IAF SPACE PROPULSION SYMPOSIUM (C4)
Hypersonic Air-breathing and Combined Cycle Propulsion, and Hypersonic Vehicle (7)

Author: Ms. Elena Mikhalchenko
Scientific Research Institute for System Analysis, Russian Academy of Sciences (RAS), Russian Federation, Vi-Velena@rambler.ru

Dr. Valeriy Nikitin
Lomonosov Moscow State University, Russian Federation, *(email is not specified)*

THREE-DIMENSIONAL NUMERICAL SIMULATION OF ROTATING DETONATION ENGINE

Abstract

Currently, the space engine industry is addressing a number of promising areas of development. One of them is the use of detonation combustion of fuel. The expediency of transition to detonation combustion is mainly due to the higher efficiency of the thermodynamic cycle with detonation combustion. The main advantages of the detonation engine: a compact combustion chamber, short nozzles, high combustion efficiency and low concentrations of harmful substances. There are two main types of detonation engines: a pulsating detonation engine (PDE) and an engine with a continuous rotating detonation wave (RDE). The energy efficiency of detonation engines has been experimentally confirmed in many studies. In recent years, RDE has received more attention due to the simple structure of the camera, as well as the possibility of obtaining higher operating frequencies. Various modifications of engines with a continuous detonation wave were proposed: annular RDE, a hollow RDE, and a disk RDE. In this work, a three-dimensional numerical simulation of the combustion chamber of an engine with a rotating detonation wave of a cylindrical type with an internal body fed by a hydrogen-air mixture or hydrocarbon fuel is performed. The simulation is performed using the author's code that has been tested by comparison with experiments and exact analytical solutions of specific problems on detonation combustion. The mathematical model is based on a model of multicomponent gas dynamics with chemical transformations, taking into account the phenomena of transport, diffusion and turbulence. In the process of modeling the kinetics of an oxygen-hydrogen mixture, six kinetic mechanisms are used: Maas – Pope – Warnatz kinetics (19 reactions), Hong kinetics (20 reactions), Williams kinetics (22 reactions), Gri-Mech 3.0 (20 reactions), Lie – Zhong – Kazakov – Dryer kinetics (18 reactions) and author's kinetic mechanism (20 reactions). The influence of the selected kinetic mechanism on the simulation results was studied. For describing combustion of hydrocarbons the reduced mechanism based on combustion of acetylene (13 reactions) was considered. Schematic structure of combustion chambers for a detonation engine with a continuous detonation wave (CDE) operating stably were developed. Their thrust characteristics were evaluated.

Russian basic research foundation (project code 18-07-00889) is acknowledged for financial support.