DISTINCTIVE FEATURES OF USING PLASMA FLOWS TO PROVIDE COMPENSATION OF AERODYNAMIC DRAG DURING THE MOTION OF MINI-SATELLITES IN THE IONOSPHERE

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At present studies are being conducted in Japan, the United States and the European Space Agency on the application of plasma electric jet engines (EJE) used to correct spacecraft orbits, to reduce aerodynamic drag of long-lived (up to 8 years) satellites intended for monitoring the Earth’s surface from low and ultra low (<200 km) orbits, in which a working fluid brought on a board, whereon the engines operate, is replaced by gases of upper atmosphere. A feature of the engines, in addition to the large resource, is the requirement of acceptable reduction in their energy efficiency and in the coefficient of utilization of the mass of working substance during the transition from xenon (used in the engines applied for correction of orbits) to nitrogen and oxygen having higher ionization potentials, lower effective ionization cross-sections and atomic numbers. Such engines must operate using appropriate air intakes. Their creation is impossible without studies in ground conditions of joint operation of the engine and air intake in a gas stream that simulates natural conditions for the flow velocity (~8 km/s) and particle concentration at the corresponding heights, and has rather large transverse dimensions. Up to now, methods for creating such flows and research techniques using them are absent abroad and in our country. Traditional gas-dynamic methods with gas acceleration in a nozzle enable one to obtain flows at speed of up to 7 km/s, while the electrostatic and electrodynamic methods are effective from speeds of ~15 to 20 km/s.

The report presents the operational experience in the TsAGI IAT-2 ionospheric wind tunnel with plasma-ion sources [1], using capabilities of which the substantially neutral flows can be created with an adjustable speed of 8 km/s and particle concentration corresponding to a flight altitude of ~180 km with a stream core diameter of ~10 cm and a flight altitude of ~220–200 km with a stream core diameter of ~20 cm. A source is used with volumetric ionization of the working gas and with oscillation of electrons in a magnetic field in the chamber between the walls that have a cathode potential, and a large multi-cell aperture of the ion-optical system to create a flow. The ion current at the source output is up to 400 mA. To obtain a substantially neutral flow, the effect of ion charge exchange is used. The facility has a length of 9 m and a diameter of 1.5 m, a vacuum at the level of (1–2)·10–5 Torr at consumptions of the working gas (nitrogen, air) necessary to provide the required parameters of the flow that simulates natural conditions. Methods for measuring the parameters of ionized and neutral flows and the results of researches are presented.

References

1. A.S. Filatyev, V.V. Skvortsov. Contribution of TsAGI to the development of electric propulsion engines for aerospace vehicles: to the 50th anniversary of the national program “Yantar” // TsAGI Science Journal, 2017. Volume 48, Issue 1, pp. 111-114.