Surface thermohardening by the fast-moving electric arch

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Abstract. This paper describes the technology of modern engineering - plasma hardening steels and prospects of its application. It gives the opportunity to manage the process without using of cooling media, vacuum, special coatings to improve the absorptive capacity of hardened surfaces; the simplicity, the low cost, the maneuverability, a small size of the process equipment; a possibility of the automation and the robotization of technological process.

1. Introduction
The majority of details and units of machines from bearing to the cutting tool- works in friction conditions, therefore, are subject to wear out.

The statement is substantially fair that the quality of machines and constructions depend on the surface layer of the material from which they are made. The durability of the machine operation depends from how wear out friction surfaces as arise and develop cracks, especially under alternating loads, i.e. the durability of parts without experiencing contact loads also depends on the quality of the surface detail layer. Therefore, methods of surface hardening are widely used in mechanical engineering.

An effective method of surface hardening of iron-carbon alloys is the treatment of concentrated streams of energy (CSE) - laser, electron, plasma are exposed to the high-speed heating of the surface metal layer and its rapid cooling as a result of the heat transfer to deep layers the material of detail [2-6]. This causes a change in the structure of the surface layer due to the phase transformation - hardening to martensite.

Among the methods of surface treatment using highly concentrated sources of energy hardening by plasma heating has a special place as the most simple and technological operation [2-12]. It is shown that hardening with the plasma heating of the surface of carbon steels leads to increase their abrasion resistance and wear resistance during the friction of metal on metal.

The purpose of plasma hardening is making of details and tools with hardened surface layer a thickness from several millimeters at constant overall chemical composition of the material and saving in the internal layers of the initial properties of the original metal.
It is necessary in some cases to harden large flat or cylindrical surfaces with high productivity inaccessible for ordinary plasma installation.

2. Experimental studies

This paper proposes an effective way of thermo-hardening of large surfaces by using fast-moving an electric arc. At this treatment one of the electrodes is a rod electrode made of different materials (steel, copper, etc.), another electrode - processed part. The speed of the arc at such treatment can achieve \( V = 150 \text{ m/s} \), the current is regulated in the range of 100-1500.

When large surfaces are treated with fast-moving electric arc important characteristic is the overlap ratio \( K_p \) defined by the ratio \( K_p = \frac{S}{d_p} \) (\( d_p \) - width of the arc spot). Strips can be imposed with an overlap (when \( K_p < 1 \)) and without overlap (when \( K_p > 1 \)). In many instances, hardened strips are located at some distance from each other so that laser-treated area was 20...50% of the total area. This allows you to achieve the greatest durability.

The treatment of flat surfaces is carried according to two schemes the imposition of strips: linear (Figure 1, a) and cellular (Figure 1, b). After imposing each strip the detail or the electrode is periodically moved in the transverse direction at a distance equal to the step \( S \). When using the cellular scheme by having strips is to cast at right angles to one another, and with the same pitch along both coordinates, there no difficulties in the case of strips imposing at a right angle and to harden when \( S_x \neq S_y \). The treatment of cylindrical surfaces is performed according to the scheme of imposing strips along the generator of an axis with periodic rotation of the detail for displacement to step \( S \) (Figure 1, c). For the same scheme produced the hardening of internal cylindrical surfaces.

![Figure 1](image)

3. Results of experimental investigation

Experimental studies for steel electrodes showed, that depending on the polarity of the electrodes and their geometric sizes, the interelectrode gap and the arc combustion mode, the traces on the hardening detail essentially differ (Figure 2). For example, at a low speed of moving arc to 10 m/s traces are a continuous process (Figure 2, a). For relatively high currents (\( \geq 150 \text{A} \)) and velocities (\( \geq 20 \text{m/s} \)) (Figure 2, b) traces on the cathode represent a plurality of lines, approximately parallel to the direction of the arc movement. The number of lines are increasing when the current grow (Figure 2v). It is obvious that at the same time there are a large number of spots which have high mobility and move with the arc, their number are increasing when the speed and current increase. When moving many spots are running along the traces of other spots.
It was investigated the thermal influence of moving arc on the internal structure of the material details, for this metallographic sections were prepared and the microstructure were investigated (Figure 3).

**Figure 2.** Pictures of the traces on the hardening surface of detail (at the top the detail is connected to "-" of power supply, from the bottom to "+"), $d$ – diameter of the rod-shaped electrode, $L$ - the interelectrode gap.

Under the impact of moving arc the metal heat to various temperatures, so it has a stratified structure (the zone reflow, the zone hardening from the solid phase, the zone transition).

**4. The conclusion**

The results of the performed research show that the proposed method provides high performance and qualitative of surface hardening of detail with a depth of the zone hardening of 1.5 mm and widths of 5mm.

Thus, the plasma hardening of working surfaces parts of machines and tools is a progressive, accessible and efficient process of the local surface hardening, to reduce their deterioration, to increase the durability and overhaul life, and also to get real saving by increasing the efficiency and reducing the volume of purchases of new products.

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