PhD project: ESR 1 of INSPIRE Project

Experimental investigation of Constant Volume Combustion and its reduced order model

Context and objectives

The thermodynamic cycle used in a gas turbine (GT) has undergone little change since its early development. Over the last decades effort has been put into increasing efficiency through reducing losses and raising overall pressure ratio and peak temperature. To break out of current limits a different cycle is required. One of the most promising is the case where a pressure rise across the combustion process is allowed. Cycle models show that such a change would reduce the fuel consumption of a large turbofan engine by ~15% and of a small engine by ~25%. An efficiency increase of up to 20% is also expected for land based GT. The pan-European team assembled within the ITN INSPIRE project offers the possibility of studying the most promising Pressure Gain Combustion (**PGC**) solutions on an innovative integrated level.
The training of new researchers familiar with the concepts of PGC will ease the adoption of the technology in European industry. Since the developmental life cycle of GT is long, familiarizing a generation of new researchers with PGC will allow them to grow along with the technology.

Objectives of the PhD work

The project aims at experimentally investigating the Constant Volume Combustion (CVC) cycle dynamics and stability associated with high dilution by Residual Burned Gas (RBG) or large scavenging associated with fuel-lean equivalence ratios. Such conditions can be used to reach acceptable operation for the gas turbine components (mechanical stresses, material temperature, etc.) and for the environment (CO_2 or NO_X emissions). Several strategies of ignition (spark, hot spot, self-ignition), and combustion (scavenging, dilution by hot RBG, synthetic dilution by neutral gas) will be characterized in terms of cycle performance and emissions to reach this target. The CV2 test bench (see figure 1) developed in the framework of the CAPA program (Alternative Combustion modes for Airbreathing Propulsion) will be used to perform this study. Time-resolved diagnostics will be performed to gain insight into the reactive flow properties (velocity, turbulence intensity, stratification) and their effects on the overall combustion behaviour.
This research will be performed in close association with ESRs 3, and 4 of the INSPIRE program and will take advantage from periods at CERFACS (where the CV2 setup will be simulated).

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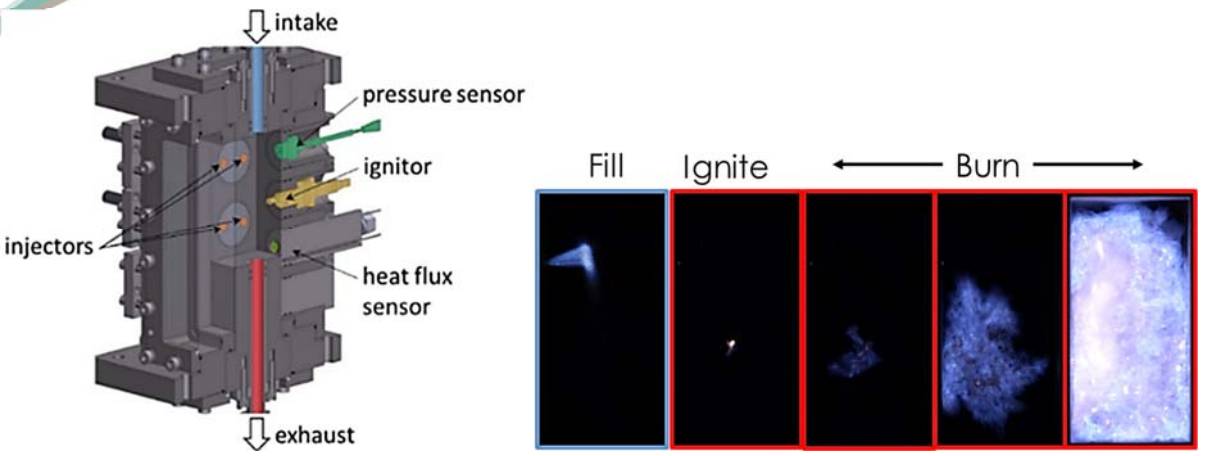

Fig 1: Sketch of the PPRIME CV2 test bench and flame imaging of a typical combustion cycle (stoichiometric air/iso-octane charge at 0.3 MPa, spark ignition, fuel direct injection)

Expected Results: Better understanding of: i) key phenomena controlling the CVC stability and performance, ii) ignition processes, iii) impact of scavenging and RBG dilution, and iv) reactive flow behaviour within the combustor.

Planned secondments: 3 months in CERFACS (Toulouse, France) for detailed analysis of CVC technology, and additional 3 months at UNIFI (Florence, Italy) to deepen about cooling schemes.

Requirements
Master or Engineering degree in Fluid mechanics, Energetics, Combustion

Hosting Institution: ENSMA

Supervisor: Prof. Marc Bellenoue and Dr Bastien Boust
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Duration: 36 months

Net Salary per month : 1891 €
Mobility allowance per month : 600€
Eventual Family allowance per month : 250 €