about plasma acceleration efficiency in atmospheric pulse-periodic plasma system

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Utilization of hybrid double-stage pulse-periodic plasma system (PPPS) [1] is a direction of development of efficient process unit, generating high-energy pulsed plasma flows under atmospheric conditions. First stage of PPPS – system of stationary arc plasmatrons (SSP), second stage – coaxial pulse electromagnetic plasma accelerator. SSP continuously fills electrode channel of coaxial accelerator with low-temperature/density/ionization degree plasma. Pulsed high-current discharge with specific off-duty factor realizes in this environment, plasma formation appears and moves in electrode channel under the action of electromagnetic and gas-dynamic forces.

Physico-mathematical model of processes in PPPS is formulated. Model of filling coaxial channel with low-temperature plasma is stated in frames of three-dimensional gas-dynamic approach and realized with computional fluid dynamic program ANSYS CFX 12.1. Computations are carried out with using SSP, consist of three microplasmatrons, generating subsonic plasma jets with mean temperature in range 8-10 kK. Peculiarities of plasma parameters spatial distribution in electrode channel of PPPS are determined. Mass distribution along channel can be approximated by quadratic function of the axial coordinate. Plasma formation movement through the PPPS electrode channel during high-current pulse discharge is described on the basis of “snowplow” electrodynamic approach [2] with quadratic law of mass variation and taking mass portion passing through plasma plow [3] into account. Plasma formation movement features in the wide range of main dimensionless criteria change, depending on energetic, electrotechnical and geometrical parameters of PPPS, are established. Conditions for realizing mode of acceleration, when maximum of plasma velocity achieves in the moment of plasma plow leaving PPPS outlet, are defined. Efficiencies of energy transformation from accumulated in capacitive element into kinetic and internal energy of plasma formation are calculated. It is indicated that mechanical efficiency has a maximum under certain dimensionless process criteria values.

Estimation of plasma formation main parameters for PPPS, developed in [1], is given. It is shown that under optimal values of main energetical parameters given PPPS can generate (in atmospheric pressure environment) plasma formations with velocity 2-2.5 km/s and temperature 25-30kK.

References

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