Experimental Determination of the Depth and Degree of Riveting of the Surface Layer of Batan Teeth

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ABSTRACT

The method of calculating the stored (latent) deformation energy of the processed material with linear and nonlinear hardening according to the deformation diagram under uniaxial tension – compression, taking into account the theory of small elastic-plastic deformations, is given.

KEYWORDS: *Riveting, micro-grinding, nitrocementation, deformation.*

The operability of the batane teeth, like most machine parts, is determined by the quality of their surface layer, determined by a complex of physico-mechanical and geometric parameters. Surface plastic deformation of the working surfaces of the batan teeth during shot blasting with microbeads leads to deformation hardening, which is evaluated using the depth hn of the degree of riveting And . To determine these parameters, the method of studying micro-grinds is used in order to determine microhardness Hμ.

The microhardness of the surface layers was investigated by indentation with a diamond pyramid on the device ПМТ-3. It is most convenient to investigate the depth of the surface layer and the change in its microhardness as it moves away from the surface along the microlift, made in the form of an oblique cut at an angle α=5°04′ to the surface under study. The sample of the microslift was cut out of a batan tooth and rigidly fixed in a special device for preparing inclined cuts. At the final stage of sample preparation, diamond paste AFM 5/3 was used to obtain a surface roughness of 0.016 microns≥ Ra. The depth of the riveted layer is determined by the dependence h = ltga.

The microhardness Hμ was found by changing the diagonals of the prints on the samples, fixed in a special device and obtained with a load of 0.98 on a four-sided diamond pyramid with angles at the top of 136 °. The depth of the imprint h depends on the shape of the indenter (?), if it is in the form of a square pyramid with an angle at the top of 136 °, it will give an imprint with a depth of h = d/7. The distance between the prints should be at least 2-3 diagonals of the print. Микротвердость определяется, как и по Виккерду деления нагрузки P на площадь поверхности отпечатка с диагональю d:

$$H\mu = \frac{P}{Fom\pi} = 2\sin\frac{\propto}{2} * \frac{P}{d^2} = 1{,}854\frac{P}{d^2} \qquad (1)$$

Where P is the load on the indenter;

A is the angle at the top of the diamond pyramid.

During the test, the diagonal of the print d is measured - which corresponds to the table (for a given load P), the microhardness H (N/ mm2 or kg / mm2) is obtained on a specially prepared slot.

At each depth of the studied surface of the part, three prints were made along the width of the plume and the arithmetic mean values from the number of equal-ton measurements were estimated.

$$\mathrm{H}\mu = \sum_{i=1}^{n} \mathrm{H}\mu | n \qquad (2)$$

Where Hμ is the microhardness of one equal-ton measurement, N/mm2 (Mpa);

n is the number of equal-numbered dimensions.

The degree of riveting is calculated by the formula

$$U = \frac{\mathrm{H}\mu max - H\mu ucx}{H\mu ucx} * 100\% \qquad (3)$$

Where H_max Hμucx is, respectively, the highest and initial microhardness of the surface layer, Mpa. The results of an experimental study of the microhardness of the surface layer of samples cut from a batan tooth (steel20) indicate that the depth hH and the degree of riveting. And an age-related increase in the duration of blowing with micro-balls. With an increase in the blowing time from t = 1 to 4 min, the hardening depth and the degree of hardening respectively increases by 0.05 mm and 10.2% at the initial microhardness H =.

The maximum degree of hardening U = 22.4% is achieved at t = 4 min (compressed air pressure p = 5 Mpa, shot diameter 0.3 ... 0.4 mm) This mode of shot blasting provides the maximum thickness of the hardened layer hH, about 0.15 mm, which practically coincides with the thickness of the saturation layer during nitrocementation of the batan teeth.

Increasing the processing time (more than 6 minutes) and the compressed air pressure p > 3MPa is impractical, since this can lead to a decrease in the effect of deformation hardening due to over-riveting, which is characterized by embrittlement of the surface due to exhaustion of the reserve of plasticity. At the same time, the microhardness on the surface of the samples decreases and the maximum hardness naturally shifts to the subsurface layer.

The obtained results of studies of deformation hardening parameters confirm experimental data [126], where the expediency of surface plastic deformation of structural steels subjected to chemical-thermal treatment (cementation, isotization, nitrocementation) and having a high hardness of NCS 58...62 is proved. Thus, the effectiveness of complex hardening, including chemical-thermal treatment and PPD, is emphasized. At the same time, cold plastic deformation significantly changes the structure of the phases within the depth of the saturation layer of the parts, thereby having a decisive effect both on the quality parameters of the surface layer and on the most important operational property of many critical machine parts – contact endurance. For example, after shot blasting (shot diameter 0.8 ... 1.0 mm at a shot consumption of 9± 1 kg/min and air pressure 0.4± 0.2 Mpa), roller samples made of chrome-nickel steel 12X2H4A (cementation, surface hardness HRC 61 ...62, in the core HRC 35...39.5) there is a 1.5-fold increase in contact tolerance compared to the initial (undeformed) state [127]. The authors attribute this fact to the favorable influence of special residual stresses in the surface layer and the maximum hardness on the surface of the samples during shot hardening. A similar effect was revealed with PPD by running in a ball (diameter 10mm, 0.1 mm/rev, normal force 60...300 kgf) of 14X2N3MA steel, which was cemented to a depth of 1.8...2.0 mm before heat treatment and having a surface hardness of samples HRC 60..62 [27].

It is important to note that the method of combined hardening, including chemical-thermal treatment + PPD, despite the increased hardness of the modified or saturated surface layer, will create in it the effect of deformation hardening with compressive residual stresses. At the same time, the depth of the riveting in the limit can reach the thickness of the modified layer. The specificity of combined hardening is that in addition to the hardening of the saturated layer, depending on the conditions of the PPD, elastic-plastic deformation of the sublayer zone of the core of the part occurs. Thus, pressing in under the action of the roller, a solid nitrided layer of small thickness causes the zone adjacent to it to bend [1], which leads to the formation of compressive stresses in not only the nitrided layer, but also in the sublayer zone. In this regard, the endurance limit is growing, since the focus of destruction is usually located in the sublayer zone (with a lower level of strength) - at the point of transition of compressive stresses to tensile stresses.

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