Development of an annular porous burner for the investigation of adiabatic unconfined flames

Johann Wäsle, Anton Winkler, Elisabeth Rößle, Thomas Sattelmayer

Lehrstuhl für Thermodynamik, TU München, Germany, waesle@td.mw.tum.de

Keywords: Entrainment effects, Porous burner, PIV, OH-LIF, Chemiluminescence

Combustion experiments are often performed on freely propagating flames. However, these flames suffer from the influence of entrainment of cold ambient gas. This influences not only the equivalence ratio but also the adiabatic flame temperature or leads to quenching effects downstream of the nozzle exit. Thus, a transfer of the results from such studies to the case of technically more relevant confined flames is difficult. To avoid entrainment effects without losing easy optical access and free field acoustics, a new burner setup was evaluated and tested. A hot exhaust gas stream is generated by a porous burner, which encloses the investigated swirl flame and avoids influences from the walls of a combustion chamber (figure 1).

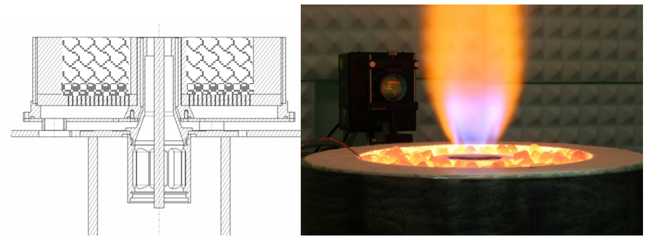

Fig. 1: Sketch of the TD1 swirl burner enclosed by the porous burner (left). Both burners during operation (right)

Durability tests of the burner showed that an operation of the burner over several hours is possible, but a continuous monitoring is recommended.

For the purpose of the proper porous burner design the flow field of the swirl burner was measured with a high-speed PIV system. The influence of the hot co-flow on the velocity fields and the chemiluminescence distributions were investigated. It was found that the distributions of u'_{rms} and the turbulent length scale l_t are almost identical for the flame with and without hot enclosure (figure 2).

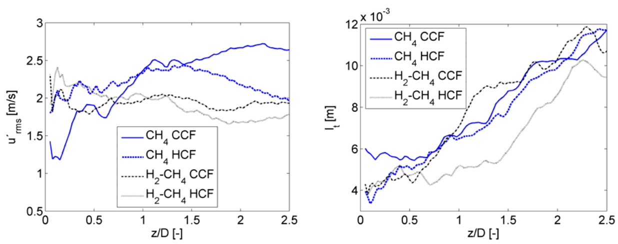

Fig. 2: u'_{rms} and l_t distribution averaged over r, plotted in axial direction.

However, the CH* chemiluminescence measurements and the planar OH-LIF distributions are substantially influenced by the entrainment of cold ambient gas. The equivalence ratio drops downstream since fresh air is mixed with the fuel-air mixture from the TD1 burner. Thus, the flame temperature decreases and so does the intensity of the chemiluminescence signals. This leads to a shift of the maximum intensity too far upstream (figure 3).

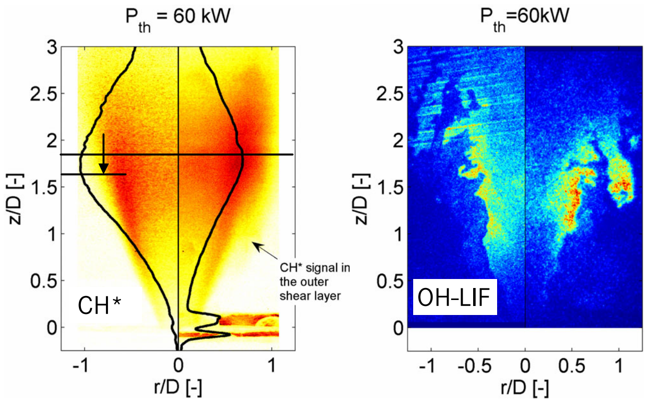

Fig. 3: CH* chemiluminescence and OH-LIF distribution for cold (left parts) and hot (right parts) co-flow

The presented paper will contain the following topics:

- Design and operation of the porous burner.
- Comparison of the velocity flow fields with and without co-flow, measured with high speed PIV.
- Comparison of the heat release distribution on the basis of CH* chemiluminescence and OH-LIF measurements.

With the presented setup a simple option for experimental investigations of the effects of the entrained cold medium on the burning behavior of unconfined flame is provided.

Acknowledgements

The authors gratefully acknowledge the financial support by the Bavarian Research Cooperation (FortVer) and the German Research Council (DFG) through the Research Unit FOR486 “Combustion Noise“.