EXPERIMETAL VALIDATION OF VIBRATION REDUCTION IN ROTATING MECHANICAL SYSTEM BY USING VISCOELASTIC MATERIAL

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Abstract

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. The dynamic behavior of visco-elastically supported bearing applications has been analyzed in this field.In day today life in most of the companies balancing and noise reduction problems are absolute due to better designing techniques of manufacturing. Vibration isolators are used for the reduction of machine vibration in every industry, so we are implementing isolation method.

1 INTRODUCTION

Vibration is a mechanical phenomenon hereby oscillations occur about an equilibrium point. The oscillations may be periodic such as the motion of a pendulum or random such as the movement of a tire on a gravel road.Vibratory systems comprise means for storing potential energy (spring), means for storing kinetic energy (mass or inertia), and means by which the energy is gradually lost (damper). The vibration of a system involves the alternating transfer of energy between its potential and kinetic forms.

1.3 Methods of Reducing Undesirable Vibration

Following basic methods exists for vibration control of industrial equipment, as detailed below;

1. Force Reduction
2. Mass Addition
3. Tuning
4. Isolation
5. Damping

2. LITERATURE REVIEW

Panda K. C., Dutt J. K. [3] In their paper frequency dependent characteristics of the polymeric supports have been found by simultaneously minimizing the unbalanced response and maximizing the stability limit speed. Dutt, J.K. and Toi T. [4] They used polymeric material in the form of sectors as bearing supports for improving the dynamic performance of rotor–shaft systems, which often suffer from two major problems (a) resonance and (b) loss of stability, resulting in excessive vibration of such systems. Polymeric material in the form of sectors has been considered in their work as bearing supports. Espindola J. J., et.al. [6] Introduced a new approach for characterization of viscoelastic materials via generalized derivatives. N. Venugopal, et.al. [7] Applied Taguchi's concept of Orthogonal arrays for designing experiments to study the transmissibility ratio of viscoelastic materials and factors affecting it. M. I. Friswell, et.al. [8]In their paper used internal variable approach to model the viscoelastic material for the transient dynamic responses, and includes an energy dissipation model. Carlos Alberto Bavastri, et.al.[2] In their paper presented a numerical methodology for predicting the dynamic response of a simple rotor system in steady state, with bearings containing layers of viscoelastic material. H.G. Tillema,[5]The excitation behavior of a bearing application under operating conditions can be efficiently simulated with a harmonic response analysis using a hybrid modeling approach.

2.1 Problem Definition

Presently all the mechanical system experiences vibration, in a varying magnitude. In today's world production reduction calls for speed increment. System working at higher speed faces service vibrations. Generation of vibration leads to mechanical failure, reduced performance & quality of product. This has become serious issue at all places. Till date engineers, designers & manufacturer are voyaging for the cost effective solution to arrest vibration. Many theories have been put forwarded so far & stepping success also being achieved. Furthermore a damping method using viscoelastic material is gaining attraction of researcher. A optimistic approach is still under investigation.

3.VISCOELASTIC MATERIALS:

3.1 Viscoelasticity:

Viscoelasticity is the property of materials that exhibit both viscous and elastic characteristics when undergoing deformation. Some phenomena in viscoelastic materials are:

1. If the stress is held constant, the strain increases with time (creep)(9)
2. If the strain is held constant, the stress decreases with time (relaxation)(9)
3. If cyclic loading is applied, hysteresis (a phase lag) occurs, leading to a dissipation of mechanical energy(9)

4 PLANNING OF EXPERIMENT

The selection of viscoelastic material is based on the properties, installation, replacement and cost. Out of this two, natural rubber is used for several applications. But flexible PVC is not used yet.

When Young's modulus was observed, it was found that flexible PVC having less value than natural rubber. Then this material was tested for stiffness in FEA. There it was found that natural rubber is stiffer than flexible PVC

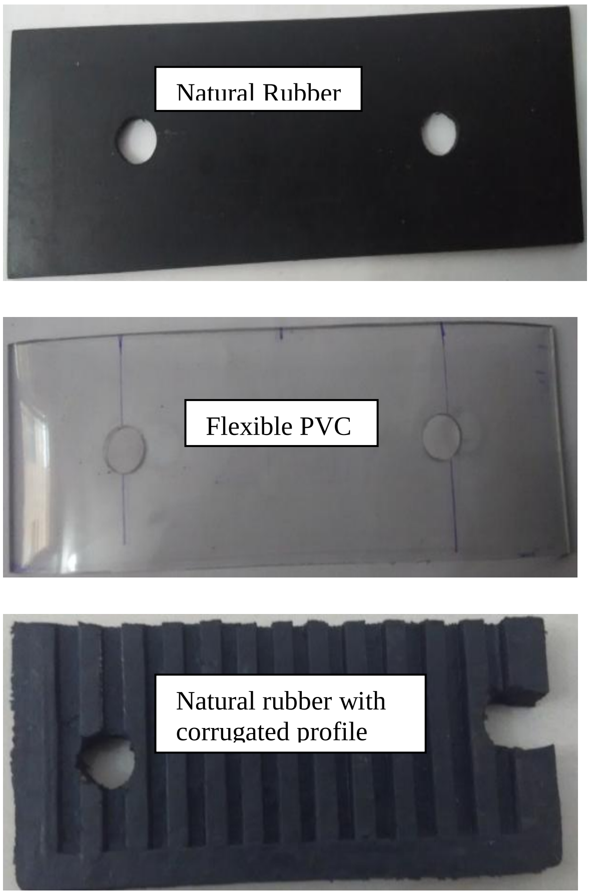

Fig. 1 Viscoelastic material used for experimentation

Table 1: Configuration of parameters under study

Parameter	Variables		
	1	2	3
Visco elastic Material	Natural rubber sheet with plain geometry	Natural rubber sheet with corrugated profile	PVC (polyvinyl chloride) sheet
Thick -ness (mm)	3/6/9/12	12	3/6/9/12
Speed (Freq.) rpm ofshaft	600/800/1000/1200/ 1400	600/800/1000/1200/ 1400	600/800/1000/1200/ 1400

4.1 EXPERIMENTAL SETUP

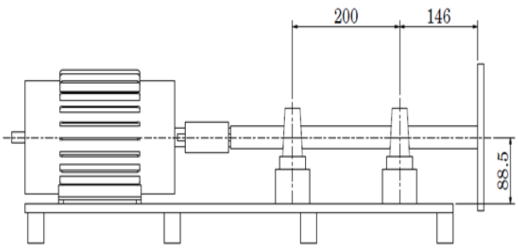

Fig. 1 Experimental setups block dia.

4.2 EXPERIMENTAL PROCEDURE

To increase the unbalance of system little mass of 20gm is added in the hole near circumference of disc. Readings are taken at motor, bearing 1 & bearing 2 on exciter & receiver side simultaneously. So that difference of vibration acceleration magnitude can be observed there itself.

5 RESULTS

5.1 Setup vibration Acceleration Magnitude without Isolator

Initially vibration acceleration magnitude of setup in without isolator condition is found out. Those magnitudes are then compared with vibration acceleration magnitudes with isolator condition.

(Note: All the readings tabulated in Exc. & Rec. column are vibration acceleration magnitudes in m/s^2)

5.2 Setup vibration Acceleration Magnitude with Natural Rubber as Isolator

Natural rubber is used as isolator and readings are taken.

5.3 Setup vibration Acceleration Magnitude with Flexible PVC as Isolator

Using similar cases for natural rubber, readings were taken for flexible PVC.

5.4 Setup Vibration Acceleration Magnitude with Corrugated Profile of Natural Rubber as Isolator

In this case, similar operations for previous two materials are carried out and readings are taken for 12 mm thickness.

Table 2 : Vibration acceleration magnitude in without isolator condition.

CASE	RPM	Motor		Bearing 1		Bearing 2	
		EXC.	REC.	EXC.	REC.	EXC.	REC.
without isolator	600	1.56	2.68	6.69	1.89	7.69	1.51
	800	1.93	3.06	9.05	2.59	8.78	1.93
	1000	2.40	3.70	12.34	3.10	12.00	2.12
	1200	2.14	3.85	14.50	3.20	16.10	3.25
	1400	4.42	7.36	18.30	3.71	19.10	3.91

Upcoming fig. shows plots for Bearing 1 at exciter & receiver side.

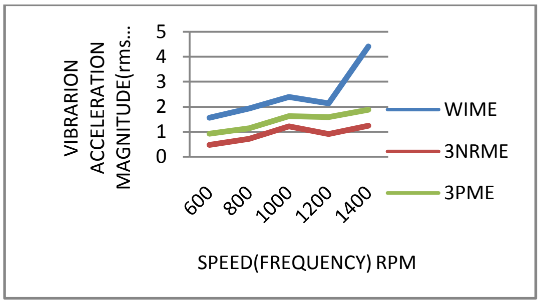

Fig. 2: vibration acceleration magnitude (rms value) mm/s^2 Vs Speed (frequency) rpm. (case 1, case 2, case 6 for motor exciter side)

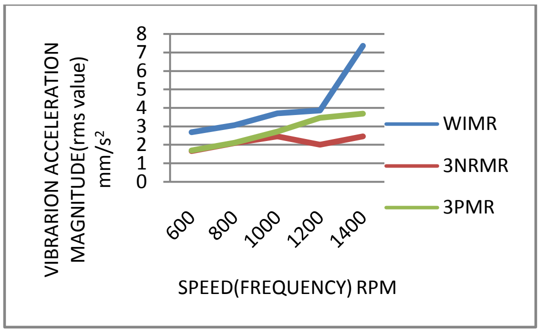

Fig. 3: vibration acceleration magnitude (rms value) mm/s^2 Vs Speed (frequency) rpm. (case 1, case 2, case 6 for motor receiver side)

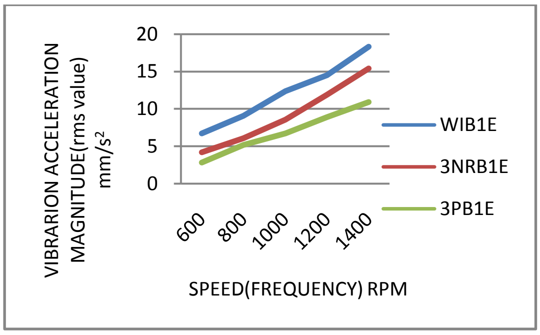

Fig. 4: vibration acceleration magnitude (rms value) mm/s^2 Vs Speed (frequency) rpm. (case 1, case 2, case 6 for bearing 1 exciter)

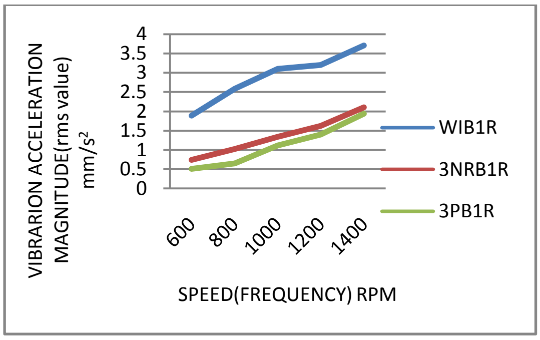

Fig.5: vibration acceleration magnitude (rms value) mm/s^2 Vs Speed (frequency) rpm

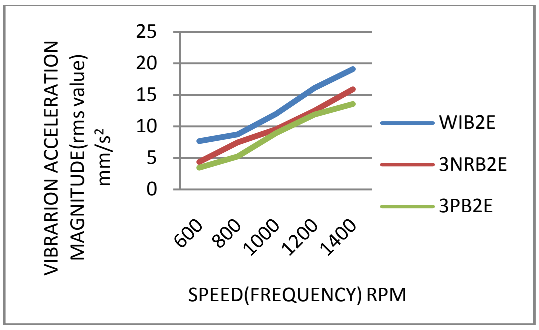

Fig.6:vibration acceleration magnitude (rms value) mm/s^2 Vs Speed (frequency) rpm. (case 1, case 2, case 6 for bearing 2 exciter)

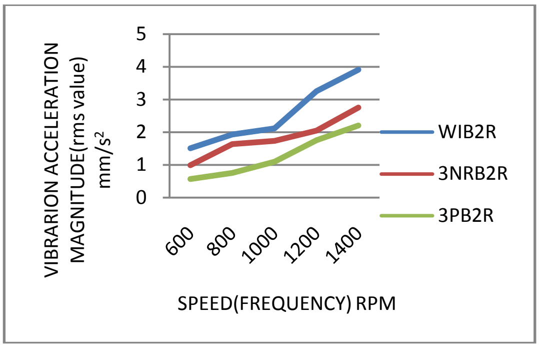

Fig.7:vibration acceleration magnitude (rms value) mm/s^2 Vs Speed (frequency) rpm. (case 1, case 2, case 6 for bearing 2 receiver)

6 CONCLUSION & FUTURE SCOPE

6.1 Conclusion

1. For motor at all thickness PVC gives better results than natural rubber, when compared for vibration magnitude, % reduction & variation in magnitude.
2. For all cases of natural rubber, variation in magnitude is more as compared to Flexible PVC material i.e. Flexible PVC gives less variation.
3. 12 mm thickness of Flexible PVC material gives less variation in vibration magnitude, as compared to 3mm thickness. ie. as isolator thickness increase to 12 mm motor, bearing1 & bearing 2 gives less variation in

magnitude (it is better for machines whose operating speed range is more.)

4. When natural rubber with corrugated profile compared with other material at 3-12mm thickness, result of this material are poor than both of natural rubber & Flexible PVC in all cases.
5. At bearing 1 & bearing 2 for all thickness & all considered operating speed PVC gives better result when compared with natural rubber & corrugated profile of natural rubber for vibration magnitude, % reduction & variation in magnitude.
6. In single point we can conclude as, when PVC, natural rubber & corrugated profile of natural rubber, are used as isolator for same thickness PVC gives less vibration than other two isolator material.

6.2 Future scope

Some of the following important corrective actions are suggested for future work:

Varying thickness & geometry can be tested for more viscoelastic material.

1. For vibration isolation in different operating conditions like temperature, pressure, flexible PVC material can be tested. Furthermore it is to be tested in contamination.
2. In combination with various viscoelastic material flexible PVC can be tested as isolator.
3. Results of PVC for reciprocating machines also can be checked to analyze intermittent & impact stresses behavior of flexible PVC.
4. Elaborate for testing parameters, working condition, stress values & types.
5. By knowing the values of damping damping coefficient & critical damping coefficient or damping ratio or loss factor of isolator material force transmissibility can be found out.

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APPENDEX

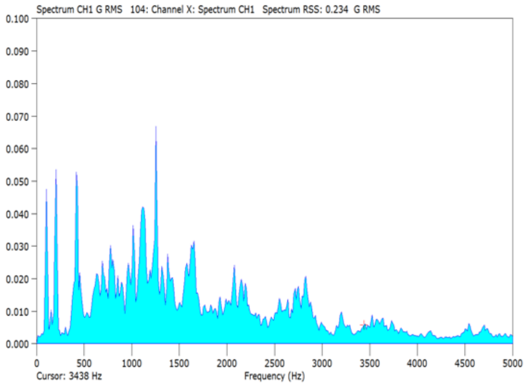

Fig. 8: Sample vibration spectrum.

ABBREVIATION

Case structure	Reading location	
	exciter	receiver
Without isolator for bearing 1.	WIB1E	WIB1R
3mm natural rubber for bearing 1.	3NRB1E	3NRB1R
6mm natural rubber for bearing 1.	6NRB1E	6NRB1R
9mm natural rubber for bearing 1.	9NRB1E	9NRB1R
12mm natural rubber for bearing 1.	12NRB1E	12NRB1R
3mm PVC for bearing 1.	3PB1E	3PB1R
6mm PVC for bearing 1.	6PB1E	6PB1R
9mm PVC for bearing 1.	9PB1E	9PB1R
12mm PVC for bearing 1.	12PB1E	12PB1R
12mm Natural rubber with corrugated profile for bearing 1.	12NRCPB1E	12NRCPB1R