Increase of steel surface operational properties by combined hardening

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Abstract. This article examines the influence of laser heat treatment of nitrocementation steel on the phase composition, structure and hardness of surface layers. It is shown that the combined heat treatment of steels – nitrocementation and laser hardening allows to provide high wear resistance of surface layers of steel.

1. Introduction

Mining, including oil and gas, requires a large amount of drilling. Drilling tools - drill bits of various types and designs readily used when conducting drilling operations. This is a consequence of the low resistance of drilling bits as well, and many other parts of the drilling equipment [1-3].

Thus, highly relevant is the development and improvement of technologies of chemical-thermal processing of drill bit steels, which provide improved abrasive wear resistance [3-7].

The impact of concentrated energy fluxes on materials currently receiving attention [8-9]. One of the directions of development of this technology is the laser heat treatment case hardening (nitrocementation) steel, which allows to increase the hardness, strength and wear resistance of the surface layers.

2. Experiment

The aim of this work is to research the influence of laser heat treatment nitrocementation layers on the phase composition, structure and hardness of surface layers of low carbon steel 18CrNi3Mo.

Nitrocementation with subsequent laser heat treatment was subjected the specimens of low carbon steel 18CrNi3Mo (0.16-0.18 % C; 3.4 % Ni; 0.8 % Cr; 0.52 % Mo; 0.43 % Mn; 0.35 % Si; 0.06 % Al; 0.008 % S; 0.012 % P; 0.015 % N; 0.01 % O; 0.01 % H).

3. Results and discussion

In nitrocementation layers with high nitrogen content, especially in obtaining layers with a thickness more than 1.2 mm, the formation of clusters of carbonitrides, oxides, troostite and bainite structures (Fig. 1, a). These structural and phase formation reduces the hardness, toughness, plastic characteristics, surface contact fatigue, wear resistance in conditions of impact-cyclic loading and under conditions of sliding friction. Application of laser heat treatment nitrozomocitina layers without melting the surface allowed to form a structure with high amounts of residual austenite (up to 80 – 100 %), crushed grain, eliminate troostite and bainite structure (Fig. 1, b), improve the hardness, ductility and wear resistance of the diffusion layer.
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Study of thin foils made of nitrocementation layers with subsequent laser heat treatment at a distance of 0.15 and 0.30 mm from the surface revealed the presence of a large number of selections of various dispersity and shape. The distribution of precipitates is uniform, their size is from 100 to 5 nm or less.
When the content of nitrogen in solid solution from 0.3 to 0.8 % of the identified region in the form of small ripples. Electronic diffraction and microdiffraction these plots revealed the reflexes of the matrix (Fig. 2).

Analysis of the physico-chemical and physico-mechanical characteristics nitrozomocevina layers showed that the nitrocoementation followed by laser treatment has a significant influence on the properties of friction surfaces. From the presented data it is seen (Fig. 3) that the highest wear resistance have nitrocoementation layers with high nitrogen content after the laser heat treatment. This is due to the particular influence of high nitrogen content on the formation before the test structure with high strength, ductility, stability and on the kinetics of changes of structure and properties of diffusion layers in the process of testing for wear. In nitrocoementation layers with nitrogen content of 0.5 – 1.0 after laser hardening the structure with the content of nitrogenous austenite 80 – 90 % undergoing the process of wear of the $\gamma \rightarrow \alpha$ transformation is not more than 5 – 10 % and has a greater ability to deformation hardening due to wear (Fig. 3).

![Figure 3](image)

**Figure 3.** The average depth of the worn hole nitrocoementation layers
○ – before the laser treatment; ● – after laser treatment

In nitrocoementation layers with nitrogen content of 0.5 – 1.0 after laser hardening the structure with the content of nitrogenous austenite 80 – 100 % undergoing the process of wear of the $\gamma \rightarrow \alpha$ transformation is not more than 5 – 10% and has a greater ability to deformation hardening in the process of wear than the diffusion layer with nitrogen concentration of 0.3 – 0.4 %. For example, the level of hardness on the surface of the wear nitrocoementation steel with a nitrogen content of 0.7 – 1.0 % treated laser reaches 1200 HV(Fig. 4).

High level of hardness while maintaining a large amount of residual austenite in nitrocoementation steel with a high content of nitrogen, treated with laser, provides a higher wear resistance.
Figure 4. The distribution of hardness in thickness nitrocementation layers of steel 18CrNi3Mo

○ – nitrocementation; ● – nitrocementation and laser treatment (to test)
▲ – nitrocementation and laser treatment (post-test)

4. Conclusion
The analysis of the research shows that combined heat treatment of steels – nitrocementation with a high content of nitrogen and laser hardening allows to form a surface structure consisting of austenite strengthened by fine precipitates. This allows, along with the required depth contact strength to provide good performance properties of surface layers of metal products.

5. References
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