IAF MICROGRAVITY SCIENCES AND PROCESSES SYMPOSIUM (A2)
Fluid and Materials Sciences (2)

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INFLUENCE OF BOUNDARY CONDITIONS ON CELLULAR DETONATION

Abstract

The structure of the gas detonation front is a complex, multidimensional and time-dependent interaction of hydrodynamics and chemical reactions. This phenomenon is the subject of numerous studies and close attention. The combined behavior of the leading and shear waves forms a triple point configuration and creates diamond-shaped patterns known as detonation cells. This key feature of gas detonation waves is usually visualized by the imprint of triple shock wave trajectories on soot foil or by stripes of enhanced light emission from shock waves using open-shutter photographic techniques. This study is devoted to the influence of boundary conditions on of the ability to maintain a detonation structure and on the size of detonation cell. The main combustive mixture under investigation is syngas-air with [CO]:[H2]=1:1. The detonation is triggered by a strong detonation wave in a primary mixture: hydrogen with oxygen. Dependent on boundary conditions: partial outflow on walls, or closed walls, the imposed detonation in syngas-air mixture is either maintained in a cellular mode, or develops into a shock wave and retarding combustion. The mathematical model is based on multicomponent gas dynamics, taking into account the chemical transformations of the components and transport properties of species. In particular, it was obtained that periodic boundary condition on walls and closed boundary conditions bring to very similar solutions and stable cellular detonation in syngas with air. Fully open boundaries bring to quick degradation of detonation structure, partial opening brings to various cell sizes. This work was supported by the subsidy given to the Federal Science Center Scientific Research Institute for System Analysis of the Russian Academy of Sciences to implement the state assignment on the topic No. 1021061509701-5-1.2.1 “Development of algorithms and codes for multiscale processes and combustion simulations” (FNEF-2022-0021). 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.