Practical Modal Analysis for Vehicles

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The methods of Stochastic Subspace Identification (SSI) and Operational Deformation Shape (ODS) were combined to perform an Operational Modal Analysis (OMA) of a test vehicle. The methods of Least Squares Complex Frequency (LSCF) and sinusoidal excitation using a small electromagnetic exciter were also combined to perform Experimental Modal Analysis (EMA) of the same vehicle.

Figure 1. shows measurement points of the test vehicle for both OMA and EMA. For OMA one single axis accelerometer was kept fixed on the right top of windshield in the lateral direction as a reference point for all the mesurements. One triaxial accelerometer was moved to 12 other locations while the measurement was conducted, instead of using 12 triaxial accelerometers at the same time. The test was conducted at the speed 40km ~ 60km/h on city roads because typical scuttle shake of a convertible car had been observed in this speed range. Since all of the data were not measured simultaneously, SSI was used to determine only the frequency and damping ratios, and ODS was used to determine only mode shapes.

Fig. 2 shows the scuttle shake which is a torsional mode of vibration. The Bending mode and windshield fluttering mode were also extracted but these modes were not strongly excited because the point of load input close to the tyre is also close to the node point of these modes.

For EMA one triaxial accelerometer was also moved to 12 locations while the measurement was conducted with sinusoidal excitation using a small electromagnetic exciter in the laboratory. In all, 14 modes were estimated by using LSCF. The three modes found by OMA were validated by EMA.

OMA is useful to find out reasons of specific trouble or problems under operating conditions. SSI is considered to be a very powerful class of identification technique for OMA. However, this technique is sensitive to the nature of the signal and to boundary conditions. It is also difficult to process data from multiple non-simultaneously recorded mesurement setups. ODS is a classical, but robust, technique for determing mode shapes only if modes are well separated from each other. Authors believe a combination of SSI and ODS is a practical usage of OMA.

EMA is useful to find the over all character of vibration because it employs artificial excitation. Sinusoidal excitation can put more energy into a specific frequency than does random excitation. LSCF is powerful curvefitting technique that can span across a wider frequency range than LSCE or other algorithms.

This paper proposes that these methods are a practical way to perform modal analysis of vehicles.

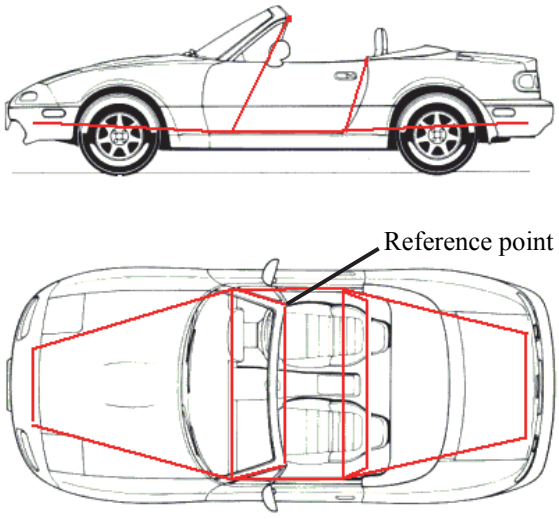

Fig.1 Measurement points of test vehicle

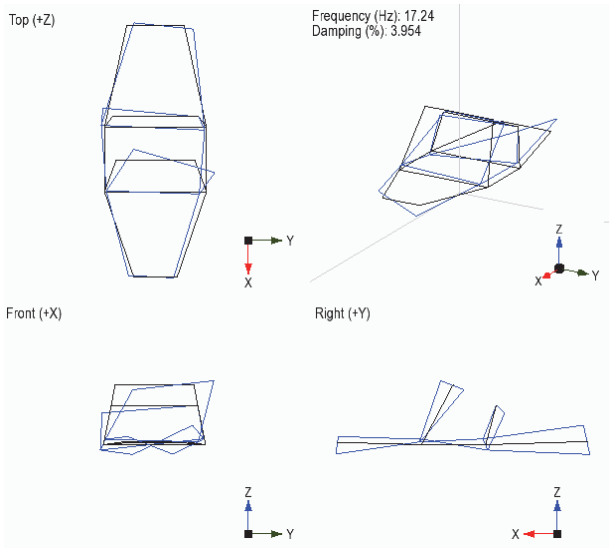

Fig.2 Torsional mode