EXPERIMENTAL STUDY OF GAS DISCHARGE WITH ELECTROLYTIC CATHODE

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Gas discharges with liquid electrolyte electrodes are attractive because they enable us to obtain a chemically active nonequilibrium plasma at atmospheric pressure directly using a relatively simple technical means. Considerable practical interest is the fact that there is a possibility of formation of the plasma flow with a large geometry, as discharge region has a sufficiently large volume, like glow discharge. At low currents measured in milliamperes, and short inter-electrode distances, within a few millimetres, there is expansion of the area of the discharge zone of binding to the liquid electrolyte electrode when the current /1/. This phenomenon leads to a rapid increase in the transverse dimensions of the discharge area. With further increase of the current expansion reaches its limit. The increase in the binding area of the zone of discharge to the liquid electrolyte electrode is due to curvature of the surface of the liquid electrolyte /2/. These laws established under the condition that the area of the free surface of the liquid electrolyte of the electrode surface area is much higher than the binding to discharge him. In this paper we consider the variant of the liquid electrolyte of the electrode with a limited area of a horizontal surface.

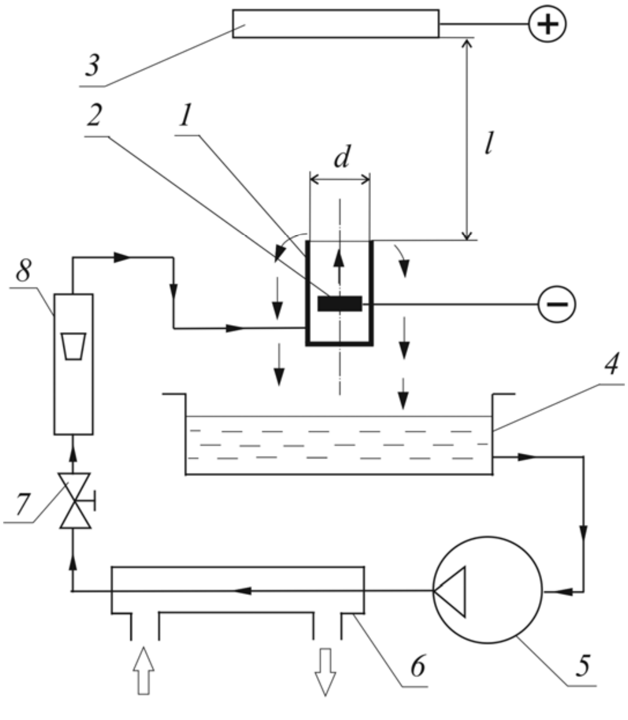


Fig. 1. The experimental setup.

Schematic diagram of the experimental setup is shown in Fig. 1. The electrolyte flowed from a vertical cylindrical channel *1* where was installed a graphite plate *2* inside. The discharge was burning in the air space between the end of the upper surface of the electrolyte flow and the metal electrode-anode *3* placed above. For brevity, the lower electrode assembly may be called "end flow electrolyte cathode". From this flowed the electrolyte in the container *4*. The electrolyte is circulated through a hydraulic pump *5*. After cooling, the heat exchanger *6* electrolyte is again fed into channel *1*. His flow was regulated by a valve *7* and controlled by a float rotameter *8*.

The sodium chloride solutions with the specific electrical conductivity of σ = (0,5-1,5) S/m are used as an electrolyte. The power supply was a three-phase full-wave rectifier. The current was changed by stepwise variation of the ballast resistance of 200 ohms to zero. For the current measurement was used pointer instrument M2015 accuracy class 0.2. The voltage U between the graphite plate *2* and anode *3*, and measured the pointer instrument M2016 with an additional resistance. To determine the voltage drop at the cathode tube was used probe, which was placed at the output of channel *1*. Oscilloscope studies were performed with an instrument AKIP 4115/1. Heat loss at the cathode is determined by calorimetric method. The electrolyte temperature was measured with a chromel-alumel thermocouples mounted on the inlet to the channel *1* and at its output, as well as in the container *4*. Discharge was used to photograph high-speed camera VIDEOSKAN-415. The electric-field strength in the discharge column was estimated from measurements of voltage at different interelectrode distances l. The current density is defined as the ratio of current to the cross-sectional area of channel *1*.

a *b* *c*

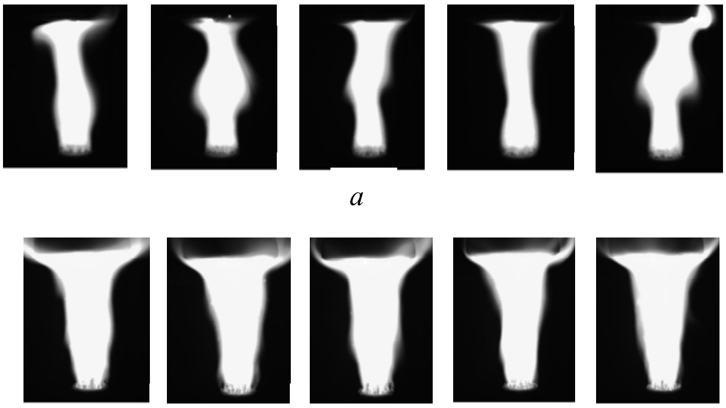
Fig. 2. The photographs of the gas discharge. l = 50 mm. d = 40 mm. *a* - I = 2,8 A; *b* – 10 A; *c* – 14,5 A. The exposure 196 μs.

As seen from the photographs (Fig. 2), with increasing current discharge region expands. Its structure is close to the electrolyte is mixed. In this area of binding to the electrolyte level is at its upper end surface and almost has a constant area. Therefore, the current increases with an increase in its density. In the present current range of its maximum value was 1,1 A/cm^2.

Speed photography has shown that the stability of the spatial position of the discharge depends on the current and the length of the interelectrode distance. At low I and large l of the geometric shape of the discharge varies continuously

(Fig. 3*a*). With the increase of the discharge current becomes stable and has a shape almost unchanged (Fig. 3*b*).

It should be noted that the formation of extended stable discharge is a distinctive feature of the "end flow electrolyte cathode"


a

b

Fig. 3. Frames of speed shooting. The interval of 40 ms. The exposure 196 μs. l = 150 mm. d = 40 mm. *a* - I = 7,5 A; *b* – 16,5 A.

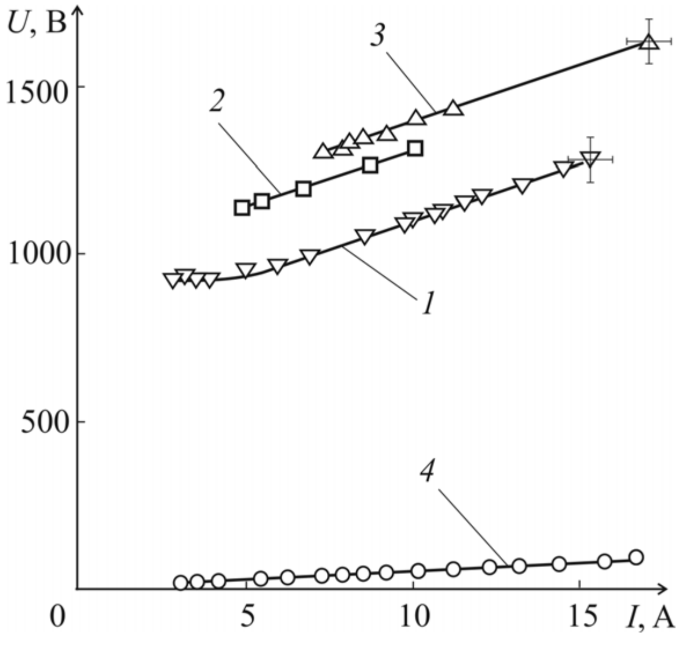
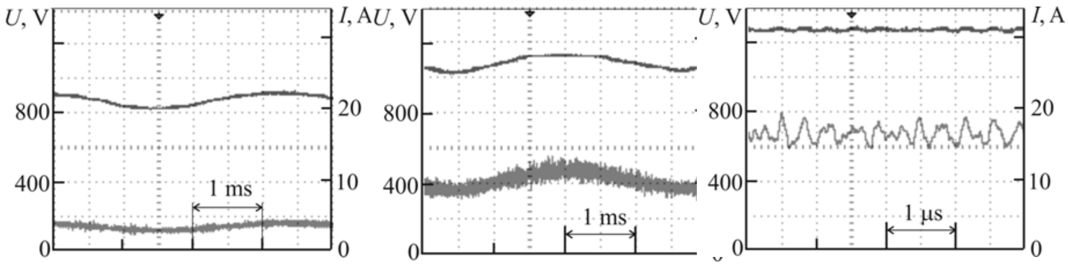


Fig. 4. Current-voltage characteristics. *1* – l = 50 mm; *2* – 100; *3* – 150. d = 40 mm. m = 16 g/s. σ = 1,5 S/m (*1*,*3*) and 1,1 (*2*). *4* - ΔU_k.

Despite the fact that the discharge region expands with increasing current-voltage characteristics are increasing (Fig. 4). Some contribution to the formation of the steepness of the CVC is making the voltage drop at the cathode (curve *4*). However, even with the deduction from the total voltage U remains positive slope of the CVC. The absence of a clear CVC slope at low currents (curve *3*), apparently due to the instability of the geometry of the discharge under these conditions. Decrease in the specific electrical conductivity σ of the electrolyte led to an increase in the values of U and ΔU_k. Similar changes occurred with increasing flow rate, and electrolyte m. For this reason, some originated in the calculations of the spread of the electric-field strength E in the discharge. In the investigated range of parameters, the values of E were obtained in the range 20-30 V/cm.

Oscilloscope studies revealed the presence of random fluctuations of electrical parameters of the discharge. The amplitude of the ripple voltage was minor compared to the total voltage U. More significant was the ripple current. As seen from the oscillograms *a* and *b*, shown in Fig. 5, their amplitude increases with current and up to 15% of its average value. One of the probable reasons for the increase of the amplitude ripple current is the flow of products of erosion of the anode in the discharge region. The frequency of pulsations in the megahertz range (Fig. 5*c*).



a *b* *c*

Fig. 5. Oscillograms of voltage and current. l = 50 mm. *a* – I = 2,8 A; *b* – 10; *c* – 14,5.

Sustainable long-term discharge is only possible in the absence of its boiling point. Therefore require cooling. Notable is the fact that the heat loss caused by the need to cool the electrolyte decreases with increasing current density at the cathode and their share in the energy balance is reduced to 10-15%. In general, experiments have shown that on the basis of the gas discharge can be created by the powerful (tens or hundreds of kW) generators steam plasma with sufficiently high thermal efficiency.

References

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2. **Miftakhov M.N., Tazmeev Kh.K., Tazmeev A.Kh., Friedland S.V.** Journal of Engineering Physics and Thermophysics, 3(2006) 109-115.