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S. S. Vasyliv, H. O. Strelnykov

Rocket engine thrust vector control by detonation product injection into the supersonic portion of the nozzle

Institute of Technical Mechanics
of the National Academy of Sciences of Ukraine and the State Space Agency of Ukraine
!5 Leshko-Popel St., Dnipro 49005, Ukraine; e-mail: gl_konstruktor@ukr.net

For solving non-traditional problems of rocket flight control, in particular, for the conditions of impact of a nuclear explosion, non-traditional approaches to the organization of the thrust vector control of a rocket engine are required. Various schemes of gas-dynamic thrust vector control systems that counteract impact actions on the rocket were studied. It was found that the dynamic characteristics of traditional gas-dynamic thrust vector control systems do not allow one to solve the problem of counteracting impact actions on the rocket. Appropriate dynamic characteristics can provide a perturbation of the supersonic flow by injecting into the nozzle the detonation products with the main shock wave propagating in the supersonic flow. This way to perturb the supersonic flow in a rocket engine nozzle is investigated in this paper.

In order to identify the principles of producing control forces and provide a perturbation of the supersonic flow by injecting into the nozzle the detonation products with the main shock wave propagating in the supersonic flow, a computer simulation of the nozzle flow was performed. The nozzle of the 11D25 engine developed by Yuzhnoye State Design Office and used in the third stage of the Cyclone-3 launch vehicle was taken as a basis. The thrust vector control scheme relies on the use of the main fuel component detonation.

The evolution of the detonation wave in the supersonic flow of the combustion chamber nozzle was simulated numerically. According to the nature of the perturbation propagation in the nozzle, the lateral force from the perturbation has an alternating character with the perturbation stabilization in sign and magnitude when approaching the critical nozzle section. The value of the relative lateral force is sufficient for counteracting large disturbing moments of short duration. Thus, the force factors that can be used to control the rocket engine thrust vector are identified. Further research should focus on finding the optimal location of the detonation product injection in order to prevent mutual compensation of force factors.

Keywords*: detonation, rocket engine, gas injection, supersonic portion, nozzle, shock wave.*

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