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THEORETICAL STUDIES ON ROCKET/SPACE HARDWARE AEROGAS DYNAMICS

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This paper presents the results of theoretical studies on rocket/space hardware aerogas dynamics obtained from 2016 to 2020 at the Department of Aerogas Dynamics and Technical Systems Dynamics of the Institute of Technical Mechanics of the National Academy of Sciences of Ukraine and the State Space Agency of Ukraine along the following lines: rocket aerodynamics, mathematical simulation of the aerogas thermodynamics of a supersonic ramjet vehicle, jet flows, and the hydraulic gas dynamics of low-thrust control jet engines. As to rocket aerodynamics, computational methods and programs (CMPs) were developed to calculate supersonic flow past finned rockets. The chief advantage of the CMPs developed is computational promptness and ease of adding wings and control and stabilization elements to rocket configurations. A mathematical simulation of the aerogas thermodynamics of a supersonic ramjet vehicle yielded new results, which made it possible to develop a prompt technique for a comprehensive calculation of ramjet duct flows and generalize it to 3D flow past a ramjet vehicle. Based on marching methods, CMPs were developed to simulate ramjet duct flows with account for flow past the airframe upstream of the air inlet, the effect of the combustion product jet on the airframe tail part, and its interaction with a disturbed incident flow. The CMPs developed were recommended for use at the preliminary stage of ramjet component shape selection. For jet flows, CMPs were developed for the marching calculation of turbulent jets of rocket engine combustion products with water injection into the jet body. This made it possible to elucidate the basic mechanisms of the effect of water injection, jet–air mixing, and high-temperature rocket engine jet afterburning in atmospheric oxygen on the flow pattern and the thermogas dynamic and thermalphysic jet parameters. CMPs were developed to simulate the operation of liquid-propellant low-thrust engine systems. They were used in supporting the development and ground firing tryout of Yuzhnoye State Design Office’s radically new system of control jet engines fed from the sustainer engine pipelines of the Cyclone-4M launch vehicle upper stage. The computed results made it possible to increase the informativity of firing test data in flight simulation. The CMPs developed were transferred to Yuzhnoye State Design Office for use in design calculations.

Keywords: *launch vehicle, flying vehicle, ramjet, low-thrust control engine, aerogas dynamics, propellant combustion product jet, numerical simulation, marching method.*

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