Journal of Physics: Conference Series **669** (2016) 012005 doi:10.1088/1742-6596/669/1/012005

Characteristics of the electric arch and stream of plasma in the channel with porous cooling

G. Yu. Dautov[1], **R. R. Khairetdinova**[2], **I. G. Dautov**[2]
[1]Kazan National Research Technical University named after A. N. Tupolev – KAI, Kazan, Russia
[2]Kazan Federal University, Kazan, Russia

E-mail: Ramilya.19@mail.ru

Abstract. We study the characteristics of the arc plasma torch with a porous wall. The increase in mass flow of gas through the porous wall leads to an increase in thermal efficiency of the plasma torch. Compared it with the characteristics of the plasma torch with interbay gas supply.

Saving energy with plasma generation by improving thermal efficiency of the plasma torch continues to be an urgent task.

The formula for thermal efficiency:

$$\eta = 1 - \frac{q_1+q_2+q_3}{IU}, \quad (1)$$

where q_1 - heat loss through the cathode, q_2 - heat loss through the anode, q_3 - the loss of heat through the wall of the arc chamber, I-force power, U - the arc voltage.

In works [1-8] have demonstrated the possibility of reducing q_3 through the use of transpiration cooling of the wall of the arc chamber. Formula (1) shows that it improves the efficiency of the plasma torch. This work is devoted to study the efficiency of the plasma torch and characteristics of electric arc in the channel with a porous cooling. The diameter of the arc chamber is 1 cm, the wall of the arc chamber was made of copper with porosity of 30%. Part of the plasma gas-air was supplied into the arc chamber through a porous wall. The speed of plasma on the axis of the arc chamber was directed from the cathode to the anode, the pressure at the outlet of the cathode was equal to 10^5 Pa. The mass flow rate of the gas through the surface per unit of length of arc in one second camera is denoted *m*. Experiments have shown that long-term stable operation of the plasma torch at I=100-200 A is possible only if $m \geq 0.02$ kg s^{-1} m^{-1}.

As can be seen from Fig.1 (graphs 1 and 2), the efficiency of the plasma torch are investigated very slowly decreases with increasing current and is determined mainly by the intensity of inflow of gas through a porous wall. A comparison of charts 1 and 2 shows a significant increase in the efficiency of the plasmotron with increasing *m*. At the same figure presents data for the plasma torch assembly with gas flow [9] (curve 3). From the comparison graphs, it follows that the plasma torch with a porous cooling provides the greatest η value. A high value of η in a porous cooling is achieved by changing the heat flow to the wall of the arc chamber and cooling stabilizing the walls of the injected gas. It should be emphasized that even at a very high intensity for the gas efficiency of the plasma torch with a cross-sectional flow remains less than the efficiency of the plasma torch with a porous cooling, since the presence of water-cooled sections does not allow to eliminate losses due to radiation. In porous cooling, the heat flow returns to the arc chamber.

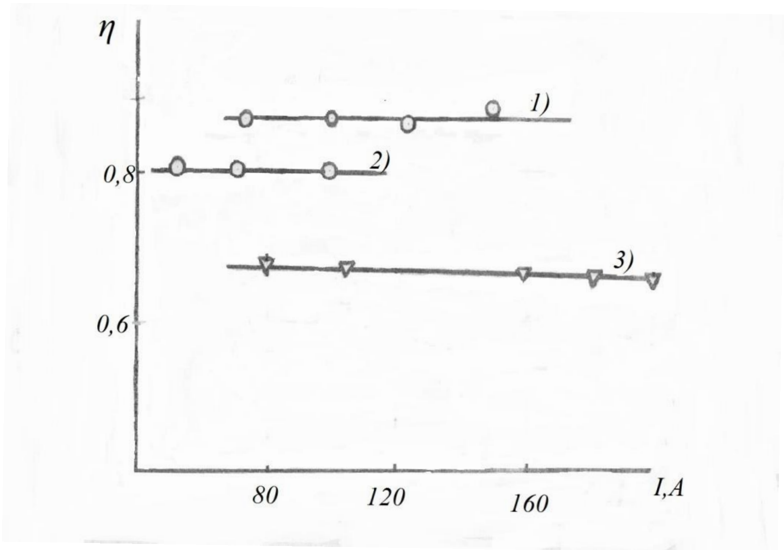

Figure 1. The dependence of the thermal efficiency of the plasma torch from a current when the length of the positive column of 7.2 cm, d = 1 cm. 1) m = 0.03 kg s^{-1} m^{-1}; 2) m = 0.02 kg s^{-1} m^{-1}; 3) [9]

Intensive cooling of the positive column of flowing through the surface of relatively cold gas leads to a narrowing of the profile and a certain growth temperature on the axis of the arc column. This is evident from comparing Fig.2 a) and b) which presents graphs of the temperature distribution of plasma along the radius of the positive arc column stabilized in a channel of the plasma torch, respectively, with gas and without it.

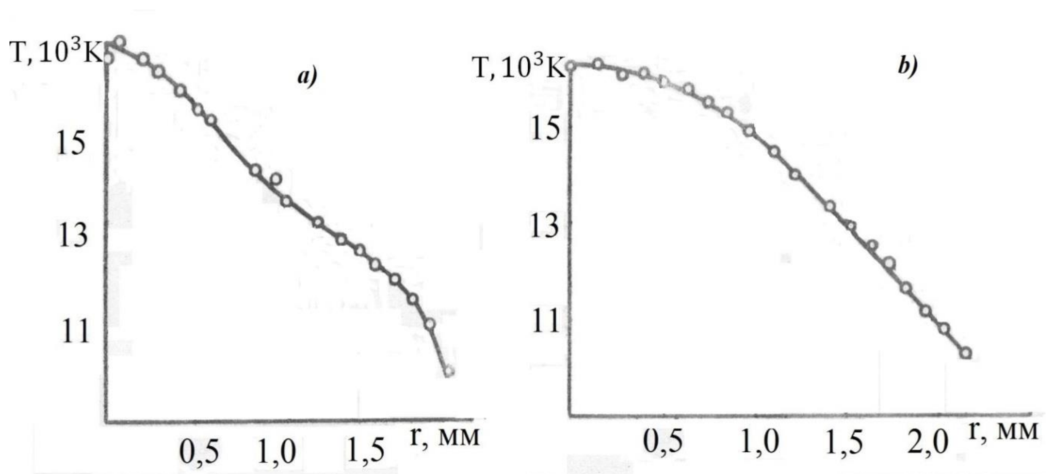

Figure 2. Distribution of plasma temperature at a distance x = 5.2 cm from the cathode spot at I = 100 A. a) the partitioned water-cooled plasma torch with the interelectrode insert, G(x)= 2 $Gauss^{-1}$, m = 0; b)porous cooling, G(x) = 2 $Gauss^{-1}$, m = 0.2 g cm^{-1} s^{-1}

Journal of Physics: Conference Series **669** (2016) 012005 doi:10.1088/1742-6596/669/1/012005

The experiments showed that the mean mass enthalpy of plasma at the exit of the plasma torch h_c increases linearly with increasing current. With increasing air flow rate through the porous wall of the h_c is reduced, and the electric field strength increases.

References

[1] Yu. V. Kurochkin, A. V. Pustogarov, « Research of plasma torches with the flow of the working fluid through a porous interelectrode insert. Experimental research of plasma torches », Novosibirsk. Science. 1977 (p. 82-103)

[2] J. Anderson, E. Eckert, « Porous cooling stable electric arc heater. Rocket technology and cosmonautics», 1967, №4 (p.113-122)

[3] Yu. V. Kurochkin, A. V. Pustogarov, V. V. Ukolov « Electric arc discharge in a porous channel with high pressure gas. Thermophysics of high temperatures », 1978, 16, №1 (p.195-197)

[4] J. Kheberlayn, E. Pfander « Porous cooling of the walls of the chamber with a stable arc of high power. Heat transfer », 1972, №2 (p.17-25)

[5] Dautov G, Dautov I, Fayrushin I and Kashapov N 2013 *J. Phys.: Conf. Series* **479** 012001

[6] Dautov G, Kashapov N, Fayrushin I and Dautov I 2013 *J. Phys.: Conf. Series* **479** 012014

[7] Dautov G, Fayrushin I, Kashapov N and Dautov I 2014 *J. Phys.: Conf. Series* **567** 012008

[8] Fayrushin I, Kashapov N and Dautov I 2014 *J. Phys.: Conf. Series* **567** 012009

[9] G. M. Mustafin «The features of stable arc in a channel with distributed gas flow », 1968, № 4 (p.127-131)