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ASSESSMENT OF THE EFFICIENCY OF PLASMA FLOW CREATION BY A HELICON SOURCE OF AN ELECTROD-LESS PLASMA ROCKET TRUSTER *)

Bragin E.Yu., Bobyr N.P., Gusev S.S., Egorova E.N., Zhiltsov V.A., Kamin D.V., Lezhennikova D.A., Korobtsev S.V., Kostrichenko I.A., Spitsyn A.V.

National Research Center "Kurchatov Institute", Moscow, bragin_ey@nrcki.ru

Research is being conducted at the Kurchatov Institute Research Center to support the creation of a domestic electrodeless plasma rocket truster (EPRT). One of the tasks being solved is to optimize the configuration of the helicon plasma source in order to increase its efficiency. This paper presents the results of studies aimed at investigating the factors influencing the efficiency of plasma creation during a helicon discharge, carried out within the framework of the federal project “Thermonuclear and Plasma Technologies”.

A helicon plasma source is one of the RF plasma sources in which energy is invested in electrons when they are exposed by the excited helicon RF wave. For the EPRT, optimum plasma flow is a dense (~10^{19} m^{-3}) low-energy one expanding from the source with a narrow radial profile.

The following parameters were selected as criteria for the efficiency of the plasma discharge: total ion current - the current created by all ions of the outgoing plasma flow; gas efficiency - the ratio of the number of ions of the outgoing plasma flow to the number of atoms of the propellant entering the system; the fraction of the input power used to accelerate the plasma flow; ionization cost is the energy expended to create one ion of the outgoing plasma flow.

The research was carried out at the PN-3, which is a model of an electrodeless plasma rocket truster. Plasma diagnostics such as a moved double Langmuir probe, a microwave interferometer, and a retarding potential analyzer were used. The dependences of the above parameters on such factors as the gas flow rate, the magnitude profile of magnetic field for various propellants at a constant input RF power were obtained.

It is shown that with increasing propellant flow rate, the total ion current increases until it reaches a maximum, corresponding to the maximum propellant flow that is capable of ionizing such an amount of input RF power. The gas efficiency has maximum values at low flow rates and decreases slightly with increasing propellant flow rate until the maximum total current is reached. With a further increase in propellant flow rate, the decline will be more significant. Since the electron temperature, and with it the ion energy, decreases with increasing propellant flow rate, the power transferred by the flow, which is the product of the average ion energy and the total ion current, has a maximum. This maximum is found at low working gas flow rates. As the working gas flow rate increases, the power transferred by the flow decreases. The cost of ionization is high at low working gas flow rates. As the propellant flow rate increases, it decreases until it reaches a constant value.

With a magnetic field increase (within the limits we consider), the total ion current, gas efficiency and the power transferred by the plasma flow monotonically increase, and the cost of ionization, on the contrary, decreases.

*) abstracts of this report in Russian