SOUND PACKAGE FOR A MAGNESIUM ALLOY DASH PANEL

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1. INTRODUCTION

New government regulations require automotive industries to reduce greenhouse gas emissions. It can be realised by increasing the energy efficiency of the automobile powertrain or by reducing the total weight of the vehicle.

The automobile companies such as Ford and Volkswagen decided to use magnesium alloy (AZ31B) to replace some steel parts of the car. The magnesium alloy has several advantages over steel. It is more malleable, more ductile, lighter, and it has a higher stiffness weight ratio. However, its low mass gives a poor sound transmission loss performance compared to steel. Thus, it is necessary to develop a new sound package for magnesium alloy.

The methodology described in this paper is to optimize a new acoustic treatment of a 2-mm thick magnesium alloy dash panel. In addition, a constraint is imposed on the mass per unit area of the dash panel with its treatment. The results of the new acoustic treatment are compared with a reference sound package.

2. METHODS

2.1 Reference sound package

Figure 1 shows the sound package typically used on the automobile dash panel [SY, 2010]. It is a multilayer of insulating and absorbing materials of various thicknesses. The mass per unit area of this treatment with a 0.9-mm thick steel dash panel is 10.15 kg/m^2.

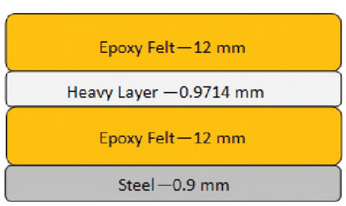

Figure 1. Typical sound package for the steel dash panel

Applying this same treatment on a magnesium alloy dash panel of 2 mm thickness, the noise reduction (NR) performance is lower than the one with steel as shown in Figure 2. The *NR* is the acoustical pressure reduction inside the car cabin due to the dash panel and sound package. The *NR* mathematical expression will be given later in this paper.

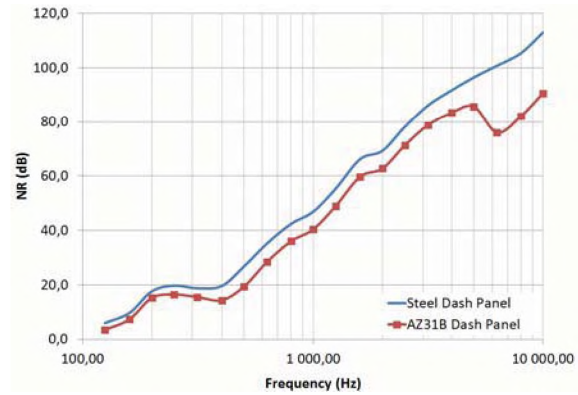

Figure 2. *NR* comparison between the reference sound package installed on a steel dash panel and on a magnesium alloy dash panel.

2.2 Methodology

A 3D model of a car has been designed in the statistical energy analysis (SEA) software VA ONE to calculate the average sound absorption of the car cabin. This model takes into account the sound absorption of seats, roof, floor and doors. The average absorption has been used to calculate the *NR* of the dash panel for optimization process [ATALA, 2011]. It is given by:

$$NR = TL - 10\log_{10}\frac{A_S}{A_C\tilde{\alpha}} \qquad \text{(Eq. 1)}$$

where TL is the transmission loss of the dash panel and sound package, $\tilde{\alpha}$ is the average absorption of cabin car, A_c is the cabin car surface area and A_s is the dash panel surface area.

An optimization program was developed in the Matlab environment. The genetic algorithm presented by [KINCAID *and al.*, 2002] is used as an optimization process. Acoustic indicators of the dash panel were calculated with the transfer matrix module of the NOVA software. The cost function to maximize is :

$$C.F. = \sum_i^n \left[NR_{NEW}^i - NR_{REF}^i\right] \qquad \text{(Eq. 2)}$$

where NR_{NEW}^i is the NR for the new sound package installed on magnesium alloy dash panel at the ith frequency and NR_{REF}^i is the NR of the corresponding reference sound package with steel dash panel. Optimization frequency range goes from 125 Hz to 10,000 Hz. In addition, new acoustic treatments concepts are classified by their performances corresponding to the differences between the NR.

3. RESULTS

Three concepts emerged after optimization and are shown in Figure 3.

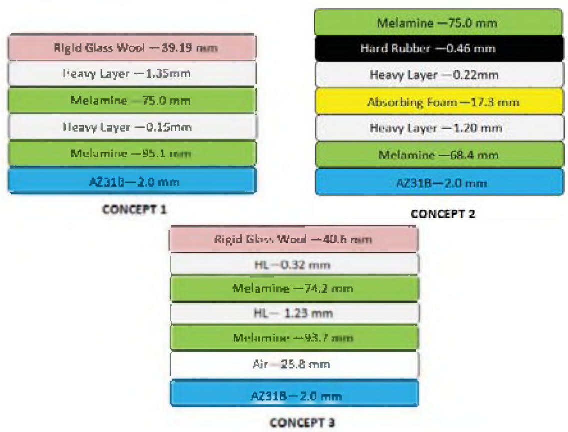

Figure 3. Three concepts emerged after optimization

The first concept is composed of absorbers and insulators materials. A similar structure was used for the second concept. Only a small damping material layer (hard rubber) was added to improve the transmission loss at low frequencies. The optimization was performed on 33 different materials considering the following criteria: the type of materials, the thickness of each layer, the positioning of the each material in the multilayer. An optimization constraint of 8.5 kg/m^2 has been imposed on the maximum surface density.

In concept 3, an air plenum was added to the multilayer. The air plenum is a separator between two layers and can improve transmission loss of the multilayer. The same optimization process than the one used for concept 1 was used for concept 3. However, an additional constraint was added to ensure that the multilayer cannot end by the air plenum.

4. DISCUSSION AND CONCLUSIONS

Figure 4 shows the noise reduction of each concept compared to the reference treatment.

Table 1 presents, for each considered concept, the surface density and their average gain in dB of *NR* with frequency compared to the reference dash panel.

For frequencies above 250 Hz, concept 1 shows a very good improvement in the *NR* (between 4 dB and 48 dB). For frequencies below 250 Hz, the transmission loss of the reference treatment is very important due to its mass, giving

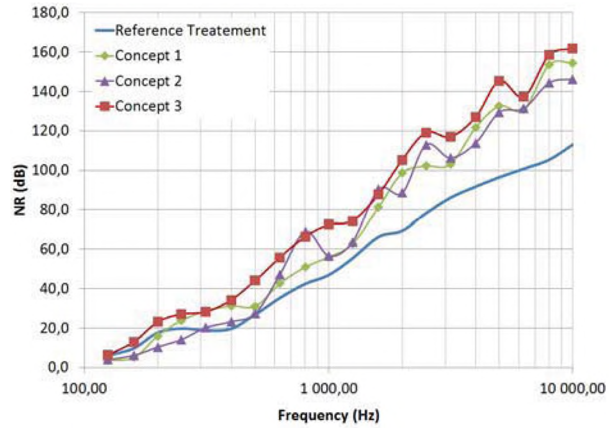

Figure 4. ***NR*** **of each concept compared to standard treatment**

Table 1. Average gain in dB of NR

Concept	Surface density	Gain
1	8.26 kg/m^2	16.2 dB
2	8.47 kg/m^2	15.0 dB
3	8.40 kg/m^2	25.0 dB

it an advantage over concept 1. However, the average gain of concept 1 over the reference treatment is 16.2 dB for the whole optimization frequency range.

The results for concept 2 are close to those obtained for concept 1. The addition of the damping material was not sufficient to improve the *NR* at low frequencies (125 Hz to 250 Hz).

Finally, concept 3 shows the best *NR* over the whole frequency range. However, the main disadvantage of concept 3 is the difficulty to maintain an air layer in its fabrication. It is possible by installing rigid supports but this will add some extra mass. Also, the total thickness of this concept is too large for real car application. The next step of the optimization process is to impose the maximum thickness constraint and to fabricate prototypes of the three concepts to validate these results.

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