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THIN METALLIC SUPERFICIAL LAYERS WITH SPECIAL PROPERTIES DEPOSED ON STEELS BY ELECTRIC DISCHARGE IN IMPULSE

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ABSTRACT

The surface engineering, as interdisciplinary technical science is a relative new concept which appeared in high developed countries as a result of the processing of the metallic materials with distinct properties and as a result of spectacular development of the thermal treatments.

The obtaining of the thin layers by electric spark presents some advantages as: high adherence of the layers, permits deposition of all materials which have electrical conductivity, but there are some disadvantages as: residual stress in layer and large roughness.

KEYWORDS: thin layer, electric discharge, impulse, properties

1. Introduction

The surface engineering, as interdisciplinary technical science is a relative new concept which appeared in high developed countries as a result of the processing of the metallic materials with distinct properties and as a result of spectacular development of the thermal treatments.

According by David Melford, "Surface Engineering" consists in essence in designing of surface and sublayer between, as a system, for conferring performances neither one not having selected separately. So, the surface engineering is not a simple superficial treatment technology, but is about designing of the system basic material – superficial layer thus it too responsible at it role at rational use of materials and at accessible cost prices.

In figure 1 are presented the characteristic areas, the proprieties and some of the criterions in consideration at designing of a system basic materials – superficial layer.

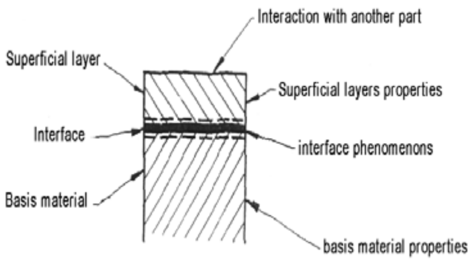


Fig. 1. *Characteristically areas and proprieties.*

The obtaining of the thin layers by electric spark presents some advantages as:

high adherence of the layers, permits deposition of all materials which have electrical conductivity, but there are some disadvantages as: residual stress in layer and large roughness.

The deposition and alloying by electric spark (DAES) uses inverse polarity (the part = cathode, the electrode = anode). In this case the deposition takes place in air or another gas, the electrode making a vibrating movement with or without a rotation.

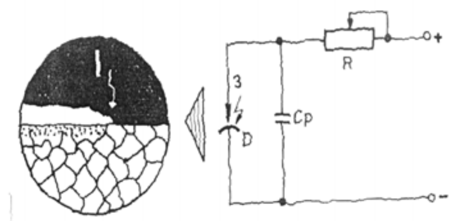


Fig. 2. *Superficial hardening by electric spark.*
a – the process; b – the electrical scheme.

The deposition process begins when the electrode is near the part at a critical distance (≅ 10 μm) when takes place the electrical discharge in impulse (the spark) which ends at the contact of the electrodes.

Because of high energy, on the surface of electrodes appears craters of electric erosion by melting and vaporisation. The obtained material, under the influence of hydrodynamic pressure and hydrodynamic force from the channel of discharge is deposed on the part in small quantity $(2–3)\cdot 10^{-6}$g.

The discharge energy takes values between 8 … 18 Joule at 15 … 220 V, and the intensity of medium current may be 0,2 … 80 A.

Decreasing the energy of discharge has as result smaller thickness of deposed layers, smaller roughness and the deposed layer is more dense with more clean surface.

The process takes place with a electrode which vibrates at a 50 … 400 Hz frequency. The vapor pressure from interelectrodic space is very big (10^8 Pa).

The characteristic feature of this process is the polar transfer of the material from electrode or from interelectrode space is limitated by the parameters of work system (the discharge energy) and by the nature of the material from part and electrode.

2. Research and results

The research work consist in deposition of wolfram on a steel OLC55 – STAS 880-88 normalised (850^{0}C/air) and quenched at 840^{0}C/oil tempered at 600^{0}C/air with work surface grinded at Ra = 5 … 10μm.

The chemical composition of the steel is: 0,57%C; 0,74% Mn; 0,23% Si; 0,022% P; 0,025% S; 0,24% Cr.

The deposition scheme of thin layers is presented in figure 3.

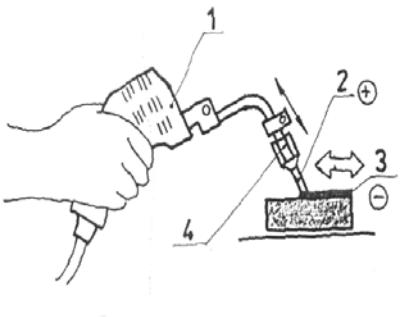


Fig. 3. *The device for deposition of thin layers; 1 – vibrator; 2 – electrode; 3 – deposed layer on the part; 4 – device for electrode fixing.*

Work parameters at the deposition of the thin layers using on original device for electrical discharge in impulse MAX 101 where:

- the angle of electrode 70^0
- the energy of discharge in impulse 0,3 J
- tension: 220 V
- current intensity: 1,2 A
- frequency of vibration of electrode: 100 Hz
- productivity: 2 cm^2/min
- thickness of deposed layers 0,022 … 0,03 mm
- thickness of the electrodes: 2,2 mm

The sample were in slide shape with dimensions: 53x10x1 mm for determination of weight and arrow in time of deposition and cylindrical shape (ϕ 8x60 mm) for determination of microhardness, abrasive wear resistance and structure.

On the slide samples were made roughness measurements and carrying of surface on thin layers deposed with W electrode.

By successively deposition on slide samples of more layers of W with different specific time results that the weight of samples increase till third deposition (M_1, M_2, M_3), after that, at fourth deposition, the weight of the samples decrease (M_4) as is presented in table 1 and figure 4. the bending arrow of slide sample increases after all four depositions (a_a, a_2, a_3) and decreases after a determination by vibrating electrode without electrical discharge in impulse (table 2; figure 5).

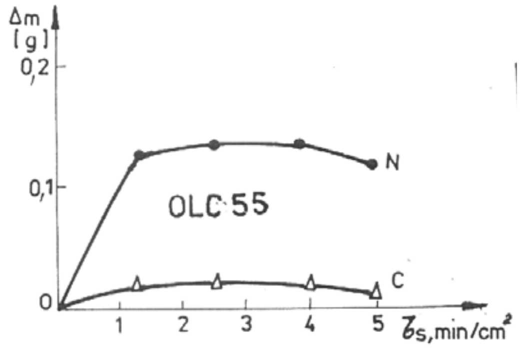


Fig. 4. *the variation of weight in specific time of deposition on OLC 55 steel.*

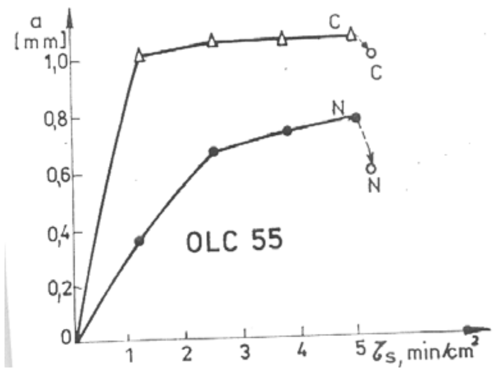


Fig. 5. *The variation of the bending arrow on OLC 55 steel.*

From table 1 results that the bigger weight (ΔM_1) is obtained at the deposition of the first layers, at other layers deposed, the weight is smaller and after the fourth deposition the weight decreases.

So, for deposed layers with a certain weight are necessary one or two deposition. By increasing of the specific deposition time, or of the number of depositions with out the layer deposed before is pulverisated and the weight and the final thickness of layer decrease.

The bending arrow (a) is maximum at the first deposition (a_1) and increases at the second deposition (a_2) then at the next depositions the increasing is smaller.

By detention with vibrating electrode without electric spark, the bending arrow decrease.

The deposed weight on steel with the initial state normalised and detensionated is aprox. 10 time bigger at the first deposition (τ_s = 1,25 min/cm^2) in comparison with weight deposed on the some steel hardened and detensionated; at the second and third depositions (τ_s = 2,5; 3,75 min/cm^2) the deposed weight is small and the difference between the normalised state and the hardened state are of 2 … 3 time bigger at each deposition.

Taking together the weight contribution and the bending arrow obtained after each deposition, results that at the second, third and fourth depositions, however that the weight contribution is not significant, or even negative, the arrow increase, so appears internal stress.

The final circles from figure 6 are the smaller values of the arrow after detention by vibrating with the electrode without electric spark.

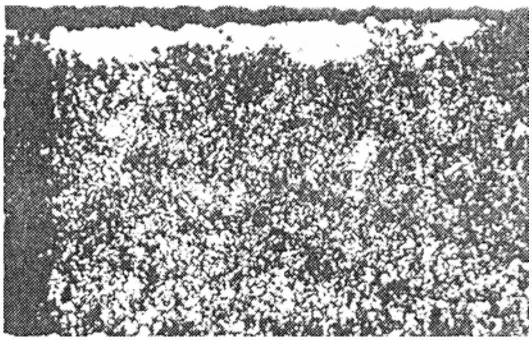
Results that at the deposition and alloying by electric spark (DAES) in terms of this research, the specific time of deposition must be under 2 min./cm^2 for obtaining of a weight contribution (thickness of deposed layer) and minimal stress. At the finish of the deposition if is make a detensionation by vibrating electrode, the stretched stress from layer decreases, removing the danger of fissure of the deposed layer.

From the analysis of the data of Table 2 results:

- the microhardness of the deposited layer does not depend on the initial status of the steel OLC 55;
- the microhardness of the sublayer has a greater value for the improved steel OLC 55 (c) than in a normalised status;
- the deposition of W through electric spark on the normalised steel OLC 55 produces a microalloy of the sublayer, implicitly a substantial growth of the microhardness, while the deposition in the some hardened steel produces a recovery of the sublayer roughness and portance of the surface resulted after the deposition of W with average values: they can be improved only through subsequent remaking (treatments into electrolytic plasma, extra-finishing etc.);

The microstructural analysis of the layer of W deposited on the steel OLC 55 into the 2 sets of thermal treatment (normalization and improvement) effectuated on an optic microscope (Neophot 21) at 100:1 parts into evidence a white, dense layer of big thickness deposited on the hardened steel and a white and less dense and thick layer deposited on the normalized steel. Figure 6, a.b.

a



b.

***Fig. 6**. Steel OLC 55 a white layer deposited with W. a) improved status; b) nominalized status.*

Table 1

Sample	St.in	Mo	M1	M2	M3	M4	ΔM1	ΔM2	ΔM3	M4Δ	ΣΔMi
OLC55	N	4,1541	4,2804	4,2841	4,2848	4,2775	0,1252	0,0037	0,0007	- 0,0073	0,1223
	C	4,3218	4,3319	4,3401	4,3409	4,3381	0,0101	0,0082	0,0008	- 0,0028	0,0163
42MoCr11	N	4,2080	4,3405	4,3430	4,3439	4,3405	0,1325	0,0025	0,0009	- 0,0034	0,1325
	C	4,3511	4,3654	4,3718	4,3791	4,3702	0,0143	0,0064	0,0073	-0089	0,0189

Table 2

Sample	St.in	a_o	a_1	a_2	a_3	a_4	a_5	Δa_1	Δa_2	Δa_3	Δa_4	Δa_5
OLC55	N	0	0,35	0,66	0,71	0,76	0,59	0,35	0,31	0,05	0,05	-0,17
	C	0	1,01	1,24	1,25	1,28	1,08	1,01	0,23	0,01	0,03	-0,2
42MoCr11	N	0	0,43	0,57	0,67	0,71	0,47	0,43	0,14	0,10	0,04	-0,24
	C	0	0,20	0,40	0,52	0,68	0,24	0,2	0,2	0,12	0,16	-0,44

3. Conclusions

The thin layer of W deposited on the supports of non-allied steel assures the resistance to corrosion to a great hardness, the resistance to wearing not and to the refraction of the pieces. The deposition of this layers of W on steel supports through electric discharge in impulse (the electric spark is an efficient method of obtaining pieces with special properties on the surface).

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