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DAMPING ANALYSIS OF PATCHED LAYERED SORBOTHANE

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Abstract*— Sound and vibration damping is the key aspect in the most of the structures. The viscoelasticity property can be used to reduce vibrations. Many polymers are used as a viscoelastic damper in Constrained layer damping(CLD) and Free layer damping. Sorbothane is basically, visco-elastic in the form of polymer. Visco-elastic property is related to the material exhibits properties of both liquids (viscous) and solids (elastic). The polymer Sorbothane is a thermoset by nature, polyether-based, polyurethane material. Sorbothane have shock absorption capacity and good memory, vibration damping characteristics and vibration isolation. In addition to this, Sorbothane polymer is a excellent acoustic damper and absorber. Damping loss factor is calculated for different Patches on cantilever beam with modal analysis on NI LabView and ANSYS.

***Keywords*— Viscoelasticity, Sorbothane, Damping loss factor**

I. INTRODUCTION

Viscoelasticity can be defined as material (polymer) which shows the both characteristics of a Viscous (fluid) and elastic (solid). A viscoelastic material (VEM) collaborate these two properties so as to return to its original shape after subjecting to the stresses, and it slowly resist the next cycle of vibration. The viscosity and elasticity behaviours are mostly temperature dependent of polymer because of the region selected for damping accordingly. Generally polymers behave as a damper in transition region. viscoelastic materials are designated by complex modulus approach. Complex modulus of viscoelastic material is the combination of storage modulus and loss modulus. Ratio of loss modulus and storage modulus is defined as loss factor. Loss factor is used to define how much energy is lost to absorb the vibrations. While material sorbothane exhibit one of these characteristics, Sorbothane combines viscoelastic properties in a stable material with long fatigue life. Sorbothane has low creep rate as compared to other polymers like natural rubber, neoprene, SBR, silicone rubber, etc. Sorbothane has a excellent damping coefficient over the very wide range of temperature as compared to any other polymer. Sorbothane absorbs shock efficiently for millions of cycles just of fluid based shock absorbers or foam products. Sorbothane works without the metal springs to return the system to its equilibrium position after absorbing a shock.

II. DAMPING MATERIAL PROPERTIES

The material having High damping in a polymer reduces the impulse peak of a shock wave for wide time span. Sorbothane can reduce the impact force up to 80% and brings the mass gradually to rest. A gradual deceleration promotes better protection of delicate equipment. Sorbothane have very low rebound when compared to other damping materials.

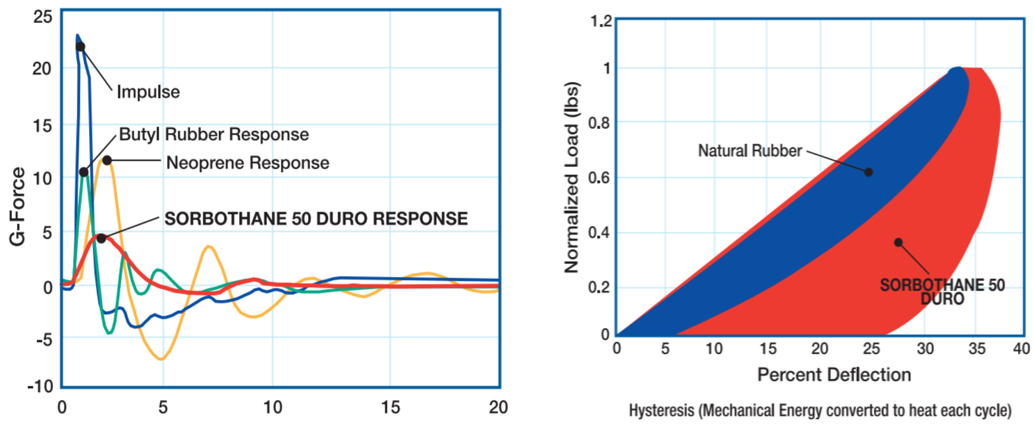


Fig:1 Vibration Respnces of Sorbothane

Sorbothane have Low transmissibility (amplification) at resonance which shows damping superiority over other damping elastomers. Low transmissibility results into less damage to sensitive components. It also provides Isolation at large frequency ratios which also show capacity of sorbothane to isolate vibration. The figure no. 1 shows the high hysteresis necessary for efficient impact absorption. By comparing the area under the curves, it is observed that Sorbothane removes more of the impact energy from the system. Natural rubber is more elastic and returns energy to the system.

High energy return results into high rebound ultimately increases the potential for damage. Impact absorption for sorbothane is up to 80% achievable at proper dynamic deflections.

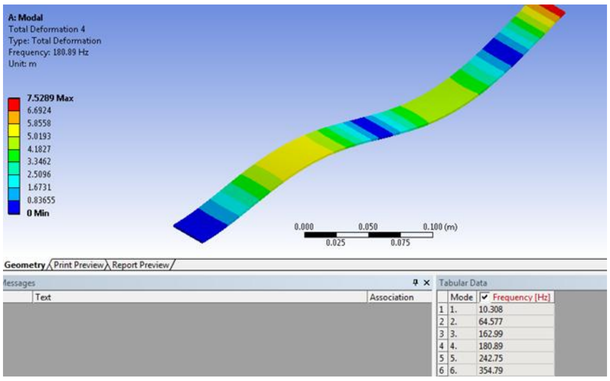
A. Specimens

To analyse the effect of variable patches (free layer damping) on obsert beam specimen, 9 patched layer beam specimen and 1 undamped beam is used.

Specimen No.	Dimension of Patch (mm)	Material	Application
1.	400*50*1	Aluminium	undamping Testing
2.	360*50*1	Sorbothane	For Patch Layer Testing
3.	320*50*1	Sorbothane	
4.	280*50*1	Sorbothane	
5.	240*50*1	Sorbothane	
6.	200*50*1	Sorbothane	
7.	160*50*1	Sorbothane	
8.	120*50*1	Sorbothane	
9.	80*50*1	Sorbothane	
10.	40*50*1	Sorbothane	

B. Undamped beam analysis

To check the damping loss factor, modal analysis is performed on undamped beam using ANSYS, MATLAB and Ni-LabView.



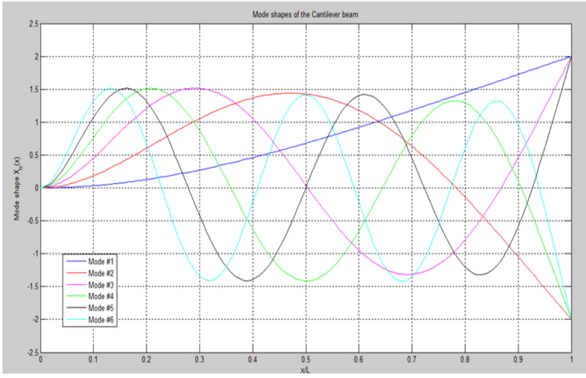
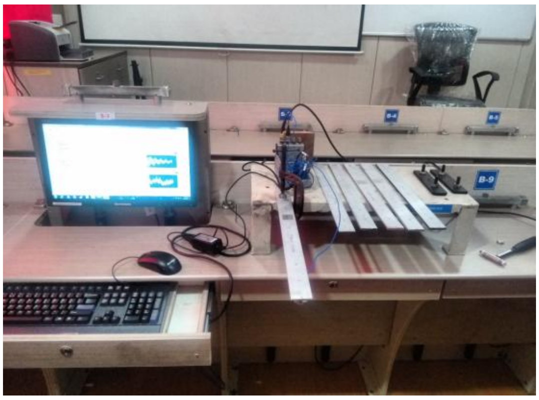


Fig:2 Modal analysis of undamped beam (ANSYS) Fig:3 Modal analysis of undamped beam (MATLAB)

III. EXPERIMENTAL ANALYSIS

For analysis of damping cantilever boundary condition is decided. Firstly natural frequency of bare beam is calculated with the help of analytical and FEM analysis. Then set up of modal analysis is used to check every specimen. Whole beam is divided in 6-8 parts for calculating hammer points. There are 8 hammer points to be considered at which we can find natural frequency and damping loss factor. Accelerometer used is very light weight. Accelerometer used is piezoelectric type of accelerometer with sensitivity of 1000Mv/EU and IEPE is 4Mv. same sensitivity is for hammer channel. Input to accelerometer is given from beam surfaces with cable. Output of accelerometer is given to the DAQ of NI-LABVIEW (cDAQ1MOD4) of modal analysis.



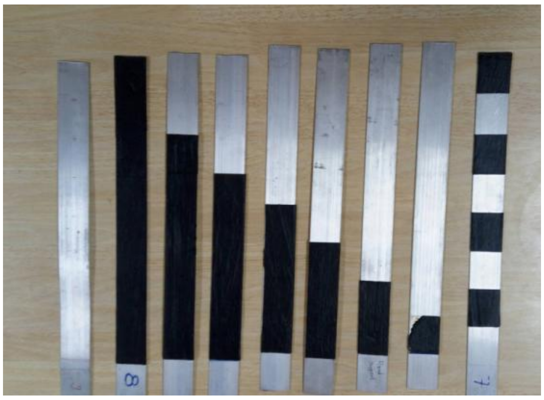


Fig:4 Experimental Setup Fig:5 Test Specimens

A. *Structural damping factor γ*

The viscous damping coefficient c, hysteretic damping coefficient h and the damping ratio δ, there is another very vital factor, structural damping factor γ, to describe the property of the damping material. The forced motion equation of a single spring mass system with a hysteretic damper is

ma + ca +kx=f(t)

For the modal damping, , therefore, we have $w=w_n$

ma +k(1-i γ)x=f(t)

Where, γ=2(zeta) = h/k is called the structural damping factor or modal damping ratio.

For the viscous damping, similarly, the viscous damping factor is γ=2δ.

B. *Complex Stiffness*

The effect of polymer material on the damping of the whole structure is influenced by the material stiffness as well as by its damping. These two properties are conveniently quantified by the complex Young‘s modulus or the complex shear modulus and Eε are usually assumed to be equal for a given material. When the material is subjected to cyclic stress and strain with amplitude ζ0 and ε0, the maximum energy stored and dissipated per cycle in a unit volume are as

Maximum energy stored per cycle $=Ee_o^2/2$

Energy dissipated per cycle= $\pi E\eta e^2_o$

A physical description of the loss factor can be found as follows. The energy dissipated per cycle for a structural damped system is,

$W= \pi hX^2= \pi\eta kX^2= 2\pi\eta*0.5*k*X^2= 2\pi\eta U_m$

Where, Um is the maximum strain energy stored. Therefore, we have energy strain maximum cycle per dissipated energy

Eta(η)= W/Um*(1/2π)= (energy dissipated per cycle/2π* maximum strain energy)

From the equation, it is found that the loss factor is a way to compare the damping of one material to another. It is a ratio of the amount of energy dissipated by the system at a certain frequency to the amount of the energy that remains in this system at the same frequency. The more damping a material has, the higher the loss factor will be. The method of representing the structural damping should only be used for frequency domain analysis (modal) where the excitation is harmonic.

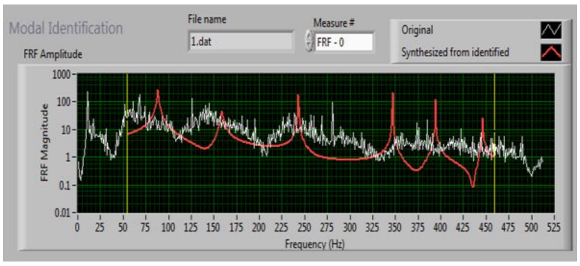


Fig:6 FRF of patch size (50*280)

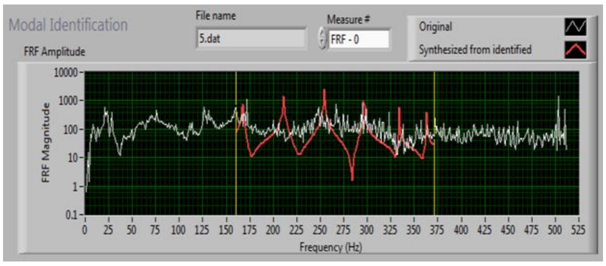


Fig:7 FRF of patch size(50*400)

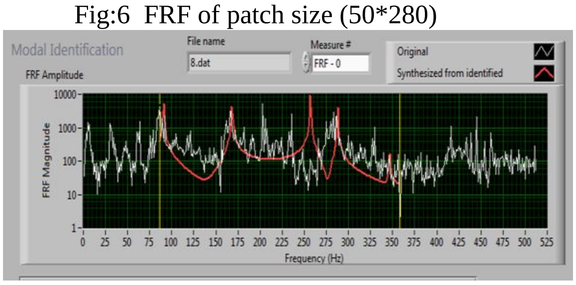


Fig:8 FRF of undamped beam

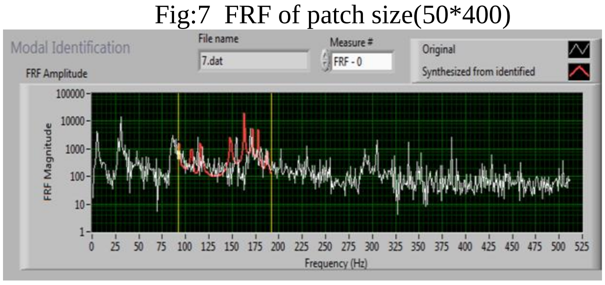


Fig:9 FRF of patch size (50*80)

Above fig shows the FRF response for various patch size. From the FRF Response damping factor and loss factor calculated. Transient analysis is performed to check the damping factor in ANSYS 15. Logarithmic decrement is calculated from the data points from the ANSYS and damping loss facror can be calculated by using relation between damping factor and logarithmic decrement.

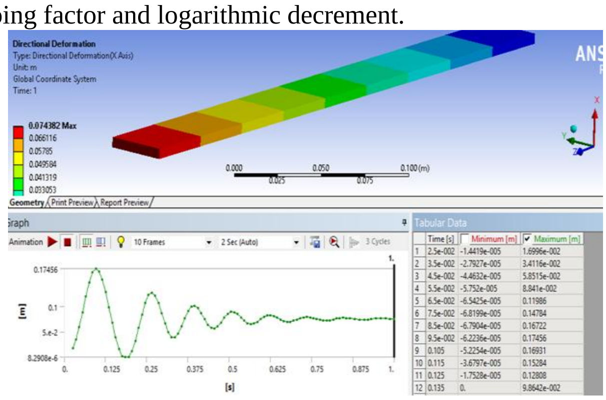


Fig: 10 Transient analysis of patch size 50*400 (ANSYS)

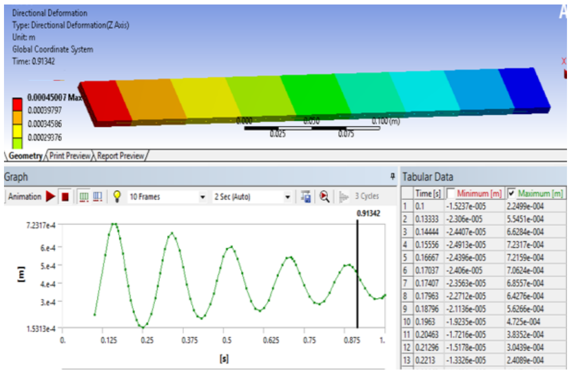


Fig: 10 Transient analysis of patch size 50*120 (ANSYS)

IV. RESULT

The damping loss factor can be calculated from experimental analysis and ANSYS

Sr no	Width of patch mm	Length of patch mm	Area of patch mm^2	Damping loss factor (Experimental)	Damping loss factor (ANSYS)	Vibration amplitude Db
1	50	400	12800	0.0498	0.0558	4.4
2	50	360	11520	0.0445	0.0510	5.8
3	50	320	10240	0.0401	0.0415	6.1
4	50	280	8960	0.0389	0.0402	6.5
5	50	240	7680	0.0347	0.0375	6.7
6	50	200	6400	0.0322	0.0358	7.7
7	50	160	5120	0.0308	0.0324	8.2
8	50	120	3840	0.0289	0.0309	8.6
9	50	80	2560	0.0267	0.0305	9.3
10	50	40	1280	0.0224	0.0285	10.7

From the Experimental and ANSYS data, damping loss factor is compared and to find the relation between the patch area and damping loss factor CFTOOL from MATLAB is used. The relation is fitted to the exponential curve y=a*e^bx. Following graph shows the plot of patch area(X Axis) vs damping loss factor (Y Axis).

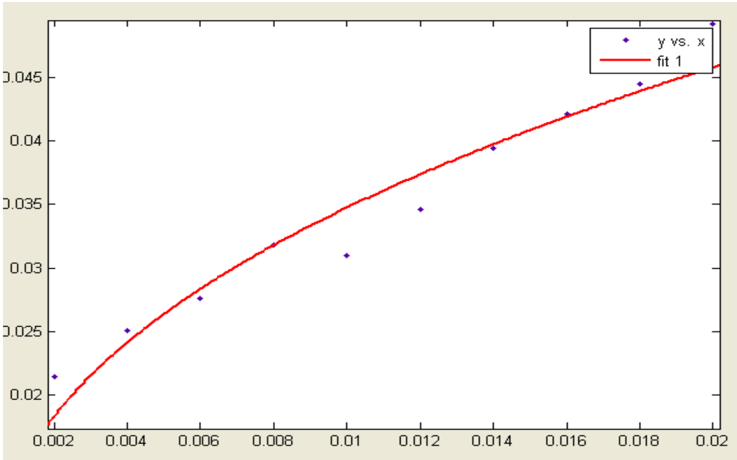


Fig:11 CFTOOL relation for the Experimental data

V. CONCLUSIONS

From the Experimental and FEM analysis of Patched layer Sorbothane, it is observed that Damping loss factor increases with increase in patch size of damping material. Nature of the relation between patch area and damping loss factor is exponential type of curve. Sorbothane also provides good range of acoustic damping. Sorbothane has good range of sound and vibration damping at high frequencies.

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