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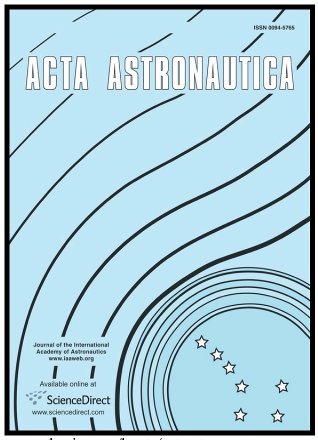

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Detonation onset following shock wave focusing

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Abstract

The aim of the present paper is to study detonation initiation due to focusing of a shock wave reflected inside a cone. Both numerical and experimental investigations were conducted. Comparison of results made it possible to validate the developed 3-d transient mathematical model of chemically reacting gas mixture flows incorporating hydrogen – air mixtures. The results of theoretical and numerical experiments made it possible improving kinetic schemes and turbulence models. Several different flow scenarios were detected in reflection of shock waves all being dependent on incident shock wave intensity: reflecting of shock wave with lagging behind combustion zone, formation of detonation wave in reflection and focusing, and intermediate transient regimes.

Keywords: combustion, detonation, shock waves, experiment, kinetics, simulation, parallel computing

Introduction

At present time RAM engines based on chemical burning of fuels and accelerating exhaust gases practically reached the top of their efficiency in terms of specific impulse. Due to that reason researchers are more and more inclined to seeking for different principles for RAM engines. As it was known since the beginning of 20-th century, combustion in gaseous mixtures could take place in two different modes: deflagration and detonation. Deflagration is a subsonic combustion mode, which serves the basis for the working cycle for all the combustion engines now. Detonation is a supersonic combustion mode, which was considered to be harmful for engines due to intense loads. Detonation combustion mode has definite exceptional properties as compared with classical deflagration mode used in modern engines. Those differences are: extraordinary higher rates of flame propagation (four orders of magnitude higher), higher pressure and temperature values in reaction zone, minimal entropy production for Chapman – Jouget regime. Unsteady-state transition processes between two combustion modes are possible. Control of detonation onset is necessary in perspective pulse detonation engines, which are under development now. In our numerical studies we'll use hydrogen fuel as an example, because, on one hand, it is a very perspective fuel making the engine exhaust much cleaner than that for hydrocarbon combustion [1,2], and on the other hand, chemical kinetics for hydrogen-air mixtures combustion are well developed [3-8]. The advantages of a constant volume combustion cycle as compared to constant pressure combustion in terms of thermodynamic efficiency has focused the search for advanced propulsion on detonation engines [9-11]. Numerical simulations of pulse detonation engines operation aimed at increasing their efficiency and developing control strategies consume much time and computational recourses. Parallel computing technologies and developing effective schemes aims at reducing the simulation time [12-18]. The thermodynamic efficiency of Chapman-Jouget detonation as compared with slow combustion modes is due

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