M2 DET – Dynamique des fluides, Energétique et Transferts

UT3 Paul Sabatier, Toulouse INP, INSA Toulouse, ISAE-SUPAERO, IMT Mines Albi-Carmaux

Internship opportunity 2023

Title: Quantification of geometrical defaults in rotor blades using acoustic measurements

Supervisors :

ISAE-SUPAERO
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RATIER
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Ratier-Figeac is the world leader in propeller design and manufacturing in the range of 1500 to 11000 SHP. Ratier-Figeac is part of the Collins Aerospace group and located in Figeac (France, Lot). It is one, if not the oldest aerospace company in the world with more than 100 years of experience in propeller design.
This project based on propeller aeroacoustic is part of a Propeller Health Monitoring system (PHM) system with the intent to provide to customers, improvements in maintenance prediction.

Working place : Département d'aérodynamique, Energétique et Propulsion (DAEP), ISAE-SUPAERO

Duration: 6 months

Key words: aircraft propellers, aeroacoustics, signal processing, programming, experiments, health monitoring, blade

Background

Aircraft propellers may deteriorate over time due to operation in harsh environments and/or hazardous impacts of objects on blades. This may lead to the propeller being imbalanced which, in terms of acoustics, is responsible for noise generation at the propeller rotation frequency. In this context, the present project aims at characterising the aeroacoustic noise generated by a propeller with one blade having slightly modified geometry (which may be due to deterioration over time) with respect to the other blades. The noise components at the rotation frequency and harmonics will be characterised through experiments and predicted using analytical models.

This internship is part of a collaboration between ISAE-SUPAERO, an engineering school in Toulouse, and RATIER-FIGEAC, a world leader in propeller design and manufacturing. The internship will take place at ISAE-SUPAERO and one or two travels will be organised at RATIER-FIGEAC in order for the intern to meet and interact with the supervisors there.

Program of internship

Experiments on propellers with one defected blade will be conducted in the anechoic chamber of ISAE-Supaero. The latter has 5x5x5 m3 wedge tip-to-wedge tip dimensions and is equipped with a directivity antenna that allows measurements of the farfield noise generated by the propeller, see figure 1. An example of the farfield spectra obtained for three-bladed propellers manufactured with different 3D-printing processes is shown in figure 2. The noise is characterised by peaks at the blade passing frequency and harmonics, and by significant broadband noise at high frequencies, i.e. around 10,000 Hz. In the present project, similar measurements will be performed for different degrees of blade deterioration and the influence on both tonal and broadband signature will be characterised.

In parallel, an analytical model developed in the 80s [1] will be adapted and used to predict the tonal signature of the defected propeller. Specifically, the goal will be to validate the analytical approach using measurements

described above and extend the analysis to a larger parameter space (allowed by the low computational cost of the analytical approach). The analytical model may help reveal unique acoustic patterns, due to constructive/destructive interferences, that were not identified in the first set of experiments. In such cases the corresponding blade defections may be tested in a second test campaign to further validate the analytical approach.

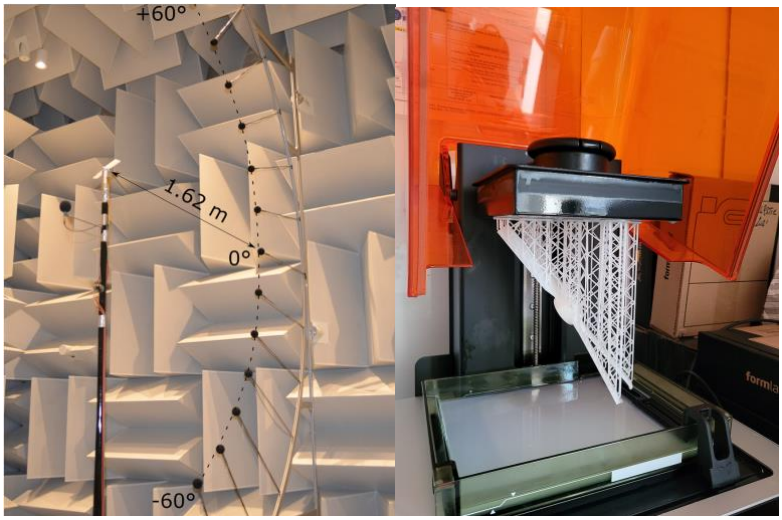

Figure 1: Experimental setup in the anechoic chamber and 3-D formlab printer

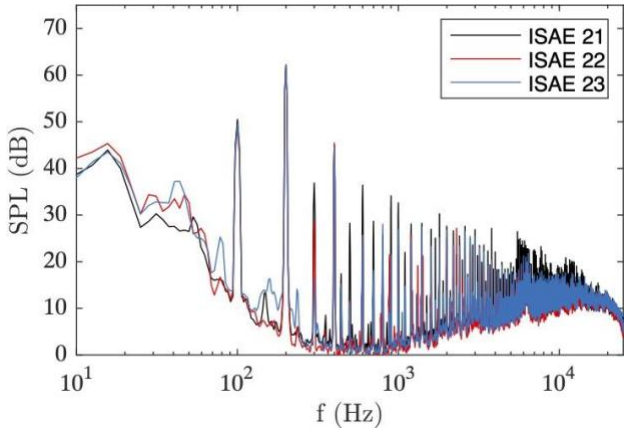

Figure 2: Typical spectra in a far field for identical two-bladed rotors 3-D printed in different directions [2]

Candidates

We are looking for candidates from engineering schools (or equivalent) with a background in aeroacoustics and who are highly motivated to work on a research project at the interface between academia and industry. Candidates should be comfortable with analytical modelling and/or experimental measurements and post-processing. Knowledge in propeller aerodynamics and aeroacoustics is a plus.

Bibliography

[1] Hanson, D. B. (1983). Compressible helicoidal surface theory for propeller aerodynamics and noise. AIAA Journal, 21(6), 881-889.

[2] Gojon, R., Jardin, T., & Parisot-Dupuis, H. (2021). Experimental investigation of low Reynolds number rotor noise. The Journal of the Acoustical Society of America, 149(6), 3813-3829.