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JOB OFFER – PhD

Simulation of high pressure hydrogen combustion for gas turbines (M/F)

OFFER INFORMATION

Reference: ES-2025-TP-01
Team: E&S

Location: 42 Avenue Gaspard Coriolis – 31057 Toulouse
Contact person: Thierry Poinsot - Quentin Douasbin

Salary: 33 K€/year (gross)
Period: 3 years - from: 01/10/2025

Key words : Hydrogen, simulation, gas, turbines

CERFACS

Cerfacs is a private research, development, transfer and training center for modeling, simulation and high-performance computing. Cerfacs designs, develops and proposes innovative software methods and solutions to meet the needs of its partners in the aeronautics, space, climate, environment and energy sectors. Cerfacs trains students, researchers and engineers in simulation and high-performance computing.
Cerfacs works closely with its seven partners: Airbus, Cnes, EDF, Météo France, Onera, Safran et TotalEnergies.

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

CERFACS is looking for PhD students for two exceptional European projects:
- SELECT-H, a European Research Council project (cerfacs.fr/select-h) focused on fundamental research, in conjunction with IMFT, which is conducting experiments on hydrogen flames and
- INSIGH2T, a project aimed at major turbine manufacturers.

These two projects concern aeronautical turbines (SAFRAN HELICOPTER AND SAFRAN AIRCRAFT in France) and land-based gas turbines (BAKER HUGHES and ANSALDO, in conjunction with Norway, Germany and Switzerland).

The context is that of hydrogen, which is one of the major levers of the energy transition towards cleaner energy sources. However, its combustion still raises fundamental questions, particularly when it comes to understanding and predicting its behavior in complex combustion chambers. This is especially true for industrial applications where hydrogen must be used at high pressure, a field that is still largely unknown in terms of modeling and simulation.

Large-eddy simulation (LES) is a key tool for analyzing hydrogen flames, particularly in high-pressure configurations [1,2,3]. Industrialists following SELECT-H and INSIGH2T seek to calculate their configurations before carrying out tests. In order to make these simulations fast and accurate, the PhD student will participate in the development of the AVBP code, which is a world standard in the field. He will work both on academic calculations (DNS type) and on applications in real turbines (LES)..

OBJECTIVES

The main objective of the thesis will be to develop methods for simulating high-pressure hydrogen-air combustion, fundamental enough to be published in the best journals but also powerful enough to change the way industrialists involved in the relevant European projects simulate their engines. This will also involve intensive training in high-performance computing, CAD, meshing, and fluid mechanics theory.

ORGANIZATION OF RESEARCH WORK (36 months)

The thesis will begin with the handling of the simulation tools used to model hydrogen flames, mainly the CERFACS AVBP solver (https://cerfacs.fr/avbp7x). An understanding of the industrial context will be proposed at the same time, to understand the industrial objectives: small turbines at BAKER HUGHES (16 MW), the largest turbines in the world at ANSALDO (800 MW), aircraft and helicopter engines.

The thesis will then be developed by an in-depth knowledge of turbulent combustion, state-of-the-art simulation models, in particular the Thickened Flame LES (TFLES) method, reference simulations without flame thickening at low and high pressure, then simulations with thickened flames under these same conditions.

These simulations will be applied to academic flames but also to real industrial configurations, in liaison with the industrialists of the projects concerned.

PROMOTING RESEARCH WORK

The work carried out can be directly applied in the simulation tools of the three manufacturers involved in the projects: SAFRAN, BAKER-HUGHES, ANSALDO. Several patents are already under discussion, for example with SAFRAN.

TRAINING

High Performance Computing, combustion, meshing, instabilities

DESIRED PROFILE

- Master 2 or engineering school
- Training in fluid mechanics and energy
- Training in CFD
- Knowledge of combustion appreciated
- Knowledge of programming (Fortran or C or C++ and Python)
- Dynamism, curiosity and autonomy

WHAT WE OFFER AT CERFACS

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- 6 weeks' annual leave (with the possibility of 22 extra days' leave per year linked to your choice of a 39-hour rather than 35-hour working week).
- Flexible working arrangements, with the possibility of working from home up to two days a week.
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HOW TO APPLY ?

To apply, please send your CV and covering letter to poinsot@cerfacs.fr , douasbin@cerfacs.fr , applications are open until 01/09/2025.

See you soon at CERFACS!

REFERENCES

1] Theoretical and numerical combustion. Textbook on combustion. T. Poinsot and D. Veynante. (2011, Third Edition: Amazon), 607 pages.
[2] Magnes, H., Vilespy, M., Selle, L., Poinsot, T., and Schuller, T. (November 25, 2024). "Interplay Between Unburned Emissions and NOx Emissions From a Dual Swirl Hydrogen Air Injector." ASME. *J. Eng. Gas Turbines Power.* June 2025; 147(6): 061013. https://doi.org/10.1115/1.4066717.
[3] Justin Bertsch, Thierry Poinsot, Nicolas Bertier, Jiangheng Loïc Ruan. Stabilization regimes and flame structure at the flame base of a swirled lean premixed hydrogen–air injector with a pure hydrogen pilot injection, *Proc. Comb. Inst.*, 40, 1–4, 2024, 105660.