TIME-RESOLVED TEMPERATURE MEASUREMENT INSIDE A COMBUSTOR CHAMBER OF A TURBOMACHINE – COMPARISON WITH LES CALCULATION

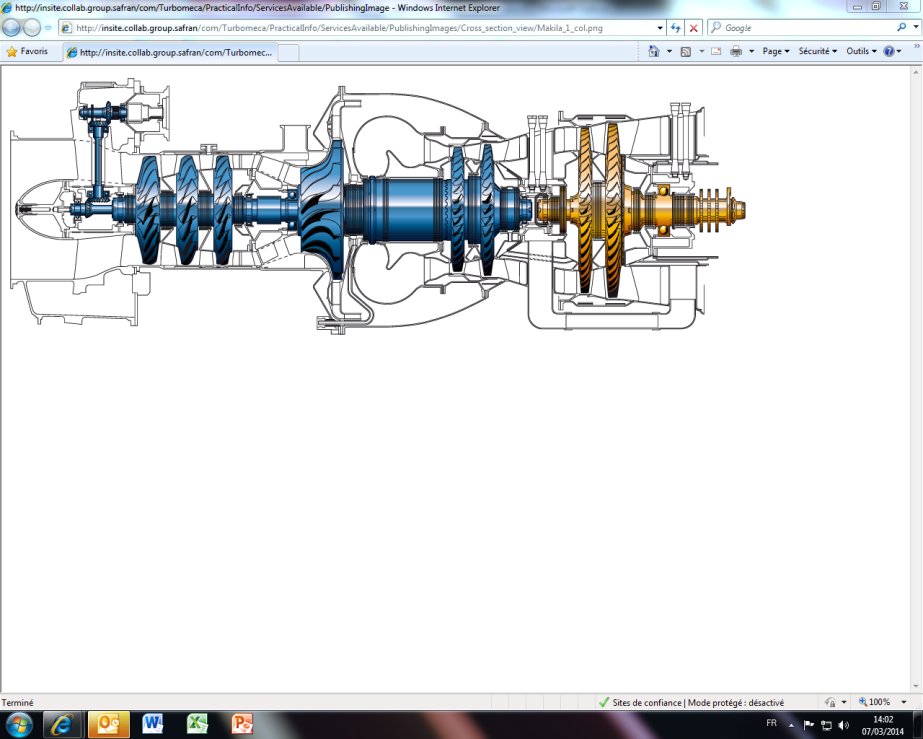
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Abstract

In this paper, we present temperature measurements performed inside a combustion chamber of a turbomachine by means of fine unsheathed thermocouples. Data post processing allows statistical, temporal and frequency analysis. Experimental results are compared with LES (Large Eddy Simulation) results.

introduction

The use of CFD codes is now usual in the development of aircraft engines. However, the degree of confidence in CFD results depends on the predictive behavior of these codes. The validation of both unsteady CFD and transient thermal codes require fine, accurate and time resolved measurements in realistic conditions, i.e. obtained at high pressures and temperatures in confined environments exhibiting strongly coupled phenomena.



**Figure 1: Cross sectional view of a MAKILA 2A1 engine.**

Such measurements are very challenging and current literature lacks of data obtained in relevant geometries and conditions. Indeed:

* actual partial test rigs do not reproduce the high levels of aero-thermal and mechanical loads to which the HP turbine is submitted (gas temperature rising up to 2000 K, …)
* available measurement systems are not suited to these confined, pressurized and hot environments,
* the acquired data do not cover the wide range of physical phenomena involved in the engine (flow , mixing, combustion, atomization and evaporation, coupling with heat transfer and acoustics.

In this context, it thus seems necessary to have a dedicated test engine with specific and innovative instrumentation.

Within its Energy & Propulsion Department, SAFRAN-Tech, the Research and Technology Centre of the SAFRAN Group, developed an experimental set-up dedicated to the study of gas turbine engines high pressure cores with the ambition to contribute to the improvement of simulation tools. This new test engine heavily instrumented is called BEARCAT ("Banc d’Essai avancé pour la Recherche en Combustion et Aerothermique des Turbomachines").

BEARCAT is based on a MAKILA engine (Figure 1), a turboshaft developed by Safran Helicopter Engines and powering H215 and H225 Airbus Helicopters. BEARCAT is operated at BORDES (Main Safran Helicopter Engines plant) with a dedicated team. The engine ran for the first time in December 2020. The BEARCAT’s instrumentation is detailed in [2].

RESULTS and DISCUSSION

In this paper we first present time resolved temperature measurements performed inside the BEARCAT’s combustor by means of fine (0.2 mm in diameter) unsheathed thermocouples (B type). Measurements are performed at 5 ksamples/s. A data post-processing allows:

* Statistical analysis, leading to the determination of average values, standard deviation flatness and skewness as well as Probability Density Function (PDF).
* Frequency analysis, leading the determination of the Spectral Density Energy (SDE)
* Temporal analysis, leading to the determination of the Self Correlation of the signal and at least the Taylor’s Turbulence micro-scale.

In the second part of the paper, the experimentally acquired data are exploited to validate CFD simulations of the combustion chamber. For this purpose, the AVBP solver developed at CERFACS is used to perform Large Eddy Simulations of the turbulent reactive two-phase flow occurring in the BEARCAT engine combustor. In this study, a single combustor sector is simulated under the assumption that the flow is axi-periodic. Comparisons with measurements are proposed in two axial cut-plane, the first one being located in the combustion chamber and the second one at the combustor exit. Both temperature and velocity field are compared, based on average and unsteady values.

References

[1]: Bidan G., and Champion-Réaud, J.-L., "Development of Ultra-High Yemperature multi-hole probes”, XXIV Biannual Symposium on Measuring Techniques in Turbomachinery, Transonic and Supersonic Flow in Cascades and Turbomachines”. Prague (CZ), 2018

[2]: Jean-Louis Champion-Réaud, Guillaume Bidan, Jean-Luc Breining, Pierre-Alain Lambert, Carlos Mendes and Nicolas Zouloumian, “Bearcat: the brand new test engine heavily instrumented for accurate comparison with CFD calculations”, ASME Paper GT2020-14295

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