ACTIVE ENHANCEMENT OF THE TRANSMISSION LOSS OF A PANEL VIA MINIMIZATION OF THE VOLUME VELOVITY: THEORETICAL AND EXPERIMENTAL RESULTS.

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I- INTRODUCTION

Among the different methods of active control of sound, the ASAC (Active Structural Acoustical Control) as employed in this study, presents the advantage of avoiding the cumbersome ,heavy and expensive microphones and speakers which are used in the ANC (Active Noise Control). The control of the acoustic radiated field is performed in modifying the response of the vibrating structure , with some piezoceramic actuators bonded on the plate. The error sensor is also bonded on the structure and provides the controller with a unique information: the volume displacement . Such a sensor, is said extended and has been adjusted in the GAUS[1],[2]. This strategy consisting in minimizing the volume displacement appears to be appropriate for the control of the transmission loss since this quantity has a good correlation with the radiation.
The present parametrical and experimental study has consisted in verifying the efficiency and the limits of this strategy on the control of the different vibrational and acoustics indicators, particularly the transmission loss of a plate.

II- STATEMENT OF THE PROBLEM:

A typical problem of transmission consists in studying how a partition-wall transmits the perturbation generated by an acoustic wave from a room to the other. In order to simplify the study of the control a thin rectangular plate, baffled in a wall has been excited by an acoustic wave and controlled by a pair of piezoceramic actuators bonded on the structure. These materials have the charateristic of contract or expand themselves when submitted to a current, flexural and distributed moments are generated along the edges , which permits to excitate the plate. Although some forces used as actuators conduct to better results than piezoceramic ones particularly in the low frequency range, their use is still not easy and expensive which is not the case for the piezoceramics . In order to achieve the parametrical study, the minimization of the volume displacement has been added in a program existing in the GAUS and determining all the acoustical indicators by a variational method, for a plate with general boundary conditions. [3][4].

III - THEORY

The total volume displacement (sum of the displacement over the panel surface) can be expressed as the sum of the primary volume displacement generated by the excitation (D_p) and the secondary volume displacement (D_s) generated by a control actuator which applied voltage should be the unity:

$$D_{tot} = \int_S W(x,y)dS = D_p + V \cdot D_s \qquad (1)$$

where V is the voltage corresponding to the actuator.
The displacement may be expanded with the polynomial functions chosen to form the basis.
As the displacement is:

$$W(x,y) = \sum_n \sum_m a_{nm}^{tot} (\tfrac{2}{a} x)^n (\tfrac{2}{b} y)^m \, dxdy \qquad (2)$$

where a and b are the dimensions of the plate and a_{nm}^{tot} the modal contribution, which permits, after some simplifications, to write the total volume displacement :

$$D_{tot} = \sum_{n,m\ odd} a_{nm}^{excit} \frac{ab}{nm} + \sum_{n,m\ odd} a_{nm}^{cont} \frac{ab}{nm} \qquad (3)$$

One can verify here that only the (odd,odd) modes participate to the volume displacement.

Minimizing this volume displacement is like finding V_c, the control voltage which has a quite simple expression:

$$V_c = -{}^{D_p}\!/_{D_s} . \qquad (4)$$

The transmission loss of the panel is:

$$TL(dB) = 10\log_{10}(\tfrac{W^i}{W^t}) \qquad (5)$$

where W^i is the incident power and W^t the transmited power calculated in the far-field:
The more large this indicator will be, the more efficient the panel will be in term of transmission.
In this model, the sensor is assumed to be perfect in the whole frequency range, which is not the case for real sensors .

IV- RESULTS AND DISCUSSION

The results presented here, are for an aluminium plate which dimensions are 0.38×0.30×0.0016 m, the assumed damping factor being 5%, it is clamped and excited by a normal wave so that only the modes whose volume displacement is not zero, are excited. Some thin piezos (0.038×0.032m) are located on the center of the plate, one on each side. The figure 1 shows that the efficiency of the control is good in a frequency domain where the symmetric (non-zero volume displacement) modes radiate significantly more than the other (zero volume displacement) modes, and consequently where the strategy of minimizing the volume displacement is relevant. The first mode is the one which is the most attenuated for it is also the one with the larger volume displacement. The antiresonances of the transmission loss correspond to the resonances of the quadratic velocity and represent the modes of the plate, however, after application of the control, the plate is excited on new frequencies (450 Hz) , this can be explained by the presence of such a weak secondary volume displacement that the voltage Vc (formula 4) applied on the piezos becomes very high, without achieving an efficient control. The figure 2 shows, nevertheless, that in the low frequency domain, the efficiency on the reduction of the transmited power is not questioned. Finally, the figure 3 shows the increase of the vibrations generated by the control. One can see that, for the first and most radiating mode, the vibration level has decreased. But it has to be known that the center of the plate is the best place for the piezo to be located, in the experiments the piezos can not be there because the sensor is also on the center.

V- CONCLUSION

The strategy of control by minimization of the volume displacement could be of great interest for the research in the "smart" structures area. It conducts to an interesting enhancement of the transmission loss of a thin plate in the frequency range where the volume displacement is sufficiently high, that is to say, at low frequencies.
The experimental results will be presented during the conference.

VI-ACKNOWLEDGEMENT

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VII- REFERENCES

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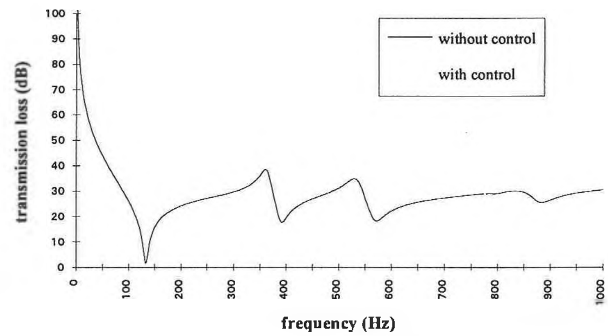

Figure 1: predicted **transmission loss** for a clamped plate excited by a normal incident wave

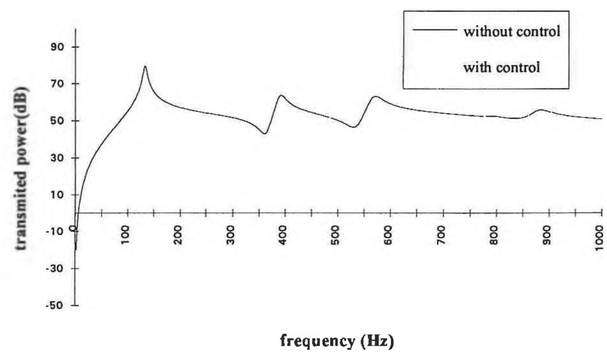

Figure 2: predicted **transmited power** for a clamped plate excited by a normal incident wave

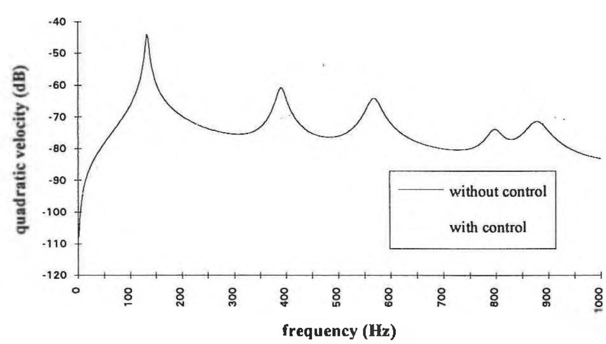

Figure 3: predicted **quadratic velocity** for a clamped plate excited by a normal incident wave