The influence of ripple current on characteristics of electric arc, stable in a cylindrical plasmatron channel.

G Y Dautov, N F Kashapov, G R Zakirova, I G Dautov.
Kazan National Research Technical University named after A. N. Tupolev
Kazan Federal University.

E-mail: gulnaraz93@mail.ru

Abstract. The paper presents the results of experimental studies of nonstationary electric arc, stable partitioned in a cylindrical plasmatron channel. The experimental data obtained in the range of electric current I=50-200A, \( I_m = 1-7 \) A, when the gas flow rate \( G = 2 \times 10^{-4} \) kg·s\(^{-1}\), the frequency of alternating current \( f = 300-20000 \) Hz.

Research shows that the arc in the plasmatron channel DC has nonstationary properties, the degree of manifestation of which depends on the ripple voltage of the power source, and processes, due to the shunting arc [1-4]. Therefore, for a more complete understanding of physical processes of interaction of the arc with the gas flow, calculation of energy characteristics of the plasma torch and the stability of the system arc the power source must take into account the nonstationarity of the discharge.

The paper presents the results of experimental studies of nonstationary electric arc, stable partitioned in a cylindrical plasmatron channel.

Transient behavior was carried out by imposing on the arc direct current alternating voltage of a predetermined amplitude and frequency source connected in parallel to the main power source. The direct and alternating currents were separated by capacitive and inductive resistances. The experiments were carried out in the range of electric current I=50-200A, \( I_m = 1 \) to 7 A, the gas flow rate \( G = 2 \times 10^{-4} \) kg·s\(^{-1}\), alternating current frequency \( f = 300-20000 \) Hz. The radius of the arc chamber of the plasma torch was 0.5 cm, the interelectrode distance \( l = 14 \) cm. Here \( I_m \) is the root-mean-square of the alternating current. As the plasma gas used was air.

In Fig.1 shows the distribution of heat flow through a unit length of the channel along \( q_o \) arc chamber in a stationary mode, the x axis is directed along the axis of the arc chamber from the cathode toward the anode, the cathode spot is in the cross-section \( x = 0 \).

Fig.1. The heat flux distribution along the channel at \( I = 60A \). Graphs 1,2 and 3 correspond to the expenditures of air \( G = 6 \times 10^{-4} \) kg·s\(^{-1}\), \( G = 4 \times 10^{-4} \) kg·s\(^{-1}\) and \( G = 2 \times 10^{-4} \) kg·s\(^{-1}\).
In the direction of the bulk temperature of the plasma and its temperature at the channel wall increases and therefore \(q_0\) along the x-axis increases. With decreasing gas flow temperature increases along the axis x increases and accordingly, increases in \(q_0\).

Present heat flow in modulated mode in the form

\[
q_i = q_0 + \Delta q
\]  

Figure 2 shows the graphs \(\Delta q\) from H.

**Fig.2.** The distribution of heat flow \(\Delta q\) along the canal at \(I_o=60A, I_m=6A, f=103Hz\). Graphs B, C, D correspond to airflow rates of \(2\cdot10^{-4}\) kg·s\(^{-1}\), \(4\cdot10^{-4}\) kg·s\(^{-1}\) and \(6\cdot10^{-4}\) kg·s\(^{-1}\).

With the growth of fluctuations of the electrical parameters of the arc voltage of the arc increases, thus increase and heat flow. As can be seen from Fig.2, the greatest increase in the heat flux \(\Delta q\) is observed in the initial and transition sections of the positive column. To limit the area effect of small perturbations on the distribution of heat flow is very weak. One of the possible reasons for this as follows. In the initial section of the channel the radius of the arc column is small, therefore, even a small current fluctuations lead to noticeable fluctuations in the radius of the arc and the emergence of enforced radial convection. Since the heat flux \(q_0\) on the initial site is small, the heat transfer enhancement due to the modulation current plays a prominent role. With distance from the initial portion of the radius of the pillar increases, the relative change of the radius of the post when the modulation current decreases correspondingly and the contribution of forced convection to the heat flux on the channel wall.

To explain this experimental fact must also take into account the nature of the change in bulk temperature of the flow along the channel. As is well known the bulk temperature of the gas increases in the direction of the gas flow. At a relatively low temperature at the initial section of the channel modulation of the current, apparently, leads to significant temperature fluctuations, consequently, the electrical conductivity of plasma. While there may be significant fluctuations in the field strength, which leads to a higher power Joule dissipation. In combination with the above-noted fact of heat transfer enhancement increased Joule dissipation can also be the reason for the increase \(\Delta q\). At high temperatures, which occurs at the maximum phase channel, the relative fluctuations of temperature, therefore, conductivity and field strength will be small. Therefore, the increase of the Joule dissipation capacity here is negligible. Minor and the increment \(\Delta q\).

Experiments have shown that changing the frequency of the disturbing current from 300 to 20000 Hz virtually no effect on heat loss through the wall of the arc chamber. In the investigated range of parameters the influence of small perturbations on the heat flows in the electrodes was found.

Thus, the obtained results are explained by the fact that fluctuations of the electric parameters of the arc contribute to an additional turbulence of the flow and change of conditions of heat and mass transfer between the arc and the plasma gas. Most clearly these effects are observed at low flow rates of gas on the initial section of the channel, i.e. when the flow without perturbation of the current is laminar. With increasing flow rate and with distance from the cathode the effect of electrical disturbances on the arc characteristics is weakened, since it increases the role of disturbances with a gas-dynamic nature.

In the electrical submersible diaphragm pump working gas, interacting with the electric arc, it is heated to high temperatures and expire through the nozzle as a plasma jet. The parameters of the plasma jet depends on the choice of power scheme and design features of the electrical submersible diaphragm pump, sort of working gas and its flow, input power, etc. The studies showed that the nature of the flow of plasma and the size of the plasma jet is significantly influenced by voltage fluctuations.
of the power source. For example, at low flow rates of gas smoothing the ripple of the power source has led to a significant reduction in the intensity of background noise and increasing the length of the plasma jet. This is because the smoothing voltage of the power source modifies the pulsation characteristics of the flow and reduces the amplitude of acoustic oscillations of the plasma. When the constancy of all other parameters of the electrical submersible diaphragm pump there is maximum gas flow rate above which the perturbation current is almost no influence on the length of the jet. For example, in our case \( G = 6 \times 10^{-4} \text{kg} \cdot \text{s}^{-1} \). With further increase in flow rate disturbed the spatial stabilization of the plasma jet and its length decreases sharply. As can be seen from Fig.2, this value of gas flow corresponds to the transition from laminar to turbulent mode of combustion of the arc. Thus, the state of the plasma jet is directly related to the processes within the arc chamber.

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