PROPOSITION DE SUJET DE THESE

Optimal design of bio-inspired liners to mitigate the effect of thermoacoustic instabilities

Reference : MFE-DMPE-2026-**28**
(à rappeler dans toute correspondance / include in all correspondence)

Thesis start : from October 2026	**Application deadline :** December 2026

Key words

Thermoacoustic Instabilities, Bio-Inspired Aeroacoustic Liners, Linearized Stability Analysis, Reactive Navier-Stokes Solver, Doctoral Network (FLAMENCO)

Ideal candidate profile

Master of science or engineering degree in physics, fluid mechanics or applied mathematics, with a strong background in numerical methods.

Context

Thermoacoustic instabilities present a critical challenge in the design of combustion chambers, as these instabilities can cause high-amplitude pressure oscillations that significantly shorten chamber lifetimes. This PhD project offers the opportunity to tackle this problem by focusing on the optimal control of thermoacoustic instabilities through innovative, bio-inspired aeroacoustic liners. These liners, made from porous or architected metamaterials, introduce controlled dissipation to the system, interrupting the feedback loops that cause thermoacoustic instabilities.

To reach our goals, it is intended to employ a reactive linearized Navier-Stokes solver [1,2], which could potentially be extended to account for further effects such as evaporation in dispersed multiphase fuel sprays. Both conventional and bio-inspired liners will be optimized, employing adjoint optimization [3,4] in order to mitigate the effects of the thermoacoustic instabilities [5] while subject to operational constraints, especially temperature resistance. The goal is to achieve stable and fuel-agnostic operation, accommodating the diverse range of future fuels in the energy sector.

In this project, the student will:

Analyze thermoacoustic mechanisms: Conduct a linear stability analysis to characterize the physical mechanisms driving thermoacoustic instabilities. This step is essential for developing a nuanced understanding of the instability onset and evolution.

Design optimal liners with advanced manufacturing: Leverage additive manufacturing to explore a range of liner architectures, optimizing for materials that enhance dissipation while withstanding high-temperature environments. Both conventional and bio-inspired liner designs will be evaluated.

Develop and apply advanced numerical tools: Use and develop a reactive, linearized Navier-Stokes solver, with potential extensions to include additional phenomena such as evaporation in multiphase fuel sprays. This comprehensive approach allows the exploration of liner effectiveness across a range of combustion conditions and fuel types.

Apply adjoint optimization techniques: Use adjoint-based optimization methods to refine liner design and placement in the combustion chamber, targeting the reduction of thermoacoustic instabilities under operational constraints.

The primary objectives of this research field are to achieve stable, fuel-flexible combustion performance while contributing to sustainable, low-emission energy solutions. The **novel aspects of the project** include a multi-level optimization approach to acoustic impedance, optimizing both liner design and positioning on chamber walls through the adjoint formalism.

Through this project, the PhD candidate will contribute to a field at the forefront of sustainable combustion technology, working with cutting-edge numerical methods and design innovations that are vital for low-emission combustion systems adaptable to a wide range of fuels. This research holds significant implications for the future of energy and clean combustion technology.

We are seeking a highly motivated candidate with a strong background in fluid dynamics, combustion, or applied mathematics. Proficiency in numerical methods and an interest in sustainable energy solutions are highly desirable.

References

[1] Douglas, C. M., Polifke, W., & Lesshafft, L. (2023). Flash-back, blow-off, and symmetry breaking of premixed conical flames. Combustion and Flame, 258, 113060.

[2] Brokof, P., Douglas, C. M., & Polifke, W. (2024). The role of hydrodynamic shear in the thermoacoustic response of slit flames. Proceedings of the Combustion Institute, 40(1-4), 105362.

[3] Schmid, P. J., & Sipp, D. (2016). Linear control of oscillator and amplifier flows. Physical Review Fluids, 1(4), 040501.

[4] Sipp, D. (2012). Open-loop control of cavity oscillations with harmonic forcings. Journal of Fluid Mechanics, 708, 439-468.

[5] Magri, L. (2019). Adjoint methods as design tools in thermoacoustics. Applied Mechanics Reviews, 71(2), 020801.

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