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Selected applications of planar imaging velocimetry in combustion test facilities

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Abstract: The contribution provides an overview on the applicability of particle image velocimetry (PIV) and Doppler global velocimetry (DGV) in combustion test facilities and summarizes experiences gained in a number of applications that were performed in the past 6 years. Emphasis is placed on the experimental aspects of each application rather than the interpretation of the acquired flow field data because many of the encountered problems and chosen solution strategies are unique to this area of planar velocimetry application. In particular imaging configurations, seeding techniques, data acquisition strategies as well as pre- and post-processing methodologies are outlined.

The article describes four similar applications of PIV in atmospheric and pressurized combustors containing single burners that are operated either with kerosene or natural gas. Aside from providing adequate optical access to the respective facilities the most challenging issue has been the reliable supply of non-volatile and non-reacting solid particle seeding. Given the rather large mass flows of up to 1 kg/s inside the combustors, sufficient seeding quantities could best be delivered by fluidized bed particle generators, sometimes even operated in parallel. The devices have been continually improved to allow constant delivery rates only during data acquisition periods, thus preventing unnecessary collection of seeding in the facility. The choice and handling of the seeding particle powder was found to be crucial for the overall success of the measurements.

The first application describes initial trials on a swirled kerosene spray fuel nozzle at 3 bars and illustrates problems encountered due to flame luminosity as well as strong light scattering from the fuel droplets. The second application summarizes the challenges faced in obtaining phase-resolved, three-component velocity data from a generic atmospheric gas combustor using stereoscopic PIV. A much larger, swirl stabilized gas burner as utilized in stationary power generation was the subject of the third described application. Here a novel methodology of data acquisition and post-processing provides phase resolved velocity maps even of flows that have non-constant oscillation frequencies. Finally, the fourth application describes how the combination of PIV with DGV can yield three-component velocity data in areas of limited optical access using only one viewing window and one separate window (or probe) for light sheet delivery.

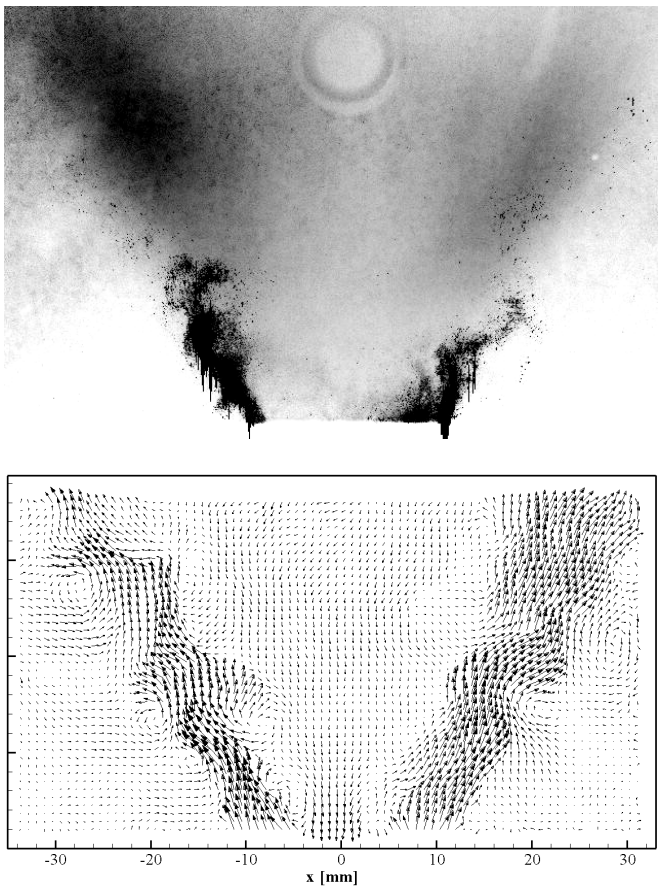

Fig.1: PIV recording of a fuel-rich kerosene flame above a double-swirled fuel nozzle at 3 bar showing strong flame luminosity and high light scattering from fuel droplets. Below: processed PIV data set obtained for leaner operating conditions exhibiting less signal saturation. (Note: to enhance contrast image intensities have been inverted)