

# NUMERICAL SIMULATION OF AEROGASDYNAMICS OF A FLIGHT VEHICLE WITH A HYPERSONIC LIQUID-FUEL RAMJET

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A key phase in creation of a real flight vehicle with a hypersonic liquid-fuel ramjet is a procedure used to form its aerogasdynamic arrangement. To reduce the number of expensive physical experiments it is worth conducting the virtual computational experiments with math simulation.

The paper provides an aerogasthermodynamic scheme of a flight vehicle with a hypersonic liquid-fuel ramjet developed with Navier-Stokes equations in the CFD package. The combined aerogasdynamic engineering of the flight vehicle and the hypersonic liquid-fuel ramjet using supercomputational hardware and computational experiments with a simulation math model allows us: •to form aerogasdynamic arrangement of the flight vehicle with the hypersonic liquid-fuel ramjet capable to maneuver within the Mach number from 6 to 8 at an altitude from 20 km to 30 km; •to demonstrate that a specific impulse from 10 to 14 km/s (1000–1400 s) can be reached at completeness of combustion more than 85%, if a pure or mixed hydrocarbon fuel is volumetrically fed in the supersonic flow inside the combustion chamber; •to show that in the above flight conditions at an attack angle from 6° to 8° a small flight vehicle consumes no more than 0.7 kg/s of liquid hydrocarbon fuel; •to illustrate that allowance for the radiation of gas and walls in the math model does not markedly change the gasdynamic processes in the hypersonic liquid-fuel ramjet passage and its integral characteristics.

More over, it is noted that intake of the outboard air through a punched or porous surface of the hypersonic liquid-fuel ramjet nozzle permits us: •to control the vehicle flight within the above ranges of altitude and speed by affecting the hypersonic flow in the nozzle; •to increase hypersonic liquid-fuel ramjet specific impulse; •to reduce the convective heat flows to the nozzle walls and bottom of the flight vehicle.

An evaluative heat analysis of the flight vehicle with the hypersonic liquid-fuel ramjet is made on which basis: •typical temperature regimes of the flight vehicle body are defined and thermal protection for the key components are selected; •it is detected that the combustion chamber can be thermally protected with active cooling with fuel while it is heated up.