PHD POSITION

2024

Numerical simulations of acoustic liners in turbulent wall-bounded flows

Keywords : Acoustic liners, Fluid mechanics and turbulence, Computational fluid dynamics (CFD), Duct acoustics

A significant part of the noise emitted by airplanes comes from the engines, and more particularly from the fan. To reduce this noise, sound absorbing materials (acoustic liners) are used. They are made up of a series of Helmholtz resonators placed in the wall of the nacelle and are separated from the grazing flow by a perforated plate (see figure 1).

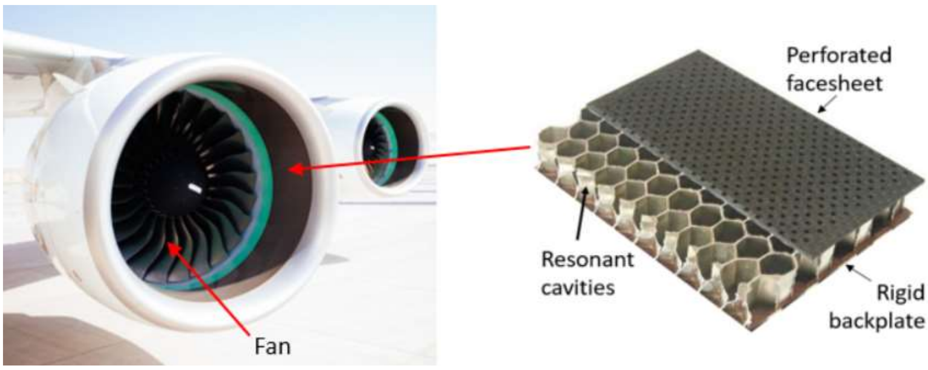

Figure 1: On the left, aircraft engine, with the fan. On the right, example of acoustic absorbing material (acoustic liner) placed on the internal wall of the engine.

In the engine, a high speed turbulent grazing flow interacts with the acoustic liner. This has two consequences. First, the acoustic properties of the liner are affected : the acoustic impedance, which constitutes the main characteristic of the liner, is modified in a non-trivial way compared to its value without flow. Second, acoustic liners increase friction (induced drag), which is a more recent area of concern. How this happens is still poorly understood and only a few numerical [1,2] or experimental [3,4] studies have addressed this question.

The general objective of this thesis is to understand the complex interaction between the flow, the acoustic waves, and the absorbing material, by means of numerical simulations. Simulations of wall turbulent flows (plane channel or boundary layer) will be performed in the presence of an incident acoustic wave to be attenuated and of an absorbent material placed on a portion of the walls. Until now, simulations of this kind have been carried out at the Pprime institute in which materials have been modeled by wall impedances [5,6]. This made it possible to study the modification of turbulence by these materials, in particular due to instabilities. However, such a framework implies that the feedback of the flow on the behavior of the liner (its impedance) is ignored, and in this thesis the aim is to go beyond this simplifying modeling by taking into account the full liner geometry in the simulations. That is, wall resonant cavities such as those in figure 1 will be meshed. The simulations will be carried out with the AVBP simulation code developed by Cerfacs (https://www.cerfacs.fr/avbp7x/), which has been used to study the thermal behavior of materials similar to the acoustic absorbing materials considered here [7] (see figure 2).

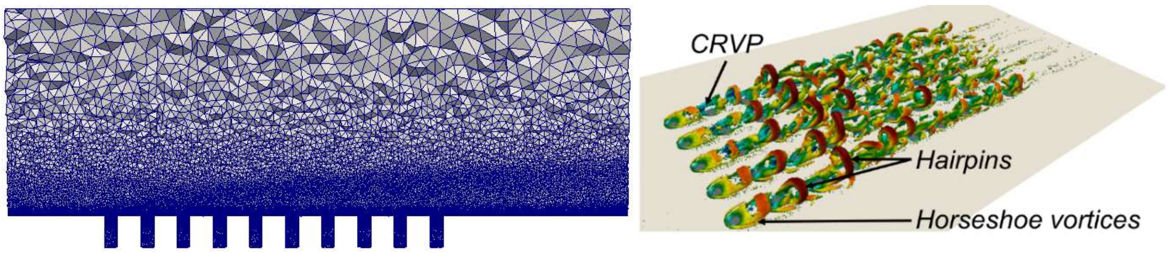

Figure 2 Simulation of heat tranfer in acoustic liners, made with AVBP code developed at Cerfacs. From Esnault et al [7].

This code solves the compressible Navier-Stokes equations via direct numerical simulations (DNS) or large scale simulations (LES). The simulations performed during this thesis will make it possible to study absorbent materials from two different perspectives:
1. that of acoustic behavior. The dependence of the impedance on the flow will be studied.
2. that of the drag induced by the liner. We will particularly wonder to what extent the latter is linked to the excitation by the incident acoustic wave.

This thesis will take place within the framework of the ANR ACOUDRAG project, associating the Pprime institute, ONERA Toulouse, and Cerfacs. Comparisons will be done between experiments carried out at ONERA and the simulations performed during this thesis at the Pprime Institute and in collaboration with Cerfacs. The data collected will make it possible to approach the modeling of acoustic materials, from both acoustics and flow drag points of view.

Candidate's profile : Master's degree and/or engineering degree, with knowledge of fluid mechanics, acoustics, and numerical simulations.

Starting date and duration : This thesis will ideally begin before October 2024, for a duration of 3 years, and will take place at the Pprime Institute, Poitiers, France (https://pprime.fr/). It is funded by ANR (French national research agency, project ACOUDRAG, https://anr.fr/Project-ANR-23-CE51-0009).

Contact :
D. Marx (CNRS, Université de Poitiers, Institut P') : david.marx@univ-poitiers.fr
F. Duchaine (Cerfacs, Toulouse) : florent.duchaine@cerfacs.fr

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