Damping Loss Factor for Damping Materials for Continuous Structures

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ABSTRACT

The half power bandwidth method is used for measuring a damping loss factor. There are different damping materials available of different configuration in the market. This paper will help to select damping materials for different applications and to give a data bank for numerical analysis. Other objectives are to observe damping loss factor at various condition which are as follows: (1) To compare the effect of fusing with base material. (2) To compare the effect of material thickness. (3) To compare damping materials with constraint layer damping (4) To evaluate the damping loss factor using double layers of constraint layer damping.

INTORDUCTION

The damping loss factor is a very important parameter in vibration engineering and it is very difficult to evaluate analytically. The damping loss factor is a measure of energy dissipation and it must be evaluated experimentally. There are three types of damping namely, dry or coulomb, viscous damping, and structural or hysteresis damping. Dry damping is constant in magnitude and opposes the motion. Viscous damping is proportional to velocity of the system.

An Oberst bar with attached layers, in particular, is of great importance for practical noise and vibration applications. A typical configuration usually consist of an Oberst bar to which are attached one or more layers of a viscoelastic (Butane rubber) damping material and possibly additional structures, such systems essentially result in a division of a labour where the bar contributes the necessary strength and the damping material produces the desirable structure borne sound properties or a reduction in the amplitude of bending waves. The damping loss factor for longitudinal waves differs from bending waves. It is very difficult to decide the material for damping treatment for a structure due to unknown values of the damping loss factor.

The damping loss factor is also dependent upon the application of the material to the base material as well as thickness of the damping material. Due to the development of technology of fusing with base material, three methods are used namely, oven heating, hot gun, and adhesive. Melt sheets (3mm and 6mm thick) are used for observing the effect of thickness. In recent years it has also become common practice to damp beam or plate like structures by attaching to such a structure a layer of viscoelastic material and placing atop secondary constraint beam or plate of structural material called the constraint layer configuration. In the constraint layer configuration, the viscoelastic material is subjected primarily to shear loading caused by covering the structure extending less than the upper surface of the basic structure. The constraint layer damping is compared experimentally to values of damping loss factor with simple damping configurations. In constraint layer damping, the thickness of butane rubber is 1.9mm and atop aluminium bar is placed of thickness 0.066 mm. Butane rubber and aluminum backed damping material is available readily in the market and this combination is directly pasted to the base material with built in adhesive of the configuration.

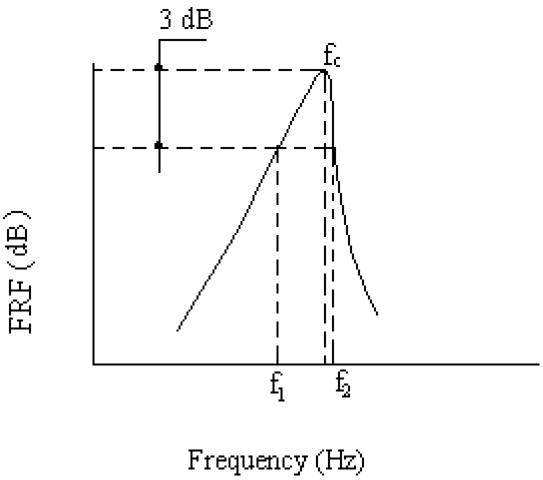

Figure 1. Typical frequency response function of Oberst bar

THEORY

The damping loss factor is measured using the half power bandwidth method. A typical frequency response function of continuos system is shown in Figure 1. The damping loss factor is evaluated and given by [1]

$$\eta = \frac{f_2 - f_1}{f_c} \qquad \ldots 1$$

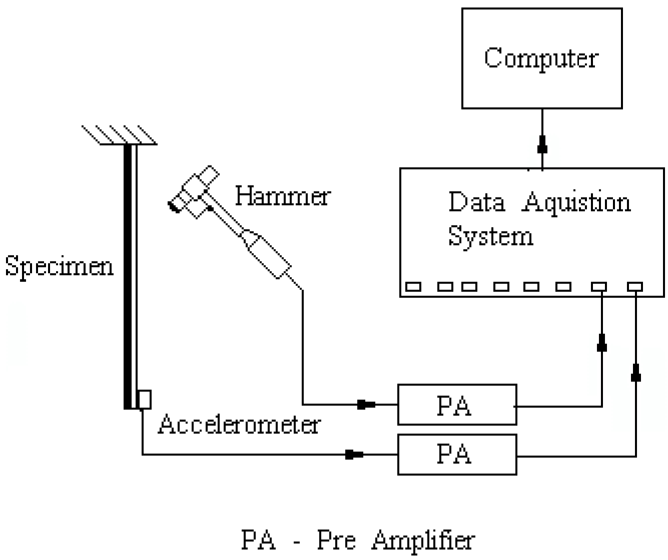

Figure 2. Experimental set-up for damping loss factor measurement.

Where f_1 and f_2 are frequencies at 3 dB below the peak values. f_c Is peak frequency in frequency response curve is shown in Figure 1. Equation 1 is used for evaluating damping loss factor of first three the modes in this paper.

EXPERIMENTAL SETUP

The Oberst bar is a mild steel bar per SAE 1631J.

The dimensions are

Total length = 225mm

Free length = 200mm

Thickness = 0.8mm

Width = 12.7mm

The experiment setup for measurement of damping loss factor is shown in figure 3. The cantilever Oberst bar is excited using a calibrated impact hammer. The response is measured using a lightweight accelerometer. The excitation signal and accelerometer signal are fed to the data acquisition system. Data acquisition and post-processing was done by using commercial software. Five averages are taken for improving the repeatability of the frequency response function (FRF).

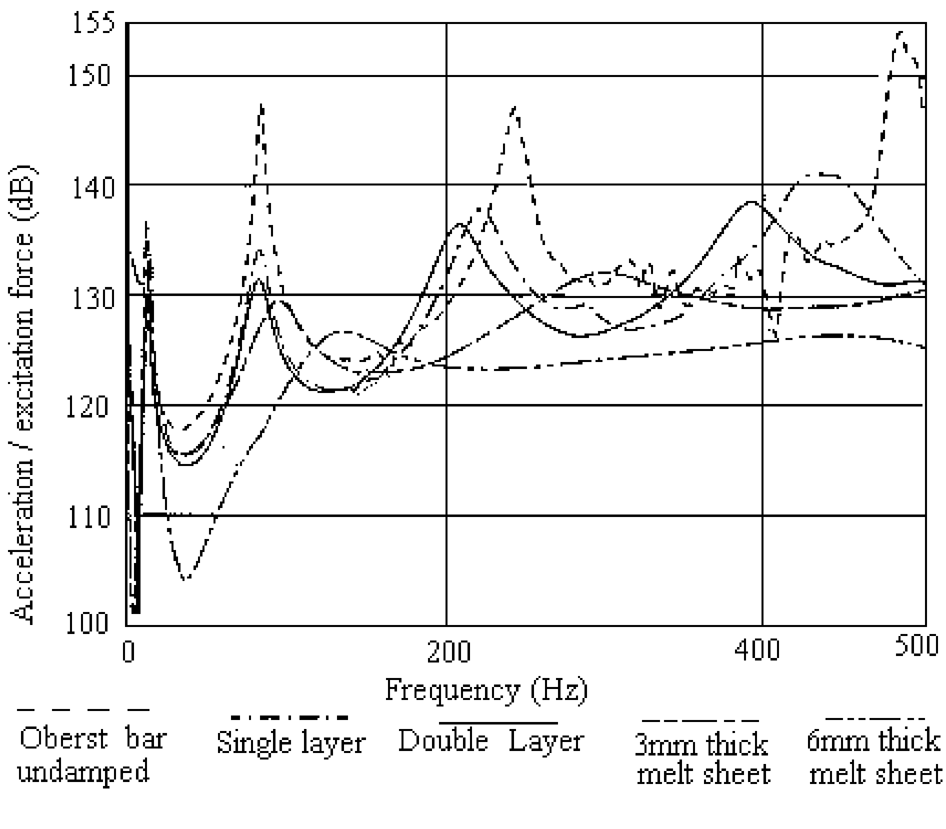

Figure 3. Frequency response function of different configuration of Oberst bar

RESULTS AND DISCUSSION

Figure 3 shows frequency response curve of the different configuration of the Oberst bar. While taking FRF, coherence of average FRF is observed for relationship of input and output. The phase angle between the input and output signal shows identification of the correct resonance values or natural frequency and their higher modes. Figure 3 and equation 1 are used for evaluating the damping loss factor. Table 1 shows values of the damping loss factor for first three modes for different configuration.

Butane rubber as a viscoelastic material shows the damping effect up to 500 Hz. Measurement of FRF shows increasing damping values as the butane rubber thickness increases from 3 mm to 6mm. The damping loss factor of Oberst bar with 6mm thick butane rubber shows different characteristics than other types of configurations due to very high mass. It also changes the values of fundamental frequency as well as higher modes frequencies. While single constraint layer damping and double constraint layer damping also increase the damping values from an undamped Oberst bar, but it changes the values of the frequencies negligibly. Fusing with base structure also changes the values of damping loss factor. Fusing of base structure with help of oven heating gives better values of the damping than hot gun due to the volumetric heating of oven heating.

Table 1. Damping loss factor for different configuration of damping material

Specimen	Mass	First mode		Second mode		Third mode	
	Grams	η	Hz	η	Hz	η	Hz
Oberst bar	18.14	0.1600	11.88	0.0100	84.37	0.0040	246.25
Oberst bar with magnetic base damping material 1.5mm thick with heat gun	27.97	0.2222	11.25	0.0667	75.00	0.0581	215.00
Oberst bar with magnetic base damping material 1.5mm with oven heating	28.28	0.2000	12.50	0.0656	76.25	0.0722	225.00
Oberst bar with Aluminum backed butane rubber with adhesive	25.70	0.2222	11.25	0.0882	85.00	0.0923	230.00
Oberst bar with Aluminum backed butane rubber double layer with adhesive	33.90	0.3000	12.50	0.1667	82.50	0.1318	208.75
Oberst bar with butane rubber (3mm thick)	35.70	0.2307	13.00	0.2421	95.00	0.2110	217.00
Oberst bar with butane rubber (6mm thick)	50.19	-	-	-	-	0.6175	135.63

Conclusion

The thickness of the damping material is the important factor for deciding the treatment. Fusion of damping material to the bar also affects the damping properties of the structure. Double constrained layer configuration gives the same damping loss factor as 3mm thick melt sheet configuration and without changing the natural frequencies.

References

1. L. Cremer, M. Heckl and E. E. Ungar, Structure – *Borne Sound,* Springer – Verlag, Second edition, 1988.

2. R. H. Lyon and R. G. DeJong, *Theory and Application of Statistical Energy Analysis,* Butterworth-Heinmann, Second edition, 1995.