Research Internship at EM2C Laboratory, CentraleSupélec, University Paris Saclay, France
Period of 6 months in 2022 (flexible start date)

Experimental study of plasma-assisted combustion for a low-NOx aeronautical combustion chamber

Context:

New energy technologies must answer the challenge of reducing CO_2 and NOx emissions in hydrocarbon combustion, which represents more than 80% of primary energy consumption worldwide. The GreenBlue program (Greenhouse gas and pollutant emissions reduction using plasma-assisted combustion for a Blue planet) is a new 5-year program started in November 2021 at EM2C to develop **carbon-free** and **carbon-neutral** solutions using **hydrogen** or **sustainable alternative fuels**, with **low NOx emissions**.

EM2C has a leading expertise in plasma-assisted combustion and operates several experimental facilities (10 to 200 kW) specifically dedicated to this program. Experimental and numerical work will be conducted to address with three major questions:

- understand the fundamental physical phenomena enhancing combustion and reducing NOx with an original method based on Nanosecond Repetitively Pulsed (NRP) discharges. The NRP approach consists in stabilizing flames with high voltage pulses of 10 ns duration applied at 10-100 kHz.
- validate and apply the acquired knowledge in medium to large-scale combustion chambers.
- Develop numerical models to simulate plasma-assisted combustion in high power rigs representative of industrial applications.

Internship goal:

A promising way to design low-NO_X combustion chambers for industrial applications consists in operating in the lean combustion regime. However lean flames are instable but can be efficiently stabilized by NRP discharges. The goal of this internship is to study the stabilization of lean flames with NRP discharges in a large-scale combustion chamber with an aeronautical injector, called BIMER. This novel facility is unique and has no equivalent worldwide. It has been shown that lean flames up to 150 kW can be stabilized in this burner. The underlying mechanisms of flame stabilization in a complex configuration are not well understood. During the internship, we will experimentally study the optimal plasma location, electrode geometry and, plasma parameters to enhance the combustion and reduce NO_X emissions. The results will serve to identify the main physical phenomena of plasma-flame interaction in complex configurations. In the long term, this study will also allow to reduce the complexity of the injection system and thus cut costs of engine production, repair, and maintenance in practical applications.

In parallel, we will study fundamental aspects of nanosecond discharges by Optical Emission Spectroscopy in various gas mixtures. These measurements will allow to improve kinetic mechanisms and develop NRP discharges models for Large Eddy Simulation (LES) solvers.

During this internship, the student will closely collaborate with the other students and Ph.D. students of the GreenBlue program as well as the members of the plasma and combustion teams.

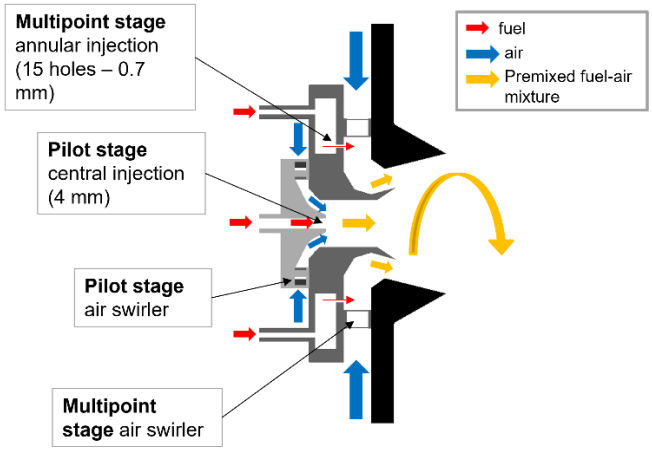

Figure 1 Schematic of the aeronautical injector

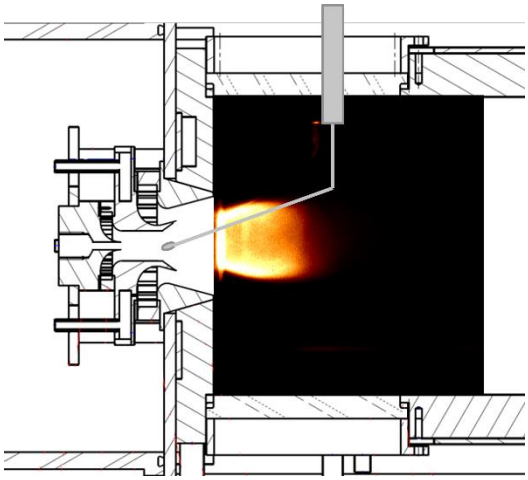

Figure 2 Stabilization of a lean flame (P = 50 kW, Φ = 0.28) in the BIMER facility

Profile of the candidate:

This internship is offered to final year engineering students or final year Master students. Knowledge of plasmas and combustion is preferred, but not required. The applicants should have a strong motivation for experimental physics, teamwork, and energy transition issues. The internship can be continued with a Ph.D. thesis at the EM2C laboratory (CNRS/CentraleSupélec) as part of the ERC program GreenBlue.

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