Glycerine as an electrolytic electrode

G Sh Akhatov, R R Kayumov, R R Valeeva and M F Akhatov
Kazan National Research Technical University named after A.N. Tupolev, 31 K. Markska str., Kazan 420111, Russian Federation

Abstract. This paper presents the results of the experimental studies of an electric discharge with liquid electrodes. An aqueous solution of NaCl in glycerine was used as liquid electrodes, in the range of discharge voltage parameters $U_p = 0 \div 1.5$ kV, currents $I = 0.01 \div 2$ A. The current-voltage characteristics of the discharge were established.

1. Introduction

By present time many studies have been published on the matter of electrical discharge, where aqueous solutions, technical and tap water are used as the electrolyte [1].

Over recent years there has developed interest in unconventional plasma sources in which one of the electrodes is an electrolyte. Such discharges can be used in plasma technology for applying high-quality heat-shielding, antifriction, dielectric and anti-corrosion coatings [1-2]. Electrical discharges with an electrolytic electrode were used a hundred years ago for the electrolysis of aqueous solutions, where one of the electrodes was removed from the electrolyte into the gas phase in order to avoid reaction on the surface of the electrode. From the mid-forties of the last century, these discharges began to be used to heat metals and alloys in an electrolyte [3].

2. Experimental setup

The experimental setup is intended to study the electric discharge in the range of discharge voltage parameters $U_p = 0 \div 1.5$ kV, currents $I = 0.01 \div 2$ A. The block diagram of the experimental setup that implements the listed conditions is presented in Figures 1.1, 1.2.

![Figure 1.1. Block diagram of the experimental setup with a metal electrode](image1)

![Figure 1.2. Block diagram of the experimental setup with an electrolytic electrode](image2)
The setup with the metal and electrolytic electrodes consists of electrical power systems, an electrolytic bath, and test equipment.

The power source 1 provides a constant voltage supply through the current leads 2 to the discharge gap. Electrode 4 provides a current lead to the electrolyte 7 in the electrolytic bath 3 (Figures 1.1-1.2). In the case of a metal electrode, the bath 3 serves as a reservoir for the accumulation of electrolyte (Figure 2.1). Electrode 5 provides a current lead to the separating funnel 8 with electrolyte 7, mounted on a tripod 9. The electrolyte flow rate is controlled by the valve 6. Hood 10 serves to suck out the generated gases from the working area.

3. Discussion

The analysis of the experimental data showed that between the jet electrolytic cathode and the metal anode (the body being processed) an electrical discharge is burning. Figure a shows the shape of the discharge between the jet and the solid anode at $U = 411 V$, $I = 0.43 mA$, $l_c = 4 mm$, $d_c = 1.5 mm$ and $G = 0.625 g / s$. As it can be seen from the figure, the discharge propagates inside the jet between the anode and the cathode, also along the outer surface of the jet cathode. Figure b shows the shape of the discharge between the jet and the solid anode at $U = 912 V$, $I = 0.39 mA$, $l_c = 4 mm$, $d_c = 1.5 mm$ and $G = 0.397 g / s$. Here the discharge burns inside the jet cathode. The figure c shows the shape of the discharge at the electrolytic anode, at $U = 380 V$, $I = 260 mA$, $l_c = 4 mm$, $d_c = 1.5 mm$ and $G = 0.625 g / s$. In this case, the discharge burns at the jet-electrolyte interface.

Figure 2. Picture of an electrical discharge with liquid electrodes of a solution of NaCl in glycerine

One of the most important electrical parameters is the current-voltage characteristic of an electrical discharge. As a result of experimental studies, an analysis was made of the structure of an electrical discharge between a jet electrolytic cathode and an electrolytic (and solid) anode at atmospheric pressure. A saturated solution of NaCl in glycerine is used as a jet electrolytic cathode; the copper plate of the M1 grade served as the anode.

From the analysis of experimental data in Figure 3, it can be seen that as the magnitude of the discharge current $I$ increases, the discharge voltage $U$ decreases, i.e. current-voltage characteristic (CVC) has a falling character.

When the electrolyte consumption is $G = 0.625 g / s$, the CVC of the discharge also has a falling character (Figure 4), i.e. with increasing electrolyte consumption at low $l_c$, the magnitude of the electric discharge current increases.
Figure 3. CVC of an electric discharge between a jet electrolytic cathode and a solid anode with \( l_c = 4 \, \text{mm}, \; d_c = 1.5 \, \text{mm} \) and \( G = 0.397 \, \text{g} / \text{s} \)

Figure 4. CVC of an electric discharge between a jet electrolytic cathode and a solid anode with \( l_c = 4 \, \text{mm}, \; d_c = 1.5 \, \text{mm} \) and \( G = 0.625 \, \text{g} / \text{s} \)

The analysis of the electrical CVC between the jet electrolytic cathode and the solid anode, when the anode is immersed in the electrolyte, for an aqueous solution of NaCl in glycerin in Figure 5 showed that the U value decreases from 150 to 270 mA sharply, and in the interval \( I = 270 \div 750 \, \text{mA} \) discharge voltage decreases slowly.

Figure 5. CVC of a multichannel discharge in a jet electrolytic cathode with \( l_c = 4 \, \text{mm}, \; d_c = 1.5 \, \text{mm} \) and \( G = 0.625 \, \text{g} / \text{s} \)

Thus, from the analysis of the experimental results, it follows that the electrical discharge on the surface of the bodies being carried out (metals and alloys) does not spread, but burns between the jet electrolytic cathode and the metal anode but in different ranges when compared with the experimental data of discharges with traditional electrolytes (NaCl, KCl etc.).

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