Université franco-allemande Deutsch-Französische Hochschule

Control of Soot Formation in Laminar Flames by Magnetic Fields and Acoustic Waves

Within the Cotutelle framework the numerical part of the work was carried out at the Institute for Combustion Technology, RWTH Aachen University and the experiments at the Institut Jean le Rond d'Alembert, Université Pierre et Marie Curie/Paris06, Sorbonne Universités.

In the thesis light is shed on soot formation processes and combustion stability in laminar coflow flames influenced by magnetic field gradients and acoustic forcing. Both influences have been assessed experimentally and numerically.
First, the CIAO in-house code was extended with improved diffusion and radiation models to well predict soot volume fraction fields, applying detailed chemistry and the Hybrid Method of Moments description in a steady coflow flame. Then, pulsating sooting flames at 20 and 40 Hz were studied. Conclusions on the coupling of flow forcing, flame temperature, and peak soot volume fraction are drawn[1]. The findings can be used to improve future soot models, especially, regarding the different timescales of gas-phase chemistry, the formation of polycyclic aromatic hydrocarbons, and soot coupled with unsteady flows. To investigate soot formation under magnetic field gradients, a Santoro type burner is used. The measurement techniques applied in the course of this thesis are high-speed luminosity measurements, Background Oriented Schlieren (BOS) and one- and two-color Modulated Absorption/Emission (MAE) techniques. The magnetic field impact on soot formation was first studied experimentally in steady laminar non-premixed[2] and partially premixed[3] flames. A magnetic scaling of soot production similar to the known scaling with oxygen was documented for the non-premixed flames. For certain conditions, a trend reversal could be observed in the partially premixed flames. Furthermore, it is shown experimentally and reproduced computationally that a magnetic field gradient can stabilize a spontaneousely oscillating non-premixed flame. A local inviscid stability analysis based on the results of the direct numerical simulation is presented for the observed flame, to investigate the flame's response to small perturbations of the mean velocity, temperature, fuel, and oxygen massfraction under magnetic field exposure. The magnetic field is found to reduce the perturbations' growth rate[4]. The study is completed by identifying a domain where naturally oscillating flames can be stabilized and controlled by magnetic field gradients.

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[2] A. Jocher, H. Pitsch, T. Gomez, G. Legros, *Modification of sooting tendency by magnetic effects*, Proc. Combust. Inst. 35: 889-895 (2015).

[3] A. Jocher, J. Bonnety, H. Pitsch, T. Gomez, G. Legros, *Dual magnetic effects on soot production in partially premixed flames*, *Proc. Combust. Inst.* 36: 1377-1385 (2017).

[4] A. Jocher, J. Bonnety, H. Pitsch, T. Gomez, G. Legros, *Combustion instability mitigation by magnetic fields*, Under review.

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