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THE POTENTISTATICAL METHOD USED FOR PURCHASING THE CORROSION BEHAVIOR OF THE WC COATINGS DEPOSITED BY PLASMA SPRAYING

M. L. BENEA

"POLITEHNICA" UNIVERSITY OF TIMISOARA,
ENGINEERING FACULTY OF HUNEDOARA

ABSTRACT

The method used for purchasing the corrosion behavior of the WC coatings deposited by plasma spraying, on a martensitic stainless steel substrate consists in measuring the electrochemical potential of the coating, respectively that of the substrate, immersed in NaCl solution as corrosive agent. The mathematical processing of the obtained experimental results in Matlab allowed us to make some correlations between the electrochemical potential difference, concentration and temperature of the NaCl solution, the result being the 2nd degree correlation surface, to make a comparison the experimental and the theoretical results and the behavement of the surface R2 around the medium point.

KEYWORDS

WC coatings, plasma deposition, corrosion resistance, potentiostatic method.

1. INTRODUCTION

The WC-Co coatings are designed to protect machines parts (roll cylinders, turbine shuffles, parts of diesel engines) during the combined wear and chemical corrosion stress [1, 2, 3].

The studied coatings within the framework of the present paper have been deposited by Air Plasma Spraying, on a martensitic stainless steel substrate using a Metco 73 spraying powder [4,5].

In order to purchase the corrosion behavior of these coatings, in literature there are mentioned the 0.1 M NaOH, 0.1 M H_2SO_4 and also NaCl solutions [6].

As corrosive agents there have been used NaCl solutions of different concentration, at different temperatures.

The protective action of the coating has been appreciated by measuring the electrochemical potentials of the substrate respectively of the coating, both immersed in the NaCl solution. The higher the electrochemical potential of the coating is, in comparison to that of the substrate, the better the protective action of the coating is being considered [7,8].

2. EXPERIMENTAL PART

The substrate is the martensitic stainless steel Z12CNDV12. Before being coated, the surface of the substrate has been preparated by sanding with corundum powder.

The coatings have been using a Metco 7MB equipment. The powder used is Metco 73, with 83 % WC and 17 % Co and particle size between 10 and 45 μm.

The coating thickness is 0.1 mm.

The corrosion resistance is determined by the potentiostatic method. The couple made of the coating (WC-Co) and substrate has been immersed in NaCl solutions having concentrations between 1 and 15 %, at temperatures between 20 and 48°C. In each case has been determined the electrochemical potential of the coating and substrate, using as reference electrode the calomel electrode.

The corrosion resistance has been tested using the installation shown in figure 1.

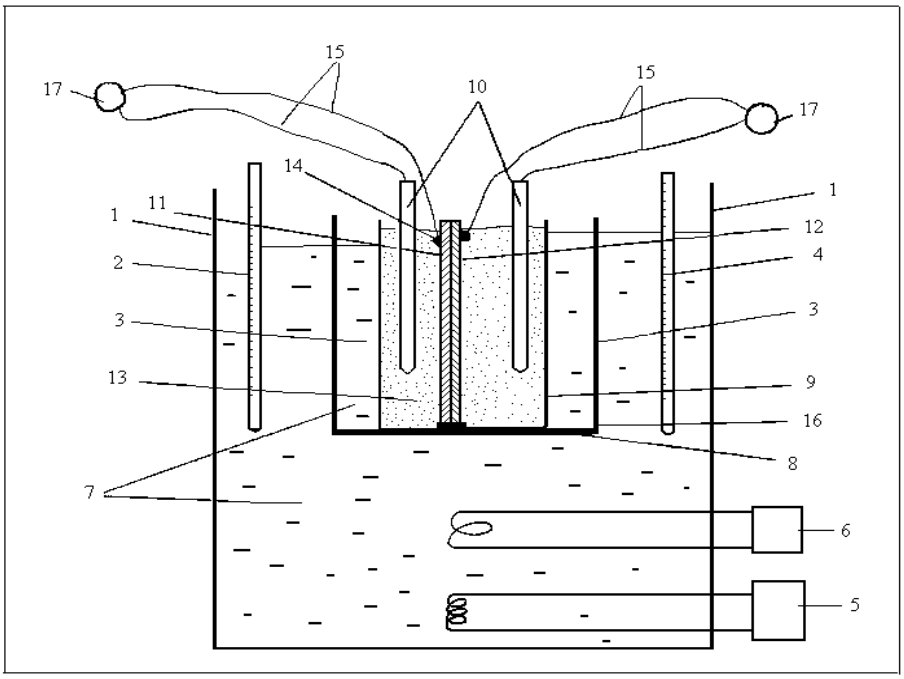

Fig. 1. *The assembly made for the determination of the corrosion resistance. 1-Thermostate; 2-Measurement thermometer; 3-Fixing device of the support; 4-Contact thermometer; 5-Heater; 6-Water recycling pump; 7-Water; 8-Support; 9-Berzelius glass; 10-Reference (calomel) electrodes; 1-Coating; 12-Metallic substrate; 13-Electrolite (NaCl solution); 14-Contact; 15-Conductors; 16-Silicon (adhesive for sealing); 17-Milivoltmeter*

3. RESULTS AND DISCUSSION

The results of the experimental determinations are shown in the table1.

Table 1 *- The values of the electrochemical potential differences [mV] between the coating and the substrate, when varying the temperature and the concentration of the NaCl solution.*

C [%]	The electrochemical potential difference [mV] for different temperatures of the NaCl solution [°C]														
	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
1	253	250	248	245	240	245	237	235	233	225	225	225	225	227	227
2	225	215	209	205	198	199	195	194	192	191	190	188	190	198	191
3	210	200	195	190	180	175	174	180	172	171	170	170	172	172	173
4	195	179	168	170	159	159	157	155	152	154	149	152	152	154	155
5	190	176	161	150	142	144	143	142	141	141	140	140	141	142	142
6	185	160	152	150	141	142	135	134	133	132	132	133	133	135	137
7	184	181	165	151	140	135	134	132	132	131	130	131	132	132	133
8	183	165	150	143	140	137	133	132	132	131	131	132	133	134	134
9	184	160	155	145	142	138	137	140	133	132	132	133	135	136	136
10	183	160	160	143	140	135	134	133	132	131	131	132	133	135	137
11	183	177	168	157	150	143	142	140	137	135	132	132	133	137	140
12	183	170	159	155	140	137	135	135	133	133	131	132	132	137	140
13	183	172	165	151	145	142	139	138	140	134	133	135	138	139	140
14	183	170	160	153	150	148	142	139	136	135	135	137	140	139	140
15	180	168	157	150	145	143	140	137	136	135	135	137	139	140	142

The experimental results were processed in Matlab, obtained correlation surface of the 2nd degree (fig.2) as well as level lines of the corresponding correlation surfaces (fig.3).

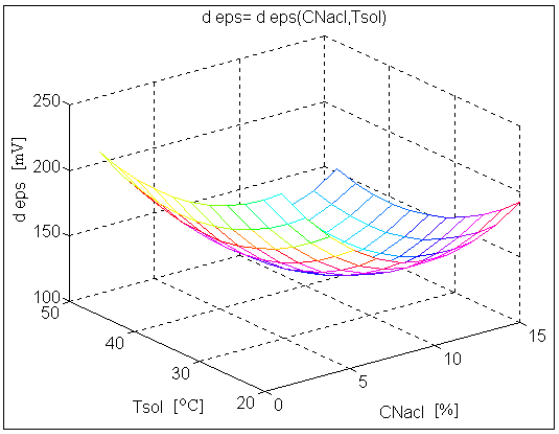

Fig. 2. *2nd degree correlation surface*

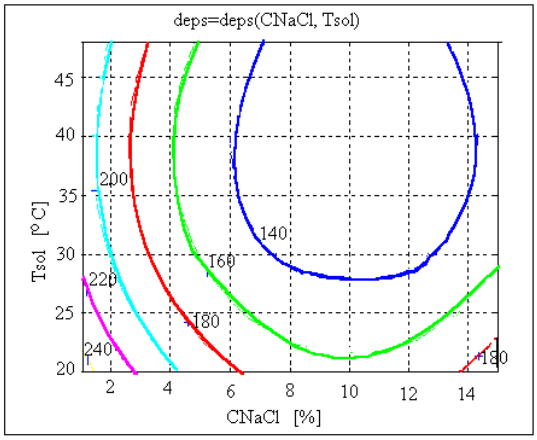

Fig. 3. *The level lines of the 2nd degree correlation surface.*

On the x axis is has been represented the concentration of the NaCl solution (CNaCl) in %. On the y axis has been represented the temperature of the NaCl solution (Tsol), in °C. u represents the electrochemical potential difference (d eps) between the coating made of Metco 73 powder and the martensitic stainless steel Z12CNDV12.

The deviations of the regression surfaces are being calculated with relation (1):

$$deviation2=\sqrt{\frac{1}{225}\sum_{i=1}^{225}\left(u_i - c_{21}\cdot x_i^{\,2} - c_{22}\cdot x_i\cdot y_i - c_{23}\cdot y_i^{\,2} - c_{24}\cdot x_i - c_{25}\cdot y_i - c_{26}\right)^2} \quad (1)$$

where c_{21}, c_{22}, c_{23}, c_{24}, c_{25}, c_{26} are the coefficients in the equation of the 2nd degree correlation surface:

$$u= c_{21}\cdot x^2+ c_{22}\cdot x\cdot y+ c_{23}\cdot y^2+ c_{24}\cdot x+ c_{25}\cdot y+ c_{26}$$

The values of these coefficients are:

$c_{21}=1$; $c_{22}= -0,01$; $c_{23}=0,11$; $c_{24}= -19,7$; $c_{25}= -8,9$; $c_{26} = 399,27$ [9,10]

so that the ecuation (2) for the correlation surfaces may be now written:

$$u= x^2-0.01\cdot x\cdot y+0.11\cdot y^2-19.7\cdot x-8.9\cdot y+399.27 \quad (2)$$

A comparison between the experimental data and the theoretical results is made in table 2.

Table 2. *The comparison of the experimental data with the theoretical ones*

Current number	C NaCl (%)	T sol (ºC)	The deviation of the experimental values from the theoretical ones, for the 2nd degree correlation surface eq.
1	1	20	5.321
2	3	20	-5.567
3	5	20	-1.479
4	7	20	8.585
5	9	20	16.63
6	11	20	15.64
7	13	20	7.633
8	15	20	-11.4
9	1	28	19.82
10	3	28	-7.814
11	5	28	-21.47
12	7	28	-7.144
13	9	28	3.154
14	11	28	11.43
15	13	28	-1.321
16	15	28	-17.1
17	1	36	25.65
18	3	36	-2.716
19	5	36	-9.111
20	7	36	-1.53
21	9	36	8.027
22	11	36	12.56
23	13	36	8.069
24	15	36	-11.45
25	1	48	11.43
26	3	48	-9.549
27	5	48	-15.56
28	7	48	-7.587
29	9	48	4.358
30	11	48	9.278
31	13	48	2.175

The first column contains the current number, the second column – NaCl solution concentration in %, and the third column – the temperature of the NaCl solution, in °C.

The forth column shows the deviation of the experimental results from those theoretical given by the 2nd degree correlation surface equation, deviation calculated according to the relation:

$$u_i - c_{21} \cdot x_i^2 - c_{22} \cdot x_i \cdot y_i - c_{23} \cdot y_i^2 - c_{24} \cdot x_i - c_{24} \cdot y_i - c_{26}$$

The medium values calculated are:

$$x_m = 8{,}000; \quad y_m = 34{,}000; \quad u_m = 157{,}5.$$

Table 3 shows the behavament of the surface R2 around the medium point.

Table 3. The behavament of the surface R2 around the medium point

Current number	Values for:		
	x	y	u
1.	8,500	34,000	128,4
2.	8,353	34,353	128,5
3.	8,000	34,500	129,7
4.	7,646	34,535	131,5
5.	7,500	34,000	132,7
6.	7,646	33,646	132,39
7.	8,000	33,500	130,9
8.	8,353	33,646	129,4
9.	9,000	34,000	127,1
10.	8,707	34,707	127,0
11.	8,000	35,000	129,2
12.	7,293	34,707	133,0
13.	7,000	34,000	135,5
14.	7,293	33,292	134,7
15.	8,000	33,000	131,7

4. CONCLUSIONS

- The paper presents an original method to purchase the corrosion behavior of the WC coatings deposited by plasma spraying, on a martensitic stainless steel substrate; the method is based on measuring the electrochemical potential of the coating, respectively that of the substrate, immersed in NaCl solution (corrosive agent), related to a reference calomel electrod.
- The values of the potential differences between the coating and the substrate are decreasing when raising the temperature and the concentration of the NaCl solution, which shows a decrease of the protection provided by the coating.
- The mathematical processing of the obtained experimental results in Matlab allowed us to make some correlation between

the electrochemical potential difference, concentration and temperature of the NaCl solution, the result being the 2nd degree correlation surface.

- Comparing the experimental data with the theoretical ones there resulted the deviations shown in table 2.
- The behavament of the surface R2 around the medium point shown in table 3.

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