Visco Elastic Damping

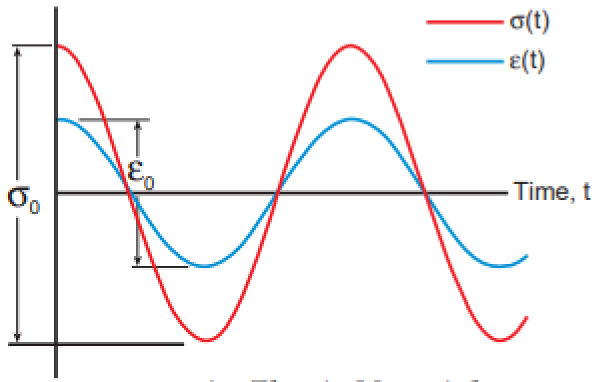
Vibration damping dissipates vibration energy. It absorbs or changes vibration energy, reducing the amount of energy transmitted through the equipment or structure. Understanding these processes — and when to use them — also requires understanding two concepts: transmissibility and natural frequency.

Transmissibility is the ratio of the vibrational force being measured in a system to the vibrational force entering a system. For example, if a material used for vibration isolation has a transmissibility of 75%, that means 75% of the vibrating force energy is being transmitted (or 25% transmission loss) through the materials and measured on the other side.

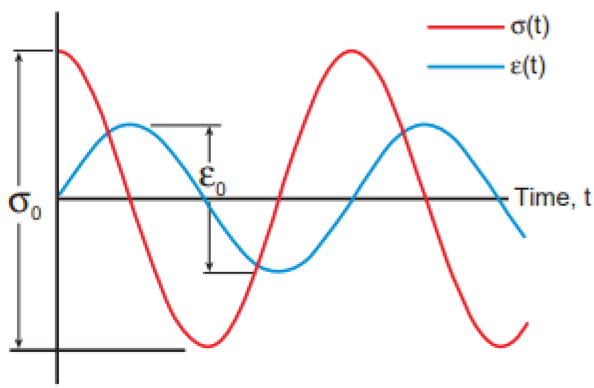
Natural frequency is the frequency (number of cyclic motions per unit time) at which an object or structure vibrates naturally or resonates. A structure vibrating at natural frequency will vibrate forever unless an outside force interferes with it. Thankfully, in nature, there's always some force affecting a vibrating object, removing energy and eventually dissipating the vibration; these forces collectively are commonly referred to as vibration damping.

So how do all these concepts and definitions help determine if vibration damping or isolation is the way to go in controlling vibrations in various products? The first step is to identify the offending source and frequencies of concern, which in many cases arise from features outside of a product designer's control. If the object or structure is simple enough, it may be possible to use isolation to shift a single critical natural frequency away from the excitation source frequency. However, for most practical product applications there are typically so many natural frequencies and dynamic loads that they all can't be shifted; energy dissipation via damping is the only way control the dynamic response and reduce transmissibility.

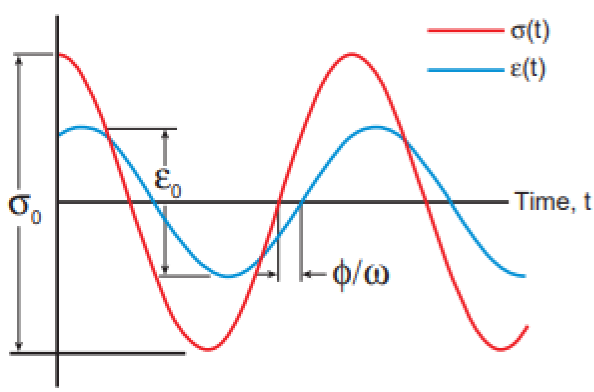
Definition of Viscoelasticity
A viscoelastic material is characterized by possessing both viscous and elastic behavior. What this means exactly is best illustrated in figure below, which shows how various types of materials behave in the time domain. For a slab of material with a cross-sectional area, A, and a thickness, T, subject to cyclic loading, F(t), the corresponding response is given by the displacement function, x(t). The cyclic stress on the sample material is found by dividing the input load by the cross-sectional area, and the resulting cyclic strain on the material is found by dividing the displacement by the thickness.



1a. Elastic Material



1b. Viscous Material

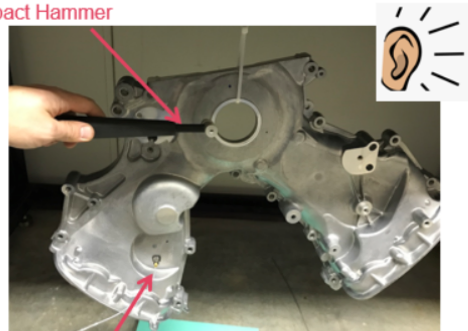


1c. Viscoelastic Material

Metal-to-Plastic Conversion

- Two engine cover designs tested:
  1) Original die-cast aluminum design
  2) Amodel (structural PPA) slightly redesigned for injection moldability

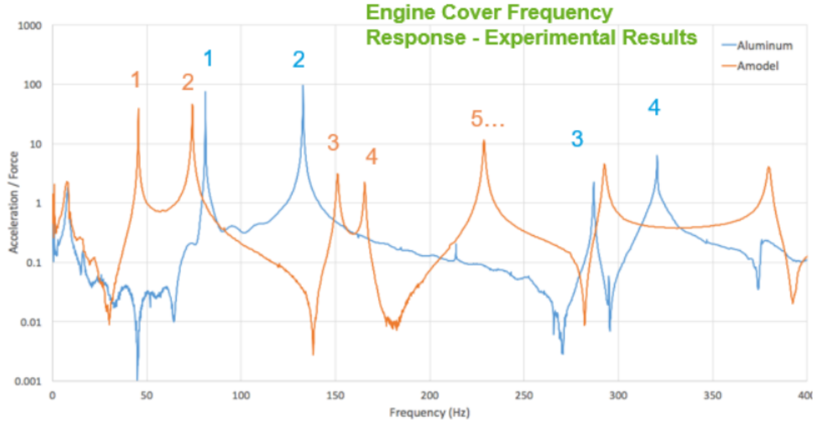
Impact Hammer



Accelerometer

Property Comparison Table

	Aluminum	Amodel PPA	Unit
Modulus	71.0	24.4	GPa
Density	2.75	1.64	g/cc
Strength	240	275	MPa
Elongation	< 1	2.0	%



	Mode 1		Mode 2		Mode 3		Mode 4	
Material	Freq (Hz)	Damping (%)	Freq (Hz)	Damping (%)	Freq (Hz)	Damping (%)	Freq (Hz)	Damping (%)
Aluminum	81.0	0.064	132.9	0.054	286.9	0.06	320.5	0.053
Amodel	45.5	0.178	74.1	0.215	151.1	0.258	165.5	0.196
% Change	-44	178	-44	298	-47	330	-48	270

Aluminum to Amodel PPA conversion → Damping factor + 250%

Link: Solvay NVH