
Fretting-fatigue	375	320	-

In addition, the characteristics of fatigue resistance in fretting specimens with holes and smooth samples are similar (endurance limits vary ~ 1,17 times), and in the voltage above the limits of endurance. It can be explained based on the analysis of the fracture surface samples to the wells, which showed that in a fretting-fatigue crack nucleation occurs in one, two or three pockets on the surface of the "dangerous" section, and is not associated with the location of the wells. Only one of the fatigue crack initiated on the contours of holes, because the edge of the support rider coincided with the line placement holes (fig.2).

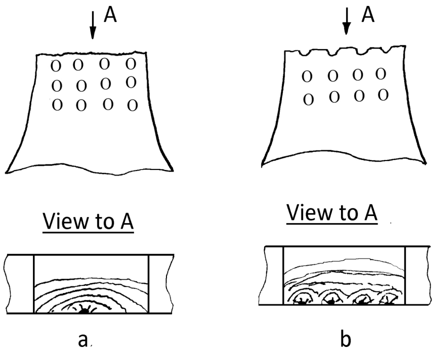

Fig. 2. Schematic representation of surface samples exposed to the wells destroyed by fretting-fatigue: a - destruction of wells, b - failure in wells

The result is illustrated in fig.2, indicates that the stress-strain state in the zone of fretting determines durability of steel at fretting-fatigue and stress concentration and residual stresses in the wells have less impact on the ultimate state of the material.

The significant reduction in the fatigue resistance characteristics of 30KhGSA in the endurance limit for application grid holes on the sample surface due to the effect of stress concentration in the wells and initiate its formation technology tensile residual stresses. Given the low values of the residual stresses in the optimal formation of a discrete coating [4], reduction of fatigue limit 30KhGSA were estimated from a chart Hay residual stresses, as asymmetry cycle may be about 3%.

The significant positive effect on the fatigue resistance characteristics of ion nitriding has a surface with holes (see chart 1). In tests by fretting-fatigue of three samples of the party, none of them collapsed from fretting. That is, the failure occurs on a "pure" fatigue in the area of the maximum stress on the line of holes (fig.3). In this section of the line contact with counterbody voltage was ~ 20% less. Despite its, these stresses are much higher than the voltage at which the destruction of fretting-fatigue and fatigue specimens with holes. It is therefore logical to conclude that proposed curve fretting-fatigue specimens with ion nitriding holes close to the curve of "pure" and fatigue resistance characteristics of fretting-fatigue is significantly higher than the samples to the wells and the original polished samples fretting.

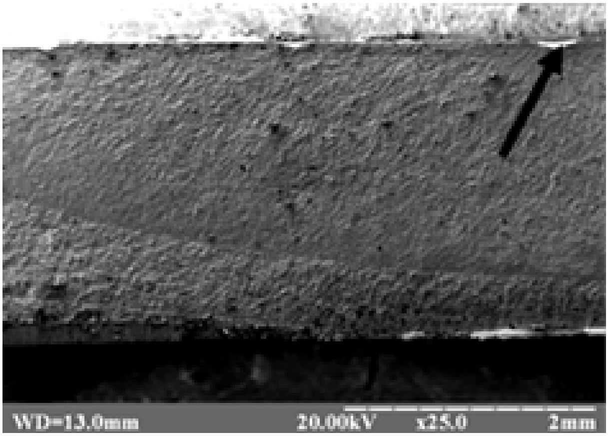

Fig. 3. Fractography fracture pattern with holes, reinforced by ion nitriding, collapsed from fretting-fatigue

Conclusions. Digital coverage in nowadays are quite promising for use in contact and friction wear and require the need of deep study its effects on the characteristics of the fatigue resistance materials under fretting through development of application methods such coatings. Its data shows that the best characteristics of fatigue resistance in fretting have discrete coverage holes in a grid, followed by ion nitriding, which provides a significant increase in the initial fatigue strength steel 30KhGSA (~ 1,4 fold) by nitriding the surface of samples.

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Аннотация

ФРЕТТИНГ-УСТАЛОСТЬ ПОКРЫТИЙ ДИСКРЕТНО-ОРИЕНТИРОВАННОЙ СТРУКТУРЫ

Марчук В.Е.

Проанализированы результаты испытаний на усталость и фреттинг-усталость образцов из стали 30ХГСА с покрытиями дискретно-ориентированной структуры. Показано, что наилучшими характеристиками сопротивления усталости в условиях фреттинга обладают дискретные покрытия в виде сетки лунок упрочненных методом ионного азотирования.

Анотація

ФРЕТТИНГ-УТОМА ПОКРИТТІВ ДИСКРЕТНО-ОРІЄНТОВАНОЇ СТРУКТУРИ

Марчук В.Є.

Проаналізовано результати випробувань на утому і фретинг-утому зразків зі сталі 30ХГСА з покриттями дискретно-орієнтованої структури. Показано, що найкращими характеристиками опору утомі в умовах фретингу володіють дискретні покриття у вигляді сітки лунок зміцнених методом іонного азотуванням.