

Development of High Performance Floor Insulation Structure of 2008 Model Year ACCORD

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ABSTRACT

The development of the new model ACCORD set out to produce a sound proof package that would result in competitive NV performance, while at the same time demonstrate good weight performance. The study of the sound proof package employed a variety of methods that have demonstrated effectiveness in other development projects, as follows: A hybrid statistical energy analysis (hybrid SEA) modeling method, a technique enabling prediction of the acoustic characteristics of multilayered materials, and FEM analysis. The results of these analyses showed that the floor, including the tunnel, displayed a high rate of contribution to road noise in the vehicle cabin. This enabled the development of a sound insulating floor structure that balanced reduced weight with enhanced sound insulating performance, which has contributed to the achievement of increased quietness in the new model ACCORD.

1. Introduction

The quietness of automobile cabins is an important element in increasing commercial appeal. The achievement of weight savings is also important from the perspective of fuel efficiency. However, in many cases, the achievement of increased quietness (enhanced sound insulation performance) and the achievement of weight savings are mutually contradictory objectives. The specifications of sound proof packages should be studied from the early stage of vehicle development in order to achieve a superior balance between these two aspects of performance⁽¹⁾. Hybrid statistical energy analysis (SEA) modeling methods^{(2), (3)}, a technique enabling estimation of the acoustic characteristics of multilayered materials^{(4), (5)}, and FEM analysis are available as proven and effective methods of studying the specifications of sound proof packages.

These techniques were used in the development of the new model ACCORD, which employs a V6 gasoline engine, in an attempt to realize a sound proof package that displayed good weight performance but also enabled the achievement of competitive NV performance. The project resulted in the development of a floor insulation structure that balanced weight savings with increased sound insulation performance. This paper will provide details of the project.

2. Method of Development of Floor Insulation Structure

The project studied sound insulation specifications for the floor carpet and the structure of the floor panels as floor insulation structures. The floor carpet acoustic specifications were established on the basis of the following set of procedures from the initial stages of the development process:

- (1) Establishment of targets for interior cavity sound pressure level
- (2) Analysis of rate of contribution using a hybrid SEA modeling method
- (3) Based on the result of the contribution analysis, the establishment of targets for acoustic performance (sound absorption performance and sound insulation performance) for areas displaying the higher contribution to interior cavity sound pressure level enabling achievement of the targets established for interior cavity noise
- (4) Establishment of targets for acoustic characteristics of sound insulating materials (absorption coefficient, transmission loss) to enable achievement of the above targets
- (5) Use of technique for prediction of acoustic characteristics of multilayered materials to study specifications for sound insulating materials (material, thickness, area) to

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enable achievement of targets for acoustic characteristics of materials

(6) Verification of effectiveness in actual vehicle

In the development of the floor panel structure, a genetic algorithm was employed to enable simultaneous optimization of the shape of the panels and the shape and positioning of the damping materials, to assist in the determination of specifications that would minimize sound radiation from the panels at the minimum weight⁽⁶⁾.

3. Study of Floor Specifications

3.1. Results of Analysis of Contribution to Noise

During the study of the sound insulating specifications, hybrid SEA modeling method was used to analyze contributions to interior cavity sound pressure level in the previous mass production model. The results of these analyses are shown in Fig. 1. The contribution of sound radiation and transmission by the floor, including the tunnel, is higher at medium frequencies, in particular at around 250 Hz, the frequency of sympathetic resonance of the air column. In addition, the contribution of sound transmission from the floor is higher in high frequency range. Based on these results, it was judged that countermeasures for sound radiation and sound transmission of medium frequency range and transmission of high frequency range would be necessary in the floor. As shown in Table 1, the concept with regard to the specifications of the floor sound proof package was to develop a floor carpet that would enhance sound insulation performance, acting as a countermeasure to the sound radiation and transmission from the floor in the previous mass production model, and that would also enhance sound absorption performance in the interior cavity. In addition, it was judged necessary to study the shape of the floor panels in order to enable reduction of the vibration of the panels, an important element of countermeasures against sound radiation from the panels, with the minimum amount of asphalt sheet.

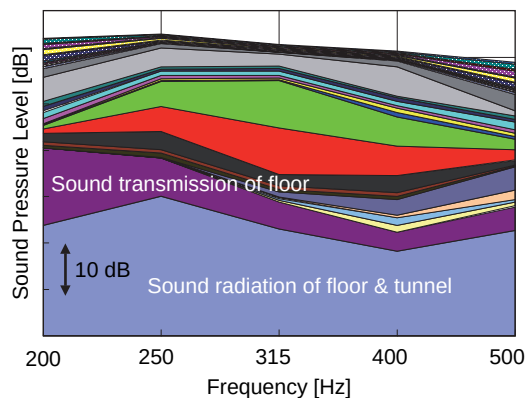


Fig. 1 Power contribution to interior cavity sound pressure level

Table 1 Countermeasure method of sound radiation and sound transmission

	Sound radiation	Sound transmission
Floor carpet	Enhancement of sound insulation performance	Enhancement of insulation performance and absorption performance
Floor panel	Reduction of panel vibration	—

3.2. Floor Carpet Specifications

The floor carpet configuration shown in Fig. 2, which displays both sound insulation and sound absorption performance, was proposed in order to reduce sound radiation and transmission and enhance the sound absorption performance in the interior cavity. The carpet has a porous layer as a sound absorbing structure on the interior cavity side and a heavy layer with porous layer as a sound insulating structure on the panel side. As Fig. 3 shows, for ensuring the aerodynamic performance of the under floor, the layout of the floor frame for the new model ACCORD has been modified to inside the cabin from outside the cabin. As a result of a contour map of the thickness of the sound insulating materials at the back of the carpet as shown in Fig. 4 and the thickness distribution of the floor carpet as shown in Fig. 5, an adequate level of thickness was able to be employed compared to the previous mass production model. The average thickness of the carpet is increased by approximately 30%.

The possibility that user treading comfort would be affected by the use of increased thickness was a concern in the study of floor carpet specifications (selection of

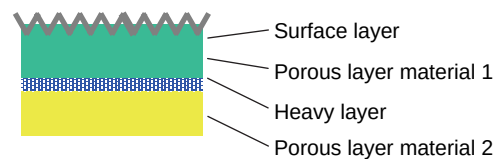


Fig. 2 Multi-layer sound-proof package

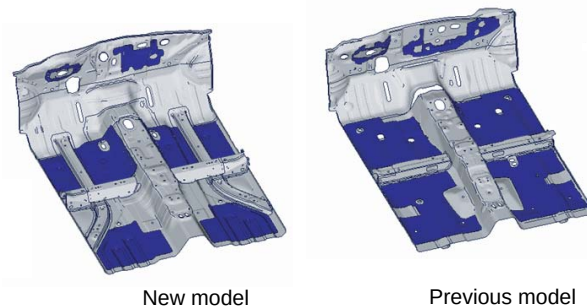


Fig. 3 Comparison of floor structure between previous and new model

material characteristics, thickness, area, etc.), and it was necessary to select materials considering this aspect of performance. Therefore, with considering the user treading comfort, the specifications were studied using the method of predicting the acoustic characteristics of multilayered materials. The use of high-rigidity expanded polypropylene beads underneath the porous material covering the panels has enabled the achievement of a balance between sound insulation performance and user treading comfort (Fig. 6).

3.3. Floor Panel Specifications

In the development of the floor panel structure, an FEM model of the vehicle was constructed and used to

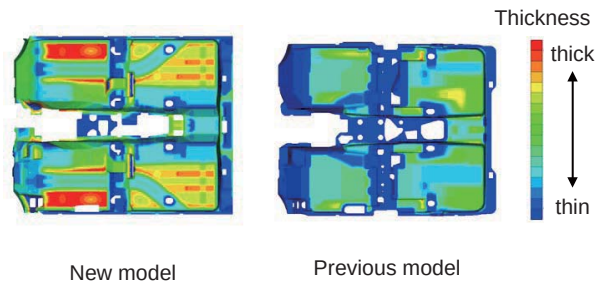


Fig. 4 Comparison of floor carpet thickness distribution between previous and new model

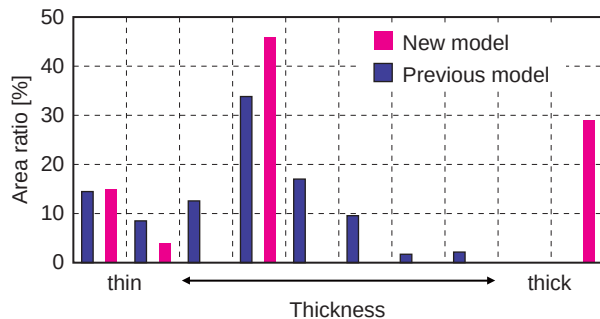


Fig. 5 Floor carpet thickness distribution of previous and new model

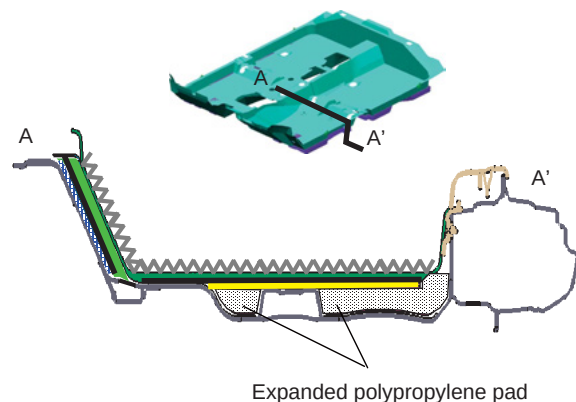


Fig. 6 Cross section of floor carpet

study sound radiation power with an excitation on the suspension mounting points. In addition, a genetic algorithm was employed simultaneously to optimize the shape of the panels and the shape and positioning of the asphalt sheet. As shown in Fig. 7, the flat panels were optimized with dimple shape and bead shape. As a result, the reduction in the sound radiation power from the panel surfaces was achieved as compared to that of the previous model (Fig. 8). The thickness of the asphalt sheet was also reduced as compared to the previous model, which contributes to the achievement of weight savings.

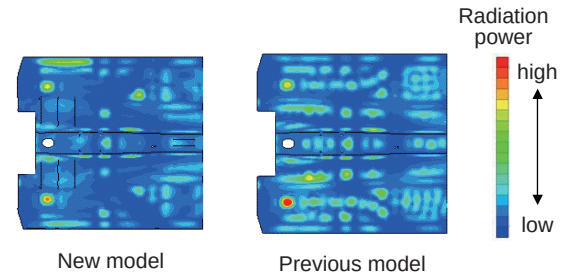


Fig. 7 Comparison of radiation power from panel

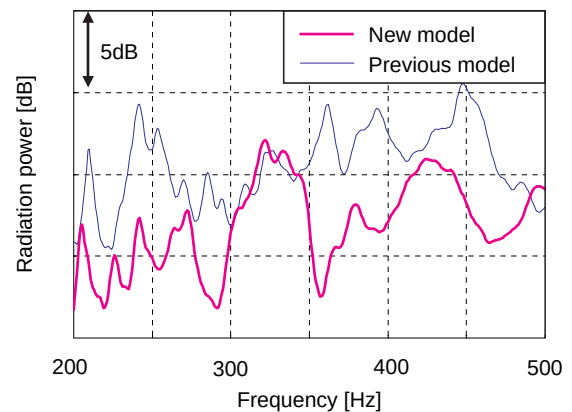


Fig. 8 Radiation power from floor panel

4. Performance of Completed Vehicle

The use of the sound-absorbing and sound-insulating floor carpet and the low-vibration floor panel structure described above has reduced the level of both radiated and transmitted sound in the new model ACCORD, in addition to increasing the sound absorption performance of the interior cavity. These countermeasures have reduced the level of road noise in mid and high-frequency range as compared to that of the previous mass production model.

5. Conclusion

The development of the new model ACCORD set out to produce a sound proof package that would result in

competitive NV performance, while at the same time demonstrate good weight performance. The project employed hybrid SEA modeling method, a technique for predicting the acoustic characteristics of multilayered materials, and FEM analysis to study the specifications of the sound proof package, with the following results:

- (1) The floor of the vehicle, including the tunnel, was demonstrated to display a high contribution to interior cavity under road noise test condition.
- (2) A sound-absorbing and sound-insulating floor carpet that achieved a superior balance between sound absorption and sound insulation characteristics was proposed as a countermeasure against sound radiation and sound transmission from the floor, which demonstrated a high rate of contribution to interior cavity sound pressure level, and to enhance the sound absorption performance of the cabin.
- (3) Dimple and bead shapes were employed on the floor panel as a countermeasure to reduce sound radiation and to enable the achievement of weight savings by using the minimum amount of asphalt sheet.

The project resulted in the development of a sound insulating floor structure that both contributes to weight reduce and acoustic performance enhancement. The use of this floor structure has contributed to increased quietness in the new model ACCORD.

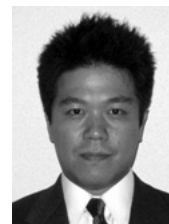
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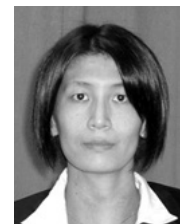
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