

HIGH CHROME ELECTRODE ELECTROSPARK DEPOSITION STUDIES

ИЗСЛЕДВАНЕ НА ЕЛЕКТРОИСКРОВОТО ОТЛАГАНЕ ПРИ СИЛНО ЛЕГИРАН С ХРОМ ЕЛЕКТРОД

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Abstract: This article represents a study about the influence of some input parameters in the process of electrospark deposition to achieve a layer with high content of chrome. Output process parameters on which the current research focused were chosen as being representative in the present conditions, namely the layer thickness and their surface roughness. In the experimental conditions were realized a number of samples whereupon the variation of input parameters was analysed in a statistical manner and were elaborated the mathematical equations that made possible the prediction on the practical result.

KEYWORDS: CHROMIUM DEPOSITION, INPUT OF ELECTROSPARK DEPOSITION, LAYERS THICKNESS, ROUGHNESS, ANOVA

1. Introduction

The electrospark deposition represent an unconventional method to obtain some layers with high adhesion that facilitate a high resistance to erosion and corrosion and superior hardness of the basic material on which was made the covering [1].

This method possesses some unique advantages in its sphere of action, through reduced energy consumption, working in an environment that fosters the layer hardening, which structure oncoming to the amorphous one [2]. One final aspect that is mentioned as an advantage of the electrospark deposition is the one of the equipment construction simplicity and also of the manoeuvrability in operation even for the most complex and irregular surfaces [4].

Obvious is the fact that in the electrospark deposition are presented some negative perspectives regarding to the covering discontinuous nature, that offers the surface roughness and also to the areas where in the layer appears gaps that occur the decreasing of its resistance [3].

In this research was used a high chrome electrode, an element that is necessary to elaborate some types of steel because of the advantage offered in increasing the mechanical properties but also to their corrosion resistance. In the present in the classical technologies, the chrome is utilized through the method of hard-chromium plating, where are obtained layers with thicknesses to 1 mm and through the decorative-chromium plating where are obtained layers with thicknesses less than 1 μm .

An approach of the covering chrome surfaces in order to obtain a better corrosion resistance was made using the spraying in spring. To achieve the desired effect in terms of corrosion liability at high temperatures was proved that the chrome content should not fall below 44%, to not facilitate the transition of the corrosive environment into the substrate [5].

The layers with chrome were obtained through electrospark deposition in order to increase the non-corroding properties. In the experiments conducted by S. Frangini and his team were deposited layers with Cr content in the ratio of 20%, with thicknesses from 10 to 30 μm , which after the conventional corrosion resistance tests gave exceptional results both in general and local [6].

2. Experimental conditions and the obtained results

In the research was used an equipment of electrospark deposition with a jigger electrode, the process developed in the environment. The electrical input process parameters of the equipment that were changed are presented in table below.

Table 1. The varied electrical parameters

Condition	Discharge voltage, V	Vibrating coil voltage, V
1	33.50	7.61
2	56.90	11.25

Experiments were realized through the manual movement of the electrode on the cathode surface. Thus it was necessary to adopt a specific time to be possible the entire covering of the established area to 200 mm².

The specific duration being an input process parameter that can bring some positive or negative outcomes to the final result was defined as variable in the actual research with two values, 4 min/200mm² and 6 min/200mm².

The semi-manufactured material on which occurred the deposition is steel for tools with composition C 0.752%, Mn of 0.343% and 0.264%, Cr 0.114% and S of 0.019%.

After approaching all the possibilities of electrospark deposition using the previously defined variables, were extracted the output data regarding to obtained layer thickness and the roughness of surface in case.

The conditions to obtain high chrome were centralized in the following table.

Table 2. The process input variables

Sample	U _D , V	U _V , V	Specific time, min/2cm ²
1	33.5	7.61	4
2	33.5	7.61	6
3	33.5	11.25	4
4	33.5	11.25	6

5	56.9	7.61	4
6	56.9	7.61	6
7	56.9	11.25	4
8	56.9	11.25	6

The characteristics determined in the analysis with an impact on the actual research were considered to be the layers thickness and the roughness obtained after the electrospark deposition.

Table 3. The layers thickness

Sample	Deposited layer, μm	Allied layer, μm	Influenced layer, μm
1	13.25	4.21	43.87
2	25.58	6.35	115.96
3	21.42	5.21	83.28
4	29.13	7.85	135.86
5	18.93	6.76	56.18
6	28.15	10.23	138.14
7	23.63	8.40	98.87
8	37.81	12.14	180.71

The layers thicknesses from the previous table were possible to be identified at SEM magnification of 750X. One of the pictures that show the three layers obtained is presented in the figure below.

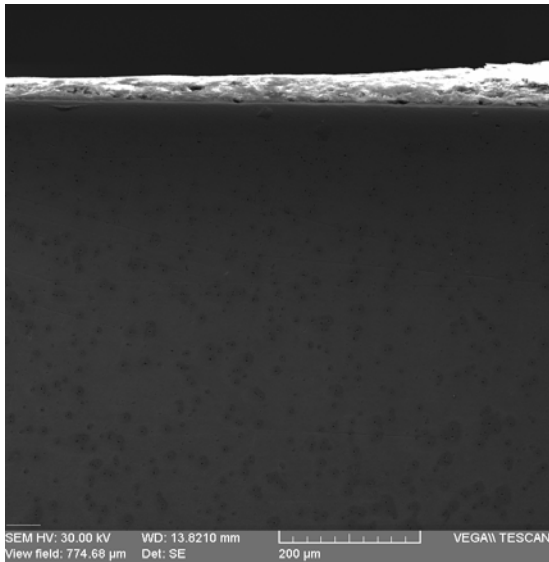


Figure1. The graphical representation of the layer obtained in the sample with number 8

To highlight the series of the layers mentioned above from surface to base material was realized and in-line analyzed the content of Cr and Fe in a depth that allows this.

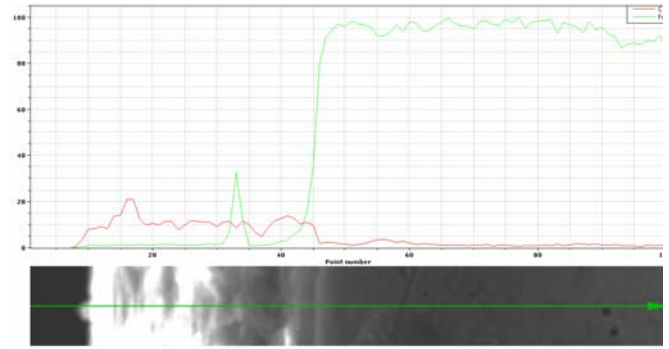


Figure 2. The chrome and iron in-line analysis

The surfaces roughness obtained in the circumstances related above were centralized in the table below.

Table 4. The surfaces roughness

Sample	Ra, μm	Ry, μm	Rz, μm	Rq, μm
1	1.31	9.34	7.70	1.61
2	1.27	8.84	8.11	1.59
3	1.52	10.26	8.74	1.87
4	1.55	10.23	9.09	1.90
5	1.92	14.40	11.35	2.35
6	2.14	12.98	11.58	2.60
7	2.28	19.22	15.02	2.97
8	2.08	14.34	10.90	2.49

3. The analysis results

3.1. The statistical analysis of the input variables influence

To identify the position of each input variable that has an independent character on the values of the output process variables that are dependent on the first ones, it was considered appropriate to apply the variance analysis (ANOVA).

The ANOVA result of the discharge voltage influence on the output variables counted in the actual research is presented in the table 5, following that in tables 6 and 7 to be presented the influences of the vibrating coil voltage and the specific duration whereby was realized the electrospark deposition.

The information given by the variance analysis is about the influence of the independent variable which is reflected in F value (the variance coefficient), having a high value, means a significant influence and by measured reliably, with notation „p” which value may be lower than 0,05 in order to have a significant influence on the output variables.

In these conditions, the obtained results in the table 5 give the information about the voltage scheme used that influence in a significant way the roughness and the thickness of allied layer

Table 5. The modality in which the voltage influences the layer thicknesses and the roughness

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
The thickness of deposited layer	Between Groups	45.792	1	45.792	.821	.400
	Within Groups	334.669	6	55.778		
	Total	380.461	7			
The thickness of allied layer	Between Groups	24.186	1	24.186	6.175	.047
	Within Groups	23.502	6	3.917		
	Total	47.688	7			

The thickness of influenced layer	Between Groups	3.213	1	3.213	.002	.963
	Within Groups	8438.162	6	1406.360		
	Total	8441.375	7			
Ra	Between Groups	.959	1	.959	44.967	.001
	Within Groups	.128	6	.021		
	Total	1.087	7			

Table 6. The modality in which the vibrating coil voltage influences the layer thicknesses and the roughness

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
The thickness of deposited layer	Between Groups	85.021	1	85.021	1.727	.237
	Within Groups	295.441	6	49.240		
	Total	380.461	7			
The thickness of allied layer	Between Groups	4.575	1	4.575	.637	.455
	Within Groups	43.113	6	7.185		
	Total	47.688	7			
The thickness of influenced layer	Between Groups	248.311	1	248.311	.182	.685
	Within Groups	8193.064	6	1365.511		
	Total	8441.375	7			
Ra	Between Groups	.078	1	.078	.464	.521
	Within Groups	1.009	6	.168		
	Total	1.087	7			

In the case of the variance analysis for vibrating coil voltage it turns out that it doesn't have a significant influence on any of the considered output process variables but it brings a significant influence on the deposited layer thickness.

The influence of the specific duration as the results show through ANOVA analysis from the table 7 is one with a significant impact on the deposited layer thickness and on the influenced layer thickness too.

Table 7. The modality in which the specific duration influences the layer thickness and the roughness

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
The thickness of deposited layer	Between Groups	235.879	1	235.879	9.789	.020
	Within Groups	144.582	6	24.097		
	Total	380.461	7			
The thickness of allied layer	Between Groups	17.970	1	17.970	3.628	.105
	Within Groups	29.718	6	4.953		
	Total	47.688	7			
The thickness of influenced layer	Between Groups	4440.118	1	4440.118	6.658	.042
	Within Groups	4001.257	6	666.876		
	Total	8441.375	7			
Ra	Between Groups	.000	1	.000	.000	.994
	Within Groups	1.087	6	.181		
	Total	1.087	7			

3.2. The significant equations

To determine the layer thickness deposited on the cathode surface, the most significant equation is:

$$G_{sd} = 78.02119 + \frac{(-389.7844)}{U_D} + \frac{(-153.3486)}{U_V} + \frac{(-130.3195)}{S_T} \quad (1)$$

$$S_G = 2.294818 \quad (2)$$

To determine the allied layer thickness in the actual conditions it was considered important the following expression:

$$G_{SA} = 0.6395352 \cdot (1.020115)^{U_D} \cdot (1.057467)^{U_V} \cdot (1.221938)^{S_T} \quad (3)$$

$$S_G = 1.591345 \cdot 10^{-2} \quad (4)$$

In the case of influenced layer, its thickness can be determined with the following expression:

$$G_{SI} = 426.377 + \frac{(-1933.246)}{U_D} + \frac{(-850.0652)}{U_V} + \frac{(-865.4072)}{S_T} \quad (5)$$

$$S_G = 61.78887 \quad (6)$$

The roughness value of the surfaces obtained on the electrospark deposition in the actual case, can be determined using the expression:

$$Ra = -9.679973 \cdot 10^{-3} + (2.959395 \cdot 10^{-2}) \cdot U_D + (5.425815 \cdot 10^{-2}) \cdot U_V + (1.249816 \cdot 10^{-3}) \cdot S_T \quad (7)$$

$$S_G = 8.325008 \cdot 10^{-3} \quad (8)$$

4. Conclusions

The issues studied by this research are able to create a perspective on the results that can be obtained on the chrome electrospark deposition of the surfaces from the corrosive environments, which can be a substitute for hard-chromium plating.

Choosing the input variables was closely linked by the manual modality in which was realized the electrospark deposition to obtain clear information for the process conditions.

The analysis of the observed results is likely to confirm the possibilities of retrieving the negative issues that can be extracted in a very simplistic way.

The mathematical expressions make easier the retrieving of one problem that wants to be solved.

Mainly to obtain layers with hard chrome of different thicknesses can be produced by chrome electrospark deposition in order to satisfy some necessities.

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5. References

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