PROPERTIES OF ELECTRIC DISCHARGE OF A JET ANODE AND AN ELECTROLYTIC CATHODE

M F Akhatov1, R K Galimova1, R R Mardanov1, A A Nizameev1, N A Loginov2

1Kazan National Research Technical University named after A. N. Tupolev - KAI, Kazan, Russia
2Kazan State Agrarian University, Kazan, Russia

ahatov.81@yandex.ru

Abstract. The paper shows some results of the definite current-voltage characteristic (CVC) of interaction of electric discharge with a jet electrolytic cathode and a steady anode at different jet lengths (lc), jet diameter (dc), electrolyte flow rate (G) for various electrolyte concentrations.

1. Introduction
For the first time, electrical discharges (ED) in water were carried out more than 200 years ago. However, the resulting powerful hydrodynamic impulses did not find practical application in those years. The effect of this type of discharge was forgotten for a long time. Later, when creating powerful high-voltage installations, they again encountered electrical discharges in liquids. The destructive effect that occurs during the electrical breakdown of dielectric liquids has formed a strong opinion about the futility of ED in a liquid. For many decades, this opinion had been persisting among scientists and electrical engineers [1].

The development of technology has again drawn attention to ED in liquids, as this type of discharge and devices developed on their basis are the cheapest and environmentally friendly [2]. In real time, active experimental studies of the electric discharge of a flow with an electrolytic cathode and an iron anode at atmospheric and reduced pressures are being conducted, at which a weakly conductive liquid (aqueous solutions, electrolytes, process and basic water) is used as a liquid electrode. Basically, in existing studies, aqueous solutions of salts are used as electrolytes [3]. However, there are a large number of varieties of electrolytes that differ from each other by their chemical compositions, and by their physical and chemical properties.

2. Experimental setup and experimental methodology
Experimental setup with electrolytic electrodes and metal (see Fig. 1) is composed of an electrolytic bath, electric power supply systems and test-measuring devices. The power supply resource 1 supports constant voltage by conductors 2 to a bit shortage of steel plate 4. The bath’s 3 function is to be a container to accumulate electrolyte. Electrode 5 supplies conductor to separation funnel 8 with electrolyte 7, fixed on the tripod 9. Electrolyte consumption is regulated by a valve 6. The hood 10 is used for suction from working zone of formed gases. The span of discharge voltage characteristics are Up=0÷1.5 kV, currents I=0.01÷2 A.
3. Experiment

The discharge ignited between the electrolytic cathode and the steady anode at atmospheric pressure, a solution of NH₄NO₃ (ammonium nitrate) in water of different concentrations was used as a jet electrolytic cathode, and the anode gave a plate of electrical steel.

4. Discussion of experimental findings

Some combustion discharge modes are given in Table 1.

| Electrolyte concentration, % | 26 | 26 | 26 | 26 | 26 |
|-----------------------------|----|----|----|----|----|

Table 1. Combustion discharge modes

| I, mA | 60 | 200 | 240 | 280 | 500 |
|-------|----|-----|-----|-----|-----|
| U,V   | 840| 811 | 780 | 730 | 500 |
| lc, mm| 100| 10  | 120 | 40  | 20  |
| dc, mm| 2  | 2   | 2   | 2   | 2   |
| G, g/s| 1,82| 1,82| 1,82| 1,82| 1,82|

Figures 2-4 show the CVC of an electric discharge with a jet electrolytic cathode and an iron anode for different jet lengths l, DC diameter and electrolyte flow rate G.

Figure 2. CVC of an electric discharge with a jet electrolytic cathode and a solid anode lc = 20 mm, dc = 2 mm and G = 1.82 g/s for different electrolyte concentrations.

From the review of the experimental results in Figure 2, it can be seen that for Graphs 1 and 2, at an electrolyte concentration of 26% and 20%, with an increase in the value of the I discharge current, the current discharge voltage becomes less, i.e. CVC contains a falling process.

In case concentration decreases to 13%, the graph of the 3 CVC discharge in the area from 570 mA to 750 mA has a rectilinear character (the ED burns stably). A further current increase from 750 to 900 mA results a gradual decrease in the discharge voltage. Current increase from 900 mA to 1 A results a sharp decrease in voltage (the ED does not burn stably).

Figure 3 shows the CVC of an electric discharge with jet electrolytic cathode and solid anode, for an aqueous solution of NH₄NO₃ of different concentrations at lc = 40 mm.
Figure 2. The CVC of the electric discharge between the jet electrolytic cathode and the anode at solid $l_c = 20$ mm, $d_c = 2$ mm and $G = 1.82$ g / s: 1-26%; 2-20%; 3-13%.

Figure 3. The CVC of an electric discharge between a jet electrolytic cathode and a solid anode at $l = 40$ mm, $d_c = 2$ mm and $G = 1.82$ g / s: 1-26%; 2-20%; 3-13%.

The figure shows that at electrolyte concentrations of 26% and 20%, the CVC is almost the same, i.e. it has a falling character. Unlike the CVC with a jet length of 20 mm, the 13% electrolyte solution does not have straightness sections. As the current increases, the voltage gradually decreases.

Figures 4 show the CVC and discharge at a jet length with $L = 80$ mm, $dc = 1.5$ mm and $G = 1.82$ g / s.

Figure 4. The CVC of electric discharge between a jet electrolytic cathode and a solid anode at $l = 80$ mm, $d_c = 1.5$ mm and $G = 1.82$ g / s: 1-13%; 2-20%; 3-26%.

As can be seen, in the figures there are graphs of CVC both of an increasing nature for 13% solution (ED is not observed) and decreasing 20 and 26% solutions. This is determined by the stability of the discharge combustion. As the length of the discharge jet increases, it begins to burn unstable, and the discharge occurs not only at the jet-metal boundary, but also along the jet electrolytic cathode.
5. Conclusion

Structure of electrolyte and its concentration affect the combustion ED in jet electrolytic cathode. The shape of discharge and its CVC depend on the length of the jet. Experimental setup and experimental methodology.

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References

[1] Kayumov R.R. Experimental study of the effect of electric discharge on carbon fiber/Zakirov Zh.U., Kayumov R.R., Khazeev K.I.// Journal of Physics: Conference Series This link is disabled, 2021, 1870(1), 012007
[2] Akhatov M.F. Glycerin as an electrolytic electrode / Sh. Akhatov, G., Kayumov R.R., Valeeva R.R., Akhatov M.F.// Physical Journal: conf. Series. 2019.V. 1328 Is.1,01200410
[3] Bagautdinova L.N. Low-power electric discharges with metal, dielectric and electrolytic electrodes at low frequencies and atmospheric pressure / Gaisin A.F., Sadriev R.S., Bagautdinova L.N., Nasibullin R.T., Gaisin F.M., Mastyukov S.S. // High temperature, 2020, 58(6), pp. 777-780
[4] Galimova R.K. Calculation of portable properties of some real gas mixtures at high temperatures / Taxeitov R.R., Galimova R.K., Yakupov Z.Ya. // Physical Journal: Conference Series, 2020, 1588(1), 012065
[5] Fakhruutdinova, I.T. Features of the development of an electric discharge between a jet anode and a liquid cathode / Galimzyanov I.I., Gaisin A.F., Fakhruutdinova I.T., Shakirova E.F., Akhatov M.F., Kayumov R.R. // High temperature, 2018, 56(2), pp. 296-298
[6] Tsareva, A.M. Determination of natural frequencies and vibration modes of a disk of constant thickness with a central mount / Makaeva, R.Kh ., Tsareva A.M., Karimov, A.Kh . // Russian Aeronautics, 2008, 51(1), pp. 53-59
[7] Gaisin A.F. Special features of a multichannel discharge in a porous solid cathode/Loginov N.A, Son E.E., Gaisin A.F., Gaisin F.M. //High Temperature. 2009. T. 47. № 4. C. 603-605.