Analysis of the impact of informative heat treatment parameters on the properties of hardening of the surface layers

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Abstract. The change features of surface steel layer were investigated under influence of plasma source of concentrated energy. The results of research of the effect of plasma treatment process on the microstructure and the thickness distribution of microhardness of the product and the formation of heat affected zone were presented. The resulting information (informative) data and measured values of microhardness in the hardened layers, depending on the plasma processing modes allow you to manage the process of heat treatment of metals. Designed programming model that works on the basis of the solution of the heat equation, allows to predict and investigate the temperature field after exposure to the plasma stream.

1. Introduction

Improving the machines characterized by a constant increase in power and performance. The increase in performance can only be achieved with a corresponding improvement of the performance of their main components and parts. Condition of parts of the surface layer largely determines the technical and economic parameters of exploitation of machines. Therefore, improvement of surface hardening technology is an important and urgent task. One promising direction to solve this problem is the development and introduction of technologies of hardening produced by the action of concentrated streams of energy, such as laser, ion-plasma, plasma, electron beam and others. However, it is known that a laser, ion-plasma and electron beam thermostrengthening require more capital investment in equipment and operating costs of these processes is twice as high compared to the plasma thermostrengthening [1].

2. Research heat treatment processes of the steel 45

The use of concentrated energy flows improves productivity, accuracy and quality of processing, improved working conditions, increased crop production. However, chemical-thermal plasma treatment using a nitrogen or argon-nitrogen mixture is complex process. With this method of processing hardened surfaces are prone to cracking. Therefore, the lack of automatic control of technological processes (TP), no tracking information environment of informative parameters of heat treatment may reduce the quality of the machined parts, an increase in production costs, etc. [2].

Also, despite the positive results of the plasma heat treatment, its industrial application is difficult lack of information data suitable for controlling the development and heat treatment processes, and results of the study and use of electric surface heat treatment in the working gas atmosphere lacking.

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Therefore, the aim of this research is to determine the influence of information (informative) parameters on the spread of micro-hardness values and the formation of the microstructure of metals in the environment at the working gas pulsed plasma flow.

Experimental pulse plasma installation (PI) has been developed for the experiments (Fig. 1), which is the installation of a plasma generator of alternating current [3]. PI developed based on a three-electrode AC plasma torch, allows to clean the surface of the metal heat treatment in the working gas atmosphere or in air, depending on the type of process [7-8].

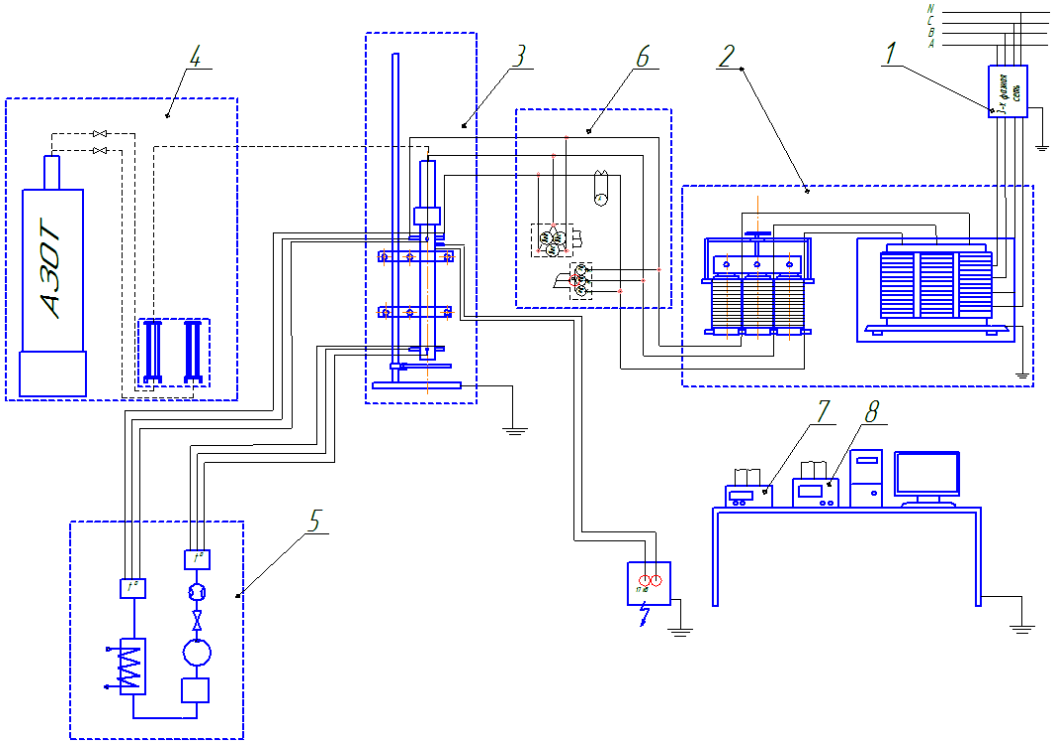

Figure 1. General view of the installation of plasma heat treatment:
1. Electromagnetic actuator. 2. Controllable power supply. 3. Three electrode plasma installation. 4. Induction system. 5. Cooling system 6. System of measurement 7.8 Area operator with monitoring and fixing of informative parameters of devices.

In the experiment, plasma flow diameter of 5 to 10 mm is directed at the sample in the working chamber with gaseous nitrogen. Heat flux on the surface of metal is 103 - 106 W / cm^2. The use of pulsed plasma jet allows precise control of the heat flux, with the possibility of reconfiguring the pulse time of 5 to 7 ms, and the delay time from 5 ms to continuous operation.

Structure and properties of the surface hardened layer is formed under the influence of temperature field arising in the metal when exposed to high-energy plasma jet [5]. The structure and properties of the treated surface determined by the nature of the thermal treatment cycle. Distribution of microhardness on the surface of the processed sample PI with optimized characteristics shown in Fig. 2.

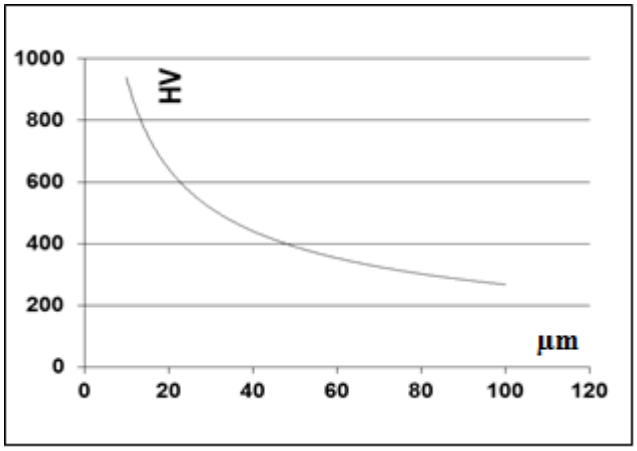

Figure 2. - Distribution microhardness depth of heat-treated zone sample steel 45

The microstructure of the treated steel is shown in Fig. 3. As can be seen from the figure the surface consists of two specific areas: the first is the hardening zone, which contains nitrogen nitrides, increase firmness; The second zone is the primary metal, the metal which has an initial hardness.

For reproducibility of quality indicators TP surface hardening of metal is necessary to control the characteristics of PI with informative parameters [6]. Informative parameters include power of the energy flow, its density on the surface of the workpiece, on the surface temperature field, energy absorption coefficient, etc. Information about the thermal state to determine the depth and width of the heat affected zone, to predict the final structure and properties of the reinforcing layer. Evaluating these parameters set, the direction and the degree of influence on them rationally processing mode using the parameters of the mathematical model steel heating surface concentrated heat source. For a preliminary assessment of technological modes of surface heat treatment process, it is advisable to use a model based on the solution of the boundary value problem of heat conduction.

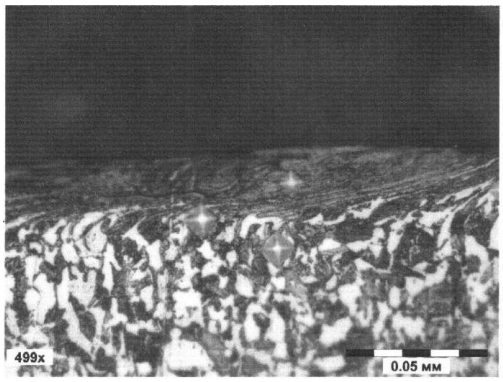

Figure 3. The microstructure of treated steel (x500)

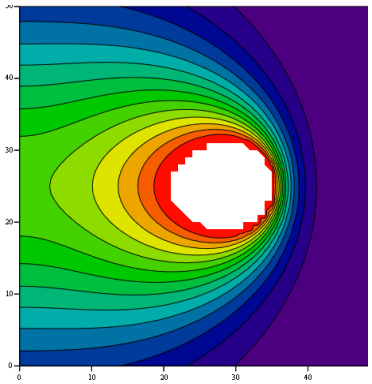

Figure 4. The model of the temperature field distribution of the ECP sources

The programming model is based on the heat equation, which allows you to: vary the heating points; calculate the temperature value at any time and anywhere in a given plane; investigate the temperature field, depending on the duration of exposure to a specific portion of the heating zone; change the speed of processing [1]. Thermogram calculation model is shown in Fig. 4.

For theoretical calculations of the temperature field can apply the equation (1) of heat propagation in a massive semi-infinite body by a powerful, fast-moving normally distributed source - torch.

$$T(x,y,t) = T_0 + \frac{q}{2 \cdot \pi \cdot \lambda \cdot v} \cdot \frac{\exp\left[-\left(\frac{y^2}{4 \cdot a \cdot t_v} \right) \right]}{\sqrt{t_v \cdot (t_0 + t_v)}}, \qquad (1)$$

where T – heating temperature, ^0C;x,y– width and the depth of heating patches, m; t– time, s; T_0 – be the initial body temperature, ^0C; q – effective power of the plasma jet, W; λ – coefficient of thermal conductivity, W/m·K; ν – processing speed, m/s; a – thermal diffusivity coefficient, m^2/s.

3. Conclusion

Metallurgical research after plasma hardening steels show improvement of the quality indicators of stability. The effectiveness of the experimental setup for thermal hardening of the surface layer of parts in a gaseous environment clear. Due to the fact that, in contrast to conventional methods of chemical-thermal treatment, not necessary to use costly vacuum chambers, reduced time and costs. However, to get indicators of quality are comparable to the methods of ion-plasma nitriding is necessary to observe the process conditions. These calculations can determine the necessary parameters of the pulsed plasma generator for the given parameters of quality of the hardened zone.

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