Noise Characterization And Reduction Techniques Of Multiple Axial Fans Unit

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1 Introduction

Digital display units usually utilize axial fans to force cooling air into enclosed spaces to regulate temperature whenever needed. The fluid-sound interaction between the air passing through the fan and the casing can lead to noise radiation that may be very unpleasant. This noise is usually attributed to the interaction of the rotating blades with the fan casing as the dominant frequency in the noise spectra usually matches the blade passing frequency (BPF). The blade passing frequency noise, being tonal in nature, causes greater discomfort compared to normal broadband noises; therefore it became a major design aspect in the construction of axial fans. The noise can further be unpleasant and destructively loud if the frequency of the passing blades is coupled with an acoustic mode of the enclosure [1, 2].

Noise control of axial fans is divided into two approaches, active or passive. The active noise reduction technique depends on the concept of measuring the noise under consideration and adopt a corrective technique to provide destructive interference between the source and the emitted anti-wave. In the passive technique, geometrical modifications are adopted to dissipate or prevent the source from building up loud noise [3]. The current study focuses on the use of passive noise reduction techniques such as downstream silencers in the attenuation of axial fans noise. Different silencer designs are investigated such as, L-shape maze, annular, and absorptive/reflective silencers in order to reach an optimum passive noise control technique.

2 Experimental setup

The noise characterization measurements took place in a hemi-anechoic room that has an overall background noise of 29 dBA. The tested fan unit comprises of three axial fans controlled by a speed control module. The fans are tested at normal operating condition, i.e. 50% of the full rotational speed, and at the maximum operating condition. The acoustic mapping measurements were performed using free-field microphones fixed at different locations above the fan unit, which was extracted from an outdoor display unit, as shown in Figure 1. The measurements are performed at discrete points following a measurements grid in order to locate the noise source and obtain an average overall sound pressure level. Several silencers are constructed following the common practices in the industry. The first tested silencer comprises an L-shaped maze in order to allow flow through the maze but break up the noise line of sight, as shown in Figure 2a. The second silencer consist of two concentric hollow cylinders with acoustic insulation filling the empty annulus, as shown in Figure 2b. The third silencer is much more compact than the first two silencers and it is designed to allow the flow out from the fans through a perforated cylinder fitted with reflective plates to distort the noise.

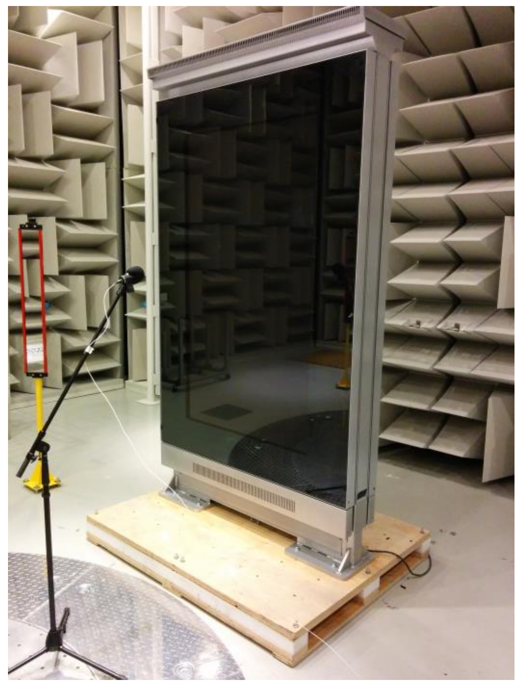

Figure 1: Picture of the outdoor display unit comprising the multiple axial fans unit under investigation.

3 Results

Figure 3 shows a spectral analysis sample of the noise signal measured above the multiple fans unit at normal operating conditions. The figure shows that, in addition to the turbulent flow noise at the low frequency range, there is a significant contribution by a tonal noise that occurs at 445 Hz. Measurements of the rotation speed at this condition show that the blades are rotating at 5370 rpm, which corresponds to a blade passing frequency of 447.5 Hz, based on the equation:

$$f = \frac{\omega N}{60} \quad (1)$$

Where ω is the rotation speed in rpm and N is the number of blades (5 blades in this case). The measurements show a maximum noise peak of 70.9 dB at the blade passing frequency. Similar behaviour is obtained at the maximum

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operating conditions where the noise level is elevated to 89.7 dB at a frequency of 943 Hz. The rotational speed at the maximum operating conditions is 11370 rpm, which is almost twice that of the normal operating conditions. Yet, it is observed that the sound pressure level is increased by 20 dB approximately, which means that the resulting acoustic pressure has increased by an almost one order of magnitude.

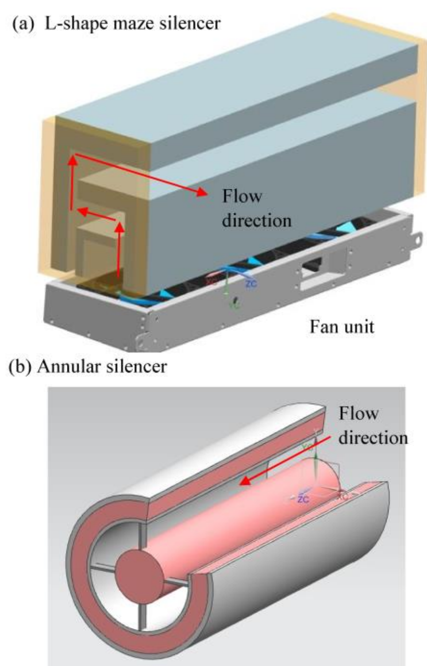

Figure 2: Drawings of the different silencers used in attenuating axial fans noise.

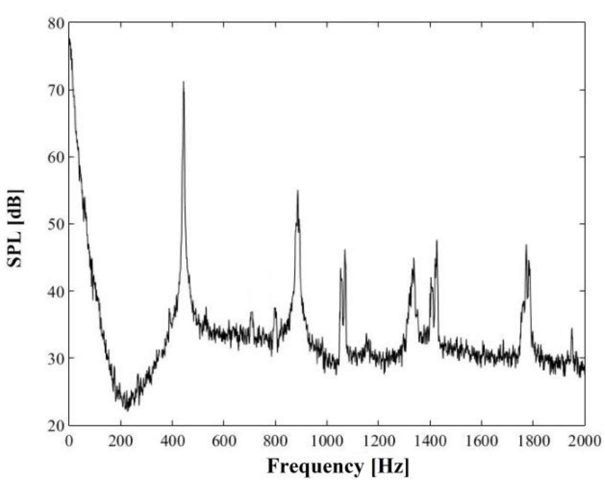

Figure 3: Sample of spectral analysis of the noise signal above the multiple fans unit at normal operating conditions.

The overall sound pressure level is mapped above the multiple fans unit, as shown in Figure 4a. The averaged sound pressure in normal operation is 70.7 dBA and goes up to 90.1 dBA in the maximum operation. The use of the different silencers showed good results in attenuating the noise from the fans unit, as shown in Figure 4b. The compact reflective/absorptive silencer that was specifically designed for this multiple fans unit showed the most promising results in attenuating the noise among the other silencers, as summarized in Table 1.

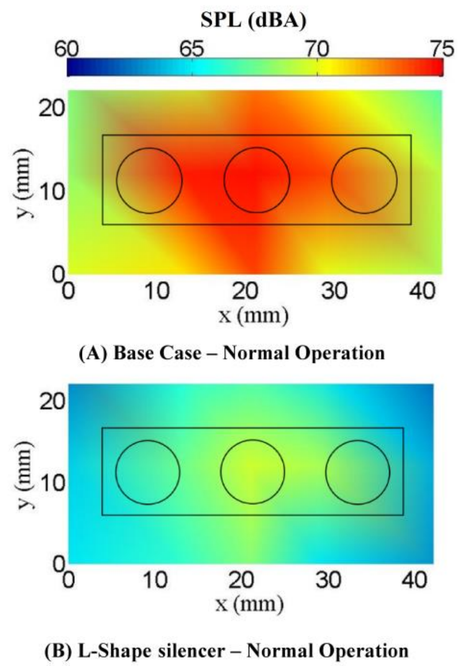

Figure 4: Contour plot of the overall sound pressure levels above the fans unit at the normal operating conditions.

Table 1: Summary of the attenuation obtained by each noise reduction technique (dBA).

	Normal operation	Max. operation
L-shape silencer	5.3	4.4
Annular silencer	6.1	6.9
Reflective silencer	6.3	9.5

4 Conclusion

An experimental characterization of the noise generation from a multiple axial fans unit is presented in this work and several noise reduction techniques are investigated. Comparison of different silencers that were designed specifically for noise reduction from axial fans show that the best approach is to incorporate reflective and absorptive aspects into the construction of a silencer. An innovative silencer design is proposed and shows better results than conventional L-shape maze or annular silencers.

References

[1] E. Canepa, A. Cattanei, and F. M. Zecchin. Effect of the rotor–stator gap variation on the tonal noise generated by axial-flow fans. Applied Acoustics, 94:29-38, 2015.

[2] M. Abdelmwgoud, M. Shaaban, N. Arafa, K. Sachedina, A. Mohany, and M. Hassan. Use of helmholtz resonators to suppress acoustic pressure pulsations in pipelines. 37th Annual Canadian Nuclear Society Conference, p. 41. 2017.

[3] A. Gérard, A. Berry, P. Masson, and Y. Gervais. Experimental validation of tonal noise control from subsonic axial fans using flow control obstructions. Journal of Sound and Vibration, 321(1):8-25, 2009.