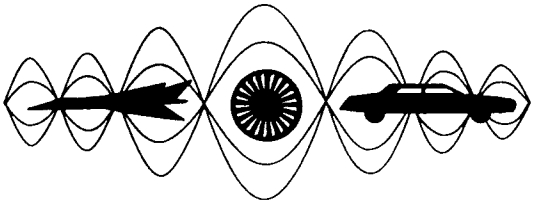


FIFTH INTERNATIONAL CONGRESS ON SOUND AND VIBRATION
DECEMBER 15-18, 1997
ADELAIDE, SOUTH AUSTRALIA

A SOLUTION FOR ANC TREATMENT IN FLOW NOISE FOR VERY LOW FREQUENCIES : A PRODUCT NAMED ACTA™ :

Ch. Carme, V. Delemotte, P. De Man

TechnoFirst® S.A., Parc de Napollon, 399 avenue des Templiers
13676 Aubagne Cedex, France

ABSTRACT

Because of the increasing demand about sound insulation in building, tradesmen have today to find and apply new solutions to reduce noise. With this aim in view, Aldes Aéraulique company, french leader in ventilation, and TechnoFirst company decided to develop an active muffler in partnership. TechnoFirst, specialized in active noise and vibration control, brings its know-how for the development and the industrialization of systems based on this new technology. From research works realized by the « Laboratoire de Mécanique et d'Acoustique », TechnoFirst has developed a single system which will be compatible with all the configurations of the products proposed by Aldes. Technical choices had been made to obtain optimum conditions about acoustic performances (great noise attenuation), dimensions and negligeable charge loss. Today, Aldes and TechnoFirst are in position to propose a muffler on the ventilation market, combining passive and active effects. The acoustic attenuation of this device is greater than the one obtained with a standard waffle muffler, with less charge loss introducing.This single system can be installed anywhere in the duct whatever diameter.

INTRODUCTION

The requirements of silent system coming from people working in the building trade and from people living in them are evolving to more and more severe criterion concerning acoustical comfort. Recent studies have shown that one people over three declares to be annoyed by noise (traffic, equipment, neighbour,...). Today, one thing is clear : the acoustics has become a basic factor of comfort, as lighting, heating and air quality are. Policies taking into account this evolution of the user need have been developped in France and authorities are concerned with regulations related to acoustics in new construction and limitation of the noise level of equipment in public premises.

In this paper, an active muffler for ventilation and air-conditioning networks is presented. This high technology device has been jointly developped by TechnoFirst® and Aldès Aéraulique, and is currently proposed on the market. The major steps of the study are explained and illustrated by technical data and experimental results.

PROJECT HISTORY

Sound countrol in ducts, has been investigated by a lot of people and for a long time. The work presented here, is originated from the studies carried out by the Laboratoire de Mécanique et d'Acoustique of Marseille (LMA) in the 1980's [1,2,3]. The feasibility of active acoustical control in ducts has been proved, and results on real installations have been presented. It was stated in the conclusions that attenuation from 20 to 30 dB could be reached up to the first cutting frequency. But there was still a long way to convince any industrial to transform this laboratory experiment into a rentable commercial product.

TechnoFirst®, which is specialized in active noise control found great interest in this challenge and decided to get involved in the project. With the partnership of Aldès Aéraulique, one of the european leaders in ventilation systems, the laboratory set-up has been transformed into an attractive and efficient product. This active muffler is intended to fully replace standard passive muffler, with two major advantages : small size and better efficiency.

PRELIMINARY WORKS

Numerous improvements have been brought to the initial laboratory prototype, in order to fulfill industrial and performance requirements. Before the all process, the attenuation of 20 to 30 dB obtained in the duct could only be achieved on quasi-harmonic noise emerging from a background broadband noise. This is obviously not the type of spectrum encountered in ventilation networks. One can also mentionned two others bad points : the length of the active muffler (2 to 3 meters) and the sensitivity of microphones to aeraulic turbulences [4].

Besides, these problems to solve, the following requirements had to be taken into account.

- diameter of concerned ducts : normalized serie AFNOR from 125 mm to 1 250 mm;
- optimised coupled technology : active broadband noise control concentrated on low frequencies (less than 250 Hz) and economic passive absorption;
- expected attenuation of low frequencies at least 20 dB at third octave bands of 125 Hz and 250 Hz (insertion ISO measuring method);
- neglectable charge loss (lower than 20 Pa for an average speed in the duct of 5 m/s)
- auto-adaptive system;
- easy installation of the device by non specialized people;
- targeted airflow speed from 2 to 15 m/s.

MAIN DEVELOPMENTS AND LABORATORY PERFORMANCES

First of all, some considerations about the choice of the control strategy. The active noise control strategy used in this project is feedforward. Experiments have been realized to test the efficiency of feedback system. This technology seems to be very attractive because less microphones are needed and the electronic equipment is cheaper. Nevertheless, propagation of the attenuation is very difficult to achieve using feedback, and performances are strongly dependent on the environment [5]. Designing an industrial product with reliable performances, and which is intended to be installed in an unknown aerolic network configuration, would have been unreasonable.

The majors improvements brought to the active muffler during the industrialization process are described below. Fig. 1 shows the basic principle. One detection microphone is placed upstream and gives real-time noise measurement to the controller. Downstream of this sensor, the anti-noise source emits the acoustic wave phase-opposed to the noise to cancel. Finally, the control microphone, placed after the speaker allows the electronic controller to perform the real-time processing which provides active attenuation.

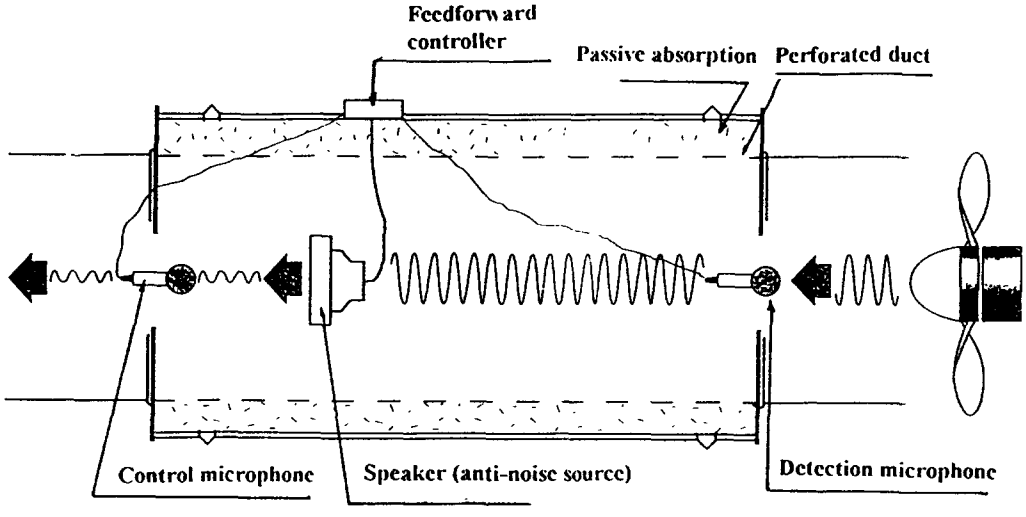
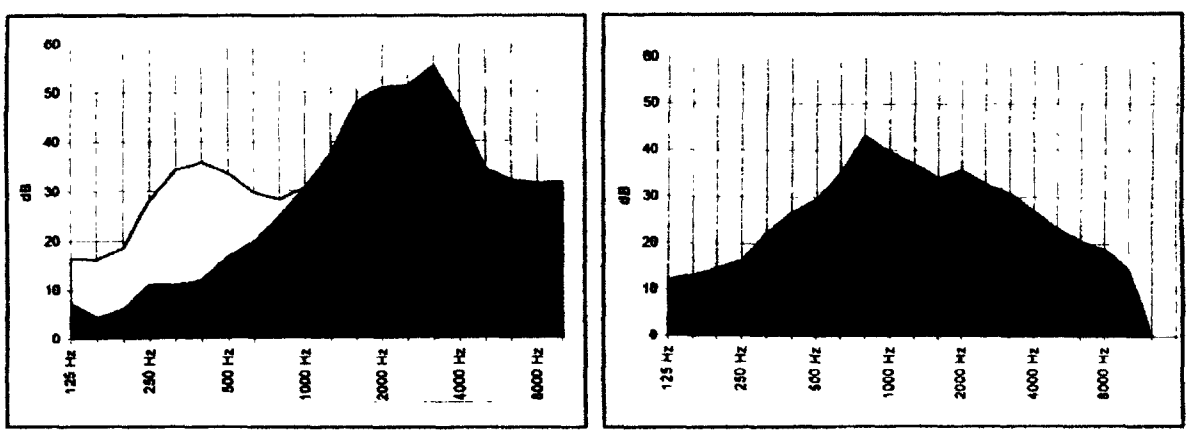


Fig. 1 :Principle of the active muffler

Length reduction. Experiments carried out by TechnoFirst® have shown that it was possible to reduce the muffler length without decrease of the active attenuation. Firstly, the distance separating the detection microphone and the speaker was reduced by optimisation of the algorithm parameters in such a way that the system remains causal. This is essential in the processing of broadband noise.

Secondly, the overall length of the muffler was also reduced by bringing the control microphone nearer of the speaker. A critical distance has been defined. If the distance between the control microphone and the speaker is shortest than the critical distance, the attenuation is not propagated downstream. Both reductions led to an active muffler no longer than 1.2 meters (4 feet). This size is an exceptional result which may be applied to diameters equal or less than 630 mm and which increases considerably the muffler installation possibilities.

Joined passive and active technology. The use of passive sound insulation and active sound control together is essential. Very good performances are obtained over all the audible frequency bandwidth. Figures 2 shows passive attenuation obtained with a standard muffler and performances of the active muffler Aldès/ TechnoFirst® combining passive and active attenuation [6]. It is clear that the active control brings a substantial additional attenuation at low frequency. One also notes very good performances of the passive material.



Active muffler

Standard passive muffler

Fig. 2 :Noise attenuation (standard muffler and active muffler)

Optimized anti-noise source. In order to optimize the antinoise source response and to combine perfectly the active and passive technology, it appeared that it was very interesting to integrate the speaker in a supporting structure placed in the centre of the muffler section. As a matter of fact, this arrangement has several advantages :

- increased absorbing surface and improved passive performances
- directive source

The central part of the muffler has also been designed in order to minimize charge loss.

Table 1 shows the characterisitics of the 315 mm diameter prototype.

Mean airflow speed ms^{-1}	Charge loss of the active/passive 315 mm diam. prototype (Pa)	Charge loss of a standard passive muffler
2	4,5	7,8
4	16,7	27,5
6	39,2	61,8

Table 1 : Charge loss of the 315 mm prototype

The aeraulic efficiency of this prototype is more better than the standard passive muffler one, which is besides cumbersome.

Remarks on performances. For each model (diameter) of the ACTA™, the active attenuation bandwidth starts from 50 or 150 Hz (depending on the airflow speed) and extends beyond the theoritical cutting frequency of the plane wave, varying from 10 to 25 dB depending on the muffler and the frequency concerned.

IN SITU EVALUATION & FINAL PRODUCT

During more than a year, numerous active mufflers have been installed on real installations. Sites were selected by Aldès Aeraulic, and enabled the evaluation of the product in various environments (school, hospital, auditorium,...) and using different types of fans. It was one of the most important step in the development of the product. Some unexpected problems have been encountered, and with the knowledge acquired in this way, the active muffler could be finalized.

Fig. 3 shows the active attenuation measured at the control microphone on a 315 mm diameter muffler, installed in a school. One can see that the low frequency noise which is not processed by passive material, is substantially reduced by the active control. When this attenuation is performed on all the mufflers ventilating a single classroom, a noticable decrease of background noise can be heared in the room.

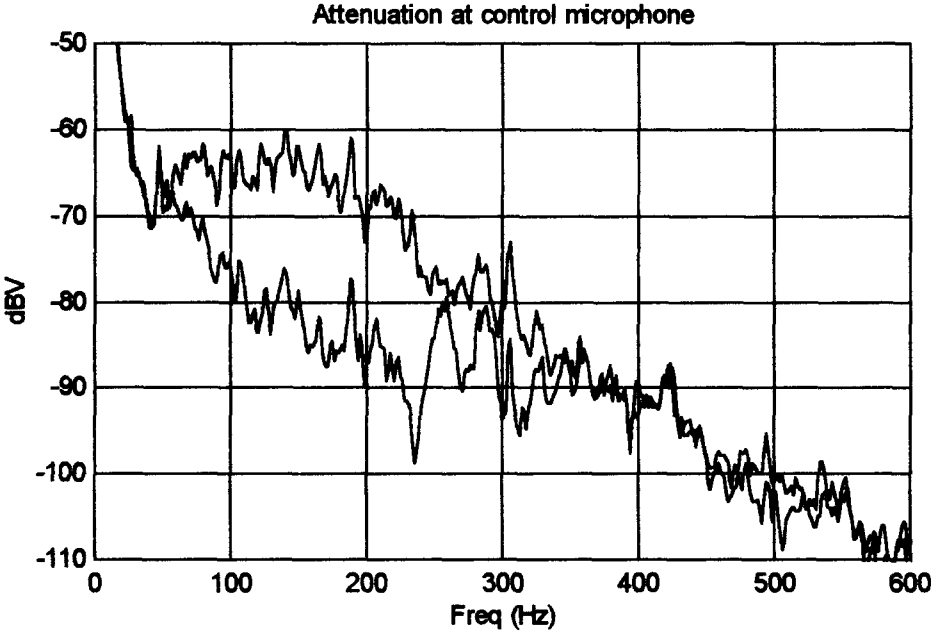


Fig. 3 :In situ active sound attenuation at control microphone (315 mm diameter ACTA ™)

The final product (see Fig. 4), can be inserted anywhere in a ventilation network, replacing completely traditionnal passive muffler. The installation is easy and no specific maintenance is required for the active part.

Fig. 4 :ACTA™ the final product

CONCLUSIONS

In this paper, an active muffler for ventilation and air-conditioning networks has been presented. This innovator device, based on feedforward control has been developped with the knowledge of TechnoFirst® in active noise control, and the know-how of Aldès Aeraulique in designing components for aeraulic installations.

The ACTA™ is intended to completely replace standard passive muffler in existing networks or to be used as the only noise attenuation component in new installations. Due to its performances cancelling low frequency noise, its small size and installation ease, ACTA™ is an attractive product for people concerned with acoustics in building.

Available in various diameters up to 630 mm and for airflow speed from 2 to 15 m/s, the active muffler will be proposed in the future for larger sections.

REFERENCES

[1] Roure A. (1985) "Self adaptive broadband active sound control system". *Journal of Sound and Vibration* 101, 429-441.

[2] Eriksson L.J. and Allie.M.C. (1987). "A digital sound control system for use in turbulent flows" *Proceedings of Noise-Con'87*.pp. 365-370. Pennsylvania State University.

[3] Jessel, M.J.M. and Mangiante, G. (1972). "Active sound absorbers in air duct", *Journal of Sound and vibration* 23, 383-390.

[4] Shepherd, I.C., LaFontaine, R.F. and Cabelli, A. (1989). "The influence of turbulent pressure fluctuations on an active attenuator in a flow duct"

[5] Carme Ch. and Roure A. (1994), "L'absorption acoustique active ou anti-bruit", *Chauffage Ventilation Conditionnement,* juin/juillet 1994.

[6] Nouvel J.F., Delemotte V. and Carme Ch., (1995), "Aéraulique et silencieux actifs", Journée de formation du Cetim sur les applications du contrôle actif à la réduction des bruits et des vibrations », p 157, novembre 1995