IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 4, Issue 12, December 2017

An Optimization in Vibration Reduction of Viscoelastic Materials by using Testing Hypothesis

Sagar Pitambar Sonawane[1], E.R. Deore[2]

PG Student, Mechanical Engineering Department, S.S.V.P.S.'s, B.S.D. College of Engineering, Dhule, India [1]

Associate Professor, Mechanical Engineering Department, S.S.V.P.S.'s, B.S.D. College of Engineering, Dhule, India [2]

Abstract: Viscoelastic materials are largely used as a means to provide damping to structures, thus mitigating resonant vibration responses. The demand for silent machine operation in any of the organization is prime need in today's environmentally conscious world. Now a days,the vibration causes rapid wear of machine parts such as bearings and gears. Most common causes of machine vibration is wear,looseness,misalignment /shaft runout,imbalance then need of the day is producing noiseless and vibration free devices. Unwanted vibrations may cause loosening of parts from the machine. Because of improper design or material distribution, the wheels of locomotive can leave the track due to excessive vibration which results in accident or heavy loss. Sometimes because of heavy vibrations proper readings of instrument cannot be taken. Also some time machine will be destroys but some time vibration can be used for useful purposes such as vibration testing equipment's, vibratory conveyors, hoppers, and comparators. Vibration is found to be very fruitful in mechanical workshops such as improving the efficiency of machining, casting, forging and welding techniques. The transfer of noise can also be reduced by decoupling the components in such a way that the noise path is interrupted. This can be achieved by adding noise reducing treatments to the structure such as elastic elements, masses, local shielding or damping layers. In the present investigation, the use of viscoelastic damping layers as a noise reducing measure in rotating machinery is considered. Here in this investigation the result obtained will give frequency value in random manner and the use of testing hypothesis will show us that vibrations are really reduced or not.

Keywords: Fast Fourier Transform analyser(FFT), T-TEST(Statistical Test), Viscoelastic Material, Vibration .

I. INTRODUCTION

Viscoelastic materials are largely used as a means to provide damping to structures, thus mitigating resonant vibration responses. Vibration produse both good or bad effect in human life.Today life we all use different appliances such as air-conditioners, flour mills, grinders, and many more all these appliances are designed to give a peaceful life, but the noise created by these appliances may have an adverse effect on the life of human being if a person is in this environment for long timeproduse very bad effect in human senses. More prone to such environment may lead to reduce in hearing strength and also lead permanent deafness. So creating the noiseless and vibration free instruments is a need of the day, because noise and vibration are the two sides of same coin. Here in our present study I am going to reduce vibration by using viscoelastic material and then I am going to implement testing hypothesist-test which will tell me whether vibration has reduced or not. The test rig is specially designed for the study.

II. VIBRATION ISOLATION

The high speed engines and machines when mounted on foundations and supports cause vibrations of excessive amplitude because of unbalanced forces set up during their working. These are the disturbing forces which damage the foundation on which the machines are mounted. So the vibrations transmitted to the foundation should be eliminated or reduced considerably by using some devices such as dampers, springs, etc., between the foundation and machine. These devices isolate the vibrations by absorbing some disturbing energy themselves and allow only a fraction of it to pass through the foundation. Thus the amplitude of vibration is minimised and the adjoining structure or foundation is not put to heavy disturbances. There are two basic requirements of isolator: firstly, there should be no rigid connection between the unit and the base otherwise the undesired vibration will be completely transmitted from the unit to base. It may damage the supporting structure. Secondly, it should be ensured that the isolators remain together in case of material fails. It should be just to keep the machine or unit in the safe position with respect to the support. The materials normally used for vibration isolation are rubber, felt, cork, metallic spring, etc. these are put between the foundation and the vibrating body.

The viscoelastic layers can be added between the external layer of the roller bearing and the bearing housing or underneath the bearing housing, as shown in Figures 1 and 2. In the former case, the inertia of the bearing can be neglected while, in the latter, it must be considered. In the current work, it was used the second alternative (Figure 2) only, with and without layers of viscoelastic material.

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 4, Issue 12, December 2017

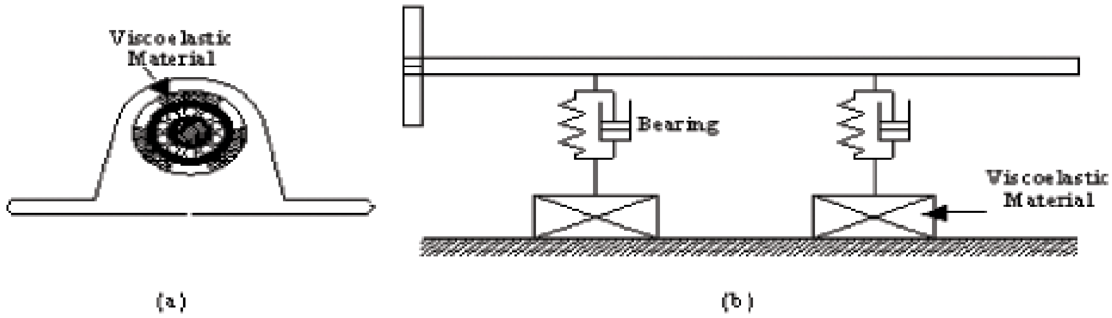


Figure 1: a/b- Bearing with Viscoelastic Layers.

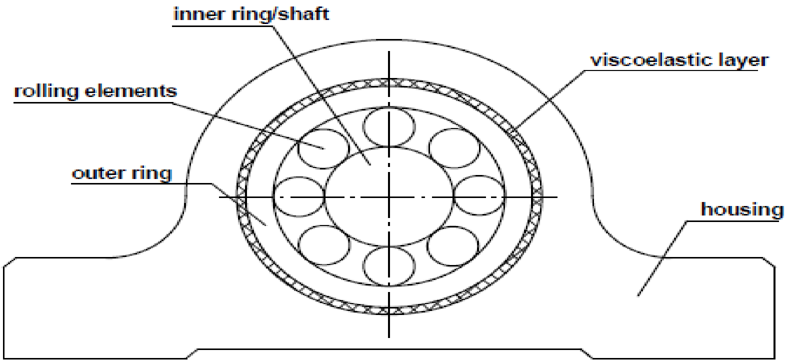


Figure 2 : A Viscoelastic Layer Mounted Between The Bearing Outer Ring and The Housing.

III. VISCOELASTIC MATERIAL

Viscoelasticity is the property of materials that exhibit both viscous and elastic characteristics when undergoing deformation. Viscous materials, like honey, resist shear flow and strain linearly with time when a stress is applied. Elastic materials strain instantaneously when stretched and just as quickly return to their original state once the stress is removed. Viscoelastic materials have elements of both of these properties and, as such, exhibit time dependent strain. Whereas elasticity is usually the result of bond stretching along crystallographic planes in an ordered solid, viscosity is the result of the diffusion of atoms or molecules inside an amorphous material.

Properties of viscoelastic materials:

1. Creep (if the stress is held constant, the strain increases with time) and Recovery
2. Stress Relaxation (if the strain is held constant, the stress decreases with time)
3. Energy Absorption.

List of Common Viscoelastic Polymeric Materials

1. Acrylic Rubber
2. Butadiene Rubber
3. Butyl Rubber
4. Chloroprene
5. Chlorinated Polyethylene
6. Ethylene-Propylene-Diene
7. Fluor silicone Rubber
8. Fluorocarbon Rubber
9. Nitrile Rubber
10. Natural Rubber
11. Polyethylene
12. Polystyrene
13. Urethane Rubber
14. Polymethyl Methacrylate (PMMA)
15. Polybutadiene
16. Polypropylene
17. Polyisobutylene
18. Polyurethane
19. Polyvinyl acetate
20. Polyisoprene
21. Styrene-butadiene (SBR)
22. Silicon Rubber
23. Polyvinyl chloride (PVC)
24. Neoprene

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 4, Issue 12, December 2017

IV. EXPERIMENTAL METHODOLOGY

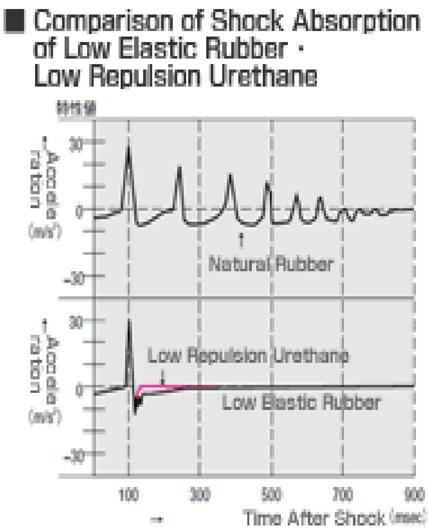
Based on the literature survey and information received from the various sources the problem has been carefully defined. To resolve the issues rose in the problem definition, it is required either to formulate a mathematical model (or analytically solved the previously available one) or conduct number of experiments to make fruitful conclusions. To conduct the successful experiments, it has to plan carefully with available standard procedures. The following sections of this chapter will elaborate the procedures for conducting the experiments of vibration analysis using Viscoelastic material as damping media.

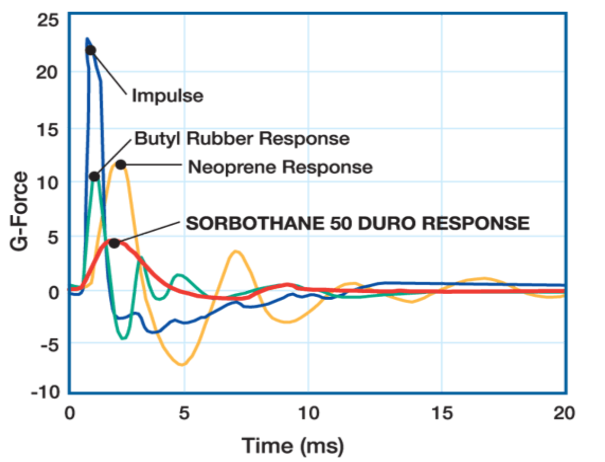
VISCOELASTIC MATERIALS FOR COMPARATIVE ANALYSIS

The selection of viscoelastic material is based on the ease of availability, installation, replacement and cost. Following viscoelastic materials were used for evaluating their effectiveness in minimizing the effect of vibration.

Table 1: Viscoelastic Materials used for experiments

Sr.No.	DESCRIPTION	PICTURE
1	Urethane rubber sheet 12 mm thick	
2	Neoprene rubber sheet 12 mm thick	
3	Butyl rubber sheet 12 mm thick	





Time Delay Effect of Impulse (Shock) Response of Selected Materials

The above selected materials are used as vibration isolators (damping agent to absorb the vibrations). The other parameters for vibration analysis were rpm of rotating shaft, location of disc on which unbalanced mass is attached and distance between bearing supports.

V. EXPERIMENTAL SETUP

Various parameters like material, thickness, rpm of rotating shaft, location of flange on which unbalanced mass is attached, Distance between Bearing Supports are varied and experiments are conducted. Experimental setup consists of electric motor (0.37 kW), shaft (material stainless steel of Φ 15 mm diameter of full length 630), two bearings, two discs, bearing's base plate, bearing's support plate, base plate and jaw coupling. The major part of this test setup is base plate which is made up from C – Channel havingdimensions 200x100x25mm. The base plate also facilitated with number of holes to change the bearing support positions according to the requirement at various locations. The main objective of bearings support plate isto give rigid and firm support to the bearings of the test setup. The dimensions of plate are 200 mm x 100 mm x 33 mm.

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 4, Issue 12, December 2017

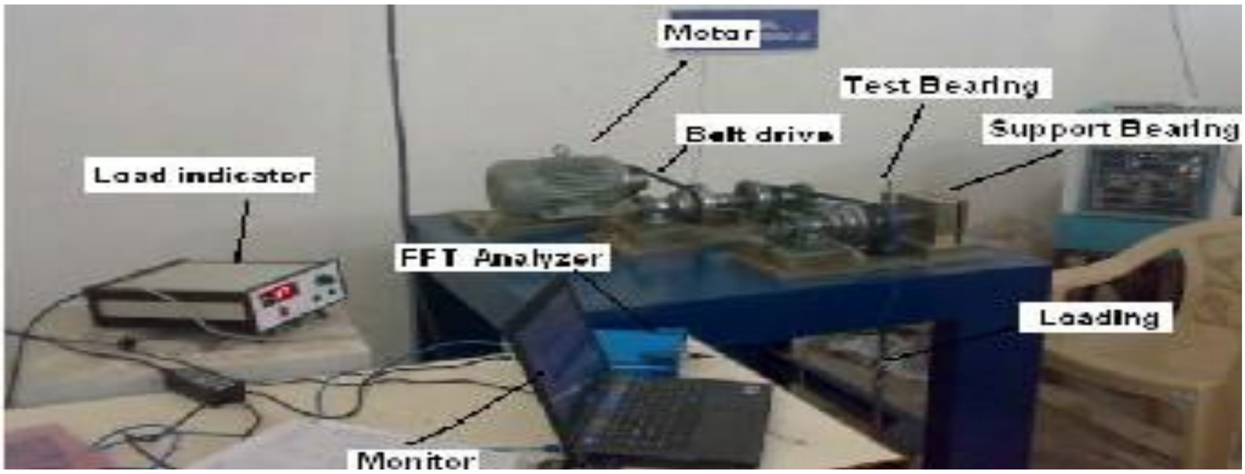


Fig. 3. Experimental Setup

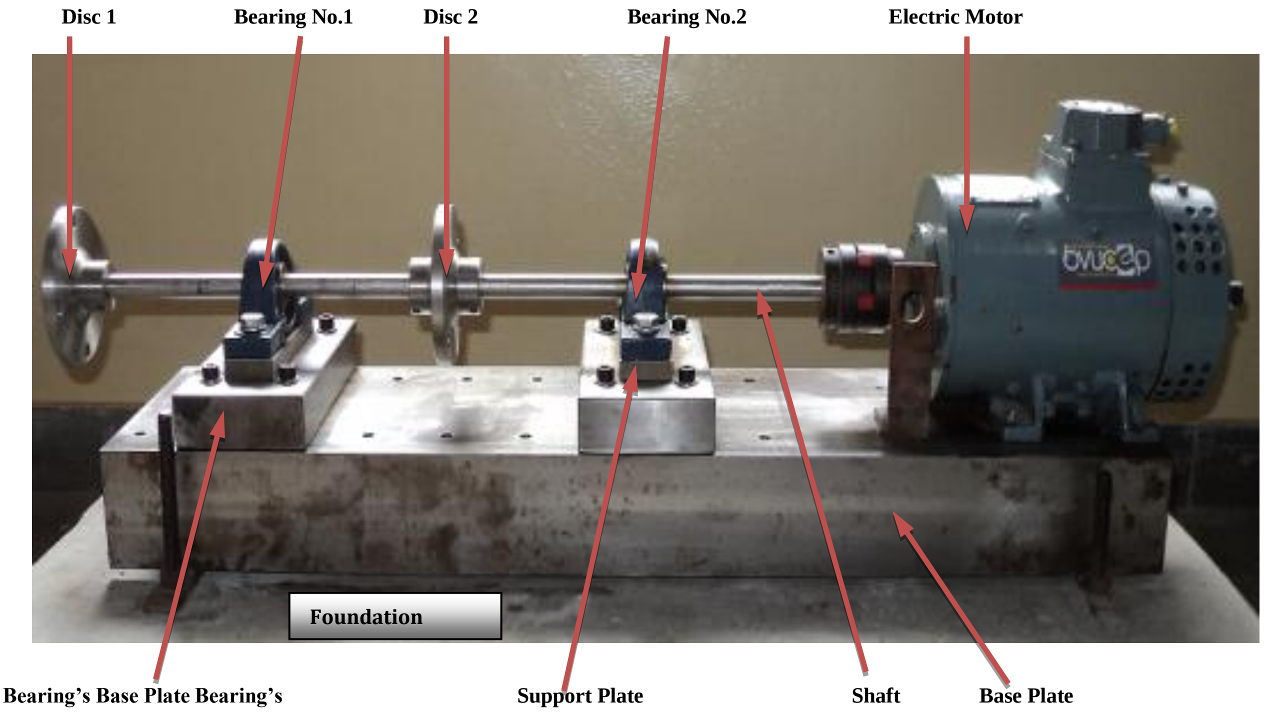


Figure 4: Experimental Setup

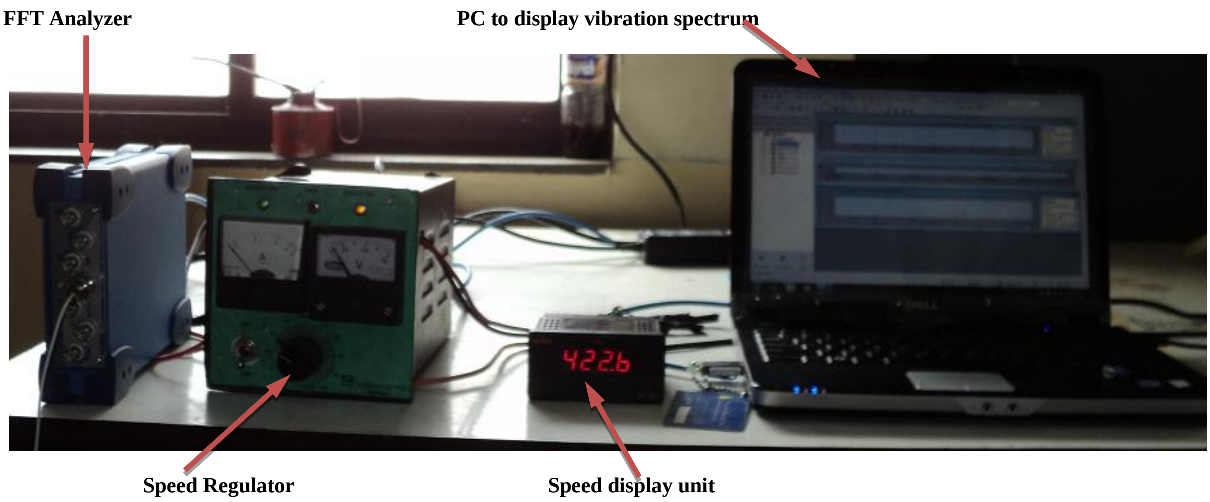


Figure 5: Experimental Setup Instrumentation

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 4, Issue 12, December 2017

Experimental Setup Instrumentation consists of
- Accelerometer (for sensing vibrations at the bearing locations)
- Inductive pickup sensor (for measuring speed (frequency) rpm of shaft)
- FFT analyser (to record the vibration signal)
- Speed regulator (to control speed of motor)
- Speed display unit (to display speed (frequency) rpm of shaft)
- PC (to record vibration spectrum).

The accelerometer is mounted on bearing senses vibration signal sends it to FFT analyser, FFT analyser processes it and converts it into signal form compatible with PC. These vibration signal values are shown in the form of vibration spectrum on the screen of PC. Experiments were carried out on specially developed vibration test rig as shown in figure 4. Which can facilitate the change of bearing support location, change in operating frequency (i.e. speed can be varied) etc. Following test plan is decided to conduct the experiments for the bearing locations shown in figure 4.

The distance between two bearings is 300 mm with speed range 500/1000/1500 rpm
- Case 1: Urethane rubber sheet with 12 mm thickness
- Case 2: Neoprene rubber sheet with 12 mm thickness
- Case 3: Butyl rubber with 12 mm thickness

For each case 20 no. of readings were taken. The speed (frequency) is measured using non-contacting type speed sensor with digital display, an accelerometer attached to FFT analyzer is mounted on both bearing support (i.e. near to the drive and away from the drive), the signal received from the accelerometer with the help of FFT analyzer is acquire and displayed on PC using NV Gate software.

Fig.6:Arrangement of Viscoelastic support beneath bearing housing for different cases

VI . RESULT

As per the test plan discussed in previous chapter, the experiments were conducted and result tables were prepared. Above result tables referred to the different case and conditions discussed previously.

Table 2: Result Table

Case 1		Case 2		Case 3	
Test No.	Vibration Magnitude (RMS Value)	Test No.	Vibration Magnitude (RMS Value)	Test No.	Vibration Magnitude (RMS Value)
1	288.10	1	349.90	1	388.11
2	286.80	2	345.70	2	387.07
3	287.43	3	346.53	3	389.13
4	287.43	4	348.63	4	388.70
5	287.77	5	347.57	5	388.53
6	288.50	6	347.40	6	386.97
7	287.77	7	350.27	7	389.23
8	287.43	8	349.53	8	389.55
9	286.50	9	347.00	9	390.17
10	285.50	10	347.47	10	388.20
11	286.97	11	345.77	11	388.37
12	284.40	12	347.43	12	389.27
13	287.07	13	247.97	13	389.40
14	287.13	14	347.60	14	389.10
15	288.83	15	346.43	15	389.77

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified

Vol. 4, Issue 12, December 2017

16	291.33	16	347.50	16	388.41
17	287.30	17	348.30	17	389.27
18	288.97	18	347.30	18	389.36
19	286.70	19	345.67	19	390.23
20	288.40	20	348.07	20	388.10

VII . T-TEST FOR VIBRATION REDUCTION

t-test is based on t-distribution and is considered an appropriate test for judging the significance of a sample mean or for judging the significance of difference between the means of two samples in case of small samples when population variance is not known. The relevant test statistic, t, is calculated from the sample data and then compared with its probable value based on tdistribution at a specified level of significance.

Significance for concerning degrees of freedom for accepting or rejecting the null hypothesis. It may be noted that t-test applies only in case of small samples when population variance is unknown.

Formulas required for carrying t-test:

$$\overline{X} = \frac{\sum X_i}{n}$$

$$\sigma_s = \frac{\sqrt{\sum(X_i - \overline{X})^2}}{\sqrt{n-1}}$$

$$t = \frac{\overline{X} - \mu_{H_0}}{\sigma_s/\sqrt{n}}$$

For Case 3 From the result analysis we have the readings for the above mentioned case let us consider those results. By using above mentioned formulae we have calculations as follows

$\overline{X} = \frac{\sum X_i}{n} = \frac{7776.93}{20} = 388.85$ $\qquad$ $\sigma_s = \frac{\sqrt{\sum(X_i - \overline{X})^2}}{\sqrt{n-1}} = 0.86$

S.No.	X_i	$(X_i - \overline{X})$	$(X_i - \overline{X})^2$
1	388.11	-0.15	0.0225
2	387.07	-0.32	0.1024
3	389.13	-1.88	3.5344
4	388.70	0.38	0.1444
5	388.53	0.7	0.49
6	386.97	1.32	1.7424
7	389.23	-0.65	0.4225
8	389.55	-0.48	0.2304
9	390.17	0.42	0.1764
10	388.20	0.55	0.3025
11	388.37	0.25	0.0625
12	389.27	0.92	0.8464
13	389.40	-0.44	0.1936
14	389.10	0.42	0.1764
15	389.77	0.51	0.2601
16	388.41	1.37	1.8769
17	389.27	-0.75	0.5625
18	389.36	-0.15	0.0225
19	390.23	-0.32	0.1024
20	388.10	-1.88	3.5344
Total		0.56	14.1322

μ= highest value of Xi = 390.23

$$t = \frac{\bar{X}-\mu_{H_0}}{\sigma_s/\sqrt{n}} = \frac{388.85-390.23}{0.86/\sqrt{20}} = -7.17621$$

From the table "critical values of student's t-Distribution"
Degree of freedom = n-1 = 20-1 =19
At 5% significance level for 17 degree of freedom we have from the table of "Critical value of student's t-distribution"
R:t<1.74

The observed value of t is -7.17621 which is in the acceptance region and thus H0 is accepted at 5% level of significance and thus we can conclude that the sample data indicate that vibrations have reduced by the use of 12mm thick Butyl rubber sheet.
Similar can be done with other cases and results are found to be same that is vibrations are reduced by using viscoelastic materials

VIII . CONCLUSION

Case 1: Urethane rubber sheet with 12 mm thickness
Case 2: Neoprene rubber sheet with 12 mm thickness
Case 3: Butyl rubber with 12 mm thickness
These three cases are best suited in vibration reduction and if we want to any one of the three cases then case 3 is the best suited in any condition From the present study and based on above conclusions it is found that the use of Viscoelastic material is one of the best choice of passive vibration isolation technique.
1) Undoubtedly the Viscoelastic material shows its utility as a vibration damping material and can be used as vibration isolators in variety of applications.
2) The conducted research will provide the comparative study between the different readily available Viscoelastic materials. It helps to evaluate the effectiveness of these materials under various circumstances.
3) The Butyl rubber material with maximum thickness (12 mm) indicates a less effective material for absorbing the vibrations. (There is a need of paying more attention towards the study of effect of geometry and thickness of the rubber as a viscoelastic material)
4)From the present study and based on above conclusions it is found that the use of Viscoelastic material is one of the best choice of passive vibration isolation technique. Further there is a scope to conduct some part of research in the area of optimized thickness and geometry profile of the PVC sheet as a Viscoelastic material

REFERENCES

1. Severino P C Marques, Guillermo J Creus (2012), "Computational Viscoelasticity", Springer Heidelberg Dordrecht London, New York, p. 3.
2. Dutt J K and Toi T (2003), "Rotor Vibration Reduction with Polymeric Sectors", Journal of Sound and Vibration, Vol. 262, VOL. 4, pp. 769-793.
3. Eduardo Marcio de Oliveira Lopes et al. (2004), "Characterization Dynamics in Integrated Elastomers Generalized Derivatives", Proceedings of the IIIrd CONEM, Belem, Brazil.
4. Espindola J J, Silva Neto J M and Lopes A (2005), "Generalized Fractional Derivative Approach to Viscoelastic Material Properties Measurement", Applied Mathematics and Computation, Vol. 164, No. 2, pp. 493-506.
5. Panda K C, Dutt J K (1999), "Design of Optimum Support Parameters for Minimum Rotor Response and Maximum Stability Limit", Journal of Sound and Vibration, Vol. 223, No. 1, pp. 1-21.
6. Venugopal N, Chaudhari C M, Nitesh P Yelve (2006), "An Investigation on Vibration of Visco-elastic materials by Using Taguchi Method & ANOVA, NCRTM 2006".
7. Shabaneh N H and Jean W (1999), "Dynamic Analysis of Rotor-Shaft Systems with Viscoelastically Supported Bearings", Mechanism and Machine Theory, University of Toronto, Canada, Vol. 35, No. 1, pp. 1313-1330.
8. Snowdon J C (1965), "Rubberlike Materials, Their Internal Damping and Role in Vibration Isolation", Journal of Sound and Vibration, Vol. 2, No. 2, pp. 175-193.
9. H.G. Tillema, "Thesis on Noise reduction of rotating machinery by viscoelastic bearing supports". University of Twente, Enschede, Netherlands, pp. 2-3, February 2003
10. Carlos Alberto Bavastri, Euda Mara da S Ferreira, Jose Joao de Espindola, Eduardo Marcio de O Lopes (2008), "Modeling of Dynamic Rotors with Flexible Bearings due to the use of Viscoelastic Materials", Journal of the Brazil, Soc. of Mech. Sci. & Eng., Vol. 3, No. 1, pp. 23-29.
12. JadhavSainand M and JadhavDattatraya B (2012), "Comparative Analysis of Viscoelastic Material Support for Rotating Machinery", International Journal of Applied Research, Vol. 2, No. 3, pp. 63-67.