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ION-CYCLOTRON RESONANCE HEATING OF ARGON-HYDROGEN PLASMA AT THE PN-3 DEVICE *)

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The PN-3 device is used for research on the high-frequency (HF) power deposition into the plasma flow for the purpose of ion heating as part of the electrodeless plasma rocket engine second stage development. Ion cyclotron resonance (ICR) was chosen as the heating method [1].

The ICR heating system consists of an HF power generator with rated power up to PICR = 10 kW at frequency fICR = 1.8 MHz. This frequency together with the available magnetic system of the PN-3 device allows to fulfill the resonance condition $\omega=\omega ci$ only for hydrogen ions.

The plasma source is a helicon plasma discharge operating at the frequency fHEL = 10 MHz with a power up to PHEL = 15 kW. The magnetic system d allows either to provide an effective helicon discharge in hydrogen plasma in the first section of the discharge chamber or to provide a resonant condition of ICR heating in the second section. In both the first and second cases, there is also a lack of free charged particle concentration $ne=10^{11}$ cm^{-3} for electromagnetic wave deposition at the frequency of the generator of the ICR heating system [2].

To solve this problem, it was proposed to use a mixture of argon and hydrogen as a propellant. The optimum values of gas flow rates and the configuration of the magnetic field of the device for HF power input of the ICR heating system were determined empirically.

Measurements of such plasma flow parameters as electron concentration, thrust, and average ion energy with the diagnostic complex of the PN-3 device served as a criterion for the efficiency of power input of the ICR heating. The efficiency was also confirmed by calorimetric measurements of the flux in the magnetic nozzle.

The paper presents experimental conditions and measurement results of the above parameters dependence on the configuration of the external magnetic field and HF power. For the ion energy a resonant dependence on the value of the external magnetic field and a close to linear dependence on the injected power are observed. The results obtained indicate the deposition of HF power at the frequency of ion-cyclotron resonance in a linear plasma device into the plasma flow of a mixture of gases.

References

[1]. Timofeev A. V. On RF heating of inhomogeneous collisional plasma under ion-cyclotron resonance conditions //Plasma Physics Reports. – 2015. – T. 41. – №. 11. – C. 873-881

[2]. Swanson D. G. Plasma waves. – CRC Press, 2020.

*) abstracts of this report in Russian