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ROCKET ENGINE IN OUTER SPACE THREE-DIMENSIONAL NUMERICAL SIMULATION

Abstract

One of the interesting areas of space engine building is the development of detonation engines . There are two main types of detonation engines: the pulse detonation engine (PDE) and continuously rotating detonation wave engine (RDE). The feasibility of switching to detonation combustion is mainly due to the higher efficiency of the thermodynamic cycle with detonation combustion. Currently, special attention is paid to the engine with a continuous detonation wave , this due to higher work frequencies and the possibility of a single initiation of the detonation wave. There are three main geometries of a continuous detonation wave (RDE) engine: annular RDE, a hollow RDE, and a disk RDE. There are two configurations among RDEs with an internal body: with an annular chamber and with an elliptical combustion chamber (RT RDE). In General, there are still many problems in the design of the RDE series combustion chamber, for example, such as ignition of detonation, stability of detonation, mixing of fuel and oxidizer. Experimental and theoretical RDE studies are conducted all over the world.

When considering engines of this type in space conditions, such problems arise as the process of starting such an engine in a rarefied environment and reaching stable operation, as well as the influence of the external back pressure on the thrust characteristics. In this paper, we perform a three-dimensional numerical simulation of an engine combustion chamber with a rotating detonation wave of a cylindrical type with an internal body fed by a hydrogen-air mixture or an acetylene-oxygen mixture. The process of starting the engine with pre-purging with neutral gas in low back pressure conditions was studied. The influence of the width of the combustion chamber channel on the stability of the detonation wave and thrust characteristics is considered. For this study, the author's code was created, which was based on a model of multicomponent gas dynamics with chemical transformations, taking into account the phenomena of transport, diffusion and turbulence. The code was tested by comparing it with experiments and accurate analytical solutions. To describe the kinetics of combustion acetylene used a simplified chemical scheme of interaction of 10 components, without "heavy" radicals: [C_2H_2, CO, CO_2, H_2, O_2, H_2O, OH, O, H, N_2]. For combustion kinetics of hydrogen – air mixture combustion, six kinetic mechanisms with the number of reactions from 18 to 22 and with 9 reacting components were considered: [H_2O, OH, H, O, HO_2, H_2O_2, O_2, H_2, N_2]. The influence of the chosen kinetic mechanism on the simulation results was studied. Various modes of operation of the detonation engine were obtained, including those with a stable detonation wave.

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