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APPLICATION OF THE CONTINUOUS ROTATING DETONATION TO JET AND ROCKET PROPULSION

Abstract

The principle of Rotating Detonation Engine (RDE) is based on the creation of continuously propagating detonation in cylindrical combustion chamber. Since the detonation is a combustion in a constant volume, efficiency of the thermodynamic cycle is higher and there is potential to increase engine overall efficiency by order of 10 persent. Research on RDE has been continued for a last few years at the Warsaw University of Technology (WUT) as well as at the Institute of Aviation (IA) in Warsaw. In this paper experimental research on rotating detonation carried out at WUT and IL will be presented. Research at the IA are focused on evaluation of the conditions at which rotating detonation is propagating in cylindrical channels for hydrogen-air mixtures. Pressure – time history of those tests will be presented. Additionally, 3-D numerical simulations of the mixture formation as well as simulations of detonation propagation in cylindrical chambers are carried out at the Institute of Aviation. The simulations are based on the classical Euler equations describing the motion of a reacting inviscid gas. The model is capable to simulate detailed chemistry, but to save the computation time, simple single or two-step mechanisms are used. The code works on unstructured adaptive grids. This allows simulation the detonation in real geometries of the detonation chamber. The conducted simulations are used for analysis of complex flow – detonation front interaction and for estimating the thermodynamic parameters of the outflow gases. Results of calculations for RDE, which is under development at the Institute of Aviation will be presented. The experiments conducted at WUT were focused on applications of continuous rotating detonation to small scale rocket engine with aerospike nozzle fueled by gaseous hydrogen or methane with oxygen. This research demonstrated possibility of such engine operation, so there are no basic constrains to expect, that the rocket engines utilizing the continuous rotating detonation could operate on cryogenic propellants. Since the rocket engine operates on the rich mixture there are possibilities of utilizing afterburning of fuel rich products with air. In a such case rocket engine can also be used as a generator of very hot and only partially reacted "fuel" for ramjet and even scramjet applications. Such integrated rocket-ramjet engine could be proposed for propulsion of air-breading booster of future space transportation systems.