

A method for reducing blocked force by sparse structural modifications

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KEY WORDS: Vibration, noise, and ride comfort, Powertrain oscillation, Finite element method, LASSO (B3)

In the automotive industry, OEMs and parts suppliers often design and develop vehicle bodies and components independently, making it frequently difficult to share detailed product information with one another. Under these circumstances, it is difficult to meet the required specifications for vibration and noise performance with the vehicle body and components assembled, without the need for rework. As a solution, when parts suppliers share "blocked force" with OEMs, it becomes possible to appropriately allocate vibration and noise performance across the whole structure during the development phase, without disclosing detailed product information. When vibration and noise performance issues arise, parts suppliers are often asked by OEMs to improve vibration characteristics. However, making significant structural changes to components is difficult, and effective countermeasures are often not feasible. Therefore, we developed a method to reduce the blocked force through small structural modifications. In previous study, we proposed a method to derive structural modification plans that achieve the desired ODS (Operating Deflection Shape) at specified frequencies by combining CEAM (Constrained Eigenstructure Assignment Method) with LASSO (Least Absolute Shrinkage and Selection Operator). In this study, we devised a method to compute structural modification proposals for reducing blocked force by adjusting the shape and magnitude of the ODS; this was achieved by expressing the blocked force as the product of the dynamic stiffness matrix and the ODS, thereby integrating this approach with techniques from previous research. Furthermore, we identified the conditions for reducing only the magnitude of the blocked force, while maintaining the orientation of the vector representing its distribution, when deriving these structural modification proposals. The effectiveness of the proposed method was verified using a finite element model.

Figures 1 and 2 show the results of applying the proposed method to a finite element model. Figure 1 shows the weighting coefficients, which represent the structural modification solutions. A weight coefficient of one indicates that no structural modification is required for that element relative to the initial structure. As shown in Figure 1, the regions requiring structural modification are limited, confirming a high degree of sparsity. Figure 2 shows the blocked forces for the initial structure, the target blocked forces, and the blocked forces after structural modification, represented by black, blue, and red markers, respectively. The horizontal axis in Figure 2 represents the degrees of freedom in the interface region. The vertical axis of the upper plot represents the translational forces, while that of lower plot represents the moments. It can be confirmed that the desired blocked forces and the blocked forces after structural modification match almost perfectly. Furthermore, the force distribution patterns for each degree of freedom are preserved before and after the structural modification, and it can be seen that the forces are reduced at a uniform rate overall.

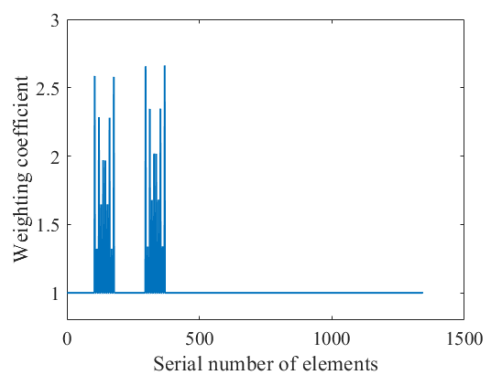


Fig. 1 CEAM weight coefficients estimated using LASSO

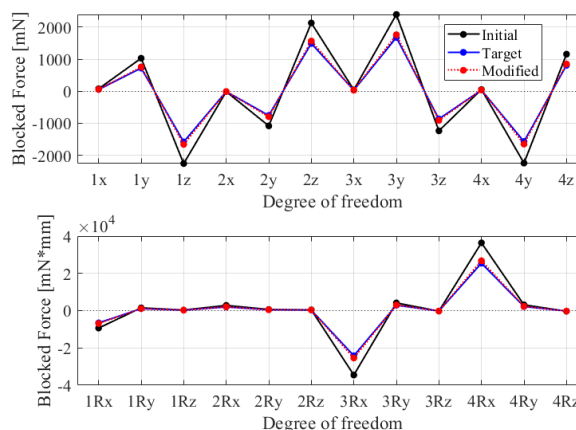


Fig. 2 Reduction in blocked forces resulting from structural modifications incorporating the estimated weighting coefficients.