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RESEARCH ON ELECTRO-SPARK ALLOYING REGULARITIES AT ADDITIONAL ACTION ON THE PROCESS BY ELECTRIC CURRENT

Pereteatcu P.*, Cracan C.
Alecu Russo Balti State University, Pushkin Str. 38, MD-3100, Balti, Republic of Moldova
*e-mail: pereteatcupavel@yahoo.com

Regularităţile alierii prin scîntei electrice cu acţiunea suplimentară asupra procesului a curentului electric se studiază în acest articol. Experimental s-a stabilit că, sub acţiunea suplimentară a curentului electric care trece prin piesa de lucru-catod, viteza de formare a straturilor de depunere creşte de cca. 2-4 ori şi sporeşte calitatea suprafeţei prelucrate.

Cuvinte-cheie: aliere prin scîntei electrice, curent electric, adaosul de masă catodică, calitatea suprafeţei.

Regularities of electro-spark alloying at additional action on the process by electric current are studied in this paper. It was experimentally established that, under the supplementary action of the electric current passing through the workpiece-cathode, the speed of deposition layer formation increases by about 2-4 times and the quality of the machined surface enhances.

Keywords: electro-spark alloying, electric current, cathode mass growth, surface quality.

It is known that one of the technologies used in structures and physico-mechanical properties modifying of the alloys on their surface is electro-spark alloying (ESA) [1].

To realize the ESA processing it is necessary firstly the electric erosion prcocesses and directional mass transfer of electrodes material to take place [1-3]. But these conditions are not sufficient for the transferred material to bind strongly with cathode-matrix. In general, the amount of material removed from the anode at the ASE process is directly proportional to the spark discharge energy ($\gamma \equiv W$), and this dependence is maintained strictly for the specific values of discharge power ($W \leq 1$ T) and the process duration.

At the same time, it is necessary to emphasize that a number of factors, such as the nature of the electrode material and the parameters of the process (electrode geometry, shape of their movement, etc.) influences on the character of material transfer from the anode to the cathode.

The dynamics of surface layers formation on the cathode at the ASE process is characterized by the fact that the material transfer intensity from the anode on the cathode, which is maximal in the first moments of the process performing, decreases with time. Finally, for certain values of discharge energy, the inversion of previously deposited material transfer, ie its erosion, takes place.

Thus, the concurrence between formation and deterioration processes of deposited layers with predominance of the last, with increasing processing time, leads to limiting formed layer thickness [3-5]. To solve this difficult problem, as noted in several works [2, 3] - ESA can be realized in vacuum or inert medium (argon, helium) or relaxation annealing of the cathode can be performed etc. But no one of these methods gives good results and allows the definitive solution of this problem. It is obvious the need to find another way, which implies the possibility of directing the transfer and electrode material interaction processes without changing (increasing) the parameters of the discharge energy, by the action of external factors. These factors, as mentioned in [6] can be electric current, whose value can be varied (increased or decreased) in the higher limits. Preliminary results showed that the direct action of not high value electric current of about 0.5-2.5 A, (current passes both through anode and cathode) leads to substantially increase the material transfer processes and physico-chemical transformations in the cathode layers.

In this context, we studied the possibility to intensify the ESA process by the pass of the electric current through electrodes volume.

For this purpose, anode and cathode (or both simultaneously) when alloying were introduced into the circuit of continuous or pulsating current which value had been adjusted in large limits depending on the processing time. The results were compared with data obtained in the absence of current, i.e. with those obtained by traditional processing.

The electrodes with diameter of 1.5-3.0 mm and length of 40 mm, made of crome, nickel, silver, alloys „VJL-2" and „VJL-14", hard alloys „VK8" and „T15K6" were used as anodes, and the samples made of steel „St-3", „St-45", copper M1, titan BT1 were used as cathodes.

The continuous current varied in such a way ensuring the current density from 0.5 to 5 A/mm^2 through the anode section. The pulsating current with electrical impulses shape, duration of 150-200 μs and amplitude of 200-600 A also passed through the anode. These parameters of electric current were chosen from the condition that passing through the anode its substantial erosion increase to take place during the spark discharge, and therefore it will accelerate the formation of coating layer on the cathode.

Experimental results have shown that for an insignificant amount of current density of 0.5...1.0 A/mm^2, which passes through the anode, the increase of its erosion takes place.

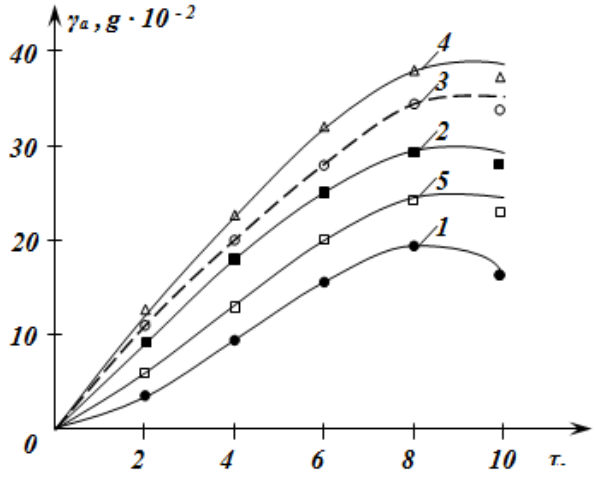

Fig. 1. Time dependence of anode erosion on the current density passing through it (Installation EFI – 10M, regime no. 3): 1 – I = 0 A/mm^2; 2 – I = 0,5 A/mm^2; 3 – I = 1,0 A/mm^2; 4 – I = 2,4 A/mm^2; 5 – I = 4,0 A/mm^2

For example, for specific work-time equal to 4 min/cm^2, the amount of material removed from the anode, through which the current with density of 2.4 A/mm^2 passes, is 2 times higher than by usual ESA at the same regime. However, for the current passing through the anode with a density of 4.0 A/mm^2 there is a decrease in the amount of material removed from the anode (Fig. 1, curve 5).

An analog picture is observed when passing through the anode a pulsating current of 200-600 A with duration of 200 μs. In this case there is also a critical current value, above which the erosion effect slows down. This corresponds to the current value of 250 A.

Determining the transfer coefficient of the material, it has been found that its amount increases not significantly comparatively with the same by traditional alloying, i.e. substantially increase of anode erosion by current passing through it has a very small influence on its adhesion with the cathode material. This shows that the current passing through the anode during ESA predominantly influences the erosion of the anode and insignificant influences processes arising in the superficial layers of the cathode and, therefore, it is obvious that such a processing scheme is only a partial solution of ESA process intensification and its enhance in practical use is unreasonable.

Besides this, the manufacture of anodes need special resources which are small due to the small size of the work sector, which makes this process to be non-technological and, therefore, another ESA scheme was used further, when the electric current passed through the cathode.

Concretely, while using cathodes made of iron and copper the highest transfer is observed when the current with density of 0.5...3A/mm^2 passes through the cathode. Further increase of the current leads to the reduction in time of the cathode mass (Fig. 2), and for the value of current density of 4 A/mm^2 the dynamic of mass increase is analogous to that observed in the case of traditional alloying.

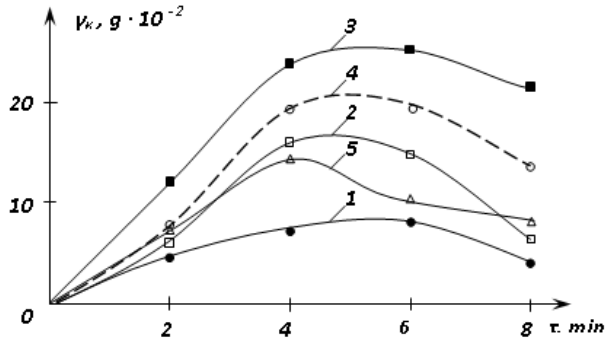

Fig. 2. Dependence of cathode mass growth in time on the current density passing through it:
1 – I = 0 A/mm^2; 2 – I = 2,0 A/mm^2; 3 – I = 3,0 A/mm^2; 4 – I = 4,0 A/mm^2; 5 – I = 5,0 A/mm^2

Similar results were obtained when pulsating current passed through the cathode (Fig. 3).

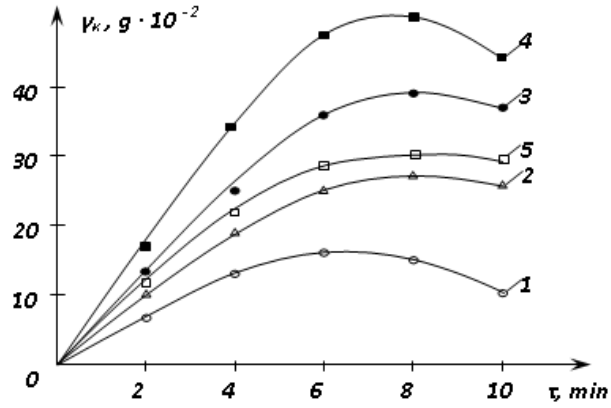

Fig.3. Dependence of cathode mass growth in time on the value of pulsating current passing through it (Installation EFI – 10M, regime no. 3; anode – Ag, cathode – Cu.; current impulse duration – 200 μs).
1 – $I_и$ = 0 A ; 2 – $I_и$ = 100 A ; 3 – $I_и$ = 200 A ; 4 – $I_и$ = 400 A ; 5 – $I_и$ = 600 A

Analysis of these data showed that the increase in mass of the cathode when the electric current passes through it takes place not because of more intensive erosion of the anode, but as a result of more favorable conditions, which are created on the cathode during the passing of current through it, where most eroded mass coats and interacts with the cathode (substrate). One of the probable factors that influence the intensification of eroded mass transfer on the cathode can be improvement of wetting and stretching of the anode liquid material transferred on the cathode at the spark discharge. A good spread of the liquid phase on the cathode surface probably contributed to "cure" the defects (pores, micro-cracks) which ultimately reduce the action of factors which limit the increase of deposited layer.

By examining the curves in Fig. 4 we can see that the peak is situated far above the axis and is shifted to the right that talks us about more slow accumulation of stretch residual tensions in layers leading to deterioration of the formed surface layer.

At the alloying with anodes made of fragile materials the effect of improvement in transfer is highlighted less, which can probably be explained by the formation of small quantities of eroded liquid mass.

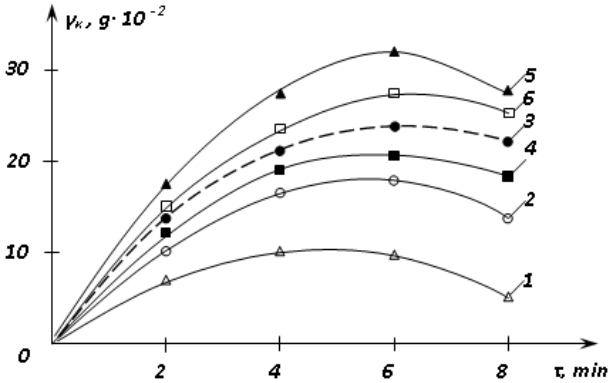

Fig. 4. Time dependence of cathode mass growth at ESA and the pass of the current with different density (cathode material – steel „St-3”, installation EFI – 10M, regime no. 3):
1 – J = 0 A/mm^2; 2 – J = 4 A/mm^2; 3 – J = 1,2 A/mm^2; 4 – J = 1,7 A/mm^2; 5 – J = 2,4 A/mm^2; 6 – J = 3 A/mm^2

For example, at the alloying with anodes made of alloy “ВК20” (with 20% cobalt) the mass transfer is of 1,2-2 times greater than it is at the processing under the same conditions (equal discharge energy and current) with anodes made of “ВК8” (containing 8% cobalt) (Fig. 5).

At the same time, it is necessary to mention that there is a critical value of the current passing through the cathode, then there is a decrease in the amount of anode material deposited on the cathode surface, which can also be explained by increasing the tensile forces till such a value at which the break of the formed pellicle from the metal drop transferred on the cathode takes place.

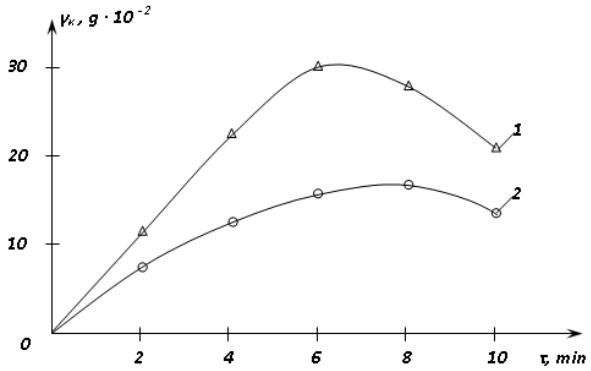

Fig. 5. Variation of the cathode mass growth change in time at alloying with anodes made of different materials but at the same current density passing through the cathode
(Installation EFI – 54A, regime no. 1, I = 2,6 A/mm^2):
1 – BK20; 2 – BK8

CONCLUSION

Therefore, the direct action of external forces on the electrodes, in particular, the current passing through the cathode leads to a 2-4 times increase in the speed of the surface layer formation on the cathode, to improve the quality of these layers (roughness reducing, uniformity increase, etc.) and to widen the set of materials, on which can be deposited coatings with additional influence of the electric current passing through the cathode that in conditions of usual ESA is difficult to obtain.

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