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THE STUDY OF ENERGY TRANSFER ON THIN LAYERS ACHIEVED BY ELECTRO-SPARK DEPOSITION WITH TiC ELECTRODE

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Abstract: *The paper aims to register tension, intensity, and time at the precise moment of mono pulse deposition, with electrode of TiC used to achieve hard-alloyed layers by electro-spark deposition method. Ferrite-pearlitic iron used as base material. An assembly used for determinations, which attached to Elitron 22A spark installation. This installation consists in an electric resistance of 0,5 Ω inserted within work system and an oscilloscope with two spots. By means of oscilloscope, intensity, tension and period of mono pulse deposition measured. Diagrams achieved by using the software Statistica 5.5.*

Keywords: *electro-spark method, deposition regimes, vibration amplitude, current, electrode*

1. INTRODUCTION

Electro-spark deposition method is a current research method, used for coating by deposition on installation components, which works in hard conditions, abrasive wear, in moist or dry environment, in order to obtain superficial layers of superior tribological qualities. Obtaining thin layers with special properties (wear resistance, corrosion resistance and shock resistance) requires a proper choice of filler material, in strict correlation with the physical and mechanical properties of the material support, [1,2,3,6,7].

Discharge parameters regimes (voltage, current and pulse time), depends on the physico-chemical properties of the electric and working circuit (device-electrode-piece).

In this context, we can say that the parameters depend on the type of electrode deposition, and its melting temperature, the thermal conductivity, chemical reactivity of the anode elements, diffusivity, density, electrical resistance, thermal inertia, flowability and parameters temperature dependence.

Equally important is the base material, meaning the discharging cathode, because the arch character depends by the two electric poles of the discharge. Base material influences the technological and electric parameters by its conductivity, affinity absorption for discharge gases, melting point, boiling point, carbon potential, (comparing to the carbon potential for the plasma atmosphere may lead to carburizing or decarburizing of the base material), oxygen potential (comparing to oxygen potential from discharge may lead to oxidation or dezoxidation of the metal bath for the deposition drop). When changing the discharge parameters, a significant importance is the interaction between the cathode (base material) and anode (electrode) as a working couple, meaning the alloying intensity, the melting temperature of the creating alloy, heat capacity of the metal bath, electrical resistance of the metal bath, electrical conductance of the chemical combinations, layer porosity, affinity of the melted material to the plasma gases (oxygen, hydrogen, nitrogen, CO_2, CO).

Another key factor is the existing state of tension during work, which is the surface tension of the droplet deposition, heat stresses and also stresses caused by the rapid cooling, which creates cracks on the layer due to the different expansion coefficients of piece-layer system (depends on the plasticity and elasticity of deposited layer), [4,5].

The multitude of factors that influence the electrical parameters of the discharge regimes (voltage, current, time, power and energy) led to the conclusion that they should be measured in terms of specific experimental work, meaning the ferrite-pearlitic iron cast base material TiC (titanium carbide) electrode deposition at regimes and scales according to the working range of the device Elitron 22A.

2. METHOD

For experiments, an assembly was attached to the Elitron 22A installation, [8], in order to record the current pulses during work (Fig. 1). Elitron 22A presents 9 amplitude steps and 6 working regimes. The installation parameters, taken from the technical handbook are: consumed power (kVA) – 0,5; productivity (cm^2/min) – 4; working voltage (V) – 220; working regimes (r), vibration amplitude (A) – (A1=0,04 mm, A2=0,06 mm, A3=0,08 mm, A4=0,1 mm, A5=0,12 mm, A6=0,14 mm, A7=0,16 mm, A8=0,18 mm, A9=0,2 mm); mass (kg) – 21, [4,5].

For recording the electrical signals characteristics to the established working regimes an assembly consisting of an electrical resistance of 0,5 Ω inserted into the working system and a two spots oscilloscope was used.

By measuring the resistor voltage the work current was set. Time variation diagrams for voltage and spark current was recorded using the two spots oscilloscope.

For each experimental determination, from the oscilloscope screen were taken the following values: impulse time (10^{-4} [s]), current (A), voltage (V). Power was calculated (with formula P=U·I [W]) and single-pulse energy (with formula P=U·I [W]), [4,5].

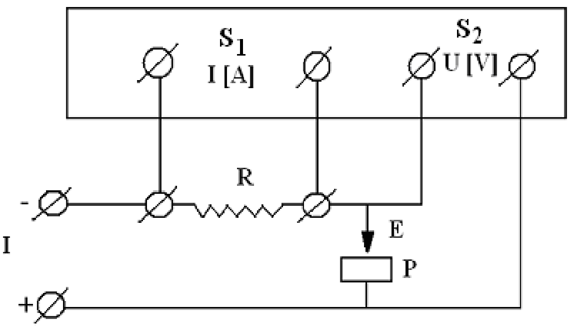

Fig. 1. Wiring diagram of installation: S1 – spot 1 for intensity of the discharge measurement; S2 – spot 2 for discharge voltage measurement; E – electrode; P – part; I – source; R – electrical resistance 0,5 Ω.

The total duration of a pulse is between 5 ÷ 14 ms. Each electrode has a different ionization capacity, according with the established working regimes, the control device positions. Power and pulse energy are different, depending on the physical properties and the quality of each electrode.

3. RESULTS AND DISCUSSIONS

Depending on the values obtained by calculation, power and energy were rendered using spatial graphs obtained with the Statistica 5.5 software.

3.1. Deposition regimes for TiC. Single-pulse energy deposition of titanium carbide electrode has large fluctuations, ranging from $45 \cdot 10^{-3}$ J (r1, A4) and $492{,}8 \cdot 10^{-3}$ J (r4, A4). Energy increases and decreases randomly with regime change and amplitude of vibration. The mean value for the 48 experiments is $E_{medium} = 161{,}83 \cdot 10^{-3}$ J, (Fig. 2).

Power single-pulse discharge electrode of titanium carbide varies between 145 W values (r2, A4) and 448 W (r4, A2), but with much uniformity as of 48 schemes 32 values between 180 ÷ 270 W. The high values, above 400 W are schemes 3 and 4, and the amplitude of between 2 and 6, (Fig. 3).

Table 1. Unipuls discharge modes for cast iron electrode TiC

Nr crt	A	r	I [A]	U [V]	t [x10⁻⁴s]	P [W]	E [x10⁻³J]	Nr crt	A	r	I [A]	U [V]	t [x10⁻⁴s]	P [W]	E [x10⁻³J]
1	2	1	15	22	6	330	198	25	2	4	14	32	11	448	492,8
2	3	1	17	10	3	170	51	26	3	4	15	12	4	180	72
3	4	1	15	10	3	150	45	27	4	4	16	22	7	352	246,4
4	5	1	14	12	4	168	67,2	28	5	4	15,5	18	5	279	139,5
5	6	1	15	20	7	300	210	29	6	4	15	14	4	210	84
6	7	1	15	16	7	240	168	30	7	4	16	15	5	240	120
7	8	1	14	14	6	196	117,6	31	8	4	13	16	5	208	104
8	9	1	15,5	18	6	279	167,4	32	9	4	13	14	4	182	72,8
9	2	2	17	14	5	238	119	33	2	5	13	16	8	208	166,4
10	3	2	13,5	12	6	162	97,2	34	3	5	17	12	4	204	81,6
11	4	2	14,5	10	4	145	58	35	4	5	16	12	5	192	96
12	5	2	16,5	14	8	231	184,8	36	5	5	15	14	8	210	168
13	6	2	15	18	7	270	189	37	6	5	18	10	5	180	90
14	7	2	17	16	8	272	217,6	38	7	5	15	12	5	180	90
15	8	2	15	18	8	270	216	39	8	5	17	12	6	204	122,4
16	9	2	13	16	8	208	166,4	40	9	5	16	12	5	192	96
17	2	3	12	36	10	432	432	41	2	6	14,5	20	8	290	232
18	3	3	12	22	7	264	184,8	42	3	6	14	14	5	196	98
19	4	3	17	26	8	442	353,6	43	4	6	16	14	5	224	112
20	5	3	15	28	9	420	378	44	5	6	18	12	4	216	86,4
21	6	3	14,5	20	7	290	203	45	6	6	12	22	6	264	158,4
22	7	3	14	24	6	336	201,6	46	7	6	16	10	5	160	80
23	8	3	15	18	5	270	135	47	8	6	18	16	7	288	201,6
24	9	3	16	20	5	320	160	48	9	6	23	18	6	414	248,4

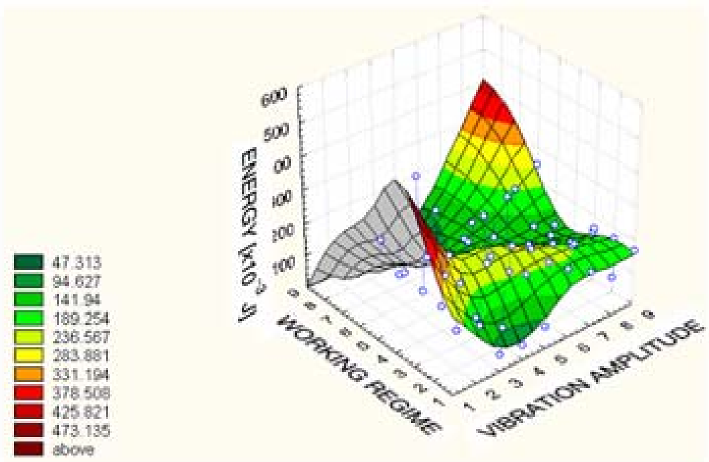

Fig. 2. Energy variation depending on the amplitude operating mode and working regime for TiC electrode.

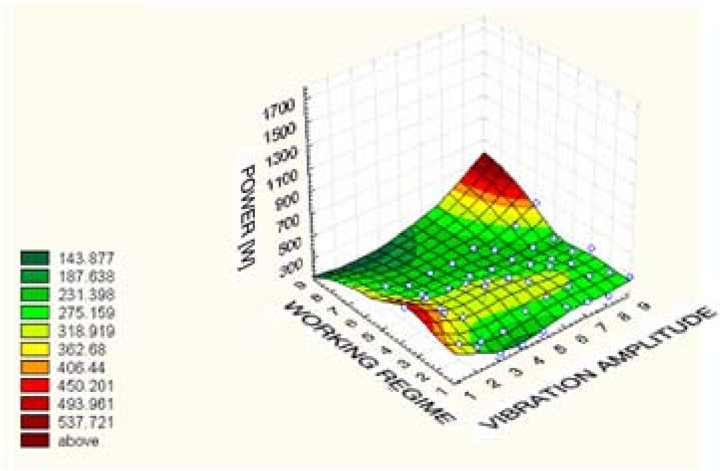

Fig. 3. Power variation depending on the amplitude operating mode and working regime for TiC electrode.

4. CONCLUSIONS

Correlation amplitude regime and deposition electrode and the base material type is important, both in terms of energy consumption and in terms of technology in order to achieve uniform deposition without burning achieve, pores or overlapping material. Energy analysis of deposits reveals that the energy deposit is inversely proportional to the size of electrical discharge pulse resistance.

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