PhD thesis proposal

Study of passive and active fan-OGV interaction noise reduction devices

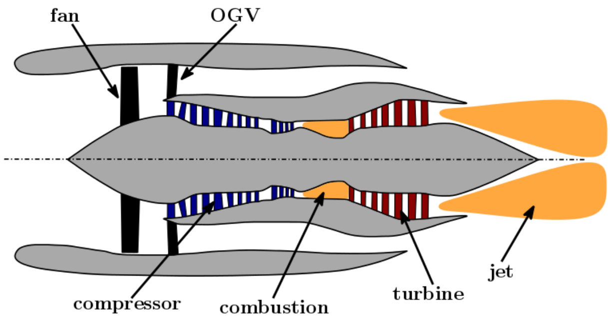
ED162 MEGA / Ecole Centrale de Lyon / LTDS & LMFA

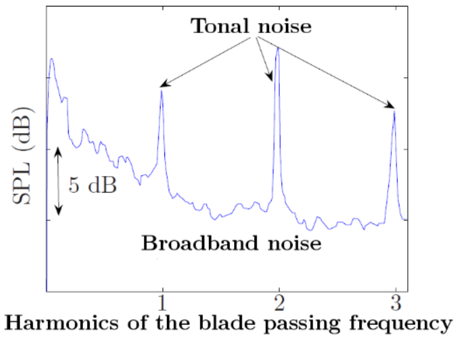
Context

Transportation noise is one of the major problem for populations located close to large infrastructures, especially airports. In the air transportation sector, the traffic is expected to increase by about 4.6% per year between 2012 and 2032. In order to limit the noise exposure around airports, the International Civil Aviation Organisation (ICAO) defines stringent regulations for aircrafts and engines manufacturers to conform to.

Aircraft noise sources are numerous, but are generally split into two categories: airframe noise (due to the landing gears, high-lift slats and flaps, etc.) and propulsion noise (due to the jet, the fan stage, the combustion, the turbine, etc.). The evolutions of turbofan architectures in the last decades saw a large increase of the by-pass ratio, which implies that the fan stage is responsible for most of the thrust in modern engines. As a consequence, fan noise, which includes the noise generated by the fan itself but also the noise generated by the outlet guide vanes (OGV) downstream of the fan, became one of the dominant noise sources of propulsion noise (especially at approach conditions).

The fan stage (fan and OGV) is responsible for the generation of a tonal noise due to the periodic wakes of the fan blades interacting with the OGV, but also of a broadband noise. The latter is associated with the small scales of the turbulence developing in the boundary layer of the vanes and of the turbulence developing in the wakes of the fan blades interacting with the OGV.





In order to reduce the noise generated by the fan stage, passive or active solutions applied to the OGV are under study. Among passive solutions (without energy supply), we can cite modifications of the geometry of the vanes or the use of acoustic absorbing material on the surface of the vanes. Active devices require a supply of energy and can try to disrupt the mechanisms responsible for noise generation or to control the propagation in the inter-vanes channels to reduce the global noise level. Active devices are more complex to implement but can, in principle, adapt to different working conditions of the source to reduce, where passive devices generally cannot. Some reduction devices have been or are the subject of preliminary studies, mostly experimental and in isolated aerofoils configurations. To date, few studies have considered vane rows configurations (linear or annular).

Objectives

The objective of this PhD studentship is to contribute to the development and the evaluation of fan noise reduction devices applied to OGV. In particular, this work is interested in an active concept aiming at controlling the impedance at the surface of the vanes to reduce the noise in the inter-vane channels, as well as in a passive concept using absorbing materials on the surface of the vanes.

From a literature review of turbulence-aerofoil interaction noise prediction models, the development of a model including the use of absorbing materials will be studied. This model should allow to identify the required characteristics of the materials to reduce the noise significantly, from the knowledge of the parameters of the incoming turbulence.

Recent results from the Tribology and System Dynamics Laboratory (LTDS) showed that the integration of piezoelectric shunts has a real potential for the control of the vibroacoustic energy flow in structures. An objective of this thesis work is to extend this technology for the attenuation of aeroacoustic noise induced by the OGV. An integrated hybrid composite materials demonstrator based on the use of piezoelectric shunts will be developed to validate the solution imagined in conditions close to real use conditions.

A significant proportion of the study of the passive and active devices mentioned above will be experimental. This work will benefit from the support of a European project in which several fan noise reduction OGV treatments will be tested in an acoustic wind tunnel on a linear vane row configuration. The student will perform acoustic and aerodynamic performance measurements for the treated and reference vanes, and will be in charge of the analysis of the collected data.

The results of modelling and experiments will then help to inform the choice of the noise reduction devices that will later be tested, within the framework of the European project, in realistic flow conditions on a 1/3 scale fan stage within the PHARE2 test rig at Ecole Centrale de Lyon.

This thesis will be co-supervised by researchers from the acoustics group of the Fluid Mechanics and Acoustics Laboratory (LMFA) and from the Tribology and System Dynamics Laboratory (LTDS) at Ecole Centrale de Lyon. Moreover, as mentioned earlier, this work will be carried out in relation with a European project on the reduction of fan noise, involving a consortium of academic and industrial partners. The student may thus have to interact with the partners and present his work during progress meetings.

Profile

The applicant must hold a Masters degree or equivalent and have scientific knowledge and skills in Acoustics and/or Fluid Mechanics, as well as in Signal Processing and Control Methods. A strong interest for applied mathematics and experimental work will be welcomed. Good writing and presentation skills in English are required.

Contacts

- Manuel Collet, Ecole Centrale de Lyon, LTDS UMR CNRS 5513 : manuel.collet@ec-lyon.fr
- Vincent Clair, Ecole Centrale de Lyon, LMFA UMR CNRS 5509 : vincent.clair@ec-lyon.fr