Low frequency noise reduction inside a passenger car by optimization of the mask-luggage porosity properties

François FOHR [a], Serge PUVILLAND [b]

[a] Centre de Transfert de Technologies du Mans, 20 rue Thalès de Milet, 72000 LE MANS, France
[b] PSA Peugeot Citröen, centre technique de Vélizy, 78943, VELIZY VILLACOUBLAY

1 Introduction

The acoustic comfort inside a car is conditioned on one hand by the insulation capacity of different parts of the body vis-à-vis external noise (primarily road noise and aerodynamic noise) and on the other hand by the absorption capacity of the different matérials inside the vehicle. Acoustic optimizations realized in recent vehicles are often efficient for the medium and high frequencies domain. In the very low frequency domain (between 50 Hz and 250 Hz), the acoustic modal behavior of the car cavity and the poor absorption performance of the porous material result in high noise level.

In this study, we are treating longitudinal modes with a resistive screen coupled with a large air gap. The car trunk representes this air gap and the resistive screen is constituted by a tuned mask-luggage.

2 Principle

In a car, the longitudinal acoustic modes are determined primarily by the interior car length (L1). The first and the second mode frequencies are around 80 Hz and 160 Hz, corresponding to a wavelentgth of approximatly 4,2 m. To control these modes, the device proposed is constituted by a resistive screen combined with a large air gap (L2).

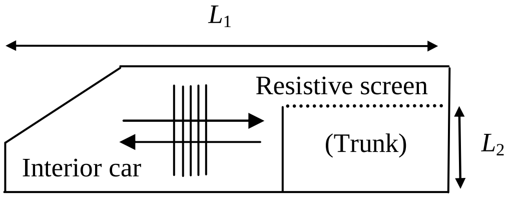

Fig.1 Schematic drawing of the very low frequencies absorption device

3 Modelization

The sumulation of the absorption properties of the device are computed with Maine3A using a simplified based Limp model where only four intrinsic parameters are used : thickness, resistivity, porosity and density.

All parameters are measured on the CTTM test benches for a current resistive screen chosen as reference (table 1).

Thickness (mm)	1,8
Resistivity (Rayls/m)	235000
Density (kg/m3)	720
Porosity (%)	15

Table 1 : Intrinsic parameters of the reference resistive screen

The model is validated by measurements on a Kundt's tube using the two microphones method for the case of a 180 mm air gap. A good agreement between measurements and simulations is shown on figure 2.

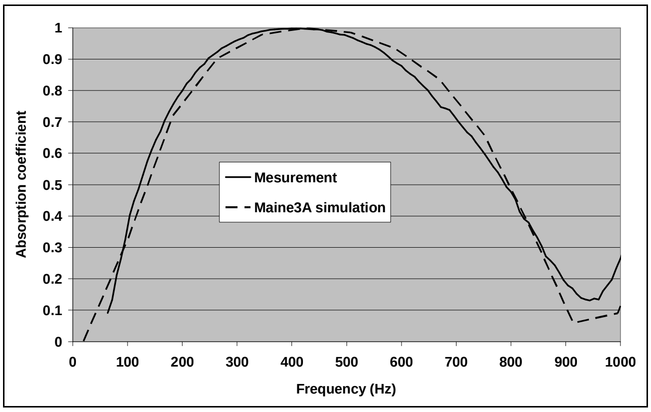

Fig.2 Comparison measurements/simulations for the reference resistive screen with 180 mm air gap

4 Optimization

For the interior vehicule case, the trunk gives approximately a 500 mm air gap. The optimization of the absorption device for the very low frequencies (80 to 250 Hz) leads to the following set of parameters where the thickness is included in the specific resistance Rs and in the area weight Ms :

$R_s = \frac{\sigma}{e} = 450$ rayls, where σ is the resistivity and e the thickness of the resistive screen,

$M_s = \frac{\rho}{e} = 1 \text{ to } 1{,}5$ kg/m², where ρ is the density of the resistive screen.

The porosity does not have a great influence on the absorption coefficient and can be chosen between 10 and 90 %.

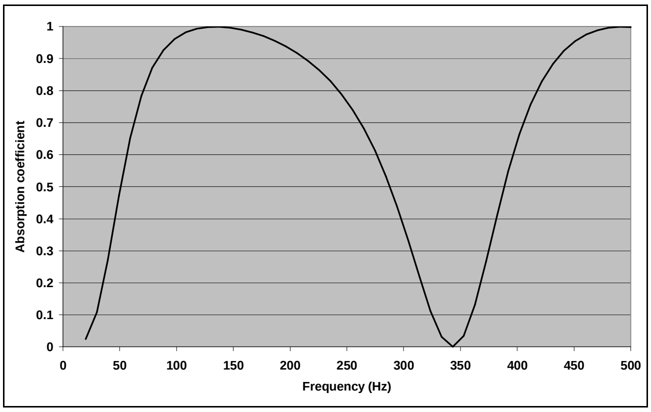

Fig.3 Maine3A optimization with 500 mm air gap

5 Application

To make measurements on vehicle, we used two prototypes mask luggages with characteristics close from the optimum calculation : solution 1 : $R_s = 386$ rayls, $M_s = 1{,}05\, kg/m^2$ and solution 2 : $R_s = 211$ rayls, $M_s = 0.65$ kg/m²

As seen on figure 4, the tuned mask lungages lead to significant noise reductions particularly between 1500 and 2500 rpm.

The measurements in vehicle corresponds to the pressure level in dB of the second harmonic engine according to the RPM. The microphones are located near the right ear of the conductor and the 3 passengers.

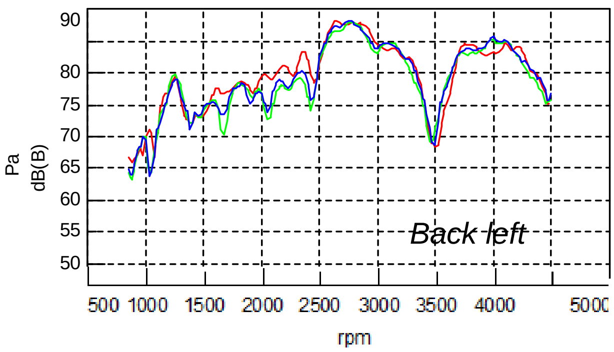

Fig.4 Acoustic pressure in the vehicle seat back left : Green curve: solution 1, blue curve : solution 2, Red curve: standard mask luggages.

These measurements show the possibility to dissipate the first longitudinal modes of the cavity vehicle with a porous mask lungage. The effect is about 3db on the back seat. It's less effective on front seat.

6 Conclusion

This study shows us a new strategy to reduce low frequency level in a car vehicle with modal absorption.

PSA and CTTM will work on new low frequency absorption applications in vehicle.