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PLASMA HEATING USING A HELICON ANTENNA IN THE PLM-M DEVICE *)

[1]Tran Q.V., [1,2] Budaev V.P., [1]Fedorovich S.D., [1,2]Karpov A.V., [1,3]Kavyrshin D.I., [1]Lukashevsky M.V., [1]Gubkin M.K., [1]Peregudov D.V., [1]Rogozin K.A., [1]Konkov A.A., [1]Anisimov D.A., [1]Chilin M.S.

[1]National Research University "MPEI", Moscow, Russia
[2]National Research Center "Kurchatov Institute", Moscow, Russia
[3]Joint Institute for High Temperatures of the Russian Academy of Sciences, Moscow, Russia

In the PLM-M device [1], research is being carried out on the interaction of stationary plasma with the surface of heat-protective materials of a thermonuclear reactor and research on the development of technology for creating a plasma engine. One of the tasks being solved is to create a plasma of high electron density (up to 10^{14} cm^{-3}) and temperature (10–15 eV) in a weak magnetic field (~0.03 T) and maintain it by exciting helicon waves at frequencies of 13.56 and 27.12 MHz.

Plasma is generated in the process of stepwise ionization by electron impact of atoms of the plasma-forming gas (helium, hydrogen). The electron current density required for the stepwise ionization process is achieved through thermionic emission when the tantalum cathode is heated to a temperature of 2300 K. To heat the plasma, an RF generator with a power of up to 5 kW and a cooled antenna installed inside the vacuum chamber in the helicon heating unit at operating frequencies of 13.56 and 27.12 MHz are used. As a result, the plasma discharge is maintained for several hours (8 hours or more).

In this work, an optimal matching system circuit has been developed, which is designed to transform the plasma load into a purely active 50 Ohm load. This system provides a high level of load power without adjusting the matching elements during discharge. A technique has been developed for determining the absorbed RF power by a plasma by measuring the RF current and determining the equivalent plasma resistance. Optimal heating modes will be determined at frequencies of 13.56 and 27.12 MHz with changes in the external inhomogeneous magnetic field and the initial electron density of the plasma. Comparative studies of the efficiency of RF plasma heating based on a cooled helicon antenna with plasma-forming working gases—helium and argon with a small addition of hydrogen have been carried out. The experiments measured the efficiency of energy transfer to plasma over a wide range of densities at different magnetic field values. Plasma parameters were measured using optical emission spectroscopy and electrical probes.

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References

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