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EFFECT OF THE SURFACE ROUGHNESS OF A POWER PLANT CHAMBER ON LOW-FREQUENCY SELF-OSCILLATIONS OF A COLD WORKING GAS

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Dynamic processes in the combustion chamber have a significant effect on the characteristics of the working processes of solid-propellant rocket engines (LPREs). Pressure jumps and a sharp increase in the local temperature of the combustion products in non-stationary engine operation modes can lead to overrating values of operating parameters and a failure of the LPRE combustion chamber structure. The dynamic processes in the LPRE combustion chamber develop in a complex interconnection of a large number of physical and chemical processes that occur in the gas-dynamic part of the working space of the engine chamber and often lead to self-oscillating modes of engine operation. This is evidenced by numerous data on LPRE fire tests. This paper presents the results of a numerical study of the effect of the LPRE chamber inner surface roughness on LPRE operating parameter low-frequency self-oscillations. The study was made using up-to-date computer simulation means and analysis.

Low-frequency (up to 1,000 Hz) oscillations in an LPRE combustion chamber were studied for a power plant test chamber in cold operation with the use of two different approaches to numerical modeling of the dynamics of in-chamber processes: the development and study of a 3D model of the dynamic system of combustion chamber structure – combustion products using the finite element method and the development and study of an axisymmetric 2D model of engine chamber gas flow using the finite volume method.

The study revealed a self-oscillatory flow regime caused by combustion product vorticity and acoustic feedback due to vortices colliding with the chamber components or the LPRE nozzle. It was shown that accounting for the wall roughness increased gas vorticity in the gas–solid dynamic interaction zone and the chamber gas oscillation amplitude (on the average, by a factor of 2.5 at a maximum wall roughness height of 56 μm). The calculated gas flow pattern in the vorticity zones of the chamber and the low-frequency gas pressure oscillation parameters are in qualitative agreement with the experimental ones.

Keywords: solid propellant rocket engine, working process self-oscillations, combustion product flow vorticity, acoustic oscillations, chamber wall surface roughness, finite volume method.

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