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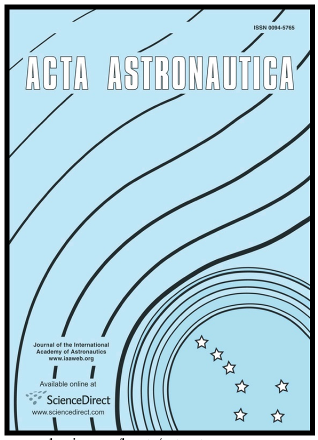

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Investigation of transient ignition process in a cavity based scramjet combustor using combined ethylene injectors

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Abstract

Large Eddy Simulation (LES) and experiment were employed to investigate the transient ignition and flame propagation process in a rearwall-expansion cavity scramjet combustor using combined fuel injection schemes. The compressible supersonic solver and three ethylene combustion mechanisms were first validated against experimental data and results show in reasonably good agreement. Fuel injection scheme combining transverse and direct injectors in the cavity provides a benefit mixture distribution and could achieve a successful ignition. Four stages are illustrated in detail from both experiment and LES. After forced ignition in the cavity, initial flame kernel propagates upstream towards the cavity front edge and ignites the mixture, which acts as a continuous pilot flame, and then propagates downstream along the cavity shear layer rapidly to the combustor exit. Cavity shear layer flame stabilization mode can be concluded from the heat release rate and local high temperature distribution during the combustion process.

Introduction:

Scramjet (supersonic combustion ramjet) engines have been widely investigated all over the world as a promising candidate for future air-breathing propulsion system [1-4]. Due to the flow residence time in the scramjet combustor is very short (order of 1 ms), consideration should be taken in the control of the flame stabilization, mixing and ignition process, and several flow choking devices and other methods were employed to improve the ignition and combustion characteristics.

The transverse injection of fuel from a wall orifice into supersonic flow fields is the simplest method and firstly studied and applied [5], a bow shock is produced because of the interaction of fuel and cross flow, where the boundary layer and fuel jet mix sub-sonically and this region is important due to its flame-holding capability of combustion. To reduce the stagnation pressure loss, weaker bow shock is achieved using angled (e.g.,60 or 30 deg rather than 90 deg) injection [6]. Accompanied by means of transverse injection, recirculation zone is generated using many kinds of flame-holders, such as backward steps [7], strut [8,9] or wall-mounted cavities [10], which will increase the flow residence time in the combustor and enhance fuel/oxidizer mixing. These typical approaches have been investigated using experiments and simulations, and the results show that the implementation of wall cavity into the combustor is an effective and robust method in the flame stabilization process without significant total pressure loss [11]. Wang et al. [12] and Adela Ben-Yakar [11] gave a brief review in the development of cavities both in the