Introduction to Noise and Vibration Control Solutions

NOISE + VIBRATION CONTROL SOLUTIONS

Introduction

If left untreated, noise and vibration can be damaging to people, structures, and equipment. In addition to being an annoyance, noise can cause permanent hearing loss in individuals when proper controls are not implemented. Excessive vibration may lead to user fatigue, which can result in user errors and unsafe working conditions. Vibration can damage structures by imparting high-cycle fatigue or causing sensitive equipment (i.e., electronics, sensors) to fail prematurely.

Both passive and active methods can be used to control noise and vibration, but this article focuses on passive methods. Active noise and vibration control solutions tend to be complicated, expensive, require additional sensors, computer-control hardware, and are unique for each application. Passive methods of controlling noise and vibration tend to be more robust. Common examples such of passive solutions include:

1. Structural damping
2. Localized Vibration Mitigation (Tuned Vibration Absorbers, Tuned Mass Dampers)
3. Isolation
4. Barriers or enclosures
5. Absorption

Many of these approaches can be used simultaneously to provide an optimal solution for the application. It is important to understand the underlying cause of the noise or vibration issue so that the correct solution can be utilized.

Structural Damping

Vibration and noise transmission into and through a structure are primarily a function of the properties of the structure (i.e., stiffness, mass, and damping), the properties of the adjacent fluid (e.g., air, etc.), and the frequency content of the excitation energy. Vibration caused by the excitation of an engine may travel within a panel structure, excite resonances of the panel, and cause damage in the form of high-cycle fatigue cracks. The same engine excitation may cause a panel or other structural element to disturb the nearby air and result in high levels of radiated noise. Such problems may be addressed with structural damping.

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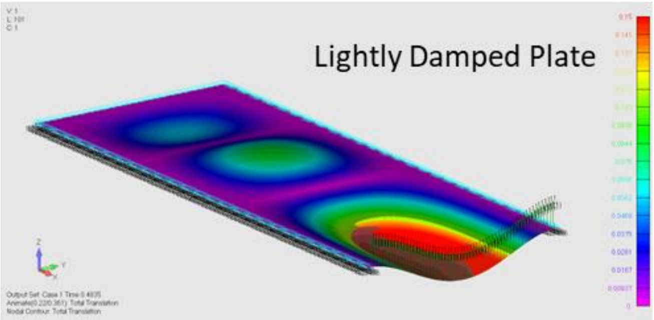
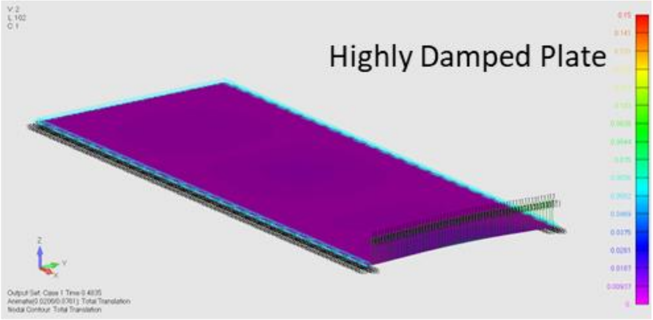
The first step to solving a vibration issue is to understand the source of the problem. The response of the structure should be analyzed to determine if the problem results from resonant response (i.e., the free propagation of vibration energy within the system results in the excitation of structural modes) or forced response (i.e., the energy is non-propagating and results from the direct excitation of a periodic force). To solve such issues, engineers commonly redesign the structure by adding mass or stiffness to mitigate the issue. This solution, however, tends to add cost, significant weight, and complexity to the system design, is often difficult to implement late in development, and potentially creates other issues as resonances are moved to other frequencies.

Structural damping is a useful tool to solve resonant vibration issues. Damping reduces the severity of freely propagating vibration waves and reduces the response of resonant vibration. Damping is also extremely weight efficient with respect to attenuation of resonance response.

DTI has a 30+ year history of designing passive damping systems that impart significant damping into a variety of structures. Our library of viscoelastic polymers and various constraining-layer materials allow us to design application specific systems that function on specified substrates at desired temperatures with minimal weight addition. DTI has robust simulation capability and has used accurate modelling to develop Stand-Off Damping Systems (SODS), Constrained-Layer Damping Systems (CLDS), and damping links designed for a wide array of applications across various industries. DTI has a team passionate about solving noise and vibration issues and improving structural robustness and reducing system weight by driving damping solutions into the design phase.





DAMPING TECHNOLOGIES, INC.

55656 Currant Road | Mishawaka, IN 46545-4802 | P: 574.258.7916
www.damping.com

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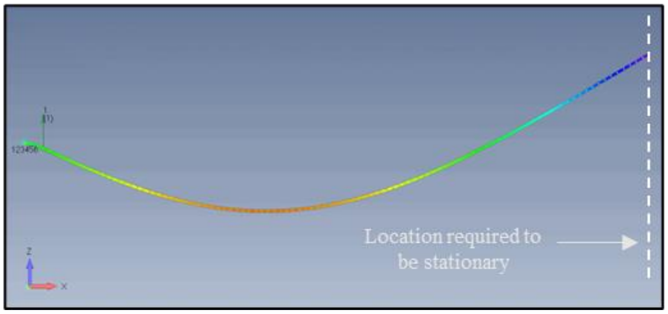
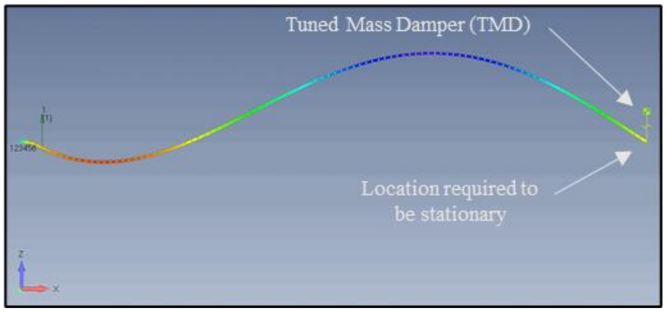
Localized Vibration Mitigation (Tuned Vibration Absorbers, Tuned Mass Dampers)

If a vibration results from the direct excitation from an input force with little contribution from resonant vibration, strategies other than structural damping must be investigated. Design changes that increase the stiffness or mass of a structure are often appropriate to solve these issues, but the impact to cost and timeline remain a challenge to the design engineer. Tuned Vibration Absorbers may be used to reduce the effect of forced vibration at a particular location. These spring-mass systems function by transmitting the vibration into the absorber resulting in a reduction of motion at the desired location. This solution is commonly implemented at sensitive instrumentation locations where vibration can impede intended functionality. A Tuned Mass Damper is a similar countermeasure but is used for control of resonance response.





Isolation

When the source of troublesome vibration is well-understood and the connection between the source and the structure occur at discrete points, it is often desirable to reduce the transmission of the vibration using vibration isolation techniques. Often, this involves decoupling the forcing function from a structure. These isolators provide an impedance that resists the transmission of energy and must be custom designed in order to function properly. The mass, stiffness, and damping of the isolator element as well as the dynamics of the attached structures are important for effective isolator design. Common examples of isolator solutions include sophisticated engine mounts, simple rubber feet on mechanical equipment, and car shocks.

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Barriers

If a noise issue arises from an (airborne) external noise source, sound barriers (i.e., materials that block noise and create soundproof walls, ceilings, cabs, or enclosures) are often the best solution. Simple barrier designs utilize mass to block noise from entering the environment. The performance of these systems is typically mass controlled and are best suited for medium to high sound frequencies. Barriers that utilize a gap between layers provide additional mid-to-high frequency performance benefits, and DTI's de-coupled mass acoustic barriers utilized this 'double-wall' effect to achieve weight-efficient transmission loss performance.

Acoustic Absorption

Once acoustic energy has entered an enclosed volume, such as a vehicle cab or aircraft fuselage, energy will continue to reverberate until it is dissipated by the surroundings. This resulting 'reverberant field' can significantly contribute to the total sound in the environment. This effect is observed when a balloon is popped in an enclosed environment with hard surfaces, and the noise can be heard reflecting from the interior surfaces. To reduce the effect of the reverberant field, acoustic absorption materials may be used to add 'acoustic damping' to the space.

Porous material such as foams and fibers tend to provide significant acoustic absorption, and the amount of total absorption is determined by the total area of used material. The thickness and type of materials determine the frequency-dependent behavior of the absorptive materials, and in general, low frequency noise absorption requires thicker materials. It should also be noted that acoustic foams do not generally prevent noise from transferring between rooms and have minimal impact to transmission loss.

Conclusion

When addressing noise and vibration related issues, understanding the cause of the issue is important to selecting the correct solution. Sound and vibration are complex issues and here at DTI we have a variety of performance materials that are utilized in a variety of industries. In addition, we offer analysis services and can formulate custom materials based on your application.