emission of a pulsed sliding surface discharge in a supersonic flow with shock wave

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The control of high-speed flows using plasma actuators (surface discharges of various types) is of fundamental and technological interest. Flow control is based on the action of gas-discharge plasma on the gas-dynamic flow near the surface [1, 2]. An experimental study of the characteristics of pulsed surface discharges in high-speed flows with shock waves are motivated by the need of analyzing the processes of interaction the discharge and the flow.

The aim of the work was registration of the radiation of a pulsed sliding surface discharge of nanosecond duration (plasma sheet) in a supersonic air flow with nanosecond resolution using the BIFO K011 CCD camera. 9-frame discharge images were taken with a 100 ns exposure and 100–200 ns gate. At the same time, the discharge current and the emission spectrum were recorded.

The experiments were carried out on a shock tube with a discharge chamber [2, 3]. Two plasma sheets with an area of 100–30 mm2 were initiated on opposite walls of the chamber at a given moment of time in the presence of shock wave in discharge area. The characteristics of the discharge at a pulsed voltage of 25 kV in motionless air and in airflows with a shock wave with a Mach number of ~3 were analyzed. The duration of the discharge current is less than 500 ns and the displacement of the shock wave front during this time does not exceed 0.5 mm.

The radiation of a sliding surface discharge in still air consists of straight channels that uniformly fill the discharge gap. The decay time of the radiation of diffuse channels of the discharge is 30–
120 ns [2], and the decay time of intense channels is ~150–350 ns.

The current of the sliding surface discharge interacting with the shock wave front occurs ahead of the shock wave front (in the low density region) when the front is inside the discharge gap. In the case that the front is beyond the discharge gap, the current can occur through U-shaped channel, including the front of the shock wave [3]. The maximum current depends on the position of the shock wave front at the time of the discharge. The duration of the discharge glow near the shock wave front increases significantly, reaching 2.5 μs, and depends on the position of the shock wave. The spectrum of radiation in this case contains a continuum and lines of atoms of nitrogen, oxygen, hydrogen.

This study was supported by the Program for development of the Moscow State University up to 2020.

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