Influence of composition of electrolyte on electric discharge in liquid

M F Akhatov, F M Gaisin, F R Iskhakov, R R Kayumov, A I Kuputdinova, R A Mukhametov, A I Shpilev

Faculty of Physics and Mathematics, Kazan National Research Technical University named after A.N.Tupolev - KAI, Kazan, 420111, Russia

E-mail: almaz87@mail.ru

Abstract. Within this work results of researches of electric discharge with liquid nonmetallic electrodes are presented. Features of formation of electric discharge depending on structure and concentration of electrolyte, electrophysical processes are described, the volt-ampere characteristic of the category is constructed. Distribution of electric field strength along an electrolyte stream is presented.

1. Introduction

One of the new directions in researches is ignition of the gas discharge in a steam-gas cover. Unlike classical types of the discharge generated between firm electrodes [1-3], features of this discharge is that one or both electrodes are liquid nonmetallic electrodes. The main attention of experts is directed to a research of composition of plasma, distribution of concentration and energy of components of plasma, a research of thermal and hydrogasdynamic processes on limit of the section of environments in a zone of formation of the discharge [4 - 8]. Along with basic researches, this type of the discharge finds broad practical application in various branches of industrial production, such as modification and cleaning of a surface of materials and products from various type of metals and alloys [9]. In the field of mechanical engineering there are relevant tasks of increase in a class of roughness, superficial hardness of details and knots of cars. However, despite a large number of publications on this type of the discharge, he remains investigated insufficiently. There are questions on influence of concentration and composition of electrolyte on physics of formation of the discharge in a steam-gas cover. Generally in the existing researches as electrolytes water solutions of salts are applied. However there is a large number of kinds of electrolytes which differ from each other in the chemical compositions, so both physical and chemical properties. Also the results of a research which are provided in electrolytic categories namely conditions of ignition of the discharge, a form of electric discharge, volt-ampere characteristics of the discharge will depend on composition of electrolyte. Results of the volt-ampere characteristic of the discharge between the jet electrolytic cathode and the firm anode for various composition of electrolyte are given in this work.
2. Experiment
The gas discharge between the jet and drooping liquid cathode and metal anode was studied at the pilot plant with the direct current source and controlled DC voltage up to 4000 V at the rated current of up to 10A.

The following research methods were applied to address the tasks specified:
1. Current and tension of the category were measured by multimeters of various class of accuracy.
2. The process of gas discharge combustion was recorded by the digital photo- and video devices SONY FDR-AX33.

Combustion of the gas discharge within the electrode spacing was identified at the voltage of \( U = 100-1500 \) В, ambient pressure \( p = [(10)]^5 \) Па, a copper plate \( d_a = 1 \) мм was taken as the anode.

In the figure 1 photos of formation of the discharge between the jet electrolytic cathode and the metal anode are submitted. After application of potential on electrodes on border of interaction of a stream of liquid and a metal electrode there is a breakdown. The discharge is formed in the form of a cone on limit of the section of environments in a zone of formation of steam-gas bubbles. After a discharge influence on a surface of a metal electrode his cleaning of organic and inorganic pollution is observed.

![Figure 1. The photo of the discharge between the string cathode and the metal anode 1 - before breakdown, 2 - after breakdown](image)

The analysis of the volt-ampere characteristic of the discharge between the jet electrolytic cathode and the firm anode for NaCl, KCl and CuSO4 solutions in technical water in fig. 1 has shown that in case of saturated CuSO4 solution (a curve 1) the category burns at small currents of \( I = 0,03 \) A and the big tension of \( U > 1200 \) V in the form of a ring near the metal anode. In a case use of saturated NaCl solution (a curve 2) in technical water leads to the fact that in the range of \( I = 250 \div 450 \) мА size \( U \) increases almost linearly. In case of use as the jet electrolytic cathode saturated KCl solution (a curve 3) size \( U \) in the range from 200 to 250 мА increases in technical water slowly, and in the range of \( I = 250 \div 380 \) мA tension of the discharge increases sharply.
Figure 2. The volt-ampere characteristic of the discharge between the string electrolytic cathode and the metal anode.

Distribution of floating potential $\phi$ on an axis of discharge it was measured by means of the tungsten probe with a diameter of 0.7 mm and a static voltmeter of C50 of a class of accuracy 1.0. All measurements were taken with the help a coordinate space. On measured $\phi$ calculations a distribution of electric field intensity on a formula $\vec{E} = -\nabla \phi$ with accuracy of $\pm 5\%$ are performed. Distribution of potential was measured in the bit camera. Results are provided in a figure 3.

Figure 3. Strength of electric field of the discharge along the jet electrolytic cathode at $U = 400 - 750$ V and $I = 0.1 - 0.6$ A with an atmospheric pressure.

3. Results

Formation of the discharge in the form of a cone on limit of the section of environments between streams of electrolyte and metal electrodes is established. It is established formation of the discharge in the interval of voltage of $U = 300 - 1250$ V, discharge current $I = 0.03 - 0.45$ A. It is established distribution $\vec{E}$ electric field strengths along a stream in the range of $E = 38 - 52$ V/mm.
Acknowledgments

This work was supported by state contract regarding resolution 220 of the Ministry of Education and Science of the Russian Federation, project no. 14.Z.50.31.0023.

References

[1] Reiser Yu.P., Physics of Gas Discharge (Edition 3, updated and revised). Dolgoprudny, 2009. - P. 734.
[2] Fortov V.E., Son E.E., Gaysin F.M., Bromberg L., Son K.E., O John Khe, I Khe Iong. Plasma Technology (in Korean) Moscow Institute of Physics and Technology, KOFST, 2006. – P. 135.
[3] Dautov G.Y., Dautov I.G, Fayrushin I.I, Kashapov N.F. 2013 Journal of Physics: Conference Series 1 012014
[4] Gaisin A.F. 2013 High temperature 6 863 – 866
[5] Gaisin A.F., Sarimov L.R. 2011 Plasma Physics Reports 6 535 – 540
[6] Gaisin A.F., Son E. E., Petryakov S. Yu. Plasma Physics Reports 7 741 -748
[7] Gaisin A.F., Son E. E., Efimov A. V., Gilmudinov A. Kh., Kashapov N. F. High temperature 3 457 – 460
[8] Gaisin A.F. High temperature 1 145–146
[9] Gaisin A.F. Inorganic Materials: Applied Research 3 392–395