Abstract for Work-in-Progress Poster ICDERS 2013

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Study of Flame Flashback in a Premixed Combustion System Using High-Speed Micro-PLIF

Premixed combustion of hydrogen-rich fuels in gas turbines is a worthwhile approach to prevent carbon dioxide emissions while simultaneously achieving very low nitrogen oxide emissions. However, safe and reliable combustion of such gas mixtures is very challenging. The presence of highly reactive mixture flow upstream of the desired flame position entails the risk of sudden flame flashback into the premixing section. This can lead to catastrophic failure of the machine components in this region as those are not designed for high temperatures.

This poster presents work in progress on transient flame propagation in a generic premixed combustion system. More specifically, wall boundary layer flame flashback in quasi-2D hydrogen-air channel flow is investigated. The objective of this study is to characterize the transition from stable flame configuration to flashback with very high temporal and spatial resolution. For this purpose, a long-distance UV-microscope (LaVision Questar QM1) is combined with a high-speed camera (Photron Fastcam SA-X) and an image intensifier (Hamamatsu C10880) to gain insight into the upstream flame propagation along the wall boundary layer employing the OH-PLIF (Planar Laser-Induced Fluorescence) technique. The resulting field of view is approximately 10x6 mm at an image resolution of 1024x632 pixel. The applied laser system consists of a dual-cavity pump laser (Edgewave, 532 nm) and a dye laser (Sirah Credo), allowing for repetition rates up to 40 kHz at an output wavelength of about 283 nm and single pulse energies up to 120 µJ. In combination with image post-processing, this technique allows for the characterization of the reaction zones, the upstream propagation speed of the flame front, and the determination of head-on and side-wall quenching distances. In addition to that, a second high-speed camera (Photron Fastcam APX-I^2) is synchronized with the PLIF camera to simultaneously record the OH*-chemiluminescence of the flame from a perspective perpendicular to that of the PLIF measurements in order to track the macroscopic flame movement during a flashback event. The ultimate goal of the measurements is to improve existing low-order correlation concepts for flashback prediction by adding physically meaningful input data, such as correct quenching distances and flame propagation characteristics.

The PLIF system has already been tested successfully on a turbulent premixed hydrogen-air swirl flame as well as on the stable channel flame using a 105 mm UV-lens (macroscopic PLIF). The results obtained are shown in the poster along with the measurement procedure and first conclusions regarding the shape and the anchoring position of the stable flame.