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DEVELOPMENT OF THE IMPROVED WIEN FILTER FOR THE ELECTRIC PROPULSION PLASMA PLUME DIAGNOSIS *)

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Due to the growth of electric propulsion (EP) applicability, the tasks associated with the diagnosis of such engines are becoming increasingly popular. One of these tasks is to study the charge spectrum of ions in an electric propulsion plasma plume. The most common device used to provide such measurements is the Wien Filter also called as ExB probe[1], which utilizes crossed magnetic and electric fields to separate ions by charge. In the EP plasma, ions having different charge values have different velocities due to the fact that they were accelerated by the same potential. The orthogonal electric and magnetic fields are applied perpendicular to the flow of particles entering the probe. The trajectory of the particles changes under the influence of the Lorentz force, while ions of different velocities and, accordingly, different charges are separated.

The main disadvantage of this design is an extremely weak signal on the ion collector (on the order of 1 nA) and when trying to improve the signal, the spectral resolution of the probe critically decreases, introducing an additional error in determining the fractions of multicharged ions in the EP plasma. Another disadvantage is the extremely high alignment requirements of the probe, which creates significant difficulties during operation, especially considering that the alignment must be carried out relative to the axis of the plasma plume, which does not coincide with the axis of the engine.

This paper presents the results of modeling the operation of an ExB probe in an ion engine jet with ion energy in the range from 500 to 2000eV and an ion current density of up to 10 A/m^2. The simulation was carried out for beams with an energy spectrum of a plume of nonzero width, at different angles of incidence of ions, taking into account the influence of spatial charge and inhomogeneity of magnetic and electric fields. The calculation results are verified experimentally using the example of a probe of standard design[1,2], and it is concluded that the model is applicable to calculate the operation of the ExB probe in real conditions. Solutions are proposed to solve these problems by focusing the ion beam and using a computational search for the most optimal probe geometry. As a result, it is shown that the ion-optical system allows collecting ions from a larger area at the same size of the input aperture of the probe and compensates for the divergence of the ion beam in the input collimator due to the space charge. Moreover, the beam is focused using an ion-optical system, thereby reducing the requirements for probe alignment. The paper concludes about the advantages of an ExB probe with an ion-optical system and the possibility of solving these problems in the proposed way.

References

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