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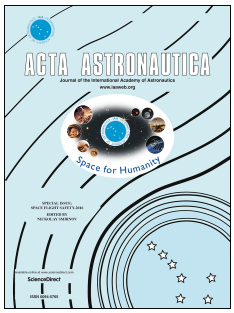

Experimental study on a rotating detonation combustor with an axial-flow turbine

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Experimental study on a rotating detonation combustor with an axial-flow turbine

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Abstract: The research on rotating detonation turbine engine is attracting much attention in recent years. In this study, experiments have been performed on a structure combining a rotating detonation combustor and an axial-flow turbine to investigate the propagation characteristics of the hydrogen-air rotating detonation wave. The stable rotating detonation wave is successfully initiated using the spark plug and pre-detonator, and there is still a velocity deficit of about 20% relative to the Chapmane-Jouguet value. There is a formation process for the stable detonation wave, and the formation time for the pre-detonator is far less than the spark plug, however the final state is independent on the ignition device. The rotating detonation wave successively appears the two-wave state with a same direction, the two-peak wave state, and the state of strong–weak alternation during the formation process. Finally, only one stable detonation wave is formed in the chamber and propagates until the operation off.

Key works: Rotating detonation combustor; Rotating detonation wave; Axial-flow turbine; Formation process

1 Introduction

The combustion is a strong chemical reaction with the conversion of chemical energy to heat. There are two main combustion types—deflagration and detonation. The detonation wave produced by the induction of shock wave propagates with a supersonic speed relative to the fresh mixture, and the detonation has the characteristics of the high thermal cycle efficiency and the rapid energy release rate. Therefore, the detonation has attracted much attention in the field of combustion research. At present, the power and propulsion systems based on detonation mainly are pulse detonation engines (PDEs) [1-4], standing detonation engines (SDEs) [5] and rotating detonation engines (RDEs) [6, 7].

The rotating detonation engine is a new machine generating continuous thrust by rotating detonation. The annular combustor is generally used in the RDE, with propellants injecting from the closed section. One or several detonation waves can be established by only igniting once during the operation. The detonation products, with the high temperature and high pressure, rapidly expand and then exhaust with the high speed at the opened section to generate thrust. The RDE not only has all of the advantages of detonation, but also has the advantages of the compact structure, the high working frequency and the stable thrust, which can also perform the thrust vector control [8-11].

Rotating detonation combustors (RDCs) can be used as the main combustion chamber for turbine engines, with an ability of pressure-gain, which can reduce the number of compressors and turbines comparing with conventional turbine engines and therefore can simplify the engine structure, reduce the weight of engine, improve the thrust/weight ratio and reduce fuel consumption. The rotating detonation turbine engine (RDTE) has several advantages over the conventional engines, so many research institutions have carried out relevant experimental and numerical simulation studies [11]. Ishiyama[12], Higashi [13] Wolanski [14], Debarmore [15], Welsh [16] and Naples [17] et al. carried out experimental studies on the rotating detonation turbine engine, and the feasibility of the engine was verified. Sousa et al. [18, 19] analyzed the thermodynamic performance of the gas turbine engine with a RDC through the results of numerical simulation, and established a fast model

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