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Experimental Study on Intrinsic Thermoacoustic Instability from a Lean-Premixed Swirl Combustor with Tunable Acoustic Liners

Liangliang Xu, Sirui Wang, Jianyi Zheng, Guoqing Wang, Xunchen Liu, Lei Li*, Fei Qi
School of Mechanical Engineering, Shanghai Jiao Tong University
800 Dongchuan Road, Minhang District, Shanghai, China

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Abstract

The combustion instabilities are traditionally considered as a couple of the fluctuated heat release rate and the acoustic modes of a combustion chamber. Recently, a flame dominated thermoacoustic instability, which is not coupled with any acoustic modes, has been observed in several studies. This combustion instability mode is named as intrinsic thermoacoustic instability (ITA). Several works have been done on studying the mechanism of the ITA mode including some theoretical and experimental explorations. However, the mechanisms of ITA mode and its characteristics in the lean premixed swirl burner are still unclear, and relevant experimental results are still scarce. Acoustic liner with bias flow is one of the effective passive control strategy of combustion instability on suppressing the unstable acoustic modes of the combustion chambers. Research about the effects of the acoustic liners on ITA mode has been hardly reported in literature, which is just the focus of this study. In present work, a lean premixed swirl combustor with a tunable acoustic liner is built. A length of quartz tube is also mounted at the bottom of the chamber to capture the heat release signal with fast speed camera and photomultiplier (PMT). A hot-wire anemometer is set at the upstream of the flame and synchronized with the PMT to obtain the flame transfer function. The results show that: (1) in most cases, the ITA mode would arise as the 1/4 wave mode becomes stable. (2) The ITA mode is more unstable at relatively higher equivalence ratio, while the 1/4 wave mode is more prone to be triggered at lower equivalence ratio. (3) Within the scope of the present experiment, for the ITA mode, the HRR (Q') are always out of phase with the acoustic velocity perturbation U'. However, for the 1/4 wave mode, Q' are in phase with U'. (4) The ITA mode could be triggered with the increase of the bias flow Mach number. The pressure amplitude of the ITA mode would almost increase with the bias flow Mach number. (5) Changing the axial position of the acoustic liner and the rows of the small holes might have some influence on the ITA mode.