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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  $\sigma_B$  under static loading <sup>[1]</sup>. Thus, experimental studies of fatigue resistance for samples made of 30KhGSA steel (hardness HRC 35...37, tensile strength  $\sigma_B = 1200...1300$  MPa, yield strength  $\sigma_T = 850$  MPa) showed that the endurance (fatigue)  $\sigma-1$  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  $\sigma_B$  and the ultimate fatigue  $\sigma-1$  is in satisfactory agreement with the generalized data obtained by S.V. Serensen <sup>[2]</sup> for

steels with ultimate strength  $\sigma_B = 500...1500$  N/mm<sup>2</sup>, 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 voltages 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 voltages acting in the structures, it is necessary in the design practice to take into account the voltages that occurred during manufacture, technological residual voltages. Residual voltages are taken into account by adding them to voltages from workloads if machine parts work in the field of elastic deformations. However, the principle of superposition of voltages 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 voltages, 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 voltages and has the following form:

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

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

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

From dependence (1) we obtain the expression for the voltage amplitude  $\sigma_a$  of the cycle

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

Where  $\sigma'_m$  is the average cycle voltage, taking into account residual voltages, and equal to

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

$\sigma_m = (\sigma_{max} + \sigma_{min})/2$  – average cycle voltage without residual voltages;  $\sigma_{max}$  and  $\sigma_{min}$  are the maximum and minimum cycle voltages, respectively.

Taking into account the assumptions made, formula (3) will take the form

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

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

$$\sigma_a = \sigma_{-1} \sqrt{1 - \frac{\sigma_{iocr}}{\sigma_B}}, \quad \text{H/MM}^2 \quad (5)$$

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

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

$$\sigma_{-1} = \frac{\sigma_a}{\sqrt{1 - \frac{\sigma_{iocr}}{\sigma_B}}}, \quad \text{H/MM}^2 \quad (6)$$

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

So, for the teeth of gin saw blades made of U8G tool steel ( $\sigma_B = 1000$  MPa), with the level of residual voltages  $\sigma_{iocr} = 200 \dots 600$  MPa after shot blasting, the fatigue

limit  $\sigma_{-1}$  was  $(1,12 \dots 1,58)\sigma_a$ . 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 voltages. Thus, according to the level of technological residual voltages, 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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