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热能工程

滞止点回流燃烧器热声脉动特性实验研究

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摘要：

为研究滞止点回流燃烧器的热声脉动特性，搭建了实验室规模的滞止点回流燃烧器试验台架，进行甲烷空气火焰的多工况试验研究。燃烧器采用同轴设计，中心管为燃料风管，外管套为空气管。燃烧室为内径48 mm，高300 mm的石英玻璃管，下端平齐密封，上端开口，燃烧器朝下并且其轴线与燃烧室轴线一致。研究发现，过低的输入功率将不能实现滞止点回流燃烧方式；当系统处于滞止点回流燃烧方式时，系统激发起剧烈的热声不稳定，其压力波的主峰振幅和有效振幅随着化学当量比的增大而增大，有效声压级超过138 dB；主峰共振频率与化学当量比无关，半峰频宽介于主峰频率的4%到10%之间，预示着滞止点回流燃烧器激发起的热声脉动在主峰频率附近声能分散，从而造成有效声压级与主峰声压级之间相差10 dB以上。另外，燃烧器出口的温度、NOx浓度和CO浓度均随着化学当量比的增大而增加，CO浓度的增加主要是由于化学当量比的增大，增加了燃料扩散的难度，从而提高了燃烧不完全性。

关键词： 滞止点回流 燃烧器 热声不稳定 频谱分析

Experimental Investigation on Characteristics of Thermoacoustic Oscillations in a Stagnation Point Reverse Flow Combustor

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Abstract:

In order to investigate the thermoacoustic features of stagnation point reverse flow combustors, a laboratory scale experimental setup was built, and a series of experiment cases of CH4/air flames were carried out. The combustor was designed to be coaxial, the central tube was used as the fuel injector, and the surrounding tube was adopted as the air nozzle. The combustion chamber was a quartz tube with an inner diameter of 48 mm and a height of 300 mm, the bottom of which was sealed, whereas the upper side was open to the atmosphere. The combustor faced towards the open side of the chamber and the axis of the combustor was consistent with that of the combustion chamber. Results show that the stagnation point reverse flow combustion mode could not be established with low system input power. Once the expected combustion mode was obtained, strong thermoacoustic instability is excited inside the combustion chamber. The main peak amplitude and the corresponding effective amplitude of the pressure oscillating waves increases rapidly with the equivalence ratio, and the effective sound pressure level is found to be larger than 138 dB, whereas the equivalence ratio has no impact on the main peak frequency. On the other hand, the ratio of half-peak breadth of the frequency to the peak frequency lies between 4% and 10%, indicating that the sound energy disperses around the main peak frequency, and results in a large difference (over 10 dB) of sound pressure level between the effective sound pressure level and the main peak sound pressure level. Moreover, the temperature and the NOx concentration as well as the CO concentration increase with the equivalence ratio. The reason of that the CO concentration increases with the equivalence ratio lies in that the fuel diffuses in a harder way at high equivalence ratios, resulting in much more serious incomplete combustion.

Keywords: stagnation point reverse flow combustor thermoacoustic instability spectrum analysis

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