

M2 Internship proposal Effect of surface catalysis on the stabilisation of hydrogen flames

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Starting date: April 2027, duration: 5-6 months, allowance: ~690 €/month

Provided that it is produced from renewable sources, hydrogen is an energy carrier that exhibits distinct advantages when compared to fossil fuels, such as a higher heat release per unit mass and a wider range of burning equivalence ratios. Decreasing the minimum value of hydrogen concentration leading to burner-stabilised flames is crucial to enabling the viability of this fuel as a substitute for hydrocarbons. Lean combustion of hydrogen mixtures is thus the key to unlock the potential use of this energy carrier as fuel for practical applications, thus enabling the advent of sustainable communities.

Fuel-oxidizer mixtures with low hydrogen content, when burned in ultra-lean conditions (high air-to-fuel ratio), exhibit intrinsic thermo-diffusive instability due to their low heat-to-mass diffusivity ratio (Lewis number). This means that heat diffuses significantly slower than the fuel, disrupting the flame front and leading to unsteady combustion. This unstable burning leads to a fluctuating heat release rate that, in turn, can couple with the acoustic modes of the burners, thus triggering thermo-acoustic instability. These combustion instabilities limit the operation range of practical combustion devices, since they may lead to destructive damages.

The goal of this internship is to conduct a preliminary investigation of the use of heterogeneous catalysis using low-cost materials to control these (intrinsic and thermo-acoustic) combustion instabilities and, thus, to significantly reduce the minimum equivalence ratio leading to flame stabilization.

Catalytic materials will be prepared at IC2MP, first platinum (expensive), as the reference catalyst, then lanthanum-based LaMnO_3 perovskite [1]. These catalytic materials will be deposited on alumina substrate at the annular slit of the ANO 2.0 burner [2] of Institut Pprime (see Fig. 1). A large range of flow rates (Reynolds number) and mixture compositions (equivalence ratio or, conversely, Damköhler number) will be covered to investigate their effect on the studied flames. The overall burner operating limits will be first characterized and compared to those obtained in the absence of surface treatment. The detailed flow behaviour will then be examined by time resolved, non-intrusive, imaging techniques. Schlieren will be used to evidence the flame surface changes in response to the presence of the catalyst, whereas the OH^* chemiluminescence will provide a measure of the corresponding heat release rate changes.

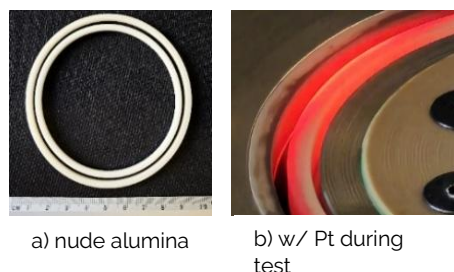


Figure 1: Images of rings a) as received b) during test in the burner with Pt (hydrogen flames do not emit visible light).

Funding is currently being sought for a PhD thesis that will further extend this study.

How to apply: send CV and motivation letter to: luis-fernando.figueira-da-silva@ensma.fr

[1] Batiot-Dupeyrat, C.; Martinez, F.; Ganne, M.; Tatibouët, J.M. Methane catalytic combustion on La-based perovskite type catalysts in high temperature isothermal conditions, Appl. Catal. A: Gen., v. 206, p. 205-215, 2001.

[2] Lopes Junqueira, N.; Figueira da Silva, L.F.; Morgenthaler, V. Modal dynamics and spectral signatures of ultra-lean H_2 -air annular flames. Combust. Flame, v. 291, p. 115032, 2026.

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