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ACTIVE CONTROL OF THE NOISE RADIATED BY AN ENGINE ENCLOSURE

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1. INTRODUCTION

The low frequency noise radiated by an engine enclosure is one of the main problems for interior noise in ship and classical passive methods for noise reduction are in conflict with the pressing demand for lighter enclosure.

The paper presents an engine enclosure with one side open, equiped with an active control system. Loud-speakers, used as the secondary sources for the active control method, are placed at the bottom of the enclosure. Microphones, used as control receivers are situated between the baffles at the open side of the enclosure.

A multiple input / output controller allows the minimization of the periodic radiated noise produced by an air compressor placed inside the enclosure.

A passive insulation device with absorbing baffles enables futher attenuation of the high frequencies radiated by the engine, for this enclosure which is slightly open.

2. DESCRIPTION OF THE ENGINE ENCLOSURE

The enclosure is in the shape of a parallelepiped 0.80 x 1.00 x 1.00 meters. On its four lateral sides it has double plates in aluminium and is composed of an open side at the top. The inside of the enclosure is coated with absorbing material protected by perforated aluminium sheets.

The superior open side is equiped with four absorbing baffles which enables reduction of high frequencies which cannot be taken into account by active control.

The engine placed inside the enclosure is an air compressor driven by an electric motor. The noise radiated in low frequencies is composed of harmonic noise linked with the rotational speed of the electric motor.

The secondary sources are composed of five loud-speakers placed in the bottom of the enclosure. Fourteen control microphones are placed in the superior part of the enclosure, in the passages situated between each baffle.

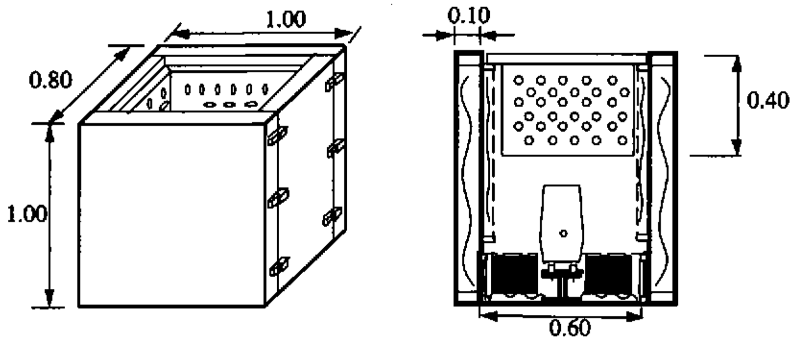

Fig. 1 Representation of the engine enclosure

3. ACTIVE CONTROL METHOD USED

Two LMS methods were used in succession, the first is a synchronous method in frequency domain and the second in time domain.
Frequency domain LMS has been selected because it presents the advantage of being particularly adapted to periodic sound field which have very weak variations in frequency.

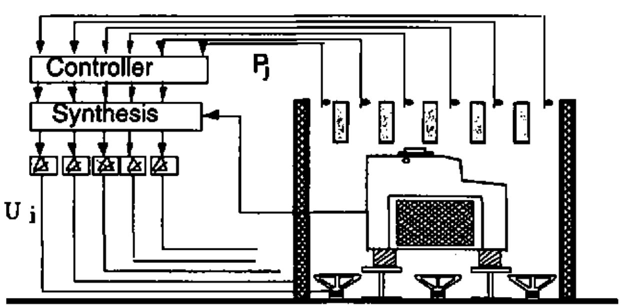

Fig. 2 Diagram of active control of an engine enclosure

For each microphone there is a linear relation for the sound pressure which is equal to the sum of the pressure transmitted by the engine plus the pressure transmitted by each of the secondary sources.

$$p_i(f) = p_{machine}(f) + \sum_{j=1}^{N} Hij(f) \;.U_j(f) \qquad (1)$$

We want to search for the voltage $U_j(f)$ which minimizes the cost function which is the sum of the square magnitude of the pressure at each microphone.

$$E(f) = P(f) \, . \, P^H(f) \qquad (2)$$

The synthesis allowed the generation of the signal which simultaneously include eight hundred frequencies. The reference signal comes from a tachometer probe which generates 1024 points synchronous with the rotation of the compressor.

4. ACTIVE NOISE CONTROL RESULTS

The acoustical power radiated by all sides of the enclosure was determined by intensity measurements when the active control was in action or not. Figure 3 shows the radiation of the engine enclosure with and without active control, for the fundamental frequency at 48 Hertz.
The acoustical intensity radiated is represented by arrows of which the length is in proportion to the intensity level.
With active control we observed a reduction of 15 dB on the superior side and also a reduction of 12 dB on the lateral sides. We notice that with active control the acoustical radiation on all sides, open and closed, is homogenous.

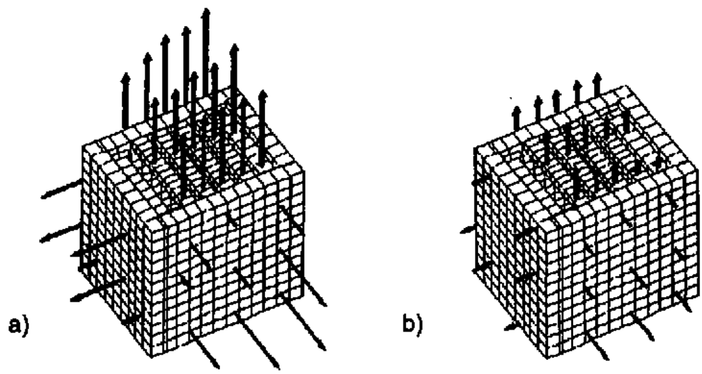

Fig. 3 Sound intensity level radiated by the engine enclosure
a) Without active control b) Active control on

The total sound level power radiated by the five sides of the engine enclosure is presented figure 4 for the two configurations, not using active control (thick line) and with minimization by microphones in the upper side (dotted line).
We obtained a global attenuation of 14 dB in low frequency, and around 8 dB for the other harmonics situated at frequencies lower than 300 Hertz. This low frequency band corresponds to a distance between control microphones, smaller than a third of a wavelength.

We noticed also that the secondary sources did not increase the noise radiated by the lateral sides of the enclosure.

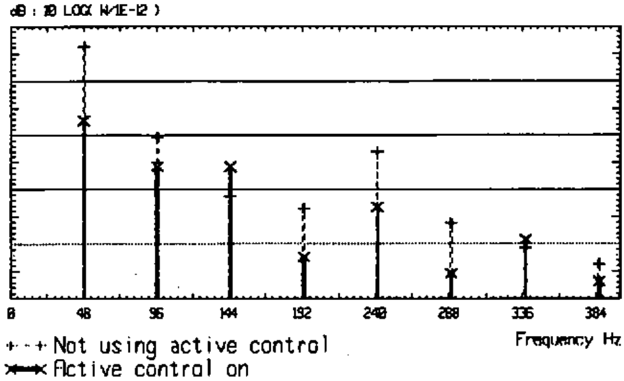

Fig. 4 Total sound power radiated by the five sides of the engine enclosure

CONCLUSION

This study has proved the possibility to incease the attenuation of an open engine enclosure, with an active control method.
The frequency domain method allows the reinforcement of sound insulation in low frequency, in the case of an engine driven by an electric motor.
Experimental results are encouraging and this strategy makes the use of a partialy open engine enclosure possible, making thermic exchanges easier.

REFERENCES

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