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DUAL-JET PLASMATRON FOR MEDICAL APPLICATIONS**

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We present a design for a dual-jet arc plasmatron operating at a frequency of 66 kHz in an argon flow at atmospheric pressure. We present the results of determination of the temperature, electron concentration, and electrode erosion obtained by atomic emission spectral analysis. The proposed convenient design for a dual-jet plasmatron and the low erosion of the copper electrodes in the plasma make it possible to use it for medical purposes.

Key words: *dual-jet plasmatron, arc plasma, electrode erosion.*

Introduction. Generation of a "pure" plasma is an important problem today in electrophysics. A plasma uncontaminated by electrode material is especially needed to solve problems in medicine, plasma chemistry, and emission spectroscopy. For medical purposes, the plasma should contain as low a level as possible (at least under the maximum permissible concentration) for heavy metals, which usually enter the plasma as a result of electrode erosion. The design of a plasmatron system for medicine created by scientists from N. É. Bauman Moscow State Technical University is well known [1]. In plasma chemistry, a plasma not containing any impurities is needed in order to obtain pure substances.

Arc plasmatrons are well known that run on d.c. or a.c. at the power grid frequency [2]. The operating principle for these plasmatrons is based on generation of a plasma jet between electrodes in a flow of plasma-forming gas. Usually for such plasmatrons, the erosion is 10^{-9} kg/coulomb. The length of the jet is a few diameters of the exit aperture of the plasmatron, which is a constraint for technological processes where longer plasma jets are needed.

Development of a dual-jet plasmatron changed the situation. The first designs for dual-jet d.c. plasmatrons appeared in the 1950s [3]. In these plasmatrons, the plasma parameters were stabilized as a result of direct passage of the current through the plasma jets and, in accordance with the local equilibrium current distribution, local equipartitioned evolution of Joule heat arose. Such a design made it possible to obtain sufficiently long plasma jets, but the problem of plasma generation with low electrode erosion remains unsolved today.

We have developed a design for a dual-jet plasmatron (Fig. 1) powered by a.c. current (kilohertz range). The basic design parameters are: the electrodes are made from copper with an aperture of diameter 1.2 mm, the electrodes are water-cooled, the plasma-forming gas is argon. The plasmatron is powered by a 12 A current with frequency 66 kHz, 60° angle between jets, length of both jets equal to 30 mm.

Studies of a single-jet plasmatron have shown [4] that electrode erosion is substantially reduced when the plasmatrons are powered by a.c. current in the kilohertz range. In this work, we determined the plasma characteristics from the emission spectra. The block diagram for recording the spectrum is shown in Fig. 2. The emission spectrum of the plasma radiation was recorded on film by a spectrograph and processed using a scanner according to the procedure in [5].

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Fig. 1 Dual-jet a.c. plasmatron (kilohertz range).

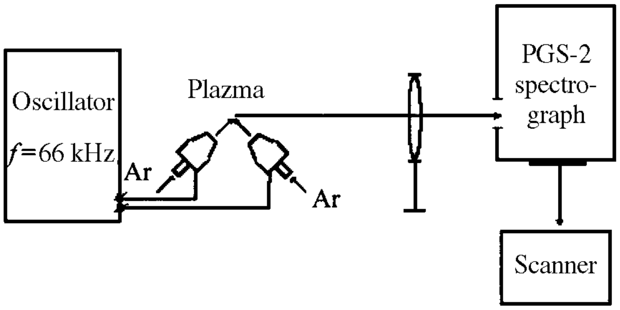

Fig. 2 Block diagram of the setup for analysis of spectral characteristics.

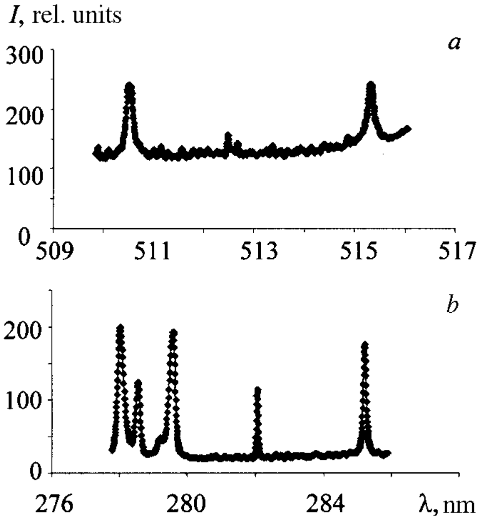

Fig. 3 Part of the emission spectrum containing lines from copper (a) and magnesium (b).

The temperature was determined by the relative spectral line intensity method using the copper lines Cu I 510.554 nm and Cu I 515.324 nm (Fig. 3a). The electron concentration was found from the relative intensity of the lines Mg II 279.553 nm and Mg I 285.165 nm (Fig. 3b). The results obtained showed that the temperature and the electron concentration remain unchanged along both jets and are equal to T = 6800 K and $N_e = 1.2 \cdot 10^{17}$ cm^{-3}.

We used the addition method for quantitative determination of the content of electrode material in the plasma of the discharge [6]. We prepared references with different copper contents in a graphite matrix (0.001%, 0.01%, 0.1%, 1%, and 5%). The samples were injected into the discharge space with the flow of plasma-forming gas by means of a specially designed sample feeder [7]. From the known values of the copper content in the samples and the values obtained for the relative intensity of the copper spectral line (λ = 510.554 nm), we plotted the dependence of the logarithms for these quantities. From this plot for the logarithm of the relative intensity of the copper line in the spectra (from a graphite matrix), we found the logarithm of the copper concentration, where the presence of copper was connected with erosion of the electrodes. The erosion of the copper electrodes was $G = 2.9 \cdot 10^{-12}$ kg/coulomb.

Thus we have developed a design for a dual-jet plasmatron that is convenient for practical use and that allows us to obtain an equilibrium argon plasma with low erosion of the copper electrodes. Such a dual-jet plasmatron has applications in both medicine and other fields where it is necessary to use a plasma not containing contaminant impurities.

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