

Extraction of High Contributing Acoustic Modes of Vehicle Luggage Compartment and Response Level Estimation Utilizing Operational TPA-CAE Combined Procedure

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Road noise characteristic in cabin is affected by not only input from tires but also the body vibration and acoustic cabin space characteristics. In this study, we focused on the noise from rear tire to rear seat via luggage room space and attempted to find out high contributing acoustical mode by utilizing experimental principal component contribution analysis (PCCA) and CAE eigenvalue analysis. In addition, we also attempted to estimate the response point SPL change by the target acoustic space modification utilizing PCCA and CAE response analysis.

The proposed method was applied to a simple luggage room space model as shown in Fig. 1. At first, CAE eigenvalue analysis was conducted to the space to find out the acoustical modes as shown in Fig. 2. Subsequently, the operational test was carried out for applying PCCA. In the test, 25 microphones were set in the space as the reference point signals and another microphone was set outside of the space as the response point and random noise was given from left lower position as shown in the arrow in Fig. 1. Through PCCA, high contributing principal component (PC) and the PC acoustic behavior (PC mode) was obtained. The high contributing acoustical modes was then obtained by evaluating the mode shape similarity between the high contributing PC mode and the acoustic mode as indicated by red rectangular in Fig. 2.

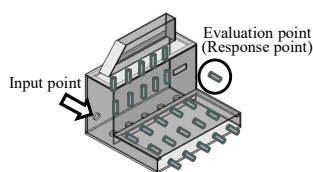


Fig.1 Target acoustic space

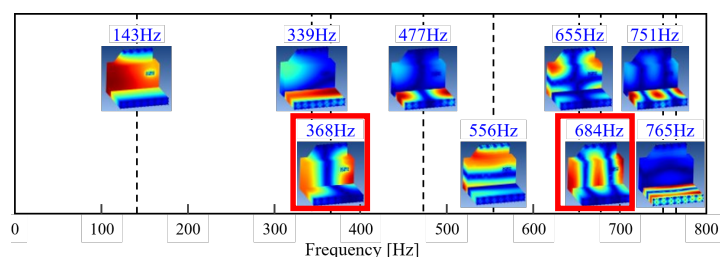


Fig.2 Acoustic modes and the high contributing modes

In the next step, we estimated the response point SPL before the actual acoustic space modification using PCCA contribution model and CAE response analysis. For utilizing PCCA contribution model, preparing PC level change before and after modification is necessary by using CAE response analysis. We then calculated the reference point SPL at the 25 points inside of the target acoustic space using CAE response analysis and PC level, that is generated by the focused high contributing acoustic modes, was calculated by applying principal component analysis to the analyzed 25 reference signals. As an instance of the modification in this study, the side space was decreased by using a plastic plate as shown in Fig. 3. And the PC level difference between original and modified acoustic space was estimated using the CAE response analysis and principal component analysis. Here, the high contributing acoustic modes only at around 690 Hz were focused to estimate the response level simply. And the response point SPL was actually estimated by inserting the PC level difference to the original PCCA contribution model. Figure 4 shows the estimated response point SPL by the modification. For the verification of the proposed estimation method, we modified the shape actually and the operational test was again conducted. As the result, the response point SPL at the target frequency band of 690 Hz was observed to be decreased and the effectiveness of the proposed method was verified.

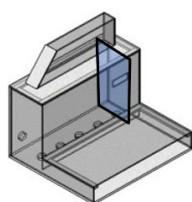


Fig.3 Modified shape

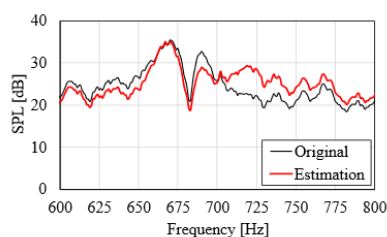


Fig.4 Estimated response point SPL

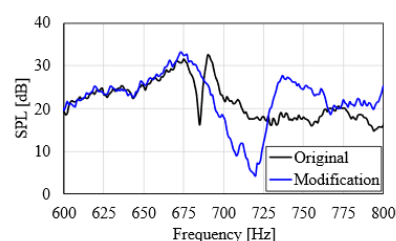


Fig.5 SPL comparison before and after actual modification