

## AXIAL SCANNING OF ARC ROOTS IN AN ELECTRIC ARC TORCH.

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**Abstract.** In addition to arc root rotation around inner surface of a cylindrical cold copper electrode, effect of axial scanning on electrode temperature and erosion has been studied. It is shown that axial scanning enables to prolong the electrode life-time.

Scanning arc roots along electrodes axis in addition to arc electrode spot rotation is one of the practical methods used for enhancement of copper cylindrical electrodes life-time. Effective realization of such a method enables not only to reduce the rate of electrodes erosion at the expense of their surface temperature decrease but to utilize electrode material more completely. Practice of cold-electrodes application shows cathode being responsible for limitation of overhaul working period. Therefore, the effect of electromagnetic and gasdynamic scanning arc roots along axis of cold-copper cathodes has been investigated in this work.

A vortex plasmotron including two tube cold-copper electrodes, insert disposed between them, gas-supply vortex chambers, and electromagnetic solenoids was used for the research. Variation of electrodes and insert diameters enabled to compose plasmotrons having different step-wise forms of the discharge canal. A design with two inlet vortex chambers disposed at both sides of inner electrode (cathode) was applied for gasdynamic scanning (Fig. 1a). For electromagnetic scanning, a sectionalized solenoid was mounted on the cathode that made possible to handle maximum of magnetic induction along the electrode axis by switching solenoid sections (Fig. 1b). Monitoring

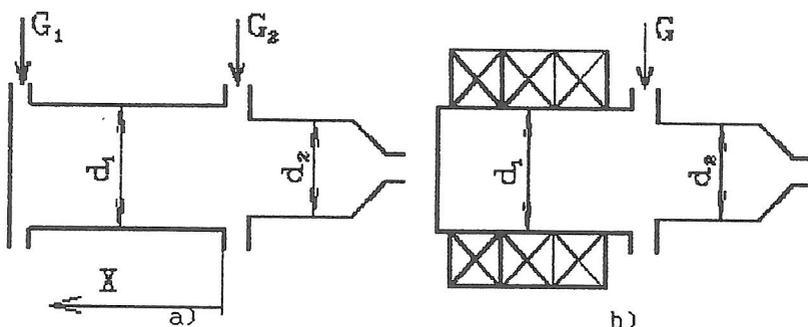


Fig. 1. Schematic diagrams of plasmatrons.  
 a) for gasdynamic scanning; b) for electromagnetic scanning.  $G_1$ ,  $G_2$  - gas flow-rate trough inlet chambers, disposed at both sides of cathode;  $d_1$ ,  $d_2$  - diameters of cathode and anode, respectively.

arc root position at the electrode surface was done by the row of thermocouples embossed along the outer surface of the cathode from the side of water-cooling tract. That enabled checking position of electrode temperature maximum, which corresponded to the arc-spot location.

Gasdynamic scanning of the root along the cathode surface was performed by periodical redistribution of gas flow-rate between two inlet vortex chambers at the constant value of gas flow-rate through the discharge canal. Generators of pulsing streams can be made on the base of jet-automatics principles or using conventional pneumatic devices incorporating such elements as valves, membranes e.t.c. We have developed and tested rather simple generator of small overall dimensions which is capable to operate at pressure up to 3.0 MPa, depending on pipe-line resistance to air-flow. The peak value of pressure pulsations at generator outlet reaches 0.5 MPa, and fluctuations frequency amounts to 5-10 Hz.

To determine an optimal geometry of plasmotron discharge canal, the location of zone in the inner electrode, where collision of opposite streams outflowing from two inlet vortex chambers occurs, was visualized in transparent model of the discharge canal by means of ultrafine powder admixing to air flow. This zone was seen to take form of a ring vortex core 2-3 mm thick rotating around the electrode axis. Rather stable position of this zone depends on proportion of gas flow-rates through the vortex chambers ( $G_1/G_2$ ) and on ratio of electrodes diameters ( $d_2/d_1$ ). As shown in [1], the arc tends to

attach the electrode at zone of the streams collision. With gas supply through puls generator the collision zone begins to oscillate along the electrode axis. The largest amplitude of pulsations was observed at  $d_2/d_1=0.8$ . Fig. 2

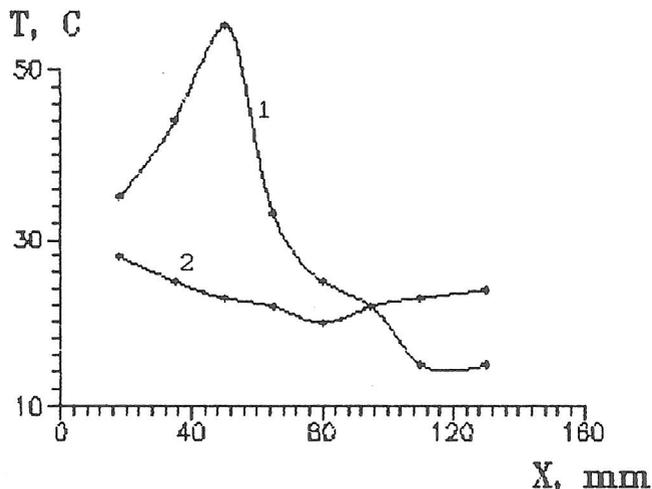


Fig. 2. Temperature distribution along the outer surface of cathode:

- 1 - without scanning  $G_1 = G_2 = 8$  g/s,  $I = 200$  A;
- 2 - with gasdynamics scanning,  $G_1 = G_2 = 0 - 16$  g/s,  $I = 200$  A.

(curve 1) depicts the temperature disturbance along the outer surface of cathode at  $I=200$  A and constant nonpulsed gas flow-rates through both vortex chambers  $G_1= G_2 = 8$  g/s. The maximum cathode overheating ( $50$  °C) corresponded to the predominant position of arc attachment to the electrode. This overheating value had been chosen as a temperature scale in our subsequent experiments. Curve 2 in Fig. 2 complies with the mode of gas feed to plasmatron inlet chambers through the puls generator. It demonstrates the temperature profile of outer cathode surface at frequency of flow-rate switching  $f=7$ Hz and the other parameters retaining constant.

Vizual examination of electrode after experiment shows the arc trace distribution around the whole inner cathode surface but the temperature profile indicates zone of the stable arc attachment being some narrower. At current rise over 400A the gasdynamic pulsation failed to scan the arc root along the electrode axis: the arc attached cathode at a given section and even two-fold

increase of gas flow-rate (up to 32 g/s) couldn't change the situation. This evidence complies with results of [1] which revealed the mismatch of streams-collision and arc-attachement zones at high currents.

Experiments with electromagnetic technique of arc-root handling were carried out using device shown in Fig. 1a. An individual unit was used for energizing solenoid and a thyristor set controlled the frequency and sequence of its sections switching. Fig. 3 (curve 1) depicts the temperature disturbance along the electrode surface at constant values of magnetic field ( $B = 3 \cdot 10^{-2}$  T) and current ( $I = 550$  A).

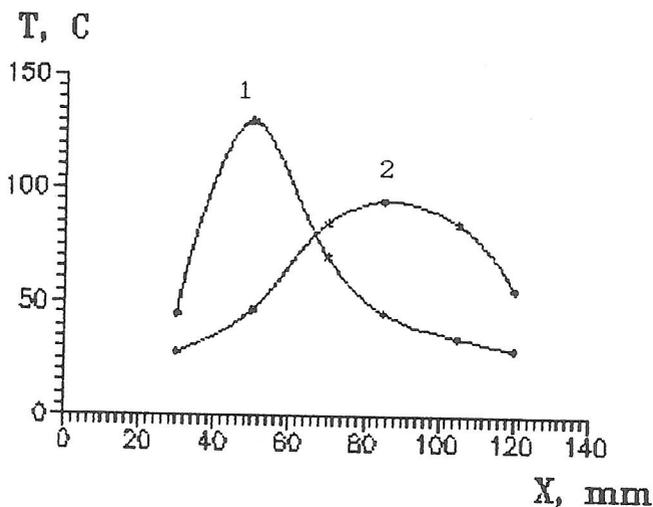


Fig. 3. Temperature distribution along the outer surface of cathode:

- 1 - at constant magnetic field  $B = 3 \cdot 10^{-2}$  T,  
 $I = 550$  A;
- 2 - at magnetic field scanning,  $B = 3 \cdot 10^{-2}$  T,  
 $I = 550$  A,  $G = 16$  g/s,  $f = 22$  kHz

In this case maximum overheat of the outer cathode surface accounted for 130 C. Reverse switching of two solenoid sections failed to bring about any change in temperature distribution or its maximum value. That indicates the low effect of electromagnetic force on the arc root rotating in a quasi-potential gas swirl which is characteristic for such kind of vortex apparatus. In order to overcome this disadvantage, we have managed to form a quasi-solid vortex flow inside the inner electrode by means of special device established at the back electrode

wall [2]. This improvement enabled to reduce the maximum temperature of the electrode surface and to stretch the zone of arc interaction with electrode. The curve 2 in Fig. 3 corresponds to temperature distribution along the electrode surface in the case of quasi-solid flow rotation. Three solenoid sections were switched at  $f = 22$  Hz,  $I = 550$  A,  $G = 16$  g/s (air). This example shows control of gas-swirl character being able to handle the arc-root movement at increased currents. The decrease of switching frequency down to 8 Hz caused the negligible change in the temperature distribution, while further frequency reduction to 1 Hz brought about the stretch of arc attachment up to three calibres. But three peaks corresponding to the centres of solenoid sections have arrived at temperature profile in the latter case that implies the predominant residence of arc root at those positions. This result has been also confirmed by distribution of erosion along the electrode inner surface. Therefore, at low switching frequencies temperature fails to distribute along the electrode and the overwhole working period increases only at the expense of enhancing mass of electrode material involved in erosion (three grooves instead of one).

However, the main obstacle to electrode life-time enhancement by means of arc-root axial scanning can be the erosion material deposition on the electrode inner surface that entails reducing zone of the root oscillation. It was revealed after six hours of operation with root scanning by electromagnetic method. But it may be the disadvantage inherent only in electromagnetic method. Therefore, application of more effective scanning methods could bring about better results. An integrate synchron gasdynamic and electromagnetic scanning can serve as one of such methods.

#### REFERENCES

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