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EXPERIMENTAL RESEARCH ON BEHAVIOR OF A NON-PREMIXED ROTATING DETONATION ENGINE

Abstract

Attributed to potential of high thermodynamic efficiencies associated with pressure gain combustion and compact engine structure, rotating detonation engines (RDEs) have received increased attention over the past few years. Experimental research on behavior of a non-premixed rotating detonation engine was carried out on a model rotating detonation engine with 60 mm inner diameter and 70 mm outer diameter using hydrogen and air as propellants. Rotating detonation was initiated by a tangentially mounted pre-detonator, which emitted a detonation wave into the rotating detonation engine. Oscillated pressures inside the annular combustor and propagation processes of detonation waves were measured by fast response pressure sensors and high speed camera, respectively. The tested modular RDE allows for variation of total mass flow rate and equivalence ratio of propellant. During the experiments, tested RDE can exhibit three statuses, such as stable rotating detonation, unstable detonation and detonation failure. Under stable case, the detonation velocity is 1680.6m/s (83.9 percent of the theoretical value) and operating frequency is 7642Hz. However, the detonation velocity exhibited strong instability with low mass flow rate, which can vary from 790.1m/s (39.4 percent of the theoretical value) to 1533.9m/s (76.6 percent of the theoretical value). It was found that the equivalence ratio can affect operating behavior of RDE significantly. Rotating detonation happened more easily at fuel-rich conditions. There are equivalence ratio boundaries for stable rotating detonation. Equivalence ratio lower than the lower limit means no detonation can sustain. During the research it was also found that rotating detonation can happen more easily with larger mass flow rate, which can also broaden the operating boundary of equivalence ratio for stable detonation. Influence of geometry variation including throat structure and nozzle on the operating behavior and performance of a RDE was investigated. A central body with throat for a RDE results in higher chamber pressure and larger specific impulse compared to that without throat structure. Two types of nozzles, such as extended nozzle and CD nozzle, were tested to enhance the RDE's performance. CD nozzle can generate more thrust augmentation than extended nozzle with largest fuel specific impulse of 6214 s. Key words: Rotating detonation engine; Operating behavior; Performance; Propagating properties; Experiments