

IDENTIFICATION OF SOUND SOURCES EMITTED BY AN AXIAL FAN

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ABSTRACT

The main objective of this work consist of diagnose the noise source emitted by a fan and determine the causes of its acoustic emission. This work has been realized using an axial fan, the number of blade is 3 and the diameter of the fan is 800 mm. It rotates at 1500 rpm. The sound pressure level at 1,5 m apart from the casing is 92,4 dB.

With this aim in view, sound pressure level measures has been made for different fan configurations, intended for differentiate between the contributions of each one of the components that the fan is formed by.

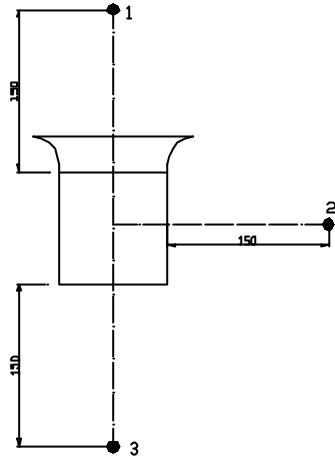
Comparing the obtained results in each measurement, it is possible to distinguish among the main emission fan sources, what allows taking out that the main noise source is caused by the fan casing design.

INTRODUCTION

Low noise emission has become a highly important factor as in the production as in the sell of low-noise fans in the world market, so that, the main objective of this work consist of diagnose, in a qualitative way, the origin of the noise source emitted by an axial fan and determine the causes of its acoustic emission. The noise produced by axial fans is caused by the dynamic interaction of the gas flow with rotating and stationary surfaces of the fan [1]. The aerodynamic noise emission may be divided into periodic and broadband types. The broadband noise is random in nature and comes from the aerodynamic interaction between the fan and the air, whereas the tonal noise produced by axial flow fans results from periodic interactions between distorted inflow and the rotor blades as well as the rotor wakes and nearby downstream surfaces including struts and guidevanes. This tonal noise is usually most prominent at the harmonics of the passing frequency of the fan blade, and it's recognizable by the frecuencial study. The main sources for each one of them have been identified [2].

EXPERIMENTAL

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fan, the fan without blades and the engine working with no load.

RESULTS

The different measurements realized on the fan state that the great sound pressure levels are caused at frequency levels lower than 700 Hz, so that the frecuencial study has been carried out only in this range of frequency. Very big differences haven't been detected among the different measurements points, so that measurements at point 2 have been taken to show the results.

The first measurement has been carried out over the fan with a different rotating speed in order to observe the relationship between the rotation speed and the obtained spectrum. Table 1 shows the passing frequency of the fan blade at a work speed 1500 rpm, comparing the theoretic results with the real ones obtained in the measurement.

Angular speed (rpm)	Fundamental		x 2		x 3		x 4	
	Theoretic	Real	Theoretic	Real	Theoretic	Real	Theoretic	Real
1500	75	68	150	135	225	203	300	270

Table 1. Comparison between the theoretic values and the real ones from the passing frequency of the fan blade and its harmonics

The spectrum of sound pressure level from the fan rotating at the work speed is shown in figure 2. The obtained spectrum shows that the main peaks, inasmuch as sound pressure level, corresponds with the passing frequency of the fan blades for the 1500 rpm speed, at which can deduce that the main noise source is caused by the fan rotation.

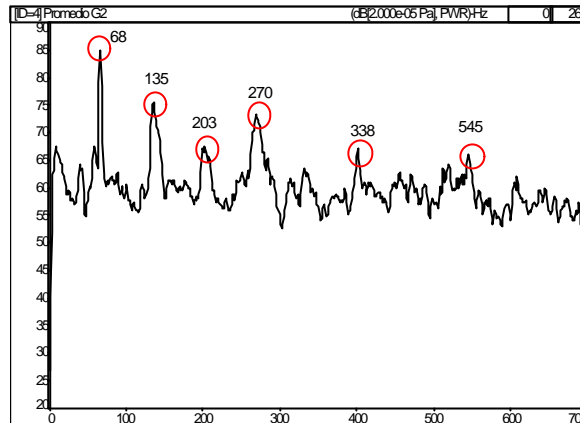


Figure 2. Noise spectrum of the fan with a rotating speed of 1500 rpm.

After the identification of the main peaks from the spectrum, it has proceeded to the study of the other fan configurations spectrum, in the order to identify the rest peaks of main significance.

The result obtained on the measurement realized over an engine rotating at 1500 rpm, mounted on a laboratory base, and the measurement due to the fan engine mounted on the casing, but without blades is shown in figure 3.

By means of comparison between these two spectrums, we can obtain the frequencies that are caused properly by the rotation engine. Those frequencies are specified in the figure 3 by a red circle.

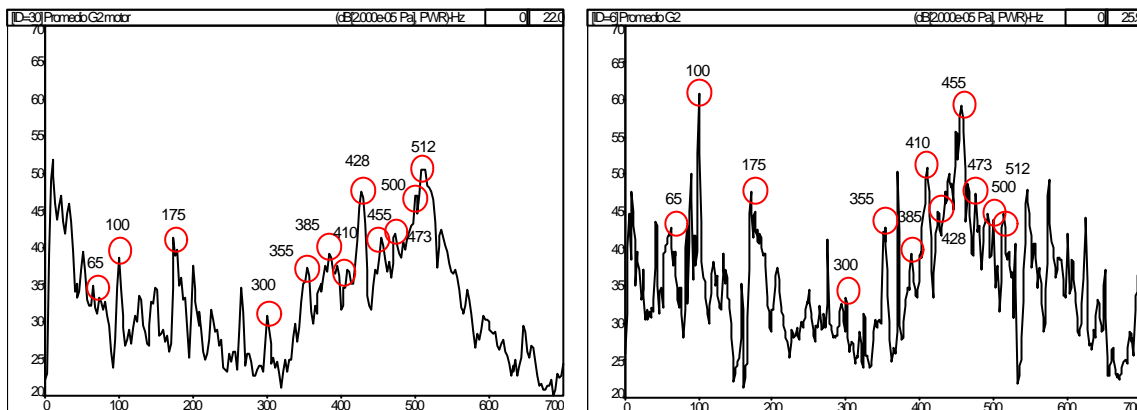


Figure 3. Noise pressure level spectrums, engine rotating at 1500 rpm (left), fan engine, mounted on the casing, but without blades (right).

In consequence of have been taking apart the blades, the peaks corresponding to the passing frequencies disappeared, even though we can observe a very important background noise diminution. This fact is caused due to the turbulence generated by the air.

Comparing the spectrums shown in figure 3, it is possible to see that in spite of the existence of many coincidental frequencies (red values), the corresponding spectrums from those configurations are different enough in form, so that the influence of the casing seems to be significant. In addition to this it has verified that the greater part of coincidental frequencies, there are an amplification of the sound level due to the presence of the casing (see table 2).

Frequency (Hz)	100	175	410	428	456	512
L_p engine	39	41	37	48	41	51
L_p engine and casing	60	48	52	46	60	56
$\Delta L_p = L_p$ (casing) - L_p (engine)	21	7	15	-2	19	-5

Table 2. Effect of the casing in the main emission frequencies of the engine (L_p engine) and the joint engine and casing (L_p engine and casing).

Natural frequencies of the fan unit has been evaluated, in an approximate way, by means of making an impact anywhere of the casing and getting the sound pressure level due to this impact (see figure 4). It must be mention that even though the point where it has making the impact can cause and spectrum variation, this is a qualitative study and therefore this fact is not outstanding.

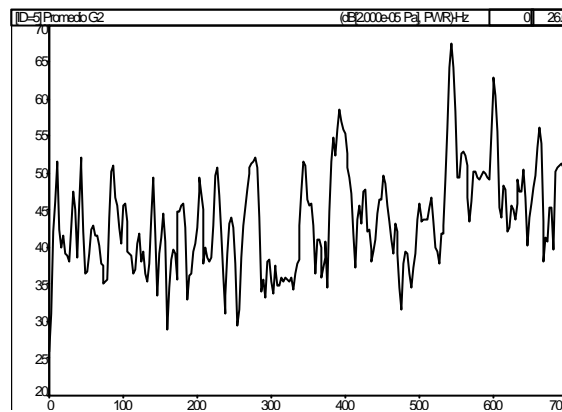


Figure 4. Spectrum of the noise pressure level of the fan natural frequencies.

Finally it has been preceded to the identification of the more significant emission frequencies. The figure 5 shows the fan spectrum rotating at 1500 rpm.

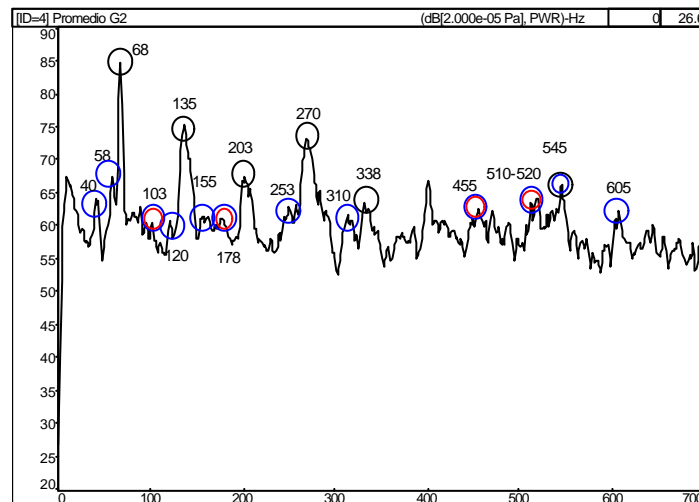


Figure 5. Spectrum of the sound pressure level of the fan rotating at 1500 rpm.

Firstly has been checked how the passing frequencies due to the fan blades (black) present the major sound pressure level, specially at the fundamental frequency and its harmonics 2x, 3x, 4x, 5x y 8x, so that this is the main noise emission source of the fan.

In addition to this it is possible to distinguish the contribution of the electric engine (red), which happens on the frequencies of 103, 178, 455 and 515. At first, the contribution of the noise emitted by the engine seems not to be very important, but if it has considered the A weighing spectrum, the contribution at the frequencies of 455 y 515 is distinguished.

The frequencies amplitude is consequence of the coincidence of the engine emission with the natural frequencies of the casing (blue), what produce the resonance effect. This effect is caused by the turbulence produced into the fan casing that lead to the broadband noise on the noise spectrum [3].

The rest of the natural frequencies (red), the most important contribution happens at 545 Hz, that coincides with the eighth harmonic (8x) of the passing fan blade, so that a resonance with this harmonic is formed. This result is very significant, as the amplitude of the harmonics goes diminishing in the way that goes increasing its order. The amplitude of the harmonics 6x (408 Hz) and 7x (476 Hz) is not practically detectable as a result, but the 8x harmonic it is, with the further difficulty that it is located in the frequency range where the hearing is more sensitive.

As only four of the rest of the frequencies (103, 178, 455 y 515 Hz) takes coincidence of the frequencies emitted by the engine, the rest of the natural frequencies should be excited by the air turbulence, that makes the casing vibrate. In consequence, the contributions of the fan casing frequencies are closely bound to the main noise.

CONCLUSIONS

- The main source of noise is the passing of the fan blade, which produce sound pressure levels at its characteristic frequencies between 5 and 30 dB over the background noise.
- The rotational speed is an important source of noise too, as for the characteristic frequencies of passing fan blade; there are increases of more than 10 dB on changing the rotation speed from 1000 rpm to 1500 rpm. Moreover there are a generalized increase of the background noise that could be coded by 5 dB between 1000 rpm and 1500 rpm.
- The casing is an important radiant source and it bears as if it was an acoustic amplifier, what has showed for the difference between the engine spectrum and the fan without blades spectrum, and the increase of the level at the coincidence frequencies in both spectrums.
- The casing seems to behave as a sound source by itself, excited by the turbulence of the air flow, according to the conclusion of the natural frequencies appearance on the fan noise spectrum.
- The noise contribution of the engine at the global noise of the fan is practically contemptible.

In order to reduce the level of the acoustic emission:

Redesign of the casing. The join casing and base of the engine acts as if was a sound amplifier, due to the slight rigidity of the union and the little damping of the material which is made of. It has been recommended a redesign of the casing more unbending, which avoids symmetries, as well as the use of a damping material, by means of a paint treatment or by means of the use of multiple capes damping material.

Restudy of the fan: number of blades and its section, and the rotation speed. It will be desirable, from the acoustic view, the speed diminution. An increase of the blade number would produce the movement of the peaks to high frequencies, where the hearing is more sensitive, so that it must be chosen good commitments between the rotation speed and the blade number. It must attempt to reduce turbulence caused by the air.

ACKNOWLEDGMENTS

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