Numerical simulation of a rotating detonation wave engine for various concentrations of combustible mixture

Elena Mikhalchenko, Valery Nikitin,

Federal Science Center "Scientific Research Institute for System Analysis of Russian Academy of Sciences", Nakhimovskiy pr. 36-1, Moscow, 117218, Russia

MikhalchenkoLena@yandex.ru

For a long time, the higher effectiveness of detonation regime of combustion against a common deflagration is well known [1], together with the possibility of its implementation in new engines. There are two main types of a detonation engine, pulse detonation engine [2], and an engine with a contiguous rotating detonation wave [3]. Recently, the second type of engines is of a great interest; its main advantages are: increased work cycle frequency, and a possibility of sub-sonic inflow of combustible mixture. There are three main geometries of a rotating detonation engine (RDE): annual RDE, hollow RDE, and disk RDE [4]. Among annual RDE's, an elliptic-shaped combustion chamber racetrack RDE is featured, e.g. such a chamber was considered in [5], and it was shown that curvatures influence processes in the chamber, and conditions for a stable detonation are stricter than for an ordinary annual RDE. A disk RDE configuration is regarded in works by Bykowski [6], and in the paper [7].

The current work presents the results of computational modeling of processes in the combustion chamber of a detonation engine. A 3D numerical simulation of the combustion chamber of an engine with a rotating detonation wave of a cylindrical type with an internal body was carried out. The mathematical model was based on a multicomponent gas dynamics model which considered chemical transformations and a RANS turbulent model. To describe the combustion of acetylene, a short kinetic scheme was used, involving the following components in the reaction: C_2H_2, CO, CO_2, H_2, O_2, H_2O, OH, O, H, N_2. The mechanism was tuned against full kinetic mechanisms using a self-ignition delay time. The calculations were carried out using the geometry of an engine prototype. Comparison with experimental data was made.

This work was supported by the subsidy of the Ministry of Science and Education of Russian Federation on the topic: "Investigation and development of detonation combustion chambers being used in perspective aerospace propulsion systems" (No. 075-15-2021-1385). We would like to express our gratitude to the Center for Collective Use of the Joint Supercomputer Center of the Russian Academy of Sciences for the provided computing resources.

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