Vibroacoustic Damping Using a Tuned Viscoelastic Damper

Tuned mass dampers (TMD) are highly effective and tunable passive vibration damping treatments. These devices are damped 2nd order systems appended to a vibrating structure; see Figure 1.

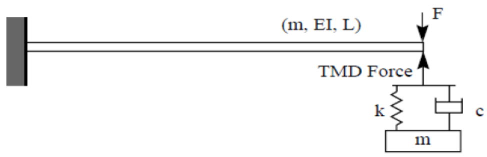

Figure 1 A TMD Schematic

Proper selection of the parameters (mass, stiffness, and damping) of a tuned mass damper, tunes the TMD to one of the natural frequencies of the underdamped flexible structure, resulting in the addition of damping to that resonance. TMDs are tunable devices, which can target a vibrating mode and add considerable amount of damping to that mode.

The mass of a TMD and its stiffness are chosen to make the natural frequency of the TMD match to the resonant frequency of the structure to be damped and provide enough damping effectiveness without adding excessive mass to the structure. In addition to the mass, damping effectiveness of a TMD is also dependent on the amount of damping built into it. The lack of enough damping in the TMD results in breaking the resonant mode, to which the device is tuned, to two underdamped modes-an undesirable phenomenon known as "mode splitting". Once the mass, stiffness, and damping ratio are decided upon, its damping coefficient are evaluated.

> When viscoelastic material, instead of a dashpot, is used as the damping element, the tuned mass damper is called *[viscoelastic tuned mass damper](#)*.

To mitigate the boominess of the cabin in a large sport utility vehicle, it was required to add damping to the 2nd mode of the flexible roof of the SUV cabin. A small tuned viscoelastic damper (with the mass of about 30 gr) was designed and installed on the roof. A substantial amount of viscoelastic damping was engineered in the tuned mass damper for 1) avoiding splitting the target vibration mode, and 2) have tolerance to slight variation to the tuned frequency.

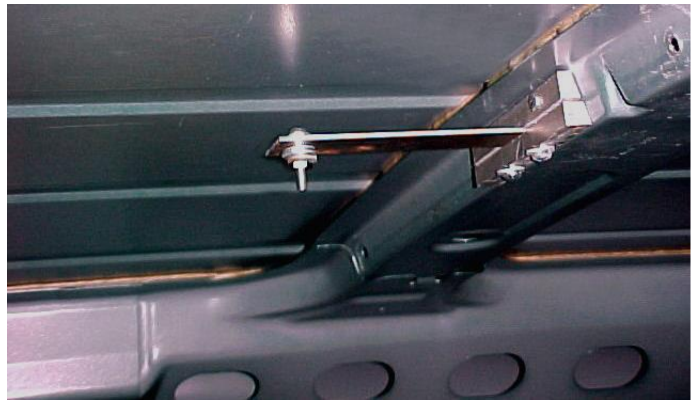

Figure 2 Viscoelastic tuned mass damper installed on the ceiling, above the headliner

The effectiveness of the tuned mass damper was evaluated by exciting the roof of the enclosure (using a shaker) and measuring the pressure (by a microphone) at a desired location.

Figure 3 depicts, the scaled magnitude of frequency response functions (FRFs) mapping the vibration disturbance (in terms of the voltage driving the shaker) to the pressure measured at the desired location. Clear from the figure, the tuned viscoelastic damper effectively added damping to the mode of the structure (roof) it is tuned to, i.e., the 2nd mode.

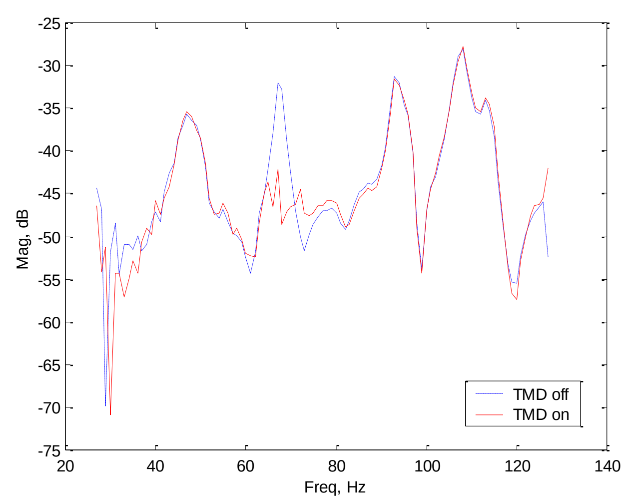

Figure 3 Frequency response function of the structure with and without the TMD