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Tomographic imaging of OH laser-induced fluorescence in laminar and turbulent jet flames

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Abstract

In this paper a new approach for 3D flame structure diagnostics using tomographic laser-induced fluorescence (Tomo-LIF) of the OH radical was evaluated. The approach combined volumetric illumination with a multi-camera detection system of eight views. Single-shot measurements were performed in a methane/air premixed laminar flame and in a non-premixed turbulent methane jet flame. 3D OH fluorescence distributions in the flames were reconstructed using the simultaneous multiplicative algebraic reconstruction technique. The tomographic measurements were compared and validated against results of OH-PLIF in the laminar flame. The effects of the experimental setup of the detection system and the size of the volumetric illumination on the quality of the tomographic reconstructions were evaluated. Results revealed that the Tomo-LIF is suitable for volumetric reconstruction of flame structures with acceptable spatial resolution and uncertainty. It was found that the number of views and their angular orientation have a strong influence on the quality and accuracy of the tomographic reconstruction while the illumination volume thickness influences mainly the spatial resolution.

Keywords: tomographic laser-induced fluorescence (Tomo-LIF), volumetric reconstruction, flame structure

(Some figures may appear in colour only in the online journal)

1. Introduction

In combustion science, laser diagnostics have contributed to understanding complex flame-flow interactions. Traditionally, two-dimensional (2D) techniques such as particle image velocimetry (PIV), Rayleigh scattering, and planar laser-induced-fluorescence (PLIF) have been used for measurements of velocity, mixing, and temperature fields as well as for the detection of reaction zones [1]. However, a deeper understanding of the inherent three-dimensional (3D) transient phenomena requires the extension of the planar techniques towards volumetric laser measurements able to provide out-of-plane data [2]. For this purpose, two general approaches can be identified based on their laser excitation scheme, namely multiple laser sheet methods and volumetric laser illumination methods. Both approaches can be implemented in combination with single [3, 4] or multiple cameras [5, 6] for signal detection.

Multiple laser sheets can be generated either by using two or more laser sources [5, 7, 8] or by scanning one single laser sheet through the measurement volume of interest [9–14].

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