THE STUDY OF GAS DISCHARGE WITH LIQUID ELECTROLIYTIC CATHODE IN TERMS OF UNCOVERING ITS CURRENT-CARRYING ELECTRODE

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In recent years, the study of gas discharge with liquid electrolytic cathode was activated. Possibilities of its application in machine building /1/, textile industry /2, 3/ and other industrial fields, particularly in industrial ecology was explored /4/. In this regard there was a need of more detailed and comprehensive study of this type of gas discharge. The aim of this work was to study its properties in such conditions, when possible contact of the discharge with a metallic current-carrying electrode was placed inside the liquid electrolyte.

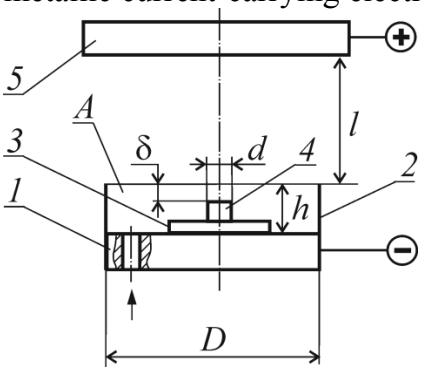

Fig. 1. The gas-discharge unit of the experimental facility

In figure 1 shows a gas discharge unit of the experimental facility. On the disc *1* with diameter D = 75 mm was mounted outside a thin-walled cylinder *2*. Thus formed cylindrical vessel *A* with depth h = 10 mm. Inside the vessel *1* was mounted washer *3*, which was pressed a short rod *4* with diameter d = 6 mm. The disc *1* was made of graphite and have internal channels for the passage of coolant. Cylinder *2* was made of a dielectric material. The washer *3* and the rod *4* are copper. Disk *1* was connected to the negative pole of the power source. The anode *5* was made of copper in the form of a water-cooled disk with a diameter of 100 mm and placed over the vessel *A*.

Through the hole in the disc *1* into the vessel *A* was fed a liquid electrolyte. In this case the rod *4*, was immersed in the electrolyte. Immersion depth δ varied by replacing one pair of "washer-rod" on the other.

The electrolyte was a solution of salt in distilled water. The experiments were conducted with solutions, the electrical conductivity of which was in the range of 10.0±0.2 mS/cm. The power supply was served from a three-phase full-wave rectifier. The pulsations of the rectified voltage was smoothed out C-L-C-filter. The output voltage amounted to 1760 V. To limit the current in the electrical circuit included a ballast resistor 150 Ω. Oscillograms of current and

voltage were recorded with a digital oscilloscope AKIP-15/1.The signal of current was the voltage drop at the shunt with resistance of 0.5 Ω, and the voltage signal was formed by ohmic divider 6kΩ/12MΩ.

Snapshots of the discharge were obtained using high-speed video VIDEOSCAN-401. Emission spectra were recorded by high-speed fiber optic spectrometer AvaSpec-3648 in the wavelength range 484-708 nm with a resolution of 0.15 nm (diffraction grating 1200 lines/mm optical input slit is 10 μm).

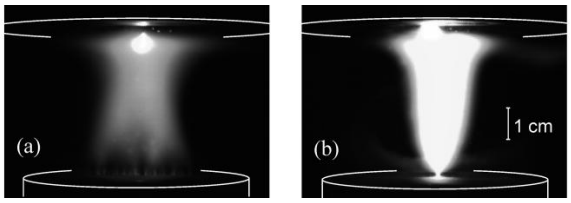

Fig. 2. Snapshots of gas discharge before and after uncovering of metal electrode. Cathode – at the bottom, the anode – top. Exposure 200 μs

The first series of experiments were conducted in the following conditions. Inside the vessel *A* was installed a couple of "washer-rod" that the upper end of the rod *4* stood at the edge of the cylinder *2*. The vessel *A* was filled with electrolyte to overflow. The end of the rod 4 was completely hidden under a thin layer of electrolyte. Further, the interelectrode gap between the electrolyte and the anode *5* was closing with a thin copper wire. It exploded when voltage was applied from the power source. Such was the ignition of a gas discharge. One of its snapshots were presented in figure 2*a*. As evident, it was voluminous and directly docked to the liquid electrolyte. Thus the binding area of the discharge to the electrolyte was distributed over its surface and occupies a significant area. In this case, the liquid electrolyte is the cathode.

Under the influence of the discharge occurred the decrease of the electrolyte in the vessel A, the upper end of the rod *4* to uncovering and formed a direct contact of the gas discharge with a metallic current-carrying electrode. In this case, the discharge was completely different. Once the discharge has docked with the metal electrode, liquid electrolyte has ceased to serve as the cathode, and the cathode binding was focused on the metal electrode, tapering to a point (fig. 2*b*).

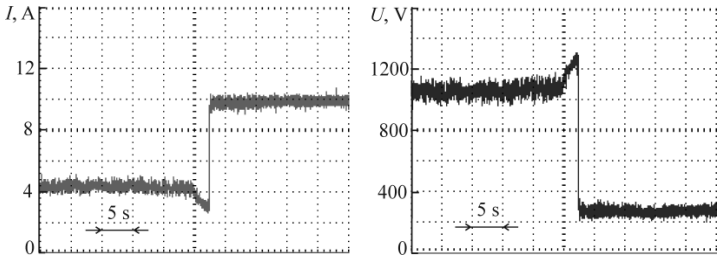

Fig. 3. Current and voltage oscillograms before and after uncovering metallic conductive electrode

Along with the restructuring of the external contours of the discharge, there was a sharp change in its physical properties. The discharge current was sharply increased, and the voltage, on the contrary,

unevenly fell (fig. 3).

In the second series of experiments was first ignited between the metal electrodes, and then filled the vessel A liquid electrolyte. In the initial period discharge was burning in the outdoor without receiving of vapors of the electrolyte in the discharge region. Between the metal electrodes were formed

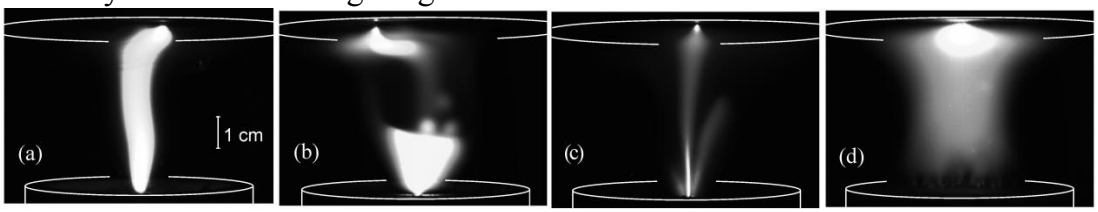

Fig. 4. Snapshots of gas discharge. Cathode: *a* - metal, *b* and *c* - metal in the electrolyte, *d* – electrolytic. Exposure 200 μs

almost homogeneous plasma column (fig.4*a*). When the electrolyte level reaches up to the upper end of the rod *4* began intense pulsation. There were constricted channels that have develop from the cathode to the anode. They were painted in scarlet. In the snapshots were fixed various moments of formation and development of such channels (fig. 4*b* and 4*c*).

Pulsating mode is continued with further filling of the vessel *A*, and then abruptly switched to the mode of combustion with liquid electrolytic cathode (fig. 4*d*). Changes in current and voltage that occurred during transitions from one combustion mode to another, was represented in figure 5*a* and 5*b*. Here are the waveforms highlighted areas correspond to modes of combustion: *K* – between the metal electrodes, *L* – transitional pulsing, *M* – with liquid electrolytic cathode. In pulsed mode L was dominated by the time intervals in which current is larger and the voltage is low (fig. 5*c*). Consequently, most of the time the discharge in contact with current-carrying metal electrode. Experiments carried out with various pairs "washer-rod", showed that at $\delta \leq 3$ mm pulsing mode *L* does not passes in a combustion mode *M*.

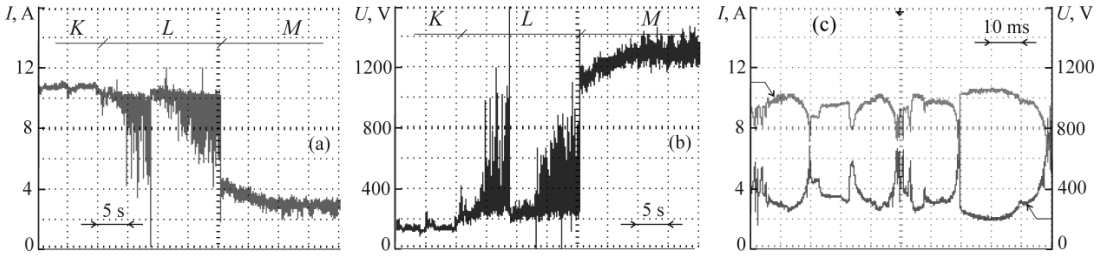

Fig. 5. Oscillograms of the currents and voltages (transition from a metal cathode to the electrolytic)

In the combustion mode *K* dominates the radiation of copper atoms. In this

mode, the discharge column painted in a greenish color. At the other extreme *M* mode dominates the radiation of atoms of sodium, the discharge column was colored in yellow. In the transition mode *L* radiation was mixed. The emission spectrum contains intense lines and copper atoms, and atoms of sodium. Also appear intense line radiation of hydrogen atoms. Analysis of the spectra showed that hydrogen emits mainly in the near-cathode region. As the distance from the cathode its radiation weakens. In all likelihood, hydrogen emits at the moment when channels constricted since scarlet coloring of these channels corresponds to the color line H_α.

Near the anode emit most intensely copper atoms. The calculation made by the method of relative intensities using lines CuI 510.55, CuI 515.32, CuI 521.82 and CuI 578.21, it showed that the maximum value of the electron temperature T_e near the anode is in the range 5100-5300 K. A similar calculation using lines H_α and H_β allows us to estimate the maximum value of T_e in the cathode region pulsed *L*. The estimated values were in the ranges of 3700-4000 K.

From the obtained experimental data it follows that in identical conditions, the discharge was shorted to a metal cathode, and not the liquid electrolyte. The emission of charges from the metal cathode is clearly electronic. In this case, the charge from the cathode in a discharge region is carried by electrons. In the case of liquid electrolytic cathode, the charge transfer were carried out mainly by ions. This process is inertial because of the massiveness of the ions. These are the factors causing the emergence of these phenomena. These factors contribute to the expansion zone binding discharge to the liquid electrolytic cathode.

References

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