AVAILABLE FOR POST-DOCTORAL POSITION

Emilien Varea **PhD CORIA - INSA Rouen**
07/12/1985
French

Work address:
Av. de l'Université
76801 Saint Etienne du Rouvray, France

Contact:
emilien.varea@coria.fr
Tel: **+33 673 533 889**
+33 232 959 807

BACKGROUND

2009-2012 **PhD degree.**
Thesis defense: **December 2012**

Title :
Experimental analysis of spherical expanding flames

Laboratory: CORIA - UMR 6614

Supervisors: **M. Bruno Renou**, Professor, CORIA, INSA Rouen, France
M. Vincent Modica, Assistant Professor, CORIA, University of Rouen, France

Grant: **Interreg Program:** Cross-Channel Centre for low Carbon Combustion (C5)

2009 **Master's degree,** CORIA, University of Rouen, France.
« Automatic post-processing development to extract simultaneous measurements of OH, mixture fraction and velocity fields at the leading edge of the flame. Application to lifted flames enhanced or not by electric field »

Research Activity

Key Words:

Optical diagnostics applied to combustion (high-speed PIV, tomography, OH-PLIF), Laminar premixed flames, flame speed, lifted flames, Lewis Number, Markstein Lengths, Biofuels.

My activities focus on experimental approaches of combustion. Two topics have been particularly investigated during my master's degree **[a]** and PhD works **[b]**. A short description is given below.

[a] Electric fields have long been known to enhance flame stabilization. However, many questions remain and a lot of contradictory results are reported. These contradictions clearly illustrate that the physical processes involved in the combustion enhancement by electric fields are not well understood; it could also be a modification of the chemistry or the action of an ionic wind on fresh flow. In order to clarify these issues, measurements of OH radical, mixture fraction and fresh gas velocity were performed on lifted propane air flames enhanced or not by an electric field.
My work consisted in post-processing sets of data from a previous PhD work (PhD thesis by Karine Criner, Supervisors: Dr. Armelle Cessou and Dr. Pierre Vervisch, CORIA). Specific algorithms were used that enable the automatic extraction of OH radical, which makes it possible to determine the leading edge flame. Conditional measurements of mixture fraction and velocity could then be performed at this position. Specific attention was given to error assessment on mixture fraction (due to filtering process and low signal to noise ratio at stoichiometric value). It was shown that, in both cases, the flame still burns at the stoichiometric value. Also, comparing the two sets of data (flame polarized or not), the electric field makes the velocity in front of the flame decrease, which supports the ionic wind assumption. This work has been published in *Experiment in Fluids* **[1]**.

[b] The work developed in my PhD focused on the determination of laminar burning velocity. It is well known that laminar burning velocity is a crucial value, very useful for both combustion modelling and kinetics scheme validation and improvement. Experimentally, accurate data are needed. To succeed in this, the spherical flame with constant pressure method was chosen. It allows high pressure, high temperature initial conditions and also, the effect of stretch can be well taken into account.
During my PhD work, an experimental apparatus was designed and the automation of acquisition procedure was realised in order to ensure reproducible experiments. In addition, an original post-processing tool coupled with high-accuracy spherical flow field measurement was developed. It is based on the determination of the displacement speed, that is the velocity at which the fresh gases enter in the preheat zone. This pure kinematic measurement ensures an extraction of the laminar burning velocity without introducing any assumption. More details on the technique and also on the validation of the post processing can be found in **[2]**.
Following this work, a second study experimentally determined the laminar burning velocities and Markstein lengths for pressurized isooctane/ethanol/air mixtures using this novel technique. Those mixtures are representative of alternative fuels that can be used in Internal Combustion Engines (ICE). These measurements are crucial for the validation and understanding of the combustion of new fuels in thermodynamic conditions close to those encountered in ICE. The measurements are compared with chemical kinetic mechanisms. This work has been presented and published at the *34th Symposium on Combustion* **[3]**.
In spherical geometries, various formulations, analytical or integral, lead to different expressions of the consumption speed. Remaining questions concern the validity of the assumptions induced in the formulation; for example: adiabaticity, stretch and flame temperature, pressure rise, profile of species in the flame thickness. A comparison of these developments with measurements performed using the kinematic method has been carried out for fuels representative of various Lewis numbers. The limitations of these approaches in terms of assumptions and experimental uncertainties are discussed. A paper is being written on this.

PUBLICATIONS

[1] A. Cessou**, E. Varea**, K. Criner, G. Godard, P. Vervisch, *Simultaneous Measurements of OH, mixture fraction and Velocity Fields to Investigate Flame Stabilization Enhancement by Electric Field*, **Experiments in Fluids**, Vol. 52, pp.905-917,2011

[2] E. Varea, V. Modica, A. Vandel, B. Renou*, Measurement of laminar burning velocity and Markstein length relative to fresh gases using a new post-processing procedure. Application to laminar spherical flames for methane, ethanol and isooctane/air mixtures,* **Combustion and Flame**, Vol. 159, pp. 577-590, 2012

[3] E. Varea, V. Modica, B. Renou and A. M. Boukhalfa, *Pressure effects on laminar burning velocities and Markstein lengths for Isooctane-Ethanol-Air mixtures*, **Proceedings of the Combustion Institute**, Vol. 34, *In Press*

INTERNATIONAL COMMUNICATIONS

[4] E. Varea, K. Criner, G. Godard, P. Vervisch, A. Cessou, Simultaneous Measurements of OH, mixture fraction and Velocity Fields to Investigate Flame Stabilization Enhancement by Electric Field, **International Symposium on Applications of Laser Techniques to Fluid Mechanics**, Lisbon (Portugal), 2010.

[5] E. Varea, K. Criner, G. Godard, P. Vervisch, A. Cessou, Investigation of Flame Stabilization Enhancement by Electric Field using Simultaneous Measurements of OH, mixture fraction and Velocity Fields, **European Combustion Meeting**, Cardiff (U.K.), 2011.

[6] E. Varea, A. Vandel, V. Modica, F. Corbin, G. Godard, B. Renou, Measurement of laminar flame speed for high pressure and high temperature conditions : validation of the facility and developpement of a new tool for post-processing, **International Symposium on Applications of Laser Techniques to Fluid Mechanics**, Lisbon (Portugal), 2010.

[7] E. Varea, A. Vandel, V. Modica, B. Renou, Laminar Burning Velocity and Markstein length relative to fresh gases determination applied on ethanol air flames**, European Combustion Meeting**, Cardiff (U.K.), 2011.

[8] E. Varea, A. Vandel, V. Modica, B. Renou, Laminar Burning Velocity and Markstein length relative to fresh gases determination Isooctane-Ethanol air flames, **International Colloquium on the Dynamics of Explosions and Reactive Systems**, University of California, Irvine (California, U.S.A.), 2011.