SUPERFICIAL LAYERS HARDENED BY ELECTRICAL SPARKING

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ABSTRACT: *The paper presents some theoretical and experimental aspects about sustainable growth in the surface layer, obtained by electrical discharge pulses. Thus increase occurs due to the thermal effect at pulsed discharges. The area of the material under the white layer is subjected to a pronounced heating followed by rapid cooling by taking heat from the base material. In this way there is a hardening of the metallic material located in the immediate vicinity of the white surface layer.*

KEY WORDS: electrode, layer, spark, microhardness

1. INTRODUCTION

The development of the technologies for elaborating the semi-finished products as well as the processing ones led to the possibility of using new materials and implicitly of some processing tools suitable for them. These materials are characterized by one or more properties: high hardness, tensile strength, compression, bending, considerable corrosion resistance, reliable mechanical properties at high temperatures or cryogenic, etc.

The production of parts from such materials, as well as the tools for their processing, has become a complicated and costly process using conventional production methods, for example as turning, milling, drilling, first of the technical requirements and secondly of the economic ones.

In order to improve such situations, it would be preferable to use easily workable materials but to which thermal or thermochemical treatments should be applied later in order to modify the structure and implicitly the mechanical properties.

One of the successful technologies for manufacturing very hard but a soft material represents the Electric Discharge Machining (EDM) method. When an electrical spark is established between working piece (anode) and tool (cathode) the discharging becomes extremely intensive, even uncontrolled with local overheating.

This heating will not only change the structure of the base material, but will cause a local melting in the surface layer. For a better understanding of the influence of EDM on metallic materials, in this paper we will discuss in more detail some structural changes of C22 steel, which belongs to a group of carbon steels with stable dimensions and relatively high hardness [1].

2. ELECTRIC DISCHARGE MACHINING

The melting effect of the material in the surface layer under the action of electric discharges was first observed when the electrical contactors were eroded due to the spark produced during their operation. Electrical erosion of these contact components is a harmful effect.

The EDM principle is quite simple, the operating principle being shown in fig. 1.

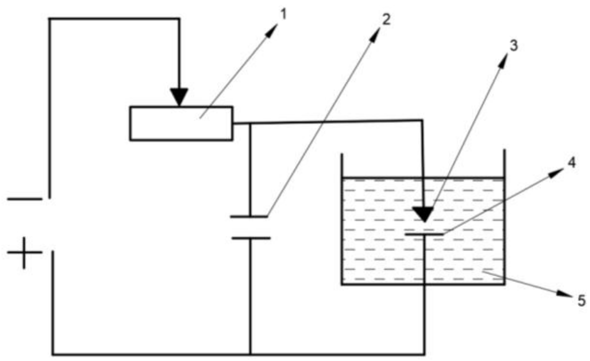


Fig.1. Scetch of equipment for electrical discharge machining

The working sample (4) is constituted as an anode and the tool is connected as a cathode (3). For establishing the EDM process serves a condenser batteries (2), so that charging of condenser is regulated by using a rheostat (1).

The space between the anode and the cathode is made up of the dielectric (5). The electric discharge depends from the anode-cathode distance, further from kind of impulse signal, and of course from another properties of working material and dielectric liquid.

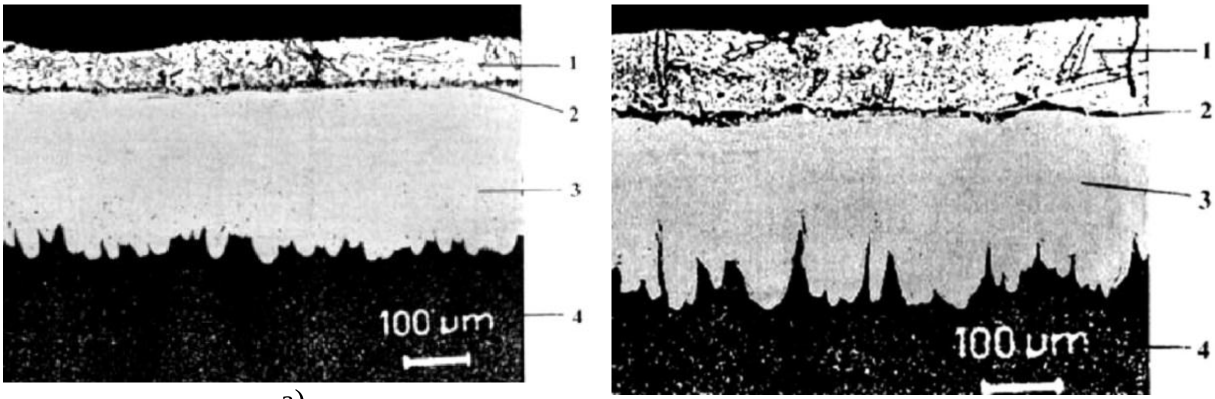
During EDM several physical, chemical and metallurgical processes take place, as follows: a) mechanism of discharging, b) time developed discharging in channel, c) energy distribution, d) heat transfer processes and e) material transfer processes [2][3].

3. CASE STUDY

The high temperatures produced by electrical discharges will undoubtedly lead to structural changes. The working sample will be cooled and hardened to a hardness of 63 HRC, with a hardened martensite structure.

As a consequence of the interruption of the impulse current, the molten metal undergoes a rapid solidification even at the periphery of the created crater. The partially evaporated metal will also condense as a consequence of the interruption of the impulse current. Following these aspects, it is possible that the surface will look like an over-welded surface.

Outside the melting zone, temperatures are lower, but are still at a higher level than the hardening temperatures of steel. This tempering is caused by EDM and this assumption is agreed by metallographic examination of eroded surface, as can be seen from fig.2.



a) b)

Fig.2. C22 sample sparking with: a) graphite electrode; b) tungsten carbide electrode

Following electric discharges, a white layer (1) is formed on the surface of the sample (cathode) which is not attacked by the reagents used for the basic structure (4).

Under the white layer, especially in hard scintillation regimes, a darker layer is formed, that layer of transition to the basic structure(3). The transition layer occurs due to the thermal action of the impulses of electric discharges and the diffusion of anodic elements to cathodic elements.

If electrical sparking process is produced at hard work condition, greatly increases the proportion of carbon.

This produces in the melting bath, a shift of the concentration from the steel area to the cast iron area. So upon rapid solidification, ledeburite and cementite appear in the newly formed layer.

Due to the carbon input from the active electrode, the white layer formed is a white cast iron with a structure that has the majority of cementite.

Experimental determinations were made with two types of electrodes: graphite electrodes and tungsten carbide electrodes. The experimental determinations are presented in table 1.

Table 1. *Experimental determinations*

Sample material	Electrode material	Microhardness [daN/mm^2]		
		White layer	Transition layer	Base structure
C22	Graphite	1320	370	340
	Tungsten carbide	1520	-	-

4. CONCLUSION

From the analysis of the presented data it is observed that the change in the hardness of the white layer is not significantly influenced by the working condition, but is little influenced by the electrode material used. Tungsten carbide electrode samples have higher white layer hardness than graphite electrode samples.

The method used is simple and inexpensive. The method is based on the effect of transferring the material from the electrode to the surface of the treated part during the electric discharge in the transfer medium between the electrode and the part.

The use of optimal working regimes will lead to the achievement of very good quality coatings. The type of coating depends on the speed of the electrode on the sample surface. Surface processing using electric sparks is a typical discharge by multiple pulses and in a very short time. In essence, during the discharge there is an erosion of the cathode and there is a transfer of material on the processed surface.

The working conditions used determine the geometry of the layer and its quality. The use of difficult working conditions will lead to thicker layers, but their structure will be with pores and cracks.

From experimental data it is observed that for C22 steel the hardness values of the transition layer are close to the hardness values of the basic structure.

The material under the white layer is subjected to a pronounced heating followed by a rapid cooling by taking heat from the base material. In this way there is a hardening of the metallic material located in the immediate vicinity of the white layer.

The hardness of layers obtained using tungsten carbide electrodes is higher than the hardness of layers obtained using graphite electrodes.

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