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Design Technique for Reducing Broadband Frequency Vibration on Structures Based on Vibration Energy Flow Analysis

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As vehicle electrification progresses due to severe environmental regulations in each country, the engineering demand of mid to high frequency noise such as road noise or motor noise is relatively getting higher. In terms of the needs of lightweight vehicles, a technology that enables incorporation of measures into the vehicle body aiming to suppress the propagation of the noise to panel is also required. This paper describes numerical technique to quantify the energy propagation of T-junction of body structure and also the method of how to define design requirements using parameters of coupling specifications.

Panel ERP was evaluated when the tip of the framework was forcibly vibrated by using a simple structure simulating the underbody of a vehicle . On the basis of the concept that average level of vibrational energy can be reduced by controlling traveling wave, propagation of traveling wave was visualized by instantaneous structural intensity calculation by time history analysis (Fig.1). The main flow of the vibration energy reaches directly to the framework connection point. Then, most of the vibration energy is diverged into the 1st cross member and flow into the member from the spot-welding point.

As a next step, the quantification method of vibrational energy propagation at T-junction of structure was studied. With placing a spring element($k_{\#1} \sim k_{\#3}$) at the center of the cross-sectional view center (#1 to #3) at T-junction of body structure, "Transfer Impedance Derivation Model" was developed in order to evaluate propagation impedance (Fig.2). For the reduction of panel ERP, aiming to suppress panel inflow, energy control designed to propagate #3 side instead of #2 side (i.e.$Z_{12} > Z_{13}$) was considered to be effective. T-junction stiffness ratio, K_{ratio}, was set as a parameter, and correlation between propagation impedance and panel ERP was confirmed. As an example, with $k_{\#2} > k_{\#3}$, it resulted to be $Z_{12} > Z_{13}$, and the panel ERP decreased (Fig.3).

The results are summarized as follows:

(1) By the FEM model, "Transfer Impedance Derivation Model" which enables to quantify the energy propagation at the centroidal axis of the frame was developed.

(2) The panel ERP reduction was suggested to be possible if energy propagation path is controlled with the parameters of T-junction stiffness ratio, K_{ratio} and propagation impedance ratio, Z_{ratio}.

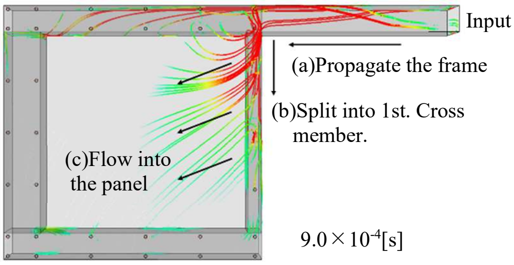

Fig. 1 Result of instantaneous structural intensity

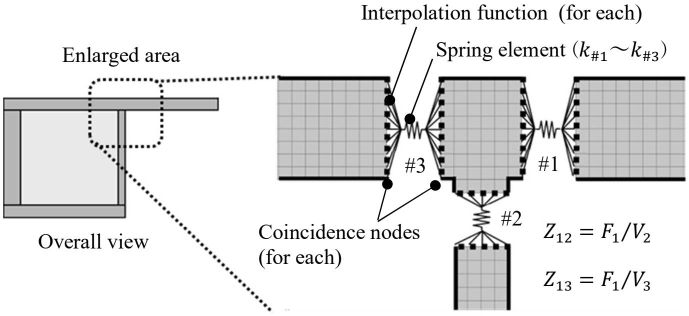

Fig. 2 Schematic diagram of transfer impedance derivation model

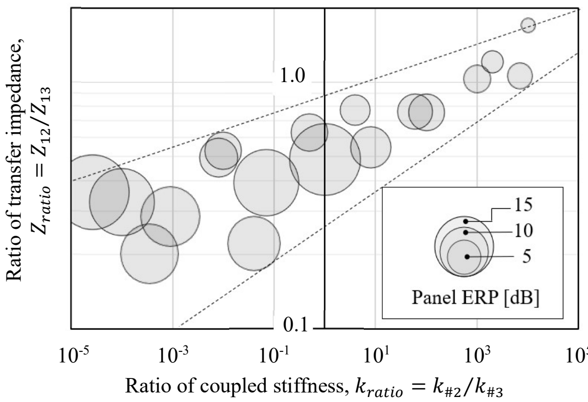

Fig.3 Bubble chart - Relativity between panel ERP and substitute characteristics

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