Effect of Thickness on Asymmetric Extensional Damping Treatment using Viscoelastic Materials

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Abstract — *Unwanted vibration effects produced in structures may be eliminated by using vibration suppression methods. The most common form of vibration suppression is to add viscoelastic damping treatment to structural elements. These treatments will be known as Extensional damping also known as free layer damping and constrained layer damping, which consist of sandwiched metal and viscoelastic layer combinations which help to reduce vibrations. A thin plate may be highly resonant and exhibit large vibration that cause fatigue and failure, or transmit vibration to other parts of the structure. Applying an elastic coating to the plate surface increases the damping of the beam and thereby significantly reduces the vibration and its transmission. In the present paper, different types of rubber damping layers such as Natural, Nitrile and Neoprene rubbers (of 60 shore A hardness) are used in the FLD treatment of metallic plate(AA 6063) to study the capability of reducing vibrations over a predefined frequency range of interest and also effect of thickness of damping layers.*

Keywords — *FLD, Frequency response function, Vibration amplitude.*

I. INTRODUCTION

Free-layer damping (FLD) is one of the simplest forms of material application. The material is simply attached with a strong bonding agent to the surface of a structure. Alternatively, the material may be towelled onto the surface, or the structure may be dipped into a vat of heat-liquefied material that hardens upon cooling. Energy is dissipated as a result of extension and compression of the damping material under flexural stress from the base structure. Damping increases with damping layer thickness. Changing the composition of a damping material may also alter its effectiveness [1]. The free layer damping treatment is as shown in the Fig.1.

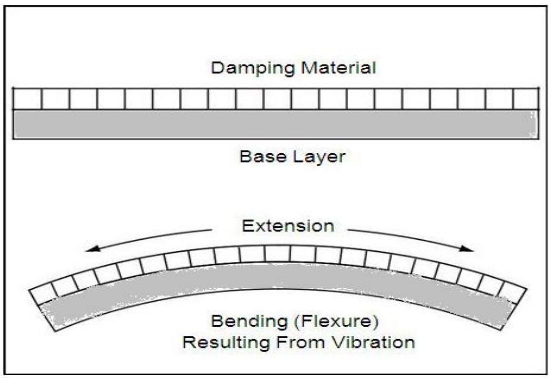

Fig. 1 Free layer damping treatment

The free layer damping treatment consists in coating one or both sides of the structure with a damping material. So, whenever the structure is subjected to cyclic flexure, the damping material is subjected to tension-compression deformation parallel to the plane of the structure. In this paper coating is applied on one side of the structure. And for the coating, different viscoelastic materials are used such as Natural rubber, Nitrile rubber and Neoprene rubber of hardness 60 shore A.

II. EXPERIMENTAL DETAILS

The present work deals with, different types of rubber damping layers with different thicknesses are used in the damping treatment of metallic plate (AA 6063), to study the capability of reducing vibrations. The vibration damping studies were carried out by using FFT analyzer with and without treatment and the experimental results were compared.

Aluminium alloys are widely used in Engineering structures and components where light weight or corrosion resistance is required. In the present work Aluminium alloy 6063 metal plate is used for the analysis as base plate. The dimensions of the test beam were taken as 250mmx1inchx3mm.

In this work, the main interest is the use of viscoelastic materials in damping treatments where the energy loss comes from the shear deformation energy of the viscoelastic material layer which is partially dissipated in the form of heat. Viscoelastic treatments are very efficient solutions as damping mechanisms for light structures but its design and analysis are quite difficult. These damping treatments are inexpensive and effective in a variety of environment. In this work, FLD structure consists of a base plate bonded with adhesive to a viscoelastic material. The viscoelastic materials are Natural rubber, Nitrile rubber and Neoprene rubber with 60 ‘shore A’ hardness taken into consideration. Another limitation is that the deformation of the damping material layer is purely extensional with no in-plane shear, which would allow the “plane sections remain plane” criterion to be violated. This restriction is not very important unless the damping layer is very thick and very soft ($h_2/h_1 > 10$ and $E_2/E_1 < 0.001$), here h_1 is the base plate thickness and h_2 is the layer thickness. The experiments were carried out without and with applied damping on the beam of 40mm and 50mm thicknesses [2][3].

Impact hammer test was carried out to determine the Frequency Response Function. The specimen is fixed to vice at one end and assumed as a cantilever beam, Accelerometer was put on fixed-end side of the sample, on the aluminium bar. It was excited by Impact hammer on the other side (on rubber bar). Having inbuilt force sensor, response was collected to determine Frequency Response Function [4][5].

III. RESULTS AND DISCUSSIONS

The response spectra were obtained in experimental studies of the AA6063 and FLD beams. It is observed that the treatment of beams with FLD had reduced the vibration amplitude. Comparative responses are also plotted. The experimental FRF curve of AA 6063 plate without treatment is shown in the figure 2. Also the experimental FRF curves for metal plate with FLD treatment using Natural rubber, Nitrile rubber and Neoprene rubber of hardness – 60 (shore A) are shown in the following figures 3 to 8. From the experimental results, it is observed that by using rubbers as damping layers, it was possible to reduce vibration amplitude of cantilevered aluminium alloy beam [6][7].

Fig. 2 Frequency Response Function of aluminium alloy plate

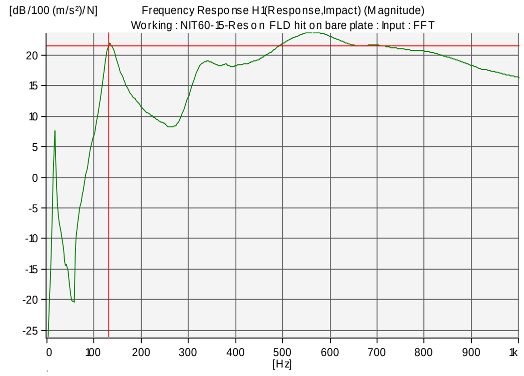

Fig. 3 FRF of FLD beam (Natural rubber - 60 ‘shore A’ with 40mm thickness)

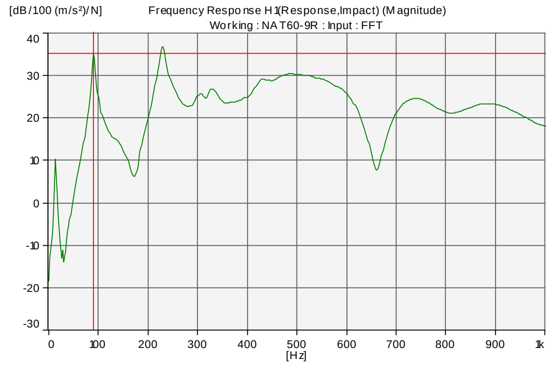

Fig. 4 FRF of FLD beam (Nitrile rubber - 60 ‘shore A’ with 40mm thickness)

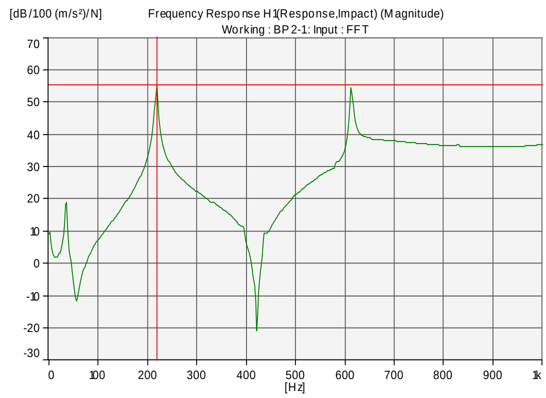

Fig. 5 FRF of FLD beam (Neoprene rubber – 60 ‘shore A’ with 40mm thickness)

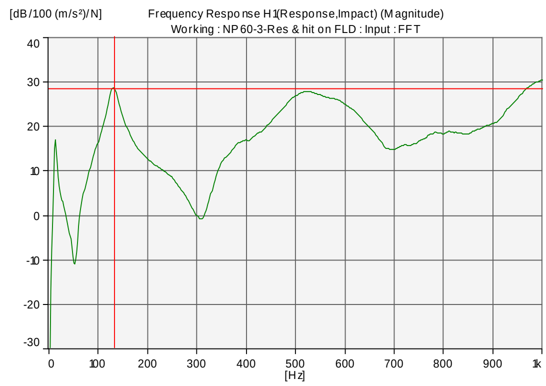

Fig. 6 FRF of FLD beam (Natural rubber – 60 'shore A' with 50 mm thickness)

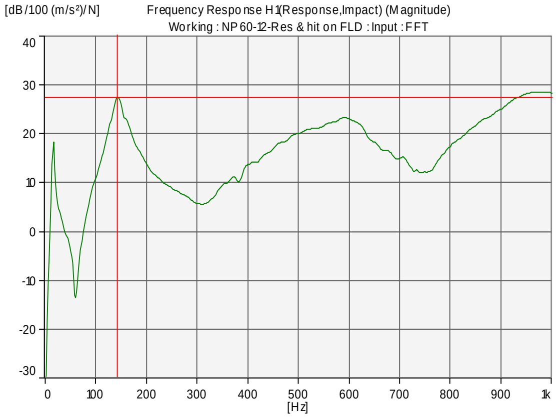

Fig. 7 FRF of FLD beam (Nitrile rubber – 60 'shore A' with 50 mm thickness)

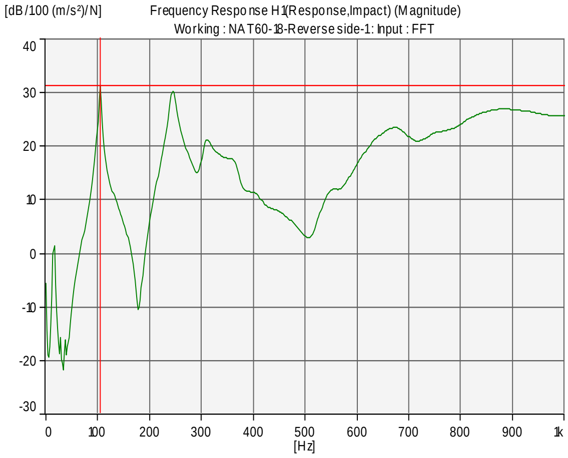

Fig. 8 FRF of FLD beam (Neoprene – 60 'shore A' with 50 mm thickness)

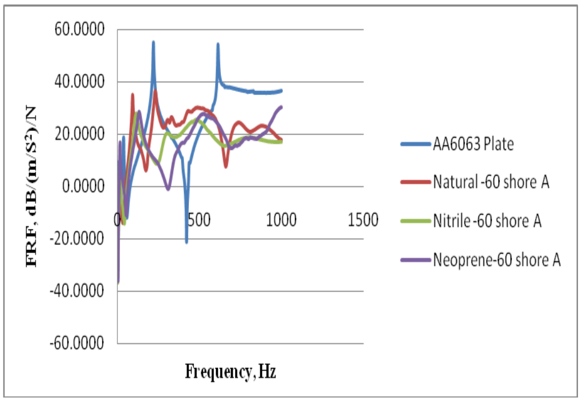

Fig. 9 Comparison of FRF curves of AA 6063 and FLD beams (40mm thickness)

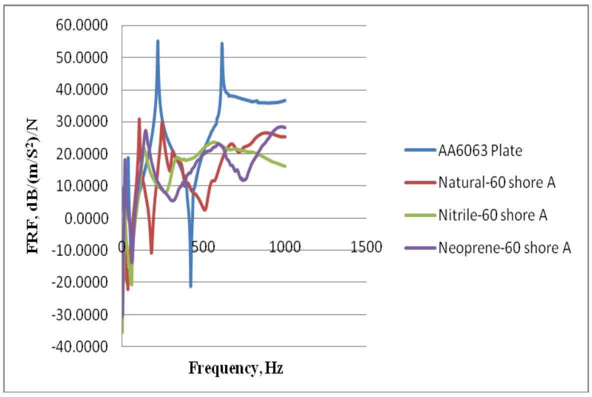

Fig. 10 Comparison of FRF curves of AA 6063 and FLD beams (50mm thickness)

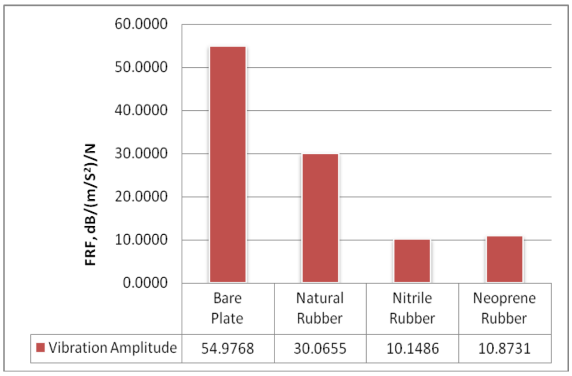

Fig. 11 Comparison of FRF's of AA 6063 and FLD beams (40mm Thickness) at resonance Frequency 218 Hz

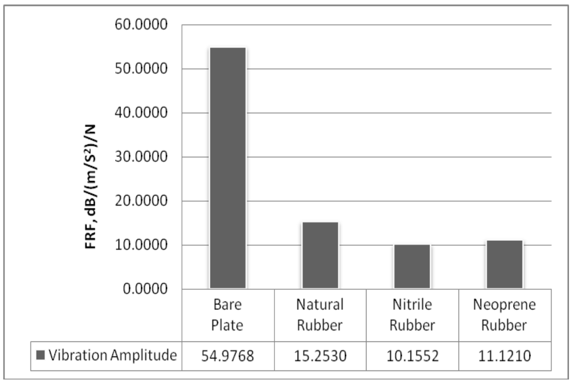

Fig. 12 Comparison of FRF's of AA 6063 and FLD beams (50mm Thick) at resonance Frequency 218 Hz

The obtained results at resonance frequency 218 Hz (from the figures 9 to 12) can be tabulated as below to compare the results and to know the percentage reduction in vibration amplitude.

TABLE I
Comparison of FRF's amplitude of specimens

Material	Thickness	Vibration Amplitude	Reduction, %
AA 6063 plate	3mm	54.9768	-
Natural Rubber	40mm	30.0655	45.31
Nitrile Rubber		10.1486	81.54
Neoprene Rubber		10.8731	80.22
Natural Rubber	50mm	15.2530	72.26
Nitrile Rubber		10.1552	81.53
Neoprene Rubber		11.1210	79.77

IV. CONCLUSIONS

With the above studies it is clear that, it is possible to reduce vibration levels of cantilevered aluminium alloy beam using rubbers as damping layers. Natural, Nitrile and Neoprene rubbers can be used for all the vibration applications. The FRF for untreated beam is more when compared with FRF for beams with unconstrained layer in treatment. Also observed that by comparison 40mm thickness and 50mm thickness with hardness 60 'shore A', maximum reduction in vibration amplitude is observed in Nitrile rubber with 40 mm thickness, and least reduction is observed in Natural rubber with 40mm thickness. FLD beam of Nitrile rubber with 40mm thickness and with 50 mm thickness had almost all same vibration levels. The frequency response for Neoprene rubber with 40mm thickness is less when compared with 50mm thickness.

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