Comparison of OH-PLIF visualization of the supersonic combustion in partly premixed and diffusion hydrogen-air flow

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1 Introduction

As the promising power device for hypersonic vehicle in the future, the dual-mode scramjet has attracted more and more attention from all over the world. Strut fuel injection and flame stabilization is a desirable configuration for the dual-mode srcamjet because of the higher penetration depth. Supersonic combustion visualization is of great significance to the development of scramjet, particularly for the premixed and the diffusion combustion system. Planar laser-induced fluorescence (PLIF) of the OH radical is employed to visualize the supersonic combustion field in a strut-based hydrogen fueled scramjet.

2 Experimental setup and results

Experiments are carried out in the scramjet test facility at Beihang University. The hydrogen combustion heater was employed to simulate Mach 2 flight conditions. The stagnation temperatures 1230 K and additional oxygen was injected into the airflow to keep a 0.21 O_2 mole fraction in the heated products. The scramjet which consists of an isolator and a combustor has a total length of 1310mm. The cross section area of the isolator is maintained at 32mm(height)×54mm(width), as shown in Fig.1. The OH-PLIF system employed in the research is based on the method outlined by Cai et al The strut locating at the central isolator can realize the hydrogen side injection and post injection, corresponding to the partly premixed and diffusion combustion respectively .

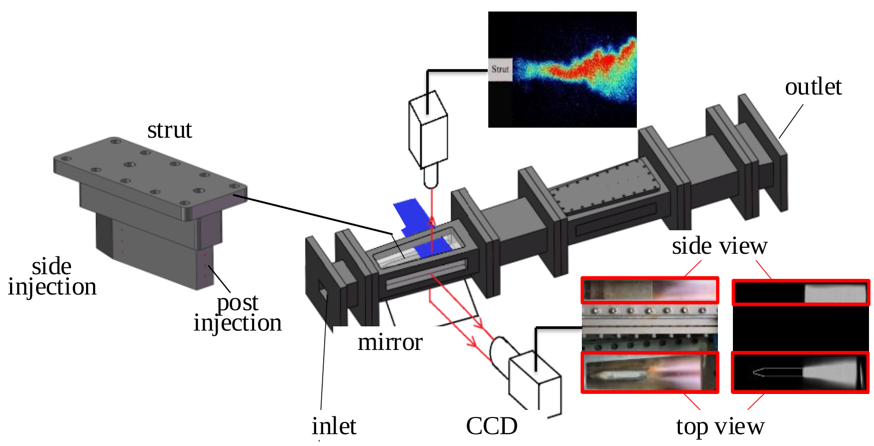

Fig.1 Strut-based scramjet and PLIF system

The instantaneous OH-PLIF images acquired at different times for the supersonic combustion in premixed and diffusion hydrogen-air flow were shown in Fig.2 and Fig.3. With regard to the premixed hydrogen-air flow, the instantaneous flame is close to the strut trailing edge. Due to the short exposure time, the dynamic behavior is very obvious, with an irregular large-scale vortex structure at the edge of the flame. The distribution range of OH was significantly reduced at low fuel equivalence ratio, mainly concentrated in the backflow zone at the tail of the strut, and began to diffuse outward only in the far downstream. With regard to the diffusion hydrogen-air flow, most of the flames in the post-injection condition demonstrate lifting phenomenon. The flame mainly distributes in the shear layer area and is closer to the top and bottom walls, showing obvious stratification phenomenon. No obvious flame is observed in the backflow area behind the strut. With the increase of equivalence ratio, the flame moves upward to the strut tail edge gradually, the overall brightness of the flame is low develops downstream. Because of the lift phenomenon, it should be a diffusion flame with partly premixed combustion.

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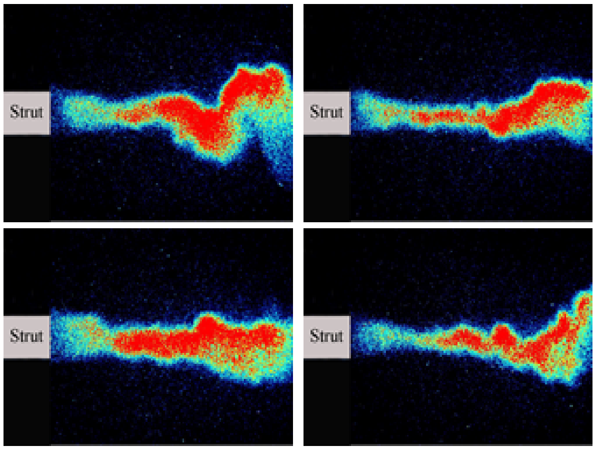

Fig.2 Instantaneous OH PLIF images at different times of the supersonic combustion in partly premixed hydrogen-air flow (ϕ=0.12)

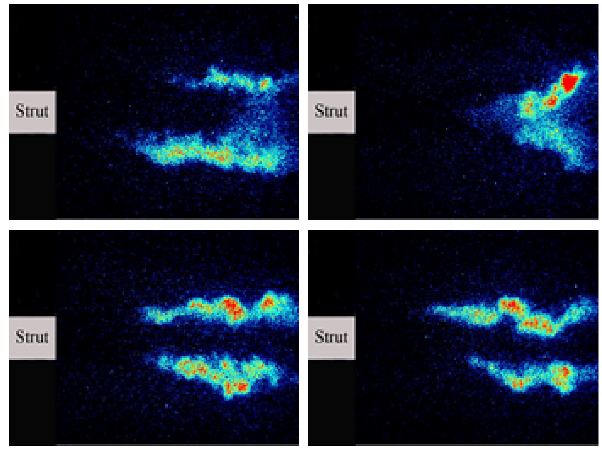

Fig.3 Instantaneous OH PLIF images at different times of the supersonic combustion in diffusion hydrogen-air flow (ϕ=0.22)

3 references

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