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Finite Element Analysis of Damping Performance of VEM Materials Using CLD Technique

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ABSTRACT

Most engineering structures experiences vibrational motion, this unwanted vibrations can result in premature structural failure. Many methods are developed which enhances capability of damping such as constrained layer damping. Shear motion is produced in VEM due to constraining layer to resist unwanted vibrational energy. This paper shows theeffect of varying the thickness of viscoelastic materials on damping performance of CLD beam.The damping performance is measured in terms of modal loss factor.

***Keywords*–**ConstrainingLayer, VEM, PCLD, Modal strain energy method, Modal loss factor.

I. INTRODUCTION

In mechanical industries where the use of lightweight structures is important, the introduction constrained layer damping, which has high inherent dampingbetween two layers, can produce a sandwich structure with high damping.The passive damping treatment usually implemented viscoelastic material in between two aluminum layers for forming shear deformation. High damping rate can be obtained by this configuration. Since it was discovered that damping materials could be used as treatments in passive damping technology to structures to improve damping performance, there has been a flurry of ongoing research over the last few decades to either alter existing materials, or develop entirely new materials to improve the structural dynamics of components to which a damping material could be applied. The most common damping materials available on the current market are viscoelastic materials. Viscoelastic materials are generally polymers, which allow a wide range of different compositions resulting in different material properties and behavior. Thus, viscoelastic damping materials can be developed and tailored fairly efficiently for a specific application.

This paper presents calculation of modal loss factor, investigated for design of effective constrained viscoelastic layer. Paper addressesexperimental analysis and Finite element analysis using Nastran software ofCLD beam with varying thickness of VEM.

II. FOCUS OF STUDY

The focus of research is devoted to find out modal loss factor in passive constrained viscoelastic material used in engineering structures, especially in automobiles for analyzing effective damping performance.

The goals of this research are mentioned below:

- To predict higher modal loss factor for various viscoelastic material under different condition for improving effectiveness.
- To gather data with help software to determine damping properties of several viscoelastic materials.
- Formulate a reliable prediction on effective loss factor based on accumulated data of viscoelastic materials.

III. FINITE ELEMENT ANALYSIS

The modal loss factor and natural frequencies are the important factors used for evaluation of damping of the material. The modal shapes and natural frequencies are considered in design of a structure for dynamic loading condition.This modal analysis is done by Hypermesh& Nastransoftware. The CLD beam is fixed at one end and kept other end free.

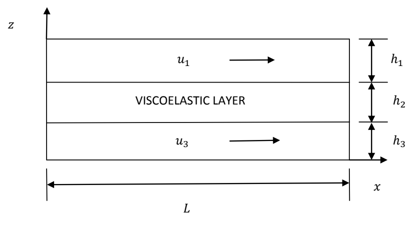

Fig: 1 CLD Beam

A sandwich beam comprising of viscoelastic layer as the core between two elastic layers of length L. The thickness of each layer is considered as h_1,h_2 and h_3. Let u, v and θ respectively, are axial, transverse and rotational deformations of the sandwich beam. The longitudinal displacement of any point in the viscoelastic layer is$u$.

The analytical model is developed on the basis of following assumption:

The stresses in the viscoelastic material are shear stresses

Their no slippage between the different materials

The shear is neglected in the elastic parts

The three layers undergo the same transverse deflection

All displacements are small compared to the structural dimensions thus linear theories of elasticity and Viscoelasticity.

The viscoelastic carries transverse shear but no normal stresses. A linear, frequency-dependent, complex shear modulus

$$G_v\,(\omega)^* \;=\; G_v\,(\omega)[1 + Jn_v(\omega)] \quad (1)$$

Where$n_v\omega$ is the loss factor, is used for the description of the viscoelastic property of the layer.

These assumptions were common to PCLD treatment for structural vibration suppression.

Stiffness Matrices

Because of the previous assumption, the total strain energy is composed of three terms: traction-compression and flexure of the elastic parts (respectively$U_{tc}\ and\ U_{fl}$), shear of the viscoelasticU_{sh}. They have the following expressions:

$$U_{tc} = \frac{1}{2}[E_1A_1 \int_0^l (\frac{du_1}{dx})^2\ dx + \ E_3A_3 \int_0^l (\frac{du_3}{dx})^2\, dx\,] \quad (2),$$

$$U_{fl} = \frac{1}{2}[(E_1A_1 + E_3A_3) \int_0^l (\frac{dw}{dx})^2\, dx] \qquad (3),$$

$$U_{sh} = \frac{\frac{1}{2}G_vS_{eq}}{(2h_2)^2} \int_0^l [h\varphi + (u_3 - u_1)^2\, dx] \qquad (4),$$

Where G_v is the shear modulus of the viscoelastic material and S_{eq} is the shear equivalent section: generally 5/6S_{visco}.

Stiffness matrices for elastic parts

The stiffness matrix for elastic parts or facing parts may be obtained from the traction-compression and flexure strain energies as follows

$$[K]_{be} \;=\; U_{tc} \,+\, U_{fl} \qquad (5)$$

Stiffness matrices for viscoelastic parts

The stiffness matrix for elastic parts or facing parts may be obtained from the shear strain energies

$$[K]_{shear} \;=\; U_{sh} \qquad (6)$$

Element Stiffness Matrix

$$[K]_T \;=\; [K]_{be} \,+\, [K]_{shear} \qquad (7)$$

Modal loss factor

A usual definition of damping is given by the ratio between the dissipated and the strain energies $(U_d\ and\ U)$.

$$n = \frac{U_d}{U} = n_v \frac{\emptyset_i^T K_{visco}\, \emptyset_i}{\emptyset_i^T K \emptyset_i} \qquad (8)$$

Where, are K_{visco} and K are respectively the stiffness matrices of the entire structure and the viscoelastic layer.

3.1Parametric study

For prediction of damping performance point of view large number of parameters involved in constrained viscoelastically damped system; it is desirable to carry out parametric study in order to identify that parameter which impact more dominantly on the vibration response of the base structure. Some parameters that do not significantly affect the amplitude of vibration response of the base structure as other ones may be considered as parameters of which the values are fixed in optimization. For finding out the maximum dissipation capability of PCLD treatments, thicknesses of viscoelastic material are considered.

3.2Properties of beam under analysis

The performance of PCLD treatment is mainly affected by thickness of VEM material.

The test specimen is composite structure of two elastic and middle viscoelastic layer as shown in "Fig 2"

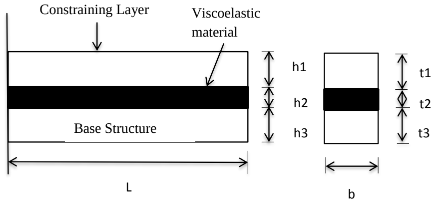

Fig: 2 Sandwich beam with viscoelastic material

The beam under analysis, having following properties

3.3Geometry

Table I: Geometry of CLD beam

Part	Length(L)	Width (b)	Thickness (T)			
Viscoelastic Layer	400	50	0.5	1	2	3
CL Layer	400	50	2			
Base structure	400	50	2			

All dimension in MM.

3.4Material Properties

Table II: Material Properties of CLD Beam

Material	E-Modulus in MPA	Poisson Ratio	Density in KG/M3
Aluminum (Upper/Lower)	69000	0.33	2700
MAT1	10.33	0.49	1485
MAT2	10.35	0.48	1538

For finite element analysis CHEXA solid element are used for VEM layer. The modal loss factor is obtained by Modal strain energy method. The result obtained by using Hypermesh and Nastransoftware is as shown in fig.

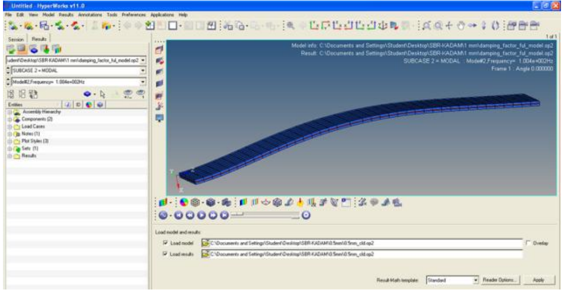

Fig: 3Mesh model of 3 MM thick Mat2- Mode2

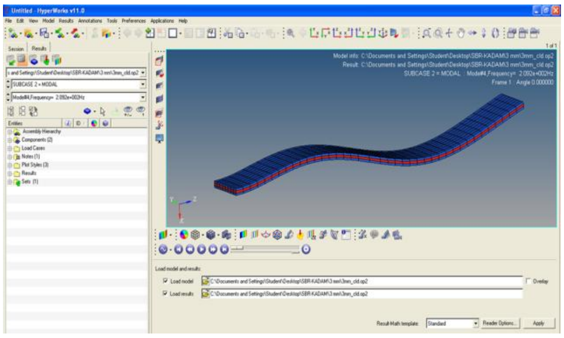

Fig: 4 Mesh model of 3mm thick Mat2- Mode3

IV. EXPERIMENTAL ANALYSIS

For experimental analysis, the CLD test beam as shown in fig.of different thickness is used.

Fig: 5 CLD Beam for Experimentation

For experimental analysis, the experimental setup is as shown in Fig. 6 is consist of multichannel FFT analyzer, accelerometer and Impact hammer of B&Kmake.

By experimentation frequency response curves of different CLD beams are obtained. The half power bandwidth method is used to find the modal loss factor from frequency response curves.

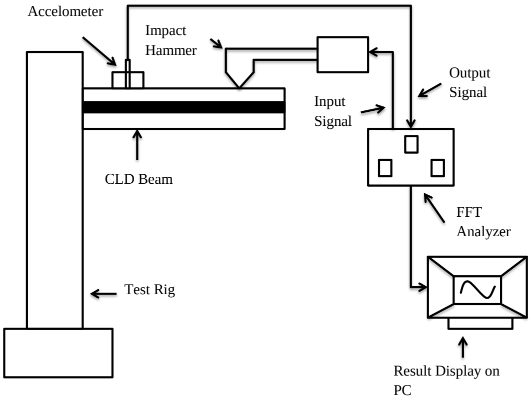

Fig: 6Schematic Diagram of experimental set up

V. RESULTS AND DISCUSSION

The result obtained by Finite element analysis and experimental analysis are shown below.

Table III: Beam Type

Beam Type	1	2	3	4
Thickness of VEM(mm)	0.5	1	2	3

Table IV: Expt &FEA result of MAT1

Beam Type	Mode No.	Expt		FEA	
		Frequency (HZ)	Loss Factor	Frequency (HZ)	Loss Factor
1	1	11	0.630	21	0.303
	2	63	0.142	105	0.094
	3	165	0.090	248	0.112
2	1	14	0.714	22	0.503
	2	74	0.243	100	0.108
	3	176	0.204	231	0.115
3	1	13	0.823	24	0.503
	2	63	0.274	97	0.108
	3	156	0.247	217	0.115
4	1	13	0.846	25	0.971
	2	71	0.323	96.79	0.1358
	3	158	0.215	209.9	0.131

Table IV: Expt & FEA Result of MAT2

Beam Type	Mode No.	Expt		FEA	
		Frequency (HZ)	Loss Factor	Frequency (HZ)	Loss Factor
1	1	15	0.230	21	0.121

	2	80	0.375	105	0.202
	3	188	0.345	248	0.183
2	1	15	0.240	22	0.121
	2	78	0.384	100	0.229
	3	176	0.301	230	0.188
3	1	15	0.286	24	0.189
	2	95	0.463	97	0.265
	3	211	0.374	282	0.139
4	1	16	0.375	25	0.235
	2	99	0.494	96	0.290
	3	207	0.362	209	0.215

Table IV shows result of Mat1with varying thickness. It modal loss factor increases with increasing thickness of Mat1.
Table V indicate the result of MAT2. It shows increment of loss factor with increasing thickness.
Experimental results are shown in Table IV&V for MAT1 & MAT2 respectively. Increase in thickness of shows increased loss factor. MAT1 has higher good performance as compared to MAT2 has validated through experimentation. This different damping material & its thickness plays important role in finding out the damping performance.

VI. CONCLUSION

The frequencies and loss factors are obtained from Numerical analysis are compared with results of experimental analysis. Thispaperis focus on effect of thickness of viscoelastic material in damping performance.

Thickness of viscoelastic material plays an important role in controlling unwanted vibration has shown by software & experimental investigation.Final conclusion from this paper is that as thickness increases thendamping performance increase with it.Hence it is helpful method enhancing damping performance of constrained layer damping.

VII. FUTURE SCOPE

Future work can be extended on this paper by optimizing thickness of viscoelastic material for find out optimum damping performance with less viscoelastic material.

REFERENCES:

Journal Papers:

[1] GregoireLepoitten, *Gerald Kress, Optimization of Segmented Constrained Layer Damping with Mathematical programming using strain energy analysis and modal data,Elsevier, Material and Design,2009.*

[2] Marcelo A. Trinade, *Optimization of passive constrained layer damping treatments applied to composite beams, Latin American Journal of Solids and Structures, 2007, 19-38.*

[3] P. Bangarubabu, K. Kishore Kumar, *Damping effects of viscoelastic materials on sandwich beams, ICTIME, 2012.*

[4] RamjiKoona, Ganesh Kumar, M. Lavnya, *Optimization of surface damping treatments for random vibration control,* https://www.pdfe2ce.org/pdf-1217498/.

[5] A. L. Marujo, P. Martins, C.A. Motasores, *Damping optimization of viscoelastic sandwich composite structure, Springer-Verag, 569-579, May 2009.*

[6] Vasudeven Raja Mohan, *Segment Optimization of a Rotating Viscoelastic Constrained Layer Damping treatment,*" *Journal of Sound and Vibration, IMCE-63399, 2011.*

[7] D. J. Mead, Markus, "*The Forced Vibration of a three Layer Damped Sandwich Beam with Arbitrary Boundary Conditions*" *Journal of Sound and Vibration, 10(2), 1969.*

[8] Hasan Koruk, Kenan Y. Sanliturk, "*On measuring dynamic properties of damping materials using Oberst beam method", Journal Sound and Vibration, 2010, ESDA-24452.*

Books:

[9] A.D. Nashif, D.I. Jones, J.P. Henderson, *Vibration Damping, New York: John Wiley, 1985.*

Theses:

[10] PalashDewangan, *Passive viscoelastic constrained layer damping for Structural damping,* M Tech diss., NIT, Rourkela,India,2009.

[11] Wanboo Liu, *Experimental and analytical estimation in beams and plates with damping treatments,* doctoral diss, University of Kanas school of Engineering, 2008.