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Analytical assessment of the influence of the intensity of technological residual Voltagees in the surface layer of teeth on the durability of Saw blades for gins

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Abstract
Annotation: Materials are presented that make it possible to make a predictive assessment of the fatigue limit of machine parts by the level of technological residual voltagees, the tensile strength of the material of the product, and the amplitude value of voltage during an asymmetric loading cycle.

Keywords: Residual voltagees, cyclic loading, strain hardening, voltage amplitude, endurance limit, working capacity

Introduction

In increasing the operational reliability of modern technological machines, including fiber separators (gins, linters), a decisive role is given to the formation of such a state and quality of the surface layer of parts that can provide long-term fatigue resistance under cyclic loads (most typical for machines). This type of destruction, as is known, is inherent in parts of the working bodies of machines that are subjected to prolonged, alternating loading. Moreover, this breaking load corresponds to voltage, which can be significantly less than the tensile strength σ_B under static loading [1]. Thus, experimental studies of fatigue resistance for samples made of 30KhGSA steel (hardness HRC 35...37, tensile strength $\sigma_B = 1200 \ldots 1300$ MPa, yield strength $\sigma_T = 850$ MPa) showed that the endurance (fatigue) σ-1 of the samples with decreasing their roughness from $R_a = 0,74$ mkm to $R_a = 0,22$ mkm increases on average by 14 % and amounts to 610 MPa, and the service life is more than 3 times. The cylindrical surface of the samples was processed by round grinding and polishing with diamond elastic bands. The established relationship between the ultimate strength $\sigma_в$ and the ultimate fatigue σ-1 is in satisfactory agreement with the generalized data obtained by S.V. Serensen [2] for steels with ultimate strength $\sigma_B = 500 \ldots 1500$ N/mm^2, the samples of which were polished thorough grinding, shot blasting.

The increased attention to the state of the surface layer of machine parts is explained by the fact that numerous experimental studies have established the fact of nucleation of fracture centers on their surface, where the greatest alternating voltagees occur during bending, torsion, voltage concentrations and various surface defects are located.

The working body of genie and linter (saw drum with the same discs) experiences variable loads. At the same time, the teeth of the saw blades are subject to cyclic loading: loading at the moment of introduction into the raw roller, capture and holding of the fiber, and unloading during their discharge. Therefore, it is important to create technological conditions to increase the endurance of parts in order to increase the durability and operational reliability of machines.

Theoretical and experimental studies of leading scientists in the field of mechanical engineering technology indicate that the endurance limit of machine parts largely depends on the residual voltagees and the degree of strain hardening (hardening) of the surface layer. The presence of tensile residual voltagees in the surface layer of parts reduces the fatigue limit, and the action of compressive macro voltagees leads to an increase in fatigue strength. This important circumstance serves as the basis for the justified use in mechanical

Engineering of mechanical methods of hardening technology (surface plastic deformation - PPD), for example, rolling in a ball, diamond smoothing, blasting with a shot. Thus, as a result of the force action during the RPD, favorable compressive residual voltagees are formed in the surface layer of the parts and hardening occurs, estimated by the depth and degree of hardening (a relative increase in micro hardness).

When analyzing the voltagees acting in the structures, it is necessary in the design practice to take into account the voltagees that occurred during manufacture, technological residual voltagees. Residual voltagees are taken into account by adding them to voltagees from workloads if machine parts work in the field of elastic deformations. However, the principle of superposition of voltagees is unacceptable under conditions of plastic deformation, which always precedes the destruction of structural elements.

The details of machines and mechanisms during operation perceive mainly time-varying voltagees, which generally change according to an asymmetric cycle described by one of the dependences [3, 4]: the Goodman line, the Birger, Gerber and Merin parabola. Among the indicated dependences of the Birger parabola, it most accurately characterizes the relationship of voltagees and has the following form:

$$\left(\frac{\sigma_a}{\sigma_{-1}}\right)^2 + \frac{\sigma_m}{\sigma_в} = 1, \quad (1)$$

Where σ_a is the amplitude of the cycle voltage; σ_{-1} is the endurance limit for a symmetric loading cycle; σ_m — average cycle voltage; $\sigma_в$ - tensile strength. When assessing the effect of technological residual voltagees on the strength and durability of structures, the following assumptions must be made, taking into account the multi-cycle appearance:

1) The residual voltagees $\sigma_{iост}$ affect the carrier voltage of the cycle σ_m;
2) Technological residual orders do not change during the operation of the product;
3) When calculating the maximum values of the intensity of residual voltagees are taken into account;
4) The residual voltagees in the bodies of revolution are distributed symmetrical about its axis.

From dependence (1) we obtain the expression for the voltage amplitude σ_a of the cycle

$$\sigma_a = \sigma_{-1}\sqrt{1 - \frac{\sigma'_m}{\sigma_в}}, \text{ N/mm}^2 \quad (2)$$

Where σ'_m is the average cycle voltage, taking into account residual voltagees, and equal to

$$\sigma'_m = \sigma_m + \sigma_{iост} \quad (3)$$

$\sigma_m = (\sigma_{max} + \sigma_{min})/2$ – average cycle voltage without residual voltagees; σ_{max} and σ_{min} are the maximum and minimum cycle voltagees, respectively. Taking into account the assumptions made, formula (3) will take the form

$$\sigma'_m = \sigma_{iост}, \text{ N/mm}^2 \quad (4)$$

Corresponding to a symmetric loading cycle and then the dependence for the amplitude of the voltage cycle:

$$\sigma_a = \sigma_{-1}\sqrt{1 - \frac{\sigma_{iост}}{\sigma_в}}, \text{ Н/мм}^2 \quad (5)$$

Having the amplitude values of the voltage cycle σ_a, it is possible to calculate the service life of critical machine parts for multi-cycle fatigue [4].

However, forecasting the endurance limit σ_{-1} depending on the maximum values of the residual voltages $\sigma_{iост}$, which can be carried out according to the formula, is no less important in engineering practice:

$$\sigma_{-1} = \frac{\sigma_a}{\sqrt{1 - \frac{\sigma_{iост}}{\sigma_в}}}, \text{ Н/мм}^2 \quad (6)$$

As follows from dependence (6), for a fixed value of the voltage amplitude σ_a, we can give a relative estimate of the influence of the level of compressive residual voltagees in the surface layer of parts with a tensile strength.

So, for the teeth of gin saw blades made of U8G tool steel ($\sigma_в = 1000$ MPa), with the level of residual voltages $\sigma_{iост} = 200 \ldots 600$ MPa after shot blasting, the fatigue limit σ_{-1} was $(1{,}12 \ldots 1{,}58)\sigma_a$. As production tests of genie saws with hardened teeth after shot-blasting showed that the increase in their durability corresponded to a limit of 1, 3…2, 0, depending on the level of compressive residual voltagees. Thus, according to the level of technological residual voltagees, the tensile strength of the product material, and the amplitude value of the loading cycle, it is possible to predict the fatigue limit characterizing the performance of machine parts under operating conditions.

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