Development of a Method to Predict Vehicle Body Openings for Improving Sound Insulation

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Improving both of sound insulation and weight reduction of vehicles are required to achieve good fuel efficiency, cost saving and cabin quietness. By filling body openings like drain holes and gaps between sheet metals, sound intrusions into cabins are prevented and interior noise can be suppressed without increasing of sound absorbing materials. However air conditioning systems and door closing performance need a certain amount of cabin ventilation capacity that depends on air outlets and body openings. Improvement of cabin airtightness by reduction of the body opening areas might harm the ventilation capacity.

To selectively fill gaps having strong bad influences for the sound insulation, we should detect distribution of the openings and estimate contributions of each opening for air ventilation in the early phase of vehicle design. It is desirable that ventilation capacity are secured by air outlets with enough size after the other openings are closed.

To specify body openings in the step of building CAD models, a leak path detecting CAE software is utilized. The commercial software can find leak paths between inside and outside of a cabin, but cannot evaluate effects of the paths on the airtightness. We developed a method to evaluate contributions of body openings for cabin airtightness by equivalent opening areas from leak path data obtained from the CAE software. The match between evaluated equivalent opening areas and experimental values is confirmed. Effects of body openings on sound insulation is experimentally validated. Improvement of cabin quietness is substantiated by filling dominant openings derived from the analysis of leak path and opening areas.

An analysis result by the leak path detecting CAE software is shown in Fig.1. Leak paths between inside and outside of a cabin through drain holes and sheet metals gaps are visualized. Fig.2 is a schematics of the new method for estimation of equivalent opening area from a leak path analysis. The analysis results have lists of openings which paths go through. The smallest opening in a path acts as bottleneck of the path. Comparison between estimation and experimental results is shown in Fig.3. The analytical results are about 20 % smaller than experimental results but their magnitude correlations show good agreement. Based on leak paths found in the analysis, body openings like drain holes at a rear end structure of an actual vehicle are filled and cabin noise is measured in constant speed driving. AIM is improved about 3% in 100km/h constant. The difference of SPL spectrum between before and after opening infilling is shown in Fig.4.

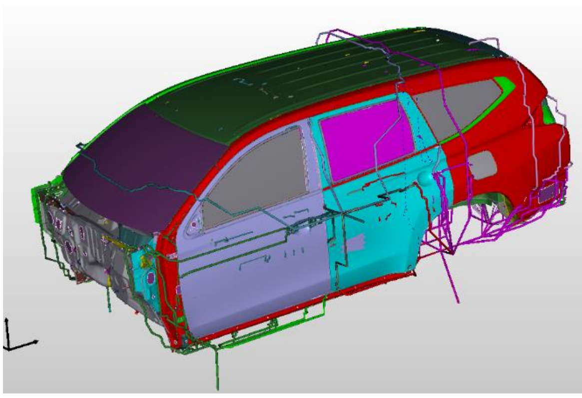

Fig.1 a CAE Analysis of Leak Paths

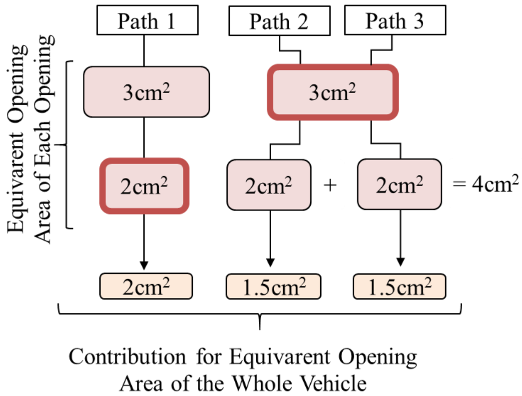

Fig.2 Schematics of Equivalent Opening Area Estimation

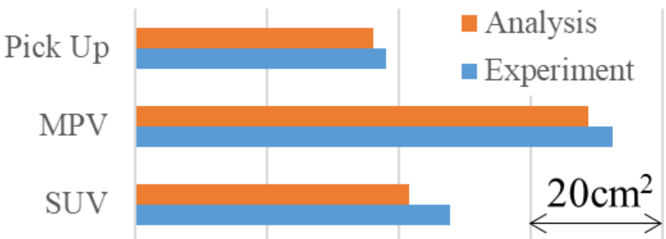

Fig. 3 Comparison between Estimation and Experimental Results of Body Opening Areas.

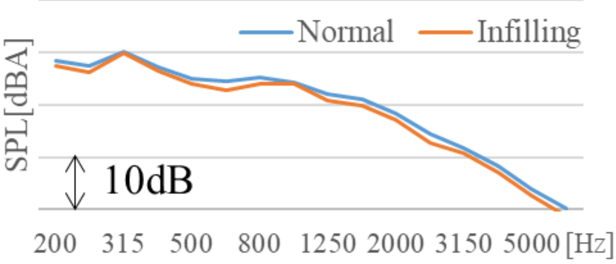

Fig. 4 Effect of Opening Infilling (100km/h constant speed driving)