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A STUDY OF A PULSE DETONATION CHAMBER CYCLE FOR PROPULSION PURPOSES

Abstract

A numerical simulation of the operation of the experimental installation aimed at developing a new propulsion system was carried out for various initial parameters, such as: the initial temperature of the mixture, the initial pressure, the concentration of the supplied mixture. The mathematical model includes a system of balance equations for transient 3D multi-component gas dynamics with chemical reactions considering a presence of a dispersed phase with low or medium density, and a RANS turbulent model. To calculate the phase of particles suspended in the supporting gas phase, a Lagrange approach is used; a group of model particles represents all the dispersed phase. The model particles are affected by the state and velocity of the gas in their vicinity, turbulent fluctuations, determined by the distributed parameters of the RANS model. The dispersed phase influence on gas is modeled by source terms in the balance equations, thus the whole model is two-way coupling one. Using a relatively small set of representative particles, a huge number of real particles are modeled so that each model particle corresponds to tens of thousands of real ones that have similar properties and are located approximately in the same place. Each model particle is determined by its position, velocity, size, temperature, the number of corresponding real particles, as well as the parameters that determine the turbulent properties of the gas in its vicinity. The dispersed fuel is inserted via injectors on the bottom edge of the combustion tube. After some delay it is ignited, and a detonation may occur in the tube. Products of detonation and combustion are ejected via the opposite side producing thrust force. Then, the products of reaction are displaced by inert gas, then filled with a fresh mixture, thus the process is repeated. The work describes the most important part of this cycle: ignition, combustion, and detonation of the flammable mixture. This work was supported by the grant in the form of the subsidy of the National Research Foundation of Korea(NRF) funded by the Korea government(MSIT) (NRF-2021K1A3A1A49097854) and 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).