International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 03, March-2015

Experimental Investigation on Performance of CLD Plate

Mr. Shinde Sagar Chandrakant
ME (Mechanical – Automotive Engineering)
Department of Mechanical Engineering
Sinhgad Academy of Engineering,
Pune - 411048

Prof. Pravin P. Hujare
Department of Mechanical Engineering
Sinhgad Academy of Engineering,
Pune - 411048

***Abstract*—Vibration reduction is very important in machines and structures. Various methods are used for vibration reduction. In this report, constrained layer damping (CLD) method is studied for vibration reduction. Constrained layer damping plate consists of base plate, viscoelastic material (VEM) and constraining layer. VEM is sandwiched in between base plate and constraining layer. Under this study, three different types of VEMs are studied by using experimental analysis. The VEMs studied are Nitrile, Butyl and Neoprene. The damping performance of VEM is measured in terms of modal loss factor. From comparison of all three materials, butyl material having more damping as the overall loss factor is more. For higher frequency range, butyl material is suitable for damping. For medium frequency range, nitrile material is suitable for damping. For lower frequency range, neoprene rubber is suitable for damping**

Keywords—Constrained-layer damping system, CLD system, Viscoelastic material, Structural vibration, Frequency Response Function, Half-power bandwidth, Loss factor.

I. INTRODUCTION

Vibration is the motion of a particle or a body or a system of connected bodies displaced from a position of equilibrium. Most vibrations are undesirable in machines and structures because they produce increased stresses, energy losses, added wear, increase bearing loads, induce fatigue, create passenger discomfort in vehicles, create unwanted noise and absorb energy from the system.
The common methods of controlling unwanted vibrations are:

- Proper design to reduce the excitation at source
- Changing of mass and/or stiffness to avoid resonance
- Using damping materials

The availability of a wide range of polymeric materials, which are essentially viscoelastic in nature, with high damping capabilities has made it possible to control the structural vibrations. The polymers are commonly used in two basically different configurations to dissipate the mechanical energy of vibrations as heat. The first configuration is the free-layer damping (FLD), where the energy is dissipated due to direct strains, i.e. alternate extension and compression of the viscoelastic layer. The second configuration is the constrained-layer damping (CLD), where the shear strains in the viscoelastic layer cause damping of vibrations. Generally, the constrained layer damping system is used for very stiff structures. In constrained layer damping of plate a viscoelastic material layer is placed between base plate and constrained plate. Viscoelastic material is combination of viscous and elastic material.
A schematic diagram of a constrained-layer damping system is shown in Fig.1. Constrained layer damping is widely used for passive damping in both commercial and aerospace applications.

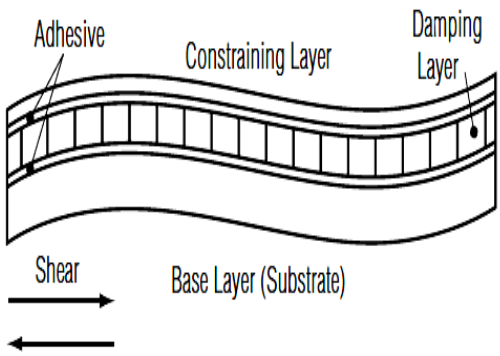

Fig.1: Constrained layer damping system

A. *Advantages of constrained layer damping*

- Very high level of damping compared to other damping methods
- Can be very weight efficient
- Many viscoelastic damping materials are available to choose from
- Can be selectively applied to highly responsive areas
- Does not require much packaging space due to the thinness
- Can be easily applied to existing structures

B. *Design of CLD plate*

Design of CLD plate is very important for the experimental investigation. According to the information collected from literature survey, dimensions of CLD plate are decided as shown in Table No. 1.The CLD plate consists of two layers of aluminum and the viscoelastic material as a core composed by 3M High-Strength Acrylic double-face adhesive [7].

For the investigation purpose dimensions of test CLD plate are as shown in Table No. 1

Table No. 1: Dimensions of CLD plate
(All Dimensions are in mm)

Sr. No.	Part Name	Material	Thickness	Length	Width
1.	Constraining Layer	Aluminum	2	350	200
2.	Damping Material	VEM Material	1	350	200
3.	Base Plate	Aluminum	2	350	200

Three types of damping materials are used for investigation purpose. They are as follows:

1. Nitrile Rubber
2. Butyl Rubber
3. Neoprene Rubber

The plate under investigation is shown in Fig.2

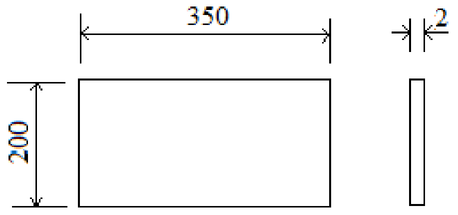

Fig. 2 (a): Undamped plate – 2D model

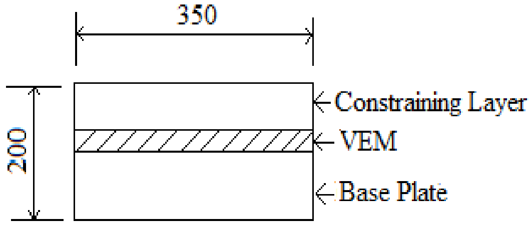

Fig. 2 (b): CLD plate – 2D model

The material properties of Aluminum and damping material under investigation are as shown in Table No. 2

Table No. 2: Material Properties

Sr. No.	Material	Poisson ratio	E (MPa)	Density (kg/m3)
1.	Aluminium	0.33	69000	2700
2.	Nitrile	0.49	10.35	1485
3.	Butyl	0.40	10.67	1487
4.	Neoprene	0.42	11.51	1483

II. EXPERIMENTAL INVESTIGATION

A. Undamped test plate

The undamped test plate under experimental Investigation is shown Fig.3. The dimensions of plate are taken from Table No. 1.

Fig. 3: Undamped test plate

B. Damped test plate

Fig.4 shows the damped test plate. Viscoelastic material is sandwiched in between two aluminum plates.

Fig. 4: Damped test plate

C. Experimental Set-up

Fig. 5 shows the schematic diagram of experimental setup.

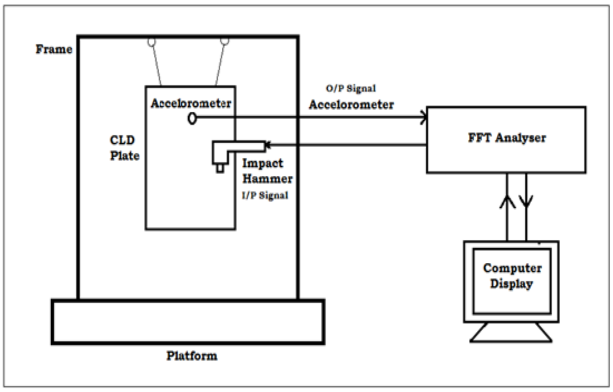

Fig. 5: Schematic diagram of experimental setup

1. The experimental setup consists of damped CLD plate fixed in a frame.
2. Frame rests on the platform.
3. Impact hammer and accelerometer are connected to FFT analyser with the help of cables.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 03, March-2015

4. CLD plate is excited with the help of impact hammer.
5. Vibrations are measured with the help of accelerometer.
6. Results are displayed on computer screen.

D. Actual Experimental Set-up

Fig. 6 shows the pictures of actual experimental setup.
It consists of frame, platform, impact hammer, FFT analyser, and accelerometer.

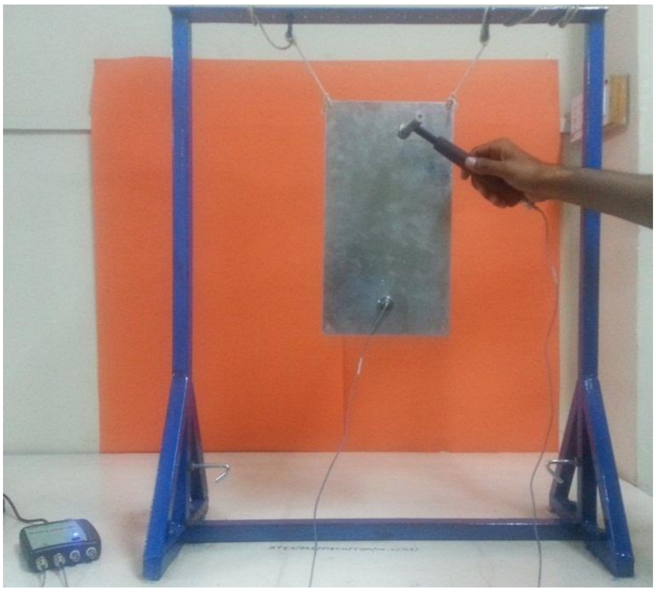

Fig.6: Experimental setup

E. Experimental Procedure

For experimental investigation, procedure is as follows:

1. Attach the accelerometer on the vibrating surface whose modal parameters are to be estimated.
2. Connect the accelerometer and impact hammer to the FFT Analyser system with the help of the cables.
3. Connect the FFT Analyser system to the computer with the help of USB port of the computer.
4. Now, impact the impact hammer on to the plate to produce excitation of the plate.
5. Repeat the procedure at different points on the plate. This is done to increase the accuracy of output.
6. Observe the FRF (Frequency Response Function) curve generated in the RT Pro software in the computer.
7. Generate a report of the same

F. Half-power bandwidth method

The most common method of determining damping is to measure frequency bandwidth, between points on the response curve, for which the response is some fraction of the resonance of the system.
Fig. 7 shows half power bandwidth method.

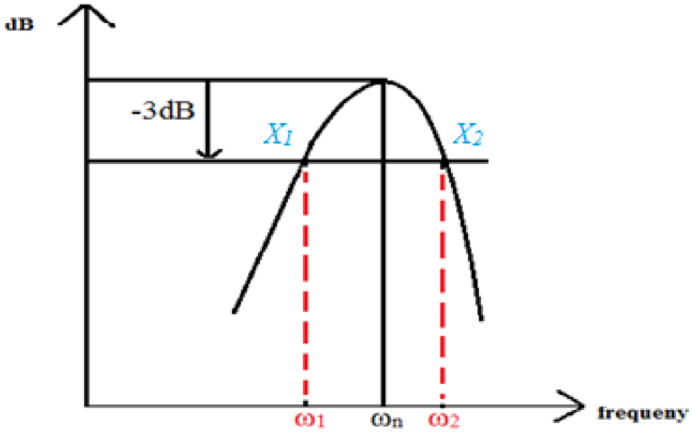

Fig. 7: Half power bandwidth method

The usual convention is to consider points X1 and X2 as shown in the above figure, to be located at frequencies on the response curve where the amplitude of response of these points is $1/\sqrt{2}$ times the maximum amplitude. The bandwidth at these points is frequently referred as 'half-power bandwidth'. The half-power points or 3dB points for small damping corresponds to the frequencies ω_1 and ω_2. The frequency interval between these two half power points is $\Delta\omega = \omega_2 - \omega_1$. Loss factor of this method is defined as:

$$\eta = \frac{\Delta\omega}{\omega_n}$$

G. Frequency Response Function (FRF) Analysis

The results of undamped plate and CLD plate frequency response function are shown below figures using RT Pro software. By analyzing the resonant peak for a particular mode, the loss factor, a measure of damping, is obtained from the response spectrum.

Fig.8 shows the FRF analysis of undamped plate.

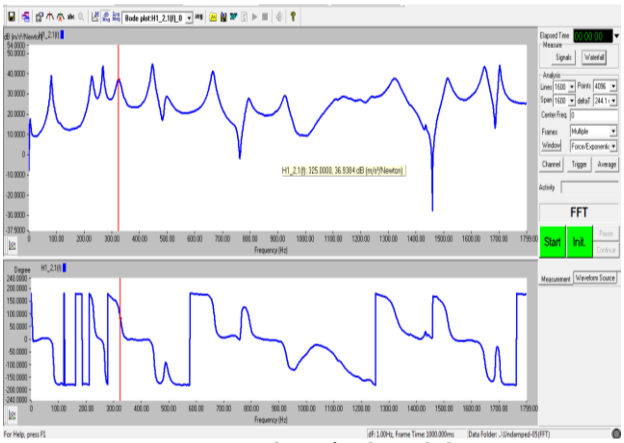

Fig.8: FRF analysis of undamped plate

Fig.9 shows FRF curve of Nitrile CLD plate.

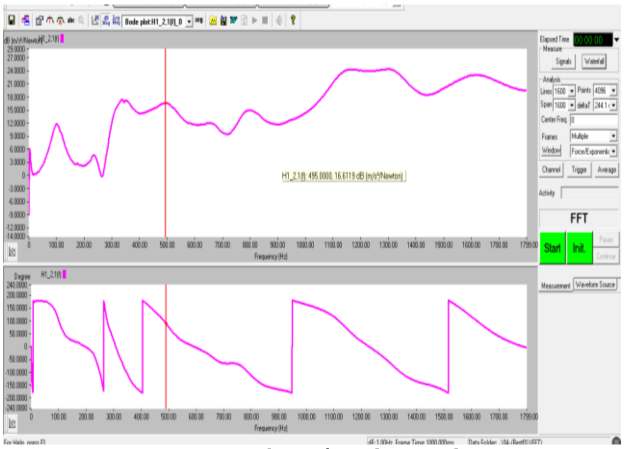

Fig.9: FRF analysis of Nitrile CLD plate

3. Fig.10 shows FRF analysis of Butyl CLD plate.

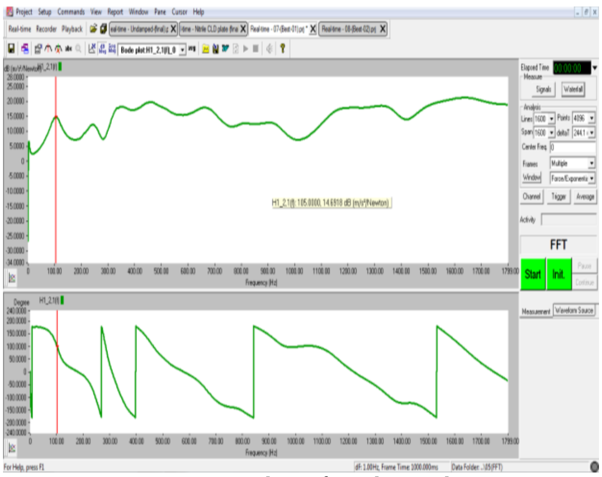

Fig.10: FRF analysis of Butyl CLD plate

4.Fig.11 shows FRF analysis of Neoprene CLD plate

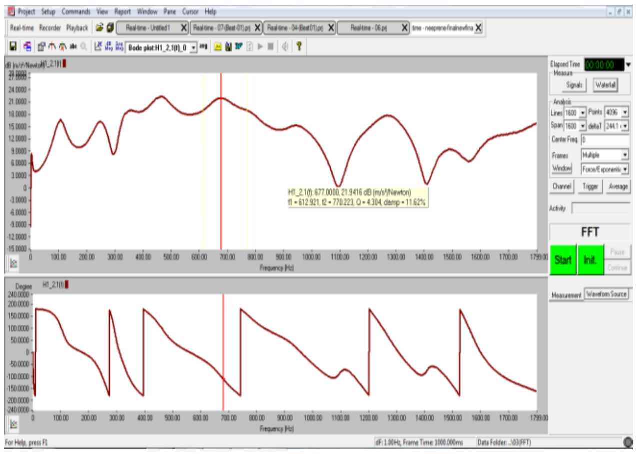

Fig. 11: FRF analysis of Neoprene plate

For the investigation purpose, the above FRF curves shown in RT PRO software are processed in MATLAB software as shown in following figures.

1. Fig.12 shows FRF curve of undamped plate

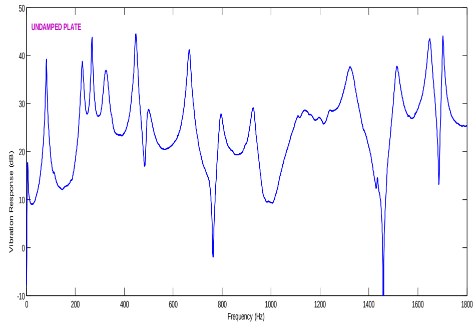

Fig.12: FRF curve of undamped plate

2. Fig.13 shows comparison of FRF curve of undamped plate and Nitrile CLD plate.

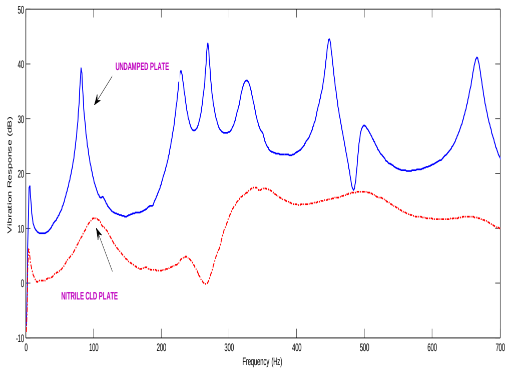

Fig.13: Comparison of FRF curve of undamped plate and Nitrile CLD plate

3. Fig.14 shows comparison of FRF curve of undamped plate and Butyl CLD plate.

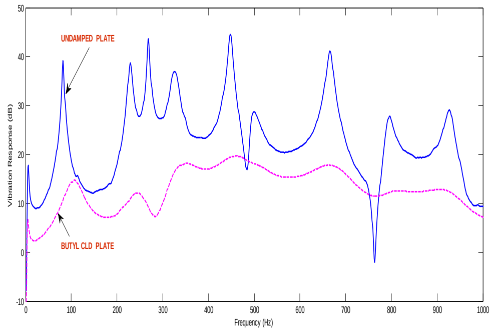

Fig.14: Comparison of FRF curve of Undamped Plate and Butyl CLD plate

4. Fig.15 shows comparison of FRF curve of undamped plate and Neoprene CLD plate.

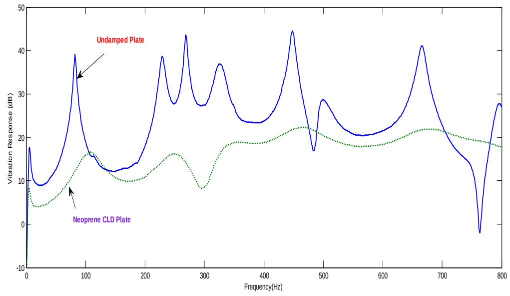

Fig.15: Comparison of FRF curve of Undamped Plate and Neoprene CLD plate

III. EXPERIMENTAL RESULT

From the experimental investigation, the natural frequencies and loss factor obtained by half power bandwidth method are shown in Table No. 3, 4 and 5.

Table No.3: Nitrile CLD Plate Experimental Result

Mode Number	Undamped Plate (Hz)	Experimental Result – CLD	
		Frequency (Hz)	Loss Factor (η)
1	81	101	0.0964
2	228	235	0.1446
3	268	337	0.0632
4	325	501	0.1596
5	447	665	0.0671

Table No. 4: Butyl CLD Plate Experimental Result

Mode Number	Undamped Plate (Hz)	Experimental Result – CLD	
		Frequency (Hz)	Loss Factor (η)
1	81	106	0.0930
2	228	244	0.0594
3	268	350	0.1714
4	325	460	0.1109
5	447	664	0.1867

Table No. 5: Neoprene CLD Plate Experimental Result

Mode Number	Undamped Plate (Hz)	Experimental Result – CLD	
		Frequency (Hz)	Loss Factor (η)
1	81	107	0.0937
2	228	248	0.0541
3	268	355	0.1126
4	325	465	0.0563
5	447	677	0.0581

IV. CONCLUSION

1. From comparison of all three materials, the Neoprene rubber is suitable for damping over lower operating frequency range.
2. Nitrile material is suitable for damping over medium operating frequency range.
3. The Butyl material is suitable for damping over higher operating frequency range.

V. REFERENCES

1. Lijian Pan , Boming Zhang
2. "A new method for the determination of damping in cocured composite laminates with embedded viscoelastic layer" Journal of Sound and Vibration 319 (2009) 822–831
3. D.D.L Chung
"Materials for vibration Damping" Journal of materials science 36 (2001) 5733-5737
4. Manex Martinez-Agirre, Marıa JesusElejabarrieta
"Characterization and modeling of viscoelastically damped sandwich structures" International Journal of Mechanical Sciences 52 (2010) 1225–1233
5. N. A. Rubayi, s. Charoenree "Natural frequencies of vibration of cantilever sandwich beams"Computers and Structures Vol.7, 1977.
6. R. F. Kristensen, K. L. Nielsen, L. P. Mikkelsen "Numerical studies of shear damped composite beams using a constrained damping layer" Composite Structures 83 (2008) 304–311
7. Y. P. Lu, J. C. CLEMENS AND A. J. ROSCOE
"Vibrations of composite plate structures consisting of a Constrained-layer damping sandwich with viscoelastic core" International Journal of Mechanical Sciences 52 (2010) 1225–1233
8. David I. G. Jones
"Handbook of Visco-elastic vibration damping"
Wiley Publications 2001