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**SIMULATION OF A GAS INJECTION INTO THE SUPERSONIC NOZZLE AREA
IN GAS-DYNAMIC THRUST VECTOR CONTROL***Institute of Technical Mechanics**of the National Academy of Sciences of Ukraine and the State Space Agency of Ukraine
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Solid-propellant rocket engines are simple in design, highly reliable, and able to store the propellant for a long time without its degradation. Their main feature is that the propellant is a mixture of a solid fuel and a solid oxidizer, thus ensuring a uniform combustion and a stable discharge of the combustion products. However, the combustion rate cannot be controlled, and the combustion cannot be stopped or restarted. This calls for efficient methods of thrust vector control. Gas-dynamic methods, such as a gas injection into the supersonic nozzle area, offer a required flight path control without complex high-power mechanical systems. The importance of this study lies in improving the accuracy and efficiency of rocket flight control, which is critical for today's space and defense tasks. The numerical simulation of gas-dynamic control systems, in particular by an asymmetric gas injection, allows one to obtain detailed data on the flow behavior and optimize the design and operating conditions of the system. This study is concerned with a full-scale solid-propellant rocket engine with a gas-dynamic thrust vector control system based on the use of asymmetric forces that occur on the nozzle wall when the supersonic flow interacts with the injected transverse jets. To simulate the process in the Ansys Fluent software package, a geometric model of a nozzle with an asymmetric injection of the chamber gas into the supersonic area was developed. The injection flow rate was controlled by moving the valve flap. The simulation was carried out taking into account the temperature dependence of the main thermophysical gas parameters with consideration for dissociation processes by way of data approximation. The approximation was performed using piecewise polynomial functions. Nozzle flow patterns were obtained. The calculated results were compared with experimental test data and shown to be in satisfactory agreement with the lateral force measured during the fire bench tests of the prototype. From a practical point of view, the results obtained may be directly used to improve existing thrust vector control systems and develop new ones. This will improve rocket navigation accuracy, flight stability, and maneuverability, which is critical for complex space and defense tasks.

Keywords: *thrust vector, gas-dynamic control, solid rocket engine, numerical simulation, gas injection.*

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