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HYBRID NOISE PREDICTIONS OF A RADIAL NOTEBOOK BLOWER

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Abstract

Small low-speed radial blowers are used in many cooling applications including very compact notebook systems. The noise level produced by these systems is one of the main concerns for customers to not exceed acoustic ergonomic limits. Thus, aero-acoustic predictions are of great importance for the computer manufacturers at the design level. Aero-acoustic sources are multiple in such dense and complex computer systems. Broadband noise component is produced by a wide range of turbulent excitations, while tonal noise component is related to large coherent flow structures strongly depending on the installation. Several measurements have been achieved on small radial blowers meant for cooling notebooks and are described in a previous study [1]. Tonal noise mitigation techniques such as daisy obstructions have also been tested (ref). In the present work, unsteady incompressible and compressible numerical simulations are performed on one standard size blower with the dimensions 60x54x9 mm to predict both tonal and broadband noise components in free flow conditions. Very few numerical tools allow to capture, at affordable computational cost, both the tonal and broadband sources and the far-field propagation, since it requires to capture large structures related to the installation to very small turbulent structures that appear in boundary layers, and a wide range of wave-numbers on a large computational domain [2, 3]. The present methodology relies on a hybrid methodology using incompressible and compressible unsteady Reynolds-
Averaged Navier-Stokes (URANS) simulations linked with an acoustic propagation tool. The selected flow solver is ANSYS-CFX and it is coupled with an in-house code applying the Ffowcs-Williams and Hawkings acoustic analogy on rotating surfaces.

The present numerical simulations have the following objectives. First they are meant to create a representative set-up on a limited domain that can reliably reproduce the large recirculation flows in free-field, and consequently reproduce the measured tonal noise. Secondly, by comparing incompressible and compressible flow simulations, they evaluate the effect of compressibility on the tonal noise radiation in such low-speed blowers. Finally, they should prove if they can capture noise mitigation effects from daisy obstructions correctly. A side objective is also to test the unstructured mesh strategy for such applications.

The numerical set-up used in the present study is shown in Fig. 1. The blower is placed in the middle of a large sphere of 150 mm radius. As outlined in the zoom on the blower, the interface between the rotating and stationary part is placed at mid-distance from the casing closest position. The final mesh size with overall dimensionless wall distance $y^+ \sim 1$ has 3 million nodes and 17 million tetrahedral elements. 4 different simulations have been run summarized in Table 1. The first three consider the baseline configuration. The last one adds the daisy obstruction placed at the blower inlet in a similar way as Magne et al did [4]. The former design was based on preliminary tonal noise control measurements in a less controlled environment yielding a lobe amplitude ΔR=0.4 mm with an angular size $\Delta\theta$=2.5°. All unsteady simulations use the sliding mesh method and a k-ω SST model for turbulence.

	Solved Equations	Configuration
CFX - I0	Incompressible	Baseline
CFX - C0	Compressible	Baseline
CFX - C1	Compressible + NSCBC	Baseline
CFX - IM1	Incompressible	M1

Table 1: Simulations of the low-speed radial blower investigated in the present study.

The overall flow performances of all simulations are shown in Fig. 2. Excellent flow rate predictions are achieved on the spherical domain and slightly improved the predictions obtained with two solvers on a smaller box. Further flow analysis will be provided in the final paper.

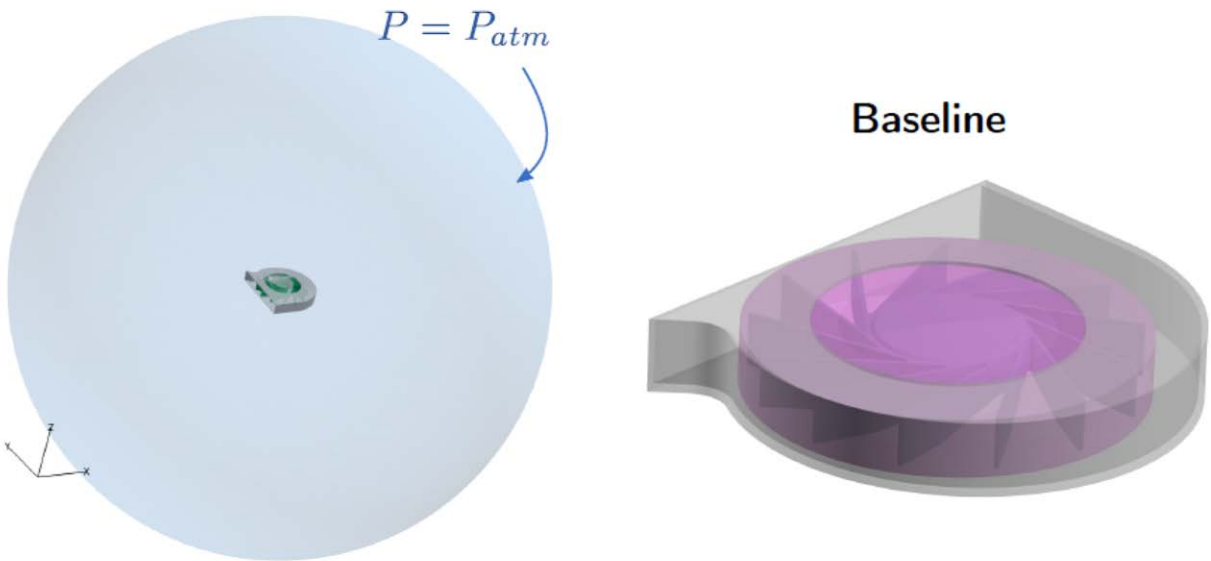

Figure 1: CFX numerical set-up.

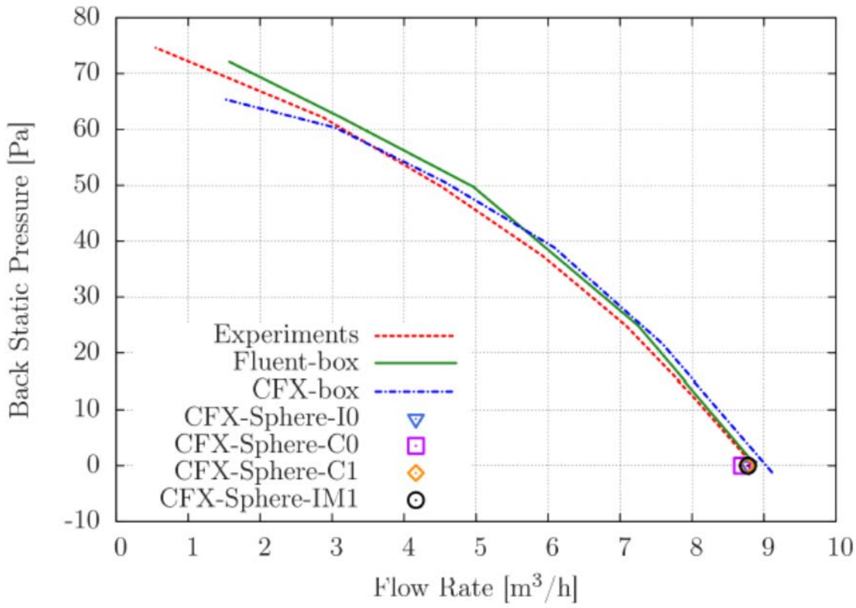

Figure 2: Global performance comparisons between experiments and simulations.

The acoustic sources are the wall pressure fluctuations on the casing and the rotor. This is a reasonable assumption since the maximum blower Mach number is very low. These fluctuations are then fed to a Ffowcs-Williams and Hawking's analogy model. The time-converged results are shown in Fig. 3. Three different blowers were used in the experiments, and the results show the effects of blower-to-blower variability. The first two harmonics yield good agreement between the experiments and the simulations (both incompressible and compressible simulations). Only the compressible simulation yield satisfactory levels up to 5000 Hz. The next step is to obtain the similar results with the daisy obstruction, which will be presented in the final paper.

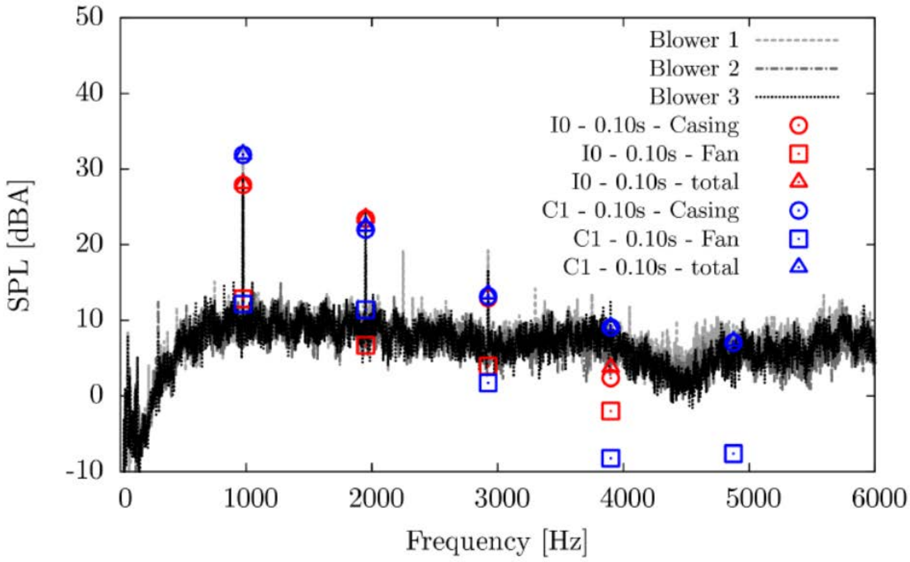

Figure 3: Noise spectra comparisons between experiments and simulations (red: incompressible and blue: compressible).

References

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