PhD – Experimental analysis of flame-wall interaction with reactive hydrogen/air flows - (F/M)

Information

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Context

Despite the COVID-19 pandemic, atmospheric **carbon dioxide** levels in 2021 reached 150% of pre-industrial levels [1], leading to huge changes in human ecosystems (food, health, etc.) [2]. The 2015 Paris Agreement set out a policy to take urgent action to combat **climate change and its impacts** (SDG 13), so that all industrial sectors dependent on fossil fuels **decarbonize** their uses [3]. In addition to these urgent environmental concerns, the current **energy crisis** also highlights the need to secure the energy sector by reducing our dependence on fossil fuels. The development of a hydrogen economy is seen as a key option for ensuring access to affordable, reliable, sustainable and modern energy (SDG 7).

Nevertheless, **major technological challenges** currently prevent the implementation of hydrogen as a chemical energy carrier in energy systems. Among others, the **higher specific energy density of hydrogen** (~120 MJ/kg vs. 50 MJ/kg for methane) raises a technological challenge concerning **the thermal management** of combustion chamber walls, which have to withstand long periods (>10,000 hours) exposed to high temperatures (~2000 K) and severe oxidizing/corrosive reactive environments. So, to fasten the generalization of future clean, efficient and robust combustion technologies, it is crucial to gain a detailed understanding of **the primary physical processes of hydrogen-based reactive flows interacting with walls.**

PhD objectives

The aim of this thesis is to understand the physical mechanisms involved when a **reactive hydrogen-air flow interacts with a wall**. The scientific strategy consists in **implementing non-intrusive optical metrology** in a generic configuration reproducing flame-wall interaction processes with or without an air film. **The originality** of the subject of this thesis is justified by the lack of experimental data with the use of near-wall hydrogen. The objectives of this thesis are as follows:

1. <u>Develop and characterize a generic case of flame-wall interaction.</u> An existing combustion bench (CENTOR) will be modified to generate a turbulent premixed flame

over a wide range of equivalence ratios. This system will be characterized by establishing the stability diagram using global measurements (OH* chemiluminescence). An (existing) parietal air film generation system will also be studied to reproduce a cooling technology. Wall temperature measurements (laser-induced phosphorescence) will complete these stability diagrams with the inclusion of the thermal aspect.

2. <u>Detailed analysis of flame dynamics.</u> An understanding of the behavior of flame dynamics in the vicinity of the wall will be carried out in order to shed light on the mechanisms by which nitrogen oxides (NOx) are formed. To this end, a number of operating points will be selected (action 1 above). Flow topology and flame structure measurements will be carried out jointly. A comparison between a solid wall and a wall equipped with an air film will illustrate the role of the air film.

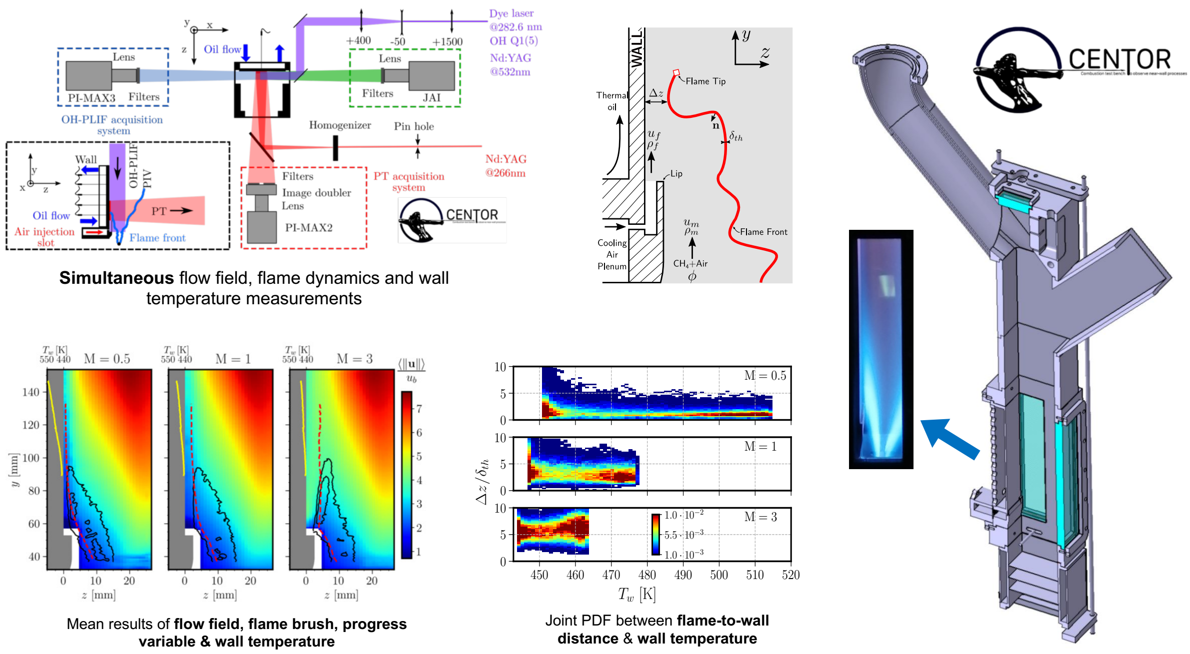

Figure 1: example of studies on flame-wall interaction (PhD of S. Petit and A. Blaise)

Work environment

The management team at the Complexe de Recherche Interprofessionnel en Aérothermochimie (CORIA) has been addressing these issues for several years. The ANR projects WALL-EE (CORIA, 2019-2023) and RIN-FEDER MATRYSSE (CORIA, 2019-2022) aimed to develop an experimental methodology (including test benches and near-wall optical diagnostics, see Figure 1) to **understand the physico-chemical processes occurring at the gas-solid interface**. This thesis will build on this work (2 theses) and related results [4-7]. This thesis is part of the ANR OASIS program. This project brings together three scientific teams from two French laboratories (CORIA-Rouen and PPRIME-Poitiers) to capitalize on their expertise/resources around the theme of near-wall combustion using hydrogen as an energy carrier. Three PhD students will be working closely together in this environment. INSA Rouen Normandie's long-standing industrial partners (SAFRAN) and other players in the aeronautics industry (AIRBUS) will also be supporting the project, with a view to technology transfer.

Candidate skills

The candidate will have an engineering/master's degree in energetics, with solid skills in fluid mechanics, heat transfer and combustion. Knowledge of metrology (e.g., spectroscopy, laser, optics) and mechanics is desirable, with a marked appetite for experimental science. The candidate will have strong interpersonal skills, as he/she will be working as part of a research team of around ten people. Strong oral and written communication skills (French and English) are essential for the dissemination of thesis work.

To apply, send a CV, cover letter, M1 and M2 grades, and contacts of people recommending you. (send to Pradip Xavier, pradip.xavier@coria.fr).

References

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