INFLUENCE OF THE EDM PROCESS PARAMETERS ON THE SURFACE ROUGHNESS OF ALNICO ALLOYS

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Abstract

This paper deals with the influence of the EDM process parameters on the surface roughness of AlNiCo alloys. A BP 93L machine with an electronic generator was used to perform the machining. The workpiece was made of an AlNiCo alloy. Kerosene was used as a dielectric. During the EDM process, the parameters of current were changed. The impulse time and break time were also changed. The surface roughness and a 3D surface profile were measured. Roughness measurement was carried out using a Talysurf CCI Lite non contact 3D surface profiler. The analysis of the results was carried out with the Statistica 10 program.

Keywords: Electrical discharge machining (EDM), AlNiCo alloys, suface roughness, 3D surface profile

1. INTRODUCTION

Modern technology development is associated with the emergence of modern construction materials. Along with new materials, it is necessary to develop methods used for their processing. Advances in material engineering caused the currently produced materials to be characterized by increasingly high strength properties, increased hardness, resistance to abrasion, etc. These materials are also characterized by lower unit weight and increased operating characteristics. High strength parameters, high hardness and wear resistance indicates that it is practically impossible or economically unjustified to process such materials with conventional methods.

The progress in the development of construction materials has made conventional manufacturing technologies (with the use of typical cutting tools such as: milling cutters, drills, turning tools, etc.), insufficient to achieve satisfactory final processing results. As a result, new techniques have appeared, for example: plasma, laser [1], hardfacing [2], vibratory machining [3-5] and hydroabrasive machining (high-pressure waterborne jet) [6,7]. With the use of laser technology, it is possible not only to cut out various shapes, but also to weld elements, as well as to shape them geometricaly thanks to the material deformation.

Erosion processing is included in the group of unconventional materials processing, among which one may distinguish: ECM (Electrochemical Machining) and EDM (Electrical Discharge Machining) [8-10].

2. ELECTRICAL DISCHARGE MACHINING (EDM)

Electrical Discharge Machining is used to shape objects by removing material layers from the workpiece. Material removal occurs as a result of periodic spark discharges between the two electrodes (one electrode is the workpiece and the other electrode is the work electrode). This process takes place in a liquid working medium with dielectric properties.

After reaching the appropriate value of the electric field strength and the border voltage between the electrodes, the electron emission from the cathode occurs. Electrons from the cathode collide with the atoms of the inter-electrode center, causing their ionization. A plasma channel is created. Its temperature can reach 18 000 K. A gas bladder with a growing diameter is formed around the channel. As a result of the local temperature increase, melting and partial evaporation of the micro-volume of the material occurs. Vigorous gasodynamic interactions cause the ejection of jets of liquid metal that solidify in the form of spherical balls [11].

Between the successive pulses there must be a break, necessary to deionize the working gap and to remove the erosion products from the processing zone. The described phenomena, in the course of spark erosion machining, is cyclical [12-14]

The distribution of discharges on the surface of the workpiece is random. As a result of the discharges, the geometrical structure of the surface arises in the form of overlapping craters, which is typical for this method of processing [15]. The craters have dimensions of the discharges depending on the energy value (depending on the current, voltage against time profile and discharge time in the working circuit).

In typical EDM machining applications, we can drill any shape in the workpiece that maps the shape of the working electrode.

Microphotography surface after EDM process is show In **Figure 1**

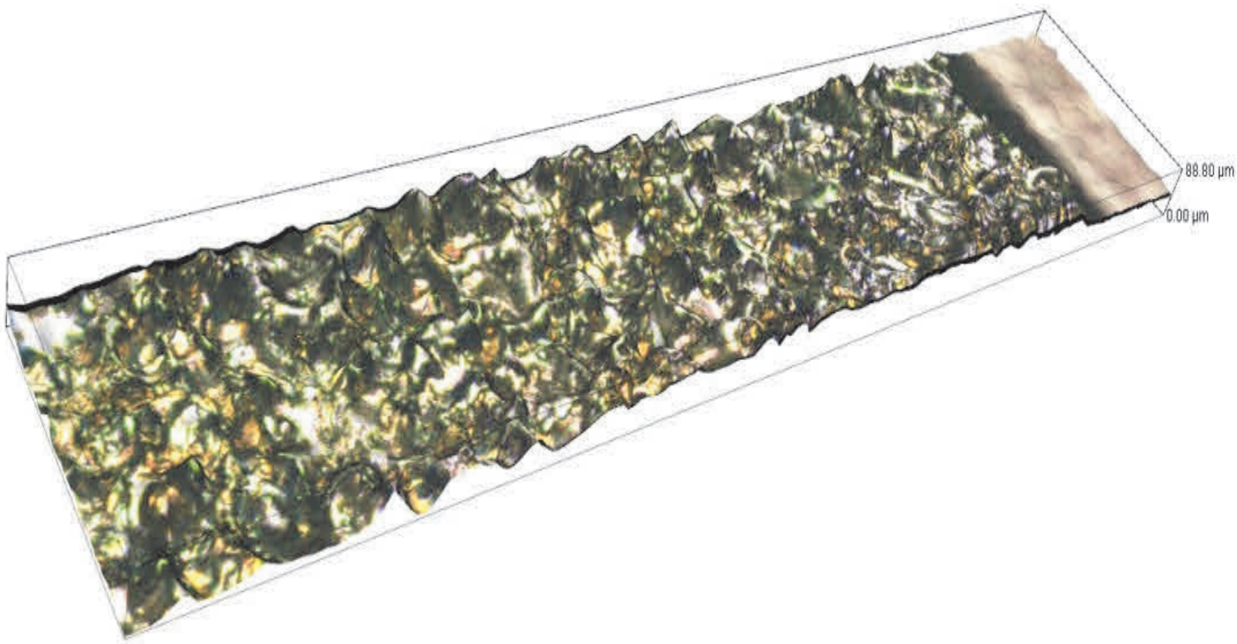


Figure 1 Microphotography surface after EDM process

3. THE RESEARCH

The aim of the research was the possibility of using the treatment for AlNiCo alloys processing and the influence of the EDM process parameters on the surface roughness of AlNiCo alloys. A BP 93L machine with an electronic generator was used to perform the machining. The workpiece was made of an AlNiCo alloy and paraffin was used as a dielectric. The BP 93L machine is shown in **Figure 1**.

During the EDM process, the parameters of current were changed. The impulse time and break time was also changed. The amplitude of the current (I_w) was changed from 15 A to 35 A, the impulse time (t_i) was changed from 100 µs to 300 µs, the break time (t_p) was changed from 50 µs to 100 µs.

There were 9 experiments carried out in the research. Three parameters were changed and each of these parameters gave three different values. The experiment was planned with the use of the Statistica 10 software. The machine settings values for individual samples in the experiment are shown in the table (**Table 1**).

Table 1 Machine settings values for individual samples in the experiment

Sample number	*Amplitude of the current*, (A)	*Impulse time*, (µs)	*Break time*,(µs)
1	25	300	50
2	35	200	50
3	35	300	100
4	35	100	75
5	15	300	75
6	25	100	100
7	15	200	100
8	15	100	50
9	25	200	75

4. THE RESEARCH RESULT

The surface roughness and a 3D surface profile was measured for all the samples. Roughness measurement was carried out using a Talysurf CCI Lite 3D non-contact surface profiler. The analysis of the results for all parameters was carried out with the Statistica 10 program. The Talysurf CCI Lite 3D non-contact surface profiler is shown in **Figure 2**.

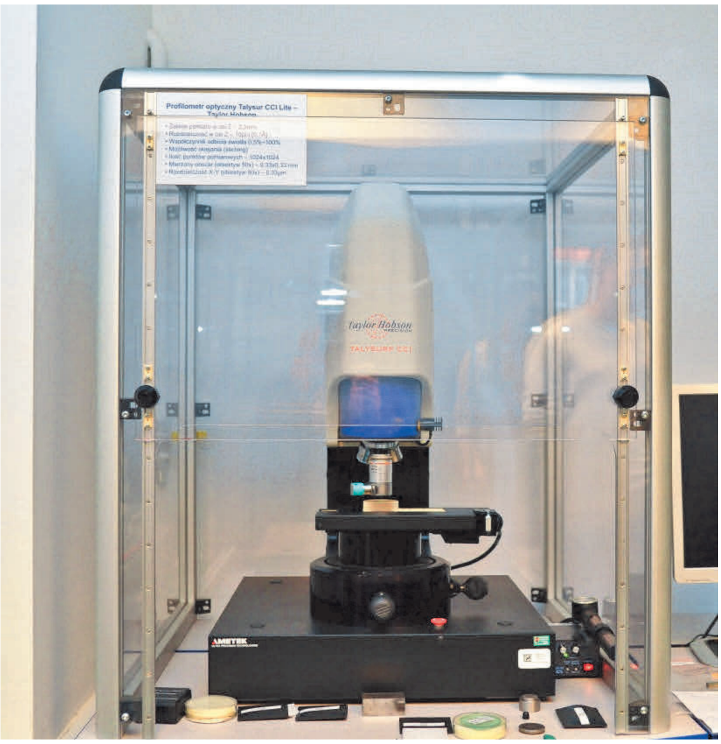


Figure 2 The Talysurf CCI Lite 3D non-contact surface profiler

The examples of measurement results (the surface roughness) is shown in (**Table 2**). The amplitude of the current was 25 A, the impulse time was 200 µs and the break time was 75 µs.

The examples of measurement results (the 3D surface profile) are shown in (**Table 3**). The amplitude of the current was 25 A, the impulse time was 200 µs and the break time was 75 µs.

Table 2 The surface roughness parameters for the ninth sample (I=25 A, t_i=200 μs, t_p=75 μs)

The surface roughness parameters	Value
Rp (μm) - Maximum peak height of the roughness profile	32.0502
Rv (μm) - *Rp* (μm) - Maximum valley depth of the roughness profile	18.6709
Rz (μm) - *Rp* (μm) - Maximum height of the roughness profile	50.7211
Rc (μm) - *Rp* (μm) - Mean height of the roughness profile elements	30.1778
Rt (μm) - Total height of roughness profile	51.1079
Ra (μm) - Arithmetic mean deviation of the roughness profile	9.1783
Rq (μm) -Root-Mean-Square (RMS) Deviation of the roughness profile	11.3879
Rsk -Skewness of the roughness profile	0.5919
Rku - Kurtosis of the roughness profile	3.1697
Rmr (%) - Relative Material Ratio of the roughness profile	1.0867
Rdc (μm) - Roughness profile Selection Height difference	19.3132
RSm (mm) - Mean Width of the roughness profile elements	0.1712
Rdq (deg) - Root - Mean - Square slope of the roughness profile	35.5268

Table 3 The 3D surface profile parameters for the ninth sample (I=25 A, t_i=200 μs, t_p=75 μs)

The 3D surface profile parameters	Value
Sq (μm) - Root mean square height	19.9141
Ssk (μm) - Skewness	0.1238
Sku (μm) - Kurtosis	2.7214
Sp (μm) - Maximum peak height	52.2346
Sv (μm) - Maximum pit height	46.7593
Sz (μm) - Maximum height	98.9939
Sa (μm) - Arithmetic mean height	15.9829

The 3D surface profiler for ninth sample is shown in **Figure 3** (the amplitude of the current was 25 A, the impulse time was 200 μs and the break time was 75 μs). The polar roughness distribution for for the same samples is shown in **Figure 4**.

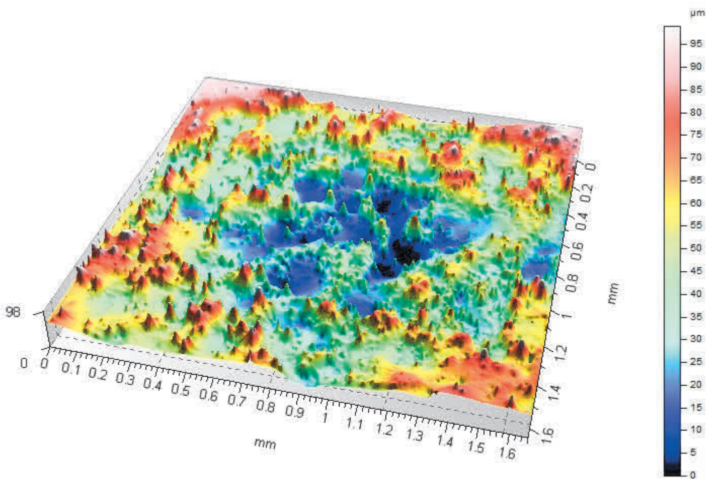


Figure 3 The 3D surface profiler for ninth sample (I=25 A, t_i=200 μs, t_p=75 μs)

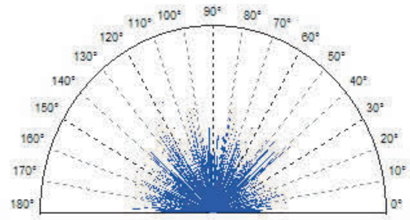
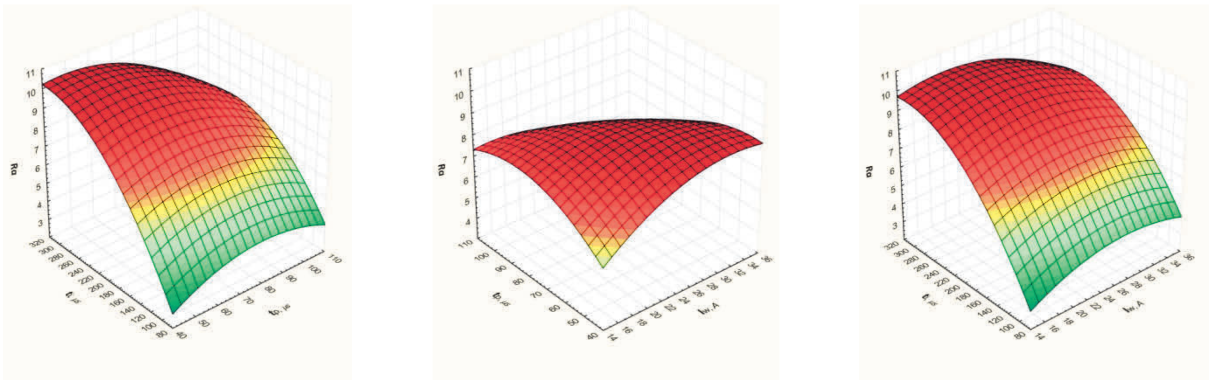


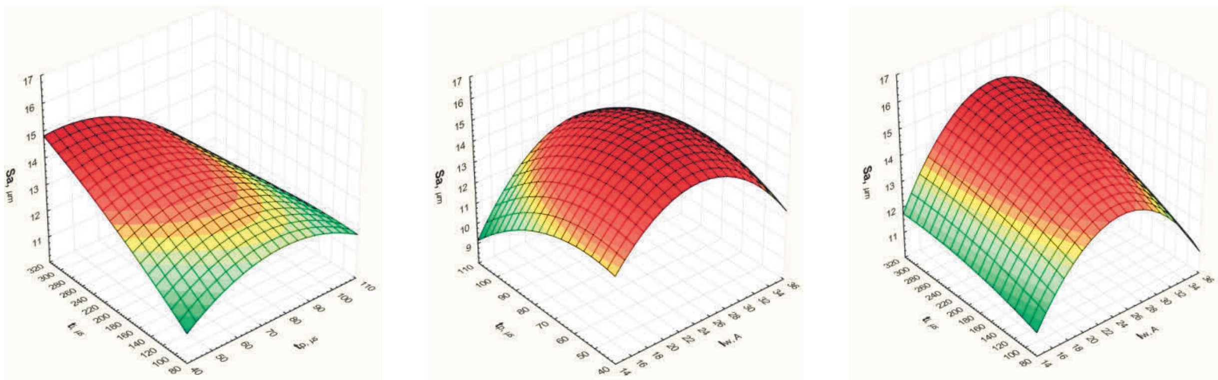
Figure 4 The polar roughness distribution for ninth sample (I=25 A, t_i=200 μs, t_p=75 μs)

All measured parameters (the surface roughness and the 3D surface profile) were analyzed in the Statistica 10 program. The Ra parameter dependance in the functions of parameters Iw, ti, tp is shown in **Figures 5a, 5b, 5c**. The *Sa* parameter dependence in the functions of parameters I_w, t_i, t_p show on **Figures 6a, 6b, 6c**.



a) b) c)

Figure 5 The *Ra parameter* dependence (arithmetic mean deviation of the roughness profile) in the functions: a - t_i, t_p; b - I_w, t_p; c - t_i, I_w;



a) b) c)

Figure 6 The *Sa* parameter dependence (Arithmetic mean height) in the functions: a) - t_i, t_p; b) - I_w, t_p; c) - t_i, I_w;

5. CONCLUSIONS

Electrical discharge machining can be used to shape difficult-to-cut materials such as: cemented carbide, composite materials based on metallic binders, steels in hardened condition. The main limitation for electric discharge machining that determines its applicability is the electrical conductivity of the material. In the conditions of correctly running EDM process, the working electrode does not come into direct contact with the workpiece. The surface roughness after the EDM is undetermined - is random. The surface roughness depends on the amplitude of the current and on the value of the pulse time and the break time. The increase of the value of the current, causes the energy of discharges and the depth of the craters to increase. The surface roughness depends on the pulse time too. With the increase of the value pulse time, the parameters of surface roughness increase. However, the current value still has the greatest impact on the surface roughness parameters.

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