JOB OFFER – STAGE

Plasma discharge assistance for Sustainable Aviation Fuel Lean Blow-Out extension

OFFER INFORMATION

Reference: E&S-2024-NB-1

Location: 42 Avenue Gaspard Coriolis – 31057 Toulouse

Team: E&S

Supervisors:

- Nicolas Barléon
- Thomas Lesaffre
- Eléonore Riber

Gratification: 700€ net per month - M2 level or last year at engineering school

Period: 6 months - from: 03/02/2025

Key words: Sustainable Aviation Fuel – Plasma-Assisted Combustion – Lean-Blow-Out – Chemistry – Large Eddy Simulations

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HOSTING TEAM - E&S

The Energy & Safety team, formerly the CFD-Combustion team, focuses on cross-disciplinary activities aimed at developing, optimizing and deploying scientific codes dedicated to advanced combustion calculations in industrial geometries. The team focuses on the simulation of flows, applying them to aircraft, rockets, helicopters, car engines, turbines and more. The result is essential tools for a wide range of applications, with the leitmotiv: let's calculate systems before we build them. More specifically, team members develop models and tools covering chemical reduction, turbulence, combustion, two-phase systems, combustion instabilities, etc., to meet both academic and industrial challenges. Thanks to its position, the team collaborates with numerous scientific groups, design offices of Cerfacs associates, and other Cerfacs teams.

CONTEXT

The aeronautical industry faces a growing pressure to reduce its carbon footprint, making Sustainable Aviation Fuel (SAF) a critical component in achieving net-zero emissions. Moreover, Drop-in Sustainable Aviation Fuels (SAFs) represent the most mature alternative fuel for aviation.

Existing SAFs exhibit unique combustion properties that can impact flame stability and operability in modern gas turbines, particularly under lean conditions necessary for reducing nitrogen oxide (NOx) emissions. Ensuring reliable performances of SAFs in combustion chambers require innovative approaches to overcome challenges such as lean blow-out (LBO). Developing advanced concepts, such as plasma-assisted combustion, offers a pathway to enhance engine operability by stabilizing flames, extending LBO limits, thus eventually promote the use of SAFs in the next-generation of aviation engines.

MISSION

This internship aims to explore the potential of plasma assistance, more precisely Nanosecond Repetitively Pulsed (NRP) discharges, in extending the Lean Blow-Out (LBO) limits in a lab-scale combustion chamber employing Sustainable Aviation Fuels (SAFs). As a first step, the non-assisted flame of the Spray Stabilized Burner (SSB) operated at DLR [SSB] will be analyzed in light of existing numerical LBO data, to propose optimal discharge locations for plasma stabilization (based on mixture composition, local residence time, ...). Large Eddy Simulations (LES) incorporating a phenomenological plasma model will be conducted with the reactive compressible AVBP solver (https://www.cerfacs.fr/avbp7x/) to evaluate the influence of plasma-generated radicals (i.e., O, OH, H ...), as well as fast and slow gas heating, on flame stabilization mechanisms.

In parallel, the second objective will be to investigate the validity of the Hybrid Chemistry (HyChem, [Wang2018]) model under non-equilibrium plasma conditions. The study will assess whether fuel fragmentation and oxidation can remain decoupled in the presence of plasma-generated radicals or whether these processes are coupled through radical-driven interactions, using canonical combustion cases such as ignition or laminar flames. If the decoupling is preserved, a C1-C5 plasma mechanism will be developed by extending validated C1-C3 cross-sections to higher hydrocarbons, following the approach used in [Kosarev2009]. If not, the coupling mechanisms will be analyzed to identify radical sensitivities and their effects on combustion chemistry (pyrolisys and oxidation). Ultimately, a plasma-adapted HyChem model will be proposed, to improve our understanding of plasma-assisted SAF combustion dynamics, and establish reduced-order models allowing for LES of plasma-assisted SAF combustion. Eventually, the new model will be implemented within the AVBP solver and compared to the baseline model.

[Grohmann2016] J. Grohmann, et al., 52nd AIAA/SAE/ASEE Joint Propulsion Conference (2016)
[Wang2018] H. Wang et al, A physics-based approach to modeling real-fuel combustion chemistry – i. evidence from experiments, and thermodynamic, chemical kinetic and statistical considerations, Combustion and Flame 193 (2018) 502–519.
[Kosarev2009] N. Kosarev et al, Kinetics of ignition of saturated hydrocarbons by nonequilibrium plasma: C2H6- to C5H12-containing mixtures, Combustion and Flame 156 (1) (2009) 221–233.

DESIRED PROFILE

- Master's degree (M2) or engineering school
- Background in fluid mechanics and energy
- Training in CFD (Computational Fluid Dynamics)
- Knowledge of combustion and/or plasma is a plus
- Programming skills (Fortran, C, or C++ and Python)
- Proactive, curious, and autonomous

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HOW TO APPLY ?

To apply, please send your CV and covering letter to nicolas.barleon@cerfacs.fr , applications are open until 30/04/2025.

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