ELECTROSPARK DEPOSITION OF CARBON STEEL USING THE TUNGSTEN ELECTRODES

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Abstract

This paper presents a study of the effect of high voltage electrospark deposition (ESD) using tungsten electrode on the carbon steel. The layers were investigated with metallographic methods. Microscopic examination was carried out to examine the structure of formed layers. Image analysis methods were used to observe the cross-section of the layer. Scanning electron microscope (SEM) and energy-dispersive X-ray spectroscopy (EDX) analysis was conducted to characterize the microstructure and composition of the coating. Micro-hardness tests were carried out to evaluate the mechanical properties of coating on carbon steel. The results of investigations showed that there is a possibility of obtaining the satisfying quality superficial layer on the carbon steel C45 using tungsten electrode.

Keywords: Electrospark deposition (ESD), surface layer, microhardness, EDM, electrical-discharge alloying

1. INTRODUCTION

Due to the present trend in constructing machines, alloys of special properties are often used. These materials are characterized by mechanical durability and high resistance to abrasion and corrosion. The production of whole structures is associated with high costs, therefore often the surface layer is modified [1-4].

The EDM is undeniably classified as a removal process [5-8]. However, the EDM process can also be used as a surface treatment method; then it is called electrospark deposition (ESD) [9-12] or electrical-discharge alloying (EDA) [13-15], which can be performed using different tool electrodes.

Electrospark deposition is used to modify surfaces coatings for specific properties or for repair of damaged high value precision products. The electric motor generates electrode movement, preventing the constant contact between the electrode and substrate. During ESD process, the release of capacitor energy will generate a high temperature plasma arc between the electrode tip and the substrate. The electrode material is ionized by the plasma arc and the molten electrode material is transferred onto the substrate.

There are other methods of modifying the top layer by HVOLF-sprayed nanocrystalline coating [16], pulse microwelding technique [17] or even production of porous structure [18, 19], but the costs can be too high compared to other treatments.

The paper is focused on electrospark deposition (ESD) as a "non-conventional" method of applying layers. The aim of research is to study the effects of ESD process to modify carbon steel C45 with tungsten electrode, using the same discharge voltage but different capacitance capacitances.

2. MATERIALS AND METHODS

Carbon steel was chosen as the base material. The samples for applying layers were prepared by CNC machine AVIA VMC800 [20, 21]. The tungsten electrode was selected to deposited on a carbon steel (C45) substrate in the ESD process experiments. The diameter of the electrode was 4 mm. The discharge voltage was 600 V, the capacitance capacitances were changed from 50 μF to 250 μF.

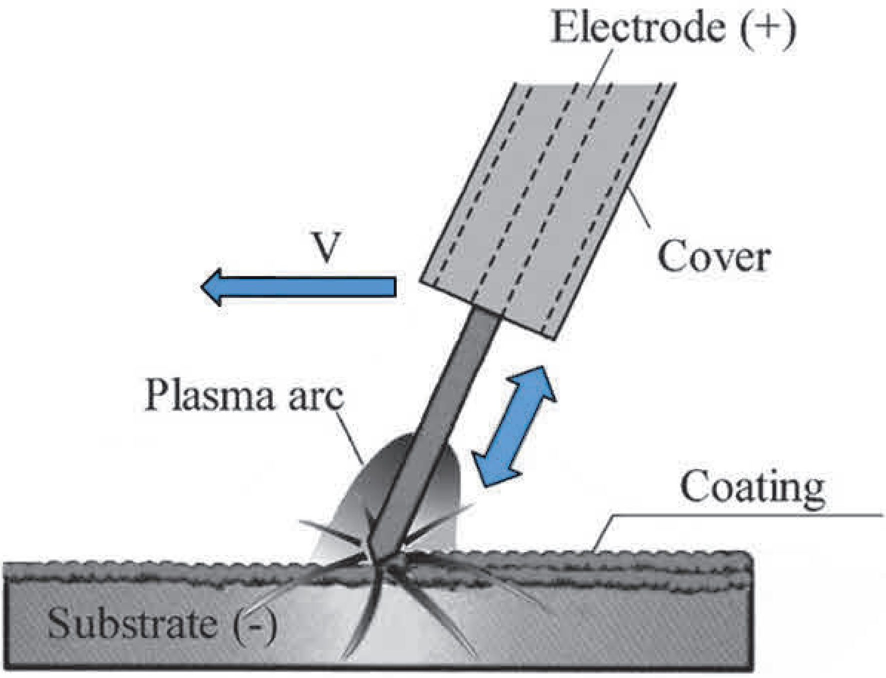

Figure 1 Scheme of the ESD process

Samples before applying the layers [22-25] were weighed to observe the growth of the material. After ESD treatment, the surface roughness was measured [26, 27]. During the preparation process for the obtained layer were cut to smaller pieces using AWJM machine [28, 29] to avoid thermal influences and mounted in resin. After proper polishing and etching using 4% HF the layer was subjected to observation (**Figure 2**).

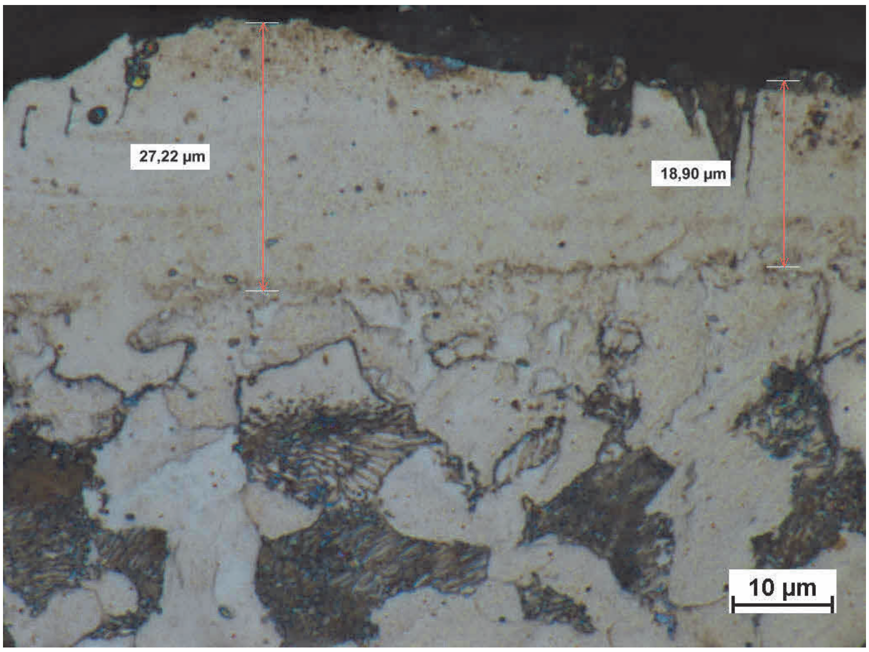

Figure 2 Micrograph image of cross-section of the surface alloyed after the ESD process

3. RESULTS

The microstructures of the alloyed layers were observed using SEM JEOL JSM 7100F microscope. To examine the alloying extent and the compositional distribution of the modified layers, SEM and X-ray diffraction was also used.

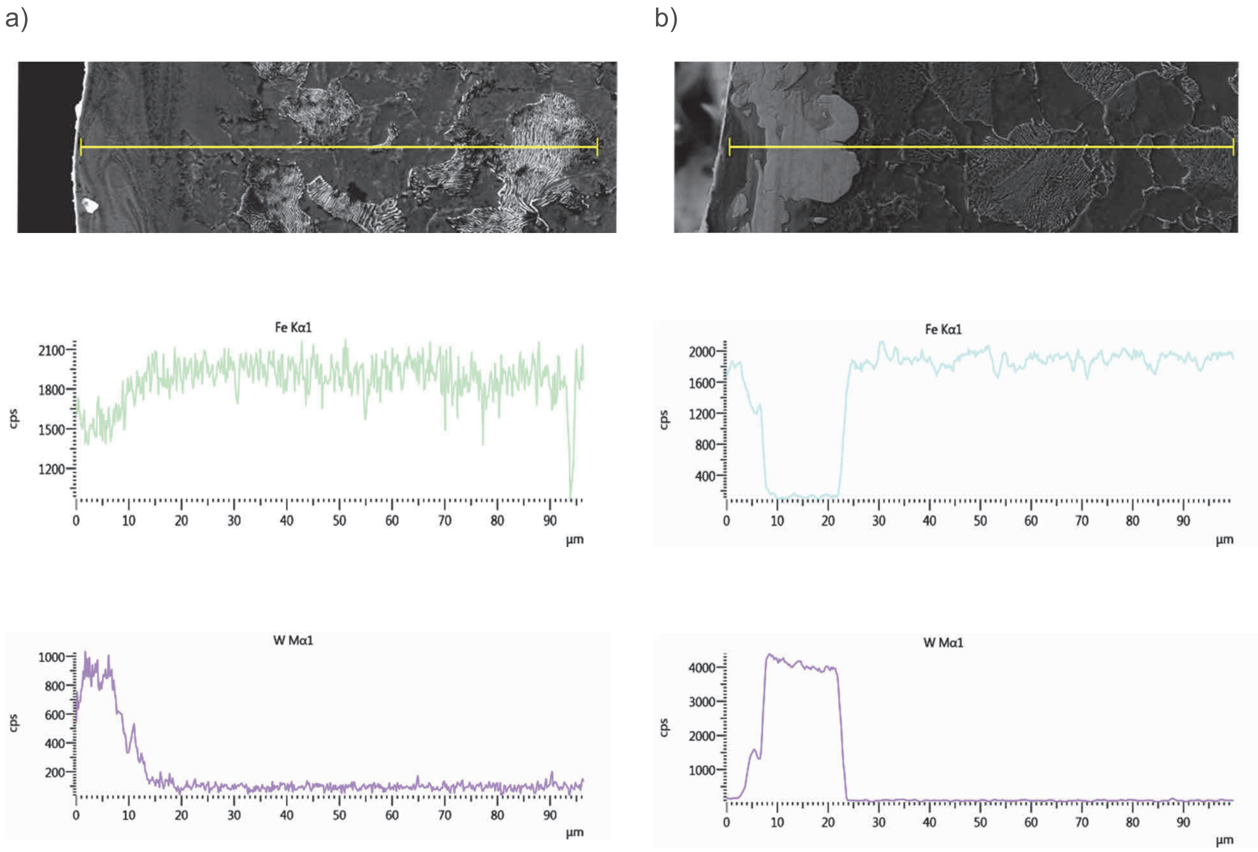

Figure 3 X-ray line scan of the surface layer after the electrospark alloying process using a tungsten electrode witch chemical elements distribution in the sub-surface layer a) 600 V, 50 µF, frequency 50 Hz, b) 600 V, 250 µF, frequency 50 Hz.

To presents the results of investigating electrospark deposition traces on the machined surface where capture and present. Analysis of the geometric structure after ESD were performed using optical profilometer Talysurf CCI Lite, using the TalyMap Platinum software, and Gaussian filter 0.8 mm (ISO 4287). The tests were performed on scanning profilometer [30] which can not only give visual information on the shape of discharge traces but also enables measurement of trace geometry and give information on volume of pits and flashes.

The analysis of the ESD process shows that relationships between the capacity of capacitors and surface roughness. Surface roughness decreased with increasing the capacity of the capacitors, from Sa 8.1 µm to 4.7 µm.

Microhardness tests were carried out by using a Vickers indenter, with an applied load of 0.1961 N for 15 s. The indentations were positioned at regular intervals in the transverse direction across the surface layer, from the fusion zone up to the base metal. The microhardness of the alloyed layers was $HV_{0.02}$ = 995, the fusion zone $HV_{0.02}$ = 680 to 780 and the base material $HV_{0.02}$ = 235.

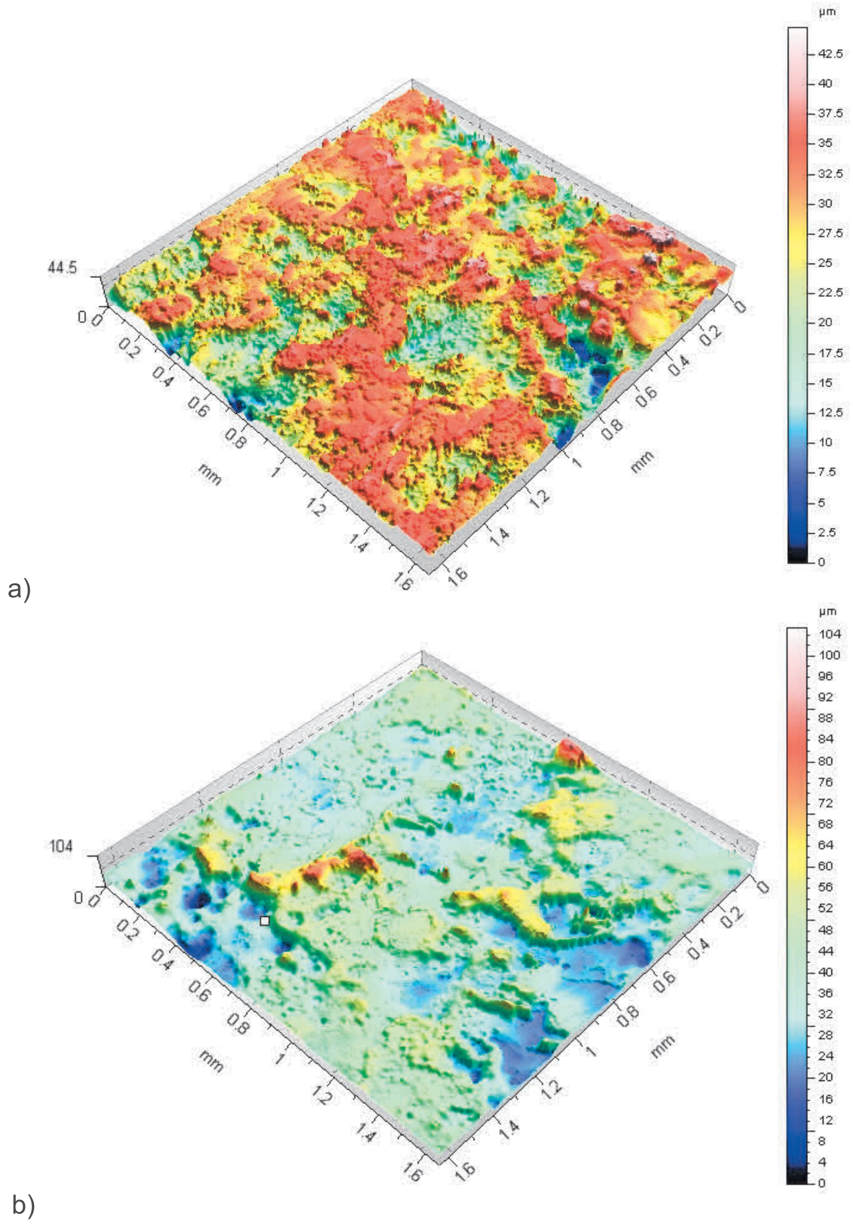

Figure 4 The 3D view of the machined surface made by Talysurf CCI Lite -Taylor Hobson scanning profilometer, a) 600 V, 250 µF, frequency 50 Hz, b) 600 V, 50 µF, frequency 50 Hz

4. CONCLUSION

The investigations into electro spark deposition process using a tungsten electrode shown that:

- increasing of the capacitance capacitances causes the discharge over a larger area,
- the surface layer subjected to the deposition process contains chemical components of the electrode,
- X-ray analysis shows an increase of tungsten up to 100% using high capacity, in the case of smaller capacity the tungsten was observed in the range between 50-60%,
- thickness recast layer was from 10 to 30 µm using high capacity,
- the hardness of the deposited layer increased significantly in relation to the substrate material,
- surface roughness decreased with increasing the capacity of the capacitors, from Sa 8.1 µm to 4.7 µm.
- The results of investigations showed that there is a possibility of obtaining the satisfying quality superficial layer on the carbon steel C45 using tungsten electrode.

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