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Hypersonic Air-breathing and Combined Cycle Propulsion, and Hypersonic Vehicle (7)

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EXPERIMENTAL STUDY ON THE COMBUSTION CHARACTERISTICS OF MULTI-PINTLE INJECTORS FOR ANNULAR COMBUSTOR

Abstract

The annular combustor is widely used in hypersonic propulsion systems such as rotating detonation engines and air turbo rocket engines. Their characteristics of high chamber pressure and wide flow range make it difficult for traditional swirl injectors to meet the requirements. Pintle injectors have attracted a lot of attention in recent research on variable-thrust rocket engines due to their inherent combustion stability and variable injection area characteristics. Owing to these advantages, pintle injectors have great potential for use in annular combustors. However, the interaction of multi-pintle injectors and their combustion characteristics in annular combustors still require further research. The liquid oxygen/kerosene engine in this study adopts two gas oxygen/kerosene torch ignitors, active cooling annular combustor produced by selective laser melting, and multiple sets of adjustable pintle injectors. A rich-oxygen ignition startup and rich-fuel shutdown timing strategy is employed to ensure the smooth and safe progress of the experiment. The injection characteristics of the pintle injectors are obtained through cold flow tests, ensuring that the flow deviation of each injector is no more than 10% by adjusting the pintle stroke. Reliable ignition and stable long-term operation are achieved in a total flow rate range of 500 to 1100 g/s and an oxygen-to-fuel ratio range of 0.35 to 0.90. The engine is capable of reuse and operating condition adjustment. Experimental results show that with the reasonable setting of valve timing, the engine starts smoothly. The combustion efficiency is significantly positively correlated with the oxygen-to-fuel ratio, which is related to the design characteristics of the pintle injectors. The successful ignition of the engine proves the feasibility of using pintle injectors in annular combustors, providing guidance for the development and application of annular combustors.