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An Optimization Approach to Vibration Reduction (Testing Hypothesis)

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Abstract: 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 (FFT analyser), T-TEST(Statistical Test), Viscoelastic Material, Vibration Reduction.

INTRODUCTION

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 time produse 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 hypothesis t-test which will tell me whether vibration has reduced or not. The test rig is specially designed for the study.

LITERATURE REVIEW

An easy way to comply with the conference paper formatting requirements is to use this document as a template and simply type your text into it. Rotor dynamics as a subject first appeared in the last quarter of the 19th Century due to the problems associated with the high speed turbine of Gustaf de Lavalwho invented the elastically supported rotor, called de Laval Rotor, and observed its supercritical operation. Recently, viscoelastic damping materials have also been used in rotor dynamic applications. For rotor stability improvement, viscoelastic bearing supports have been studied by some researchers (Dutt and Nakra, 1992; Panda and Dutt, 1999). The dynamic behavior of Viscoelastically supported bearing applications has been analyzed by Dutt and Nakra (1993), Akturk and Gohar (1994) and Shabaneh and Zu (2000).

Panda K.C., Dutt J.K. [2]In their paper frequency dependent characteristics of the polymeric supports have been found by simultaneously minimizing the unbalanced response and maximizing the stabilitylimit speed. This process yields better support characteristics than those obtained by minimizing unbalance response alone. Optimum characteristics have been found for the rotor shaft system mounted on (a) rolling element bearings and (b) plain cylindrical journal bearings at the ends having polymeric supports. The effects of viscous internal damping in the shaft, support mass and gyroscopic effect due to non-symmetrical location of the disc have been considered in the analysis. A procedure of controlling the slope of the support characteristics versus frequency of excitation has been used and found to be very suitable for obtaining feasible support characteristics. Examples have been presented to justify the above conclusions.

EspindolaJ.J., et.al. [3]Attempted a new approachfor the identification of the dynamic properties of viscoelastic materials, based on the fractional derivative model in their paper. Numerical and experimental results are produced and discussed.Sainand Jadhav, et.al. [4]In his work he has made use of viscoelastic materials for vibration reduction in a test rig. He had used natural rubber, corrugated rubber, and PVC material for reducing natural rubber, corrugated rubber, and PVC material for reducing.

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.

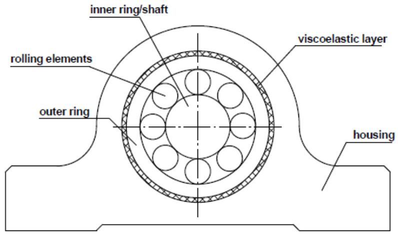

Figure 1: A Viscoelastic Layer Mounted Between The Bearing Outer Ring and The Housing.

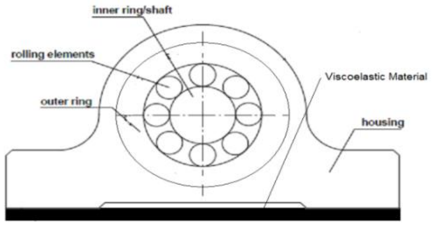

Figure 2: A Viscoelastic Layer Mounted Beneath The Bearing Housing

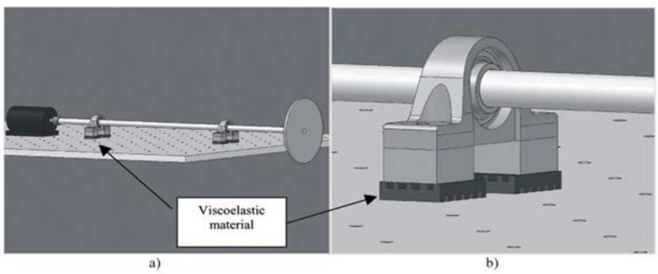

Figure 3: a/b- Rotter System and Roller Bearing with Viscoelastic Layers.

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

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

List of Common Viscoelastic Polymeric Materials

Acrylic Rubber, Butadiene Rubber, Butyl Rubber, Chloroprene, Chlorinated Polyethylene, Ethylene-Propylene-Dyne, Fluor silicone Rubber, Fluorocarbon Rubber, Nitrile Rubber, Natural Rubber, Polyethylene, Polystyrene, Polyvinyl chloride (PVC), Polymethyl Methacrylate (PMMA), Polybutadiene, Polypropylene, Polyisobutylene, Polyurethane, Polyvinyl acetate, Polyisoprene, Styrenebutadiene (SBR), Silicon Rubber, Urethane Rubber.

Common Viscoelastic Materials Application

Grommets or Bushings, Component Vibration Isolation, Aircraft fuselage Panels, Submarine Hull Separators, Mass Storage Disk Drive Component, Automobile Tires, Stereo Speakers, Bridge Supports, Caulks and Sealants, Lubricants, Fibre Optics Compounds.

List of common Viscoelastic materials (metals)

Copper-manganese alloy, Zinc-aluminum alloy, Metals at high temperatures exhibit Viscoelastic properties

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 having dimensions 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 is to 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.

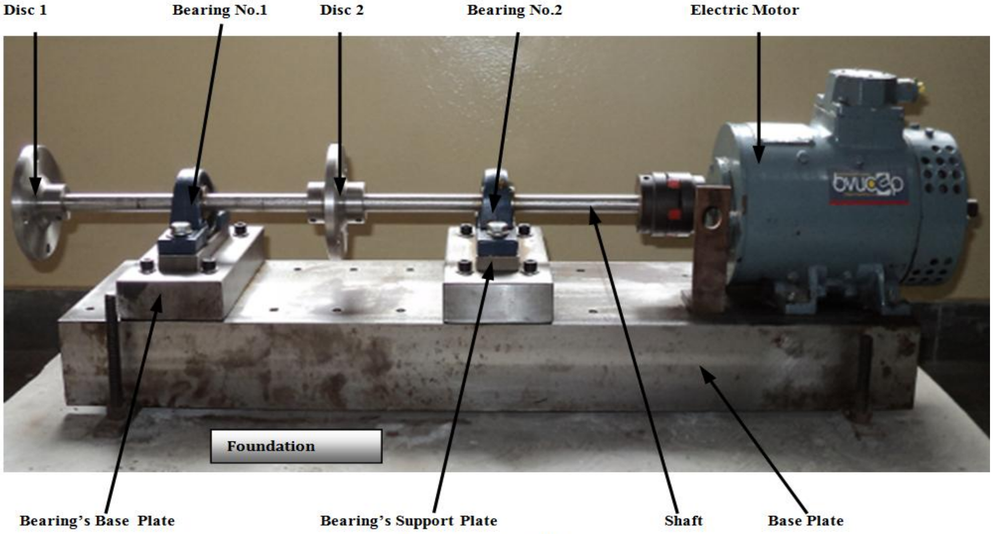

Figure 4: Experimental Setup

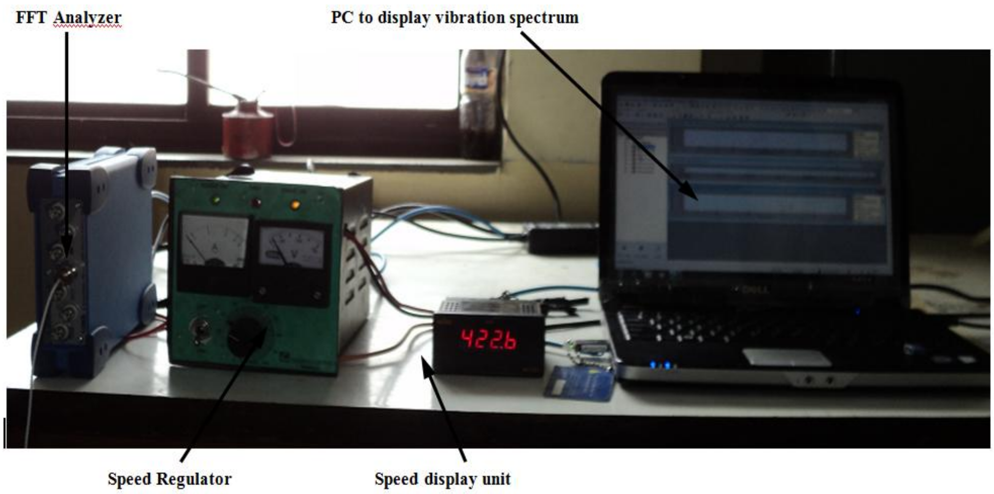

Figure 5: Experimental Setup Instrumentation

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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.

EXPERIMENTAL PROCEDURE

Experiments were carried out on specially developed vibration test rig which can facilitate the change of bearing support location, location of unbalanced mass, change in mass position, change in operating frequency (i.e. speed can be varied) etc. For each case 18 no. of readings were taken. The speed (frequency) is measured using non-contacting type speed

Table : Parameters and variables

Parameter	Variables		
	1	2	3
Viscoelastic Material	PVC (polyvinyl chloride) SHEET	PVC SHEET	PVC PLAIN SHEET
Thickness (mm)	5	12	4.5/8/15
Speed (Frequency) rpm of Rotating Shaft	300	600	900
Location of Unbalanced Mass	Disc 1	Disc 2	-
Distance Between Bearing Supports (mm)	300	-	-

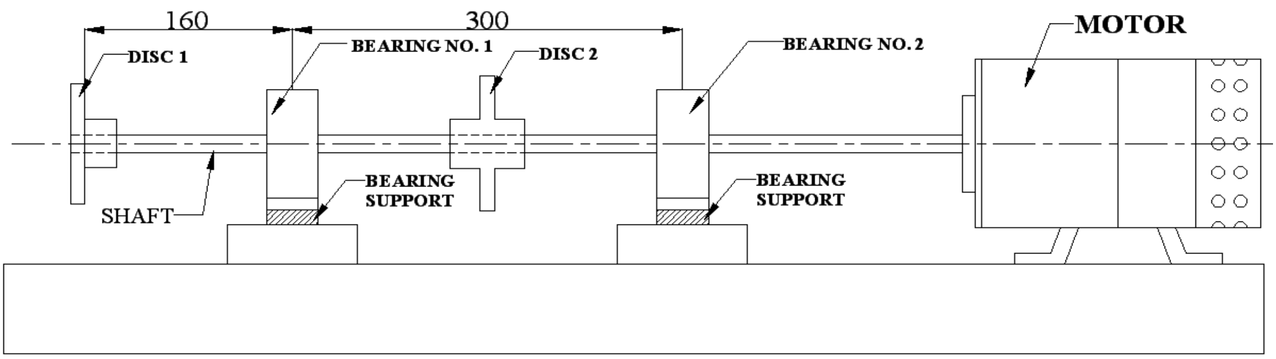

Figure 6 : Condition Distance between bearing supports = 300mm

sensor with digital display, an accelerometer attached to FFT analyser 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 analyser is acquire and displayed on PC using NV Gate software.

(I) distance between bearing supports = 300mm
Case 1: 4.5mm thick PVC sheet+7mm thick M.S. plate beneath bearing housing
Case 2: 8mm thick PVC sheet + 7mm thick M.S. plate beneath bearing housing
Case 3: 4.5mm thick PVC sheet + 9mm thick M.S. plate beneath bearing housing
Case 4: 8 mm thick PVC sheet + 9mm thick M.S. plate beneath bearing housing
Case 5: 15mm thick PVC sheet beneath bearing housing

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Table : Viscoelastic Materials used for experiments

Sr.No	DESCRIPTION	PICTURE
1	PVC (polyvinyl chloride) sheet 4.5mm thick	
2	PVC (polyvinyl chloride) sheet 8mm thick	
3	PVC (polyvinyl chloride) sheet 15mm thick	
4	Mild Steel Sheet of 7mm thick	
5	Mild Steel Sheet of 9mm thick	

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:

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

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

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

Distance Between Bearings is Kept Constant as 300 mm									
Case 1		Case 2		Case 3		Case 4		Case 5	
Test No.	Vibration Magnitude (RMS Value)	Test No.	Vibration Magnitude (RMS Value)	Test No.	Vibration Magnitude (RMS Value)	Test No.	Vibration Magnitude (RMS Value)	Test No.	Vibration Magnitude (RMS Value)
1	23.33	1	28.41	1	9.45	1	11.11	1	13.28
2	12.17	2	26.55	2	10.26	2	12.11	2	19.87
3	25.45	3	32.28	3	19.87	3	35.01	3	10.5
4	22.24	4	18	4	18.75	4	22.77	4	33.25
5	40.25	5	46.88	5	38.75	5	60.44	5	22.45
6	58.78	6	73.2	6	39.88	6	35.87	6	41.35

7	19.25	7	25	7	11.25	7	10.75	7	12.32
8	18.77	8	17.88	8	12.55	8	9.78	8	12.28
9	16.88	9	22.22	9	14.99	9	11.68	9	17.9
10	10.26	10	30.22	10	19.22	10	14.75	10	11.09
11	17.47	11	42.22	11	22.22	11	25.75	11	27.25
12	15.66	12	37.07	12	18.99	12	15.65	12	24.25
13	19.88	13	36.61	13	17.56	13	18.57	13	13.25
14	24.45	14	31.01	14	26.45	14	20.89	14	15.68
15	44.44	15	73.61	15	50.31	15	40.07	15	48.2
16	29.54	16	65.55	16	38.56	16	47.48	16	36.45
17	40.12	17	56.65	17	45.45	17	61.25	17	16.75
18	31.56	18	55.55	18	36.96	18	32.22	18	19.85

For Case 5 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

$$\overline{X} = \frac{\sum X_i}{n} = \frac{395.97}{18} = 21.9983$$

$$\sigma_s = \frac{\sqrt{\sum(X_i - \overline{X})^2}}{\sqrt{n-1}} = 11.15292$$

Test No.	Vibration Magnitude (RMS Value)
1	13.28
2	19.87
3	10.5
4	33.25
5	22.45
6	41.35
7	12.32
8	12.28
9	17.9
10	11.09
11	27.25
12	24.25
13	13.25
14	15.68
15	48.2
16	36.45
17	16.75
18	19.85

S.No.	(X -)	X	(X -)
1	8.71833	13.28	76.00927799
2	2.12833	19.87	4.529788589
3	11.49833	10.5	132.2115928
4	-11.2517	33.25	126.6000778
5	-0.45167	22.45	0.204005789
6	-19.3517	41.35	374.4871318
7	9.67833	12.32	93.67007159
8	9.71833	12.28	94.44593799
9	4.09833	17.9	16.79630879
10	10.90833	11.09	118.9916634
11	-5.25167	27.25	27.58003779
12	-2.25167	24.25	5.070017789
13	8.74833	13.25	76.53327779
14	6.31833	15.68	39.92129399
15	-26.2017	48.2	686.5275108
16	-14.4517	36.45	208.8507658
17	5.24833	16.75	27.54496779
18	2.14833	19.85	4.615321789
Total		395.97	2114.58905

μ= highest value of Xi = 48.2

$$t = \frac{\overline{X} - \mu_{H_0}}{\sigma_s/\sqrt{n}} = -9.96666$$

From the table “critical values of student’s t-Distribution” Degree of freedom = n-1 = 18-1 =17
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 -9.96666 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 15mm thick PVC sheet.
Similar can be done with other cases and results are found to be same that is vibrations are reduced by using viscoelastic materials

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CONCLUSION

Case 3: 4.5mm thick PVC sheet + 9mm thick M.S. plate beneath bearing housing

Case 4: 8 mm thick PVC sheet + 9mm thick M.S. plate beneath bearing housing

Case 5: 15mm thick PVC sheet beneath bearing housing

These three cases are best suited in vibration reduction and if we want to any one of the three cases then case 4 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.

REFERENCES

1. Venugopal N, Chaudhari C M, Nitesh P Yelve (2006), "An Investigation on Vibration of Visco-elastic materials by Using Taguchi Method & ANOVA, NCRTM 2006".
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. Severino P C Marques, Guillermo J Creus (2012), "Computational Viscoelasticity", Springer Heidelberg Dordrecht London, New York, p. 3.
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. Tillema H G (2003), Thesis Noise reduction of rotating machinery by viscoelastic bearing supports, University of Twente, Enschede, Netherlands, pp. 23, February.
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. Jadhav Sainand M and Jadhav Dattatraya B (2012), "Comparative Analysis of Viscoelastic Material Support for Rotating Machinery", International Journal of Applied Research, Vol. 2, No. 3, pp. 63-67.