Reduction of Bearing Vibrations using Suitable Damping Bush Material

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Abstract - *Rotating machinery used in mechanical engineering applications such as electrical motors, machine tools, compressor pumps, and aircraft engines is generally affected by high vibrations and noise produced due to misalignment, eccentricity, internal faults in the cross-sectional area and material imperfection, etc. These conditions are considered as undesirable and hamper the system heavily during its service life. An eccentricity is one of the major factors that affect the entire system by causing whirling of the shaft and premature failure of the shaft at high vibration condition. Such high vibration condition can be controlled by an important technique called vibration-monitoring technique. This present work focusses on studying the effect of eccentricity on bearing vibrations and to find an alternative bush material to add damping effect.*

Key Words: **Eccentricity, Bearing Vibration, Bush, Damping**

1. INTRODUCTION

Vibration is a common phenomenon observed during operation of rotating machinery. There are multiple sources of vibration, which will directly or indirectly generate the vibration and noise in the system. The reasons that are commonly seen are misalignments, looseness and eccentricity in the systems [1]. The basic Objective of this paper is to study the effect of eccentricity on bearing vibration by installing a device called accelerometer as a sensor.

To control or to eliminate the eccentricity there is a method called vibration-monitoring technique. Vibration monitoring is important technique that provides valuable information regarding symptoms of machinery faults, which in practice may lead to costly breakdowns [2].

This paper demonstrates the effect of eccentricity on bearing vibration by introducing bushes made up of different materials like rubber brass aluminum and nylon. Here an attempt has been made to suggest best performing bush amongst the selected one by studying its vibration signature and behaviour. This complete analysis is carried on LabVIEW software, which is used along with a Data Acquisition System to have better results. LabVIEW is a virtual instrument platform developed by National Instruments. After the simulation, results are compared and best suitable bush is suggested.

2. METHEDOLOGY

The setup consists of a shaft of diameter 25mm and length 300mm supported between driven and driving end. The shaft is coupled to a DC motor by using flexible couplings.

Fig -1: Test rig used for vibration measurement.

An accelerometer is mounted on the bearing housing at the driven end to sense the vibrations produced during machine running condition.

Output of the accelerometer is an analog signal, which is the input to DAQ. DAQ system is used to store information signal and data and it converts analog signal to digital form using inbuilt ADC.

The output of the DAQ being digital signal is the input to the LabVIEW software, which provides vibration signature data depicting peak amplitude of signal.

The eccentricity is provided manually with the step of 0.5mm and the experiment is carried out at 0mm, 0.5mm, 1mm and 1.5 mm eccentricity. Further, the experiment is conducted by inserting a bush at a time between shaft and the inner race of the bearing. The bush material used are aluminum, brass, rubber and nylon.

3. RESULTS AND DISCUSSIONS

The maximum and minimum vibration amplitudes for eccentricity ranging from 0 mm to 1.5 mm are measured.

The following results portray the maximum and vibration amplitudes for each level of eccentricity.

3.1 Without Bush at 0 mm Eccentricity

1. For eccentricity of e = 0 mm.
   RPM=500

Table -1: Maximum and minimum amplitudes of vibration for RPM=500 and 0mm eccentricity

Acceleration in m/s²		Average acceleration (a) in m/s²	
Max	Min	Max	Min
0.0416861	-0.0454908	0.031294	-0.02988
0.0321918	-0.0341722		
0.0308672	-0.025878		
0.0275767	-0.0227187		
0.0241465	-0.0211153		

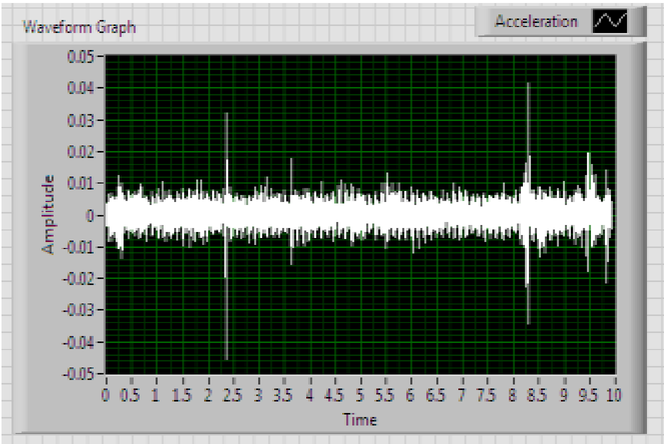

Fig -2: Vibration signatures in LabVIEW software for 500 RPM and 0mm eccentricity

2. For eccentricity of e = 0 mm.
   RPM=700

Table -2: Maximum and minimum amplitudes of vibration for RPM=700 and 0mm eccentricity

Acceleration in m/s²		Average acceleration (a) in m/s²	
Max	Min	Max	Min
0.0548566	-0.0670769	0.045089	-0.05354
0.0501384	-0.0558424		
0.0454891	-0.0490357		
0.0379729	-0.0489802		
0.0369869	-0.0467398		

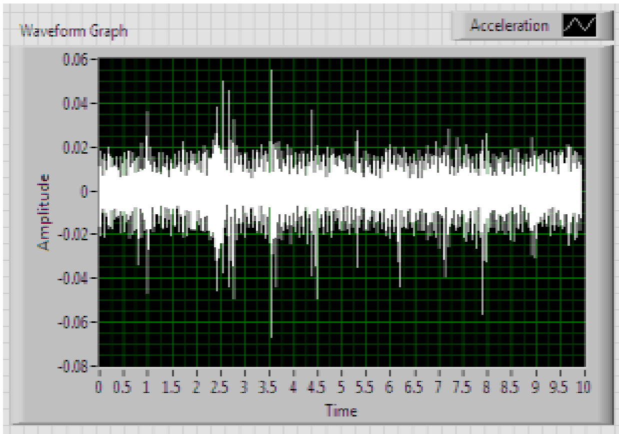

Fig -3: Vibration signatures in LabVIEW software for 700 RPM and 0mm eccentricity

3. For eccentricity of e = 0 mm.
   RPM=900

Table -3: Maximum and minimum amplitudes of vibration for RPM=900 and 0mm eccentricity

Acceleration in m/s²		Average acceleration (a) in m/s²	
Max	Min	Max	Min
0.108538	-0.137	0.099152	-0.11389
0.100639	-0.11994		
0.0974655	-0.106772		
0.0947528	-0.104331		
0.0943629	-0.101388		

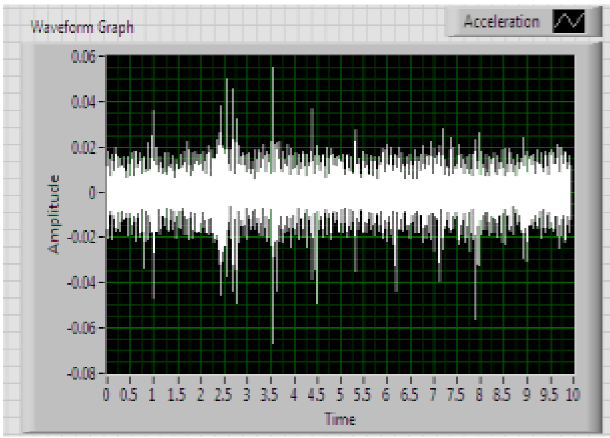

Fig -4: Vibration signatures in LabVIEW software for 900 RPM and 0mm eccentricity

Similar results were obtained for eccentricity of 0.5 mm, 1 mm and 1.5 mm at 500, 700 and 900 RPM for Aluminum, Brass, Nylon and Rubber bushes which are compared in below tables.

3.2 Comparison

Table -4: Comparison of results at eccentricity of 0 mm and 500 RPM

	Maximum acceleration, m/s^2	Minimum acceleration, m/s^2	Result
Without bush	0.031294	-0.02988	Nylon bush acts as the best damper aiding in reduction of vibrations
Aluminium bush	0.039496	-0.03083	
Brass bush	0.032597	-0.03209	
Nylon	0.008233	-0.00845	
Rubber	0.008548	-0.00872	

Table -5: Comparison of results at eccentricity of 0 mm and 700 RPM

	Maximum acceleration, m/s^2	Minimum acceleration, m/s^2	Result
Without bush	0.045089	-0.05354	Nylon bush acts as the best damper aiding in reduction of vibrations
Aluminium bush	0.144972	-0.1176	
Brass bush	0.180401	-0.13113	
Nylon	0.011943	-0.01216	
Rubber	0.015916	-0.02215	

Table -6: Comparison of results at eccentricity of 0 mm and 900 RPM

	Maximum acceleration, m/s^2	Minimum acceleration, m/s^2	Result
Without bush	0.099152	-0.11389	Nylon bush acts as the best damper aiding in reduction of vibrations
Aluminium bush	0.390112	-0.21832	
Brass bush	0.207225	-0.16149	
Nylon	0.021454	-0.01732	
Rubber	0.033073	-0.03145	

Table -7: Comparison of results at eccentricity of 0.5 mm and 500 RPM

	Maximum acceleration, m/s^2	Minimum acceleration, m/s^2	Result
Without bush	0.06696	-0.0943	Nylon bush acts as the best damper aiding in reduction of vibrations
Aluminium bush	0.035059	-0.02857	
Brass bush	0.048029	-0.05632	
Nylon	0.008556	-0.00942	
Rubber	0.009845	-0.01162	

Table -8: Comparison of results at eccentricity of 0.5 mm and 700 RPM

	Maximum acceleration, m/s^2	Minimum acceleration, m/s^2	Result
Without bush	0.126283	-0.0893	Rubber bush acts as the best damper aiding in reduction of vibrations
Aluminium bush	0.414962	-0.24169	
Brass bush	0.100619	-0.09743	
Nylon	0.013624	-0.01587	
Rubber	0.009845	-0.01162	

Table -9: Comparison of results at eccentricity of 0.5 mm and 900 RPM

	Maximum acceleration, m/s^2	Minimum acceleration, m/s^2	Result
Without bush	0.282147	-0.22034	Rubber bush acts as the best damper aiding in reduction of vibrations
Aluminium bush	0.464427	-0.25327	
Brass bush	0.169218	-0.14854	
Nylon	0.024576	-0.02595	
Rubber	0.015744	-0.01883	

Table -10: Comparison of results at eccentricity of 1 mm and 500 RPM

	Maximum acceleration, m/s^2	Minimum acceleration, m/s^2	Result
Without bush	0.052502	-0.06699	Nylon bush acts as the best damper aiding in reduction of vibrations
Aluminium bush	0.057956	-0.04693	
Brass bush	0.057273	-0.05254	
Nylon	0.012821	-0.01522	
Rubber	0.028297	-0.02353	

Table -11: Comparison of results at eccentricity of 1 mm and 700 RPM

	Maximum acceleration, m/s^2	Minimum acceleration, m/s^2	Result
Without bush	0.05643	-0.067	Nylon bush acts as the best damper aiding in reduction of vibrations
Aluminium bush	0.0884	-0.05923	
Brass bush	0.064965	-0.05574	
Nylon	0.038221	-0.03	
Rubber	0.005877	-0.00569	

Table -12: Comparison of results at eccentricity of 1 mm and 900 RPM

	Maximum acceleration, m/s^2	Minimum acceleration, m/s^2	Result
Without bush	0.09938	-0.10672	Rubber bush acts as the best damper aiding in reduction of vibrations
Aluminium bush	0.21997	-0.202	
Brass bush	0.237793	-0.16428	
Nylon	0.025989	-0.02605	
Rubber	0.010858	-0.01298	

Table -13: Comparison of results at eccentricity of 1.5 mm and 500 RPM

	Maximum acceleration, m/s^2	Minimum acceleration, m/s^2	Result
Without bush	0.009249	-0.07898	Both Rubber and Nylon bush act as the best dampers aiding in reduction of vibrations
Aluminium bush	0.173543	-0.1558	
Brass bush	0.044463	-0.04869	
Nylon	0.088521	-0.00868	
Rubber	0.023505	-0.01983	

Table -13: Comparison of results at eccentricity of 1.5 mm and 700 RPM

	Maximum acceleration, m/s^2	Minimum acceleration, m/s^2	Result
Without bush	0.114044	-0.14128	Nylon bush acts as the best damper aiding in reduction of vibrations
Aluminium bush	0.630731	-0.30448	
Brass bush	0.160617	-0.1356	
Nylon	0.014681	-0.0138	
Rubber	0.01701	-0.01489	

Table -14: Comparison of results at eccentricity of 1.5 mm and 900 RPM

	Maximum acceleration, m/s^2	Minimum acceleration, m/s^2	Result
Without bush	0.114057	-0.13633	Nylon bush acts as the best damper aiding in reduction of vibrations
Aluminium bush	0.797591	-0.28775	
Brass bush	0.201503	-0.22055	
Nylon	0.022977	-0.02639	
Rubber	0.018173	-0.01758	

4. CONCLUSION

Aluminum and Brass bushes in the bearing are showing high vibration amplitudes in comparison with bearing without any bush during eccentric as well as non-eccentric operating condition. Thus, aluminum and brass prove to be non-damping materials. Nylon bush is showing very less vibration amplitudes in both eccentric as well as non-eccentric operating condition, proving to be the best damping material. In some cases, Rubber is showing good damping characteristic, but the limitation with the rubber bush is that it will tear out quickly and at high-speed operation, it extrudes out from the inner surface of the bearing. The results show the average percentage difference between Nylon and Rubber bushing is in the range of 16.6%-24.34% reduction in vibration amplitudes.

REFERENCES

[1]. Akhil Deshpande, Jeevan Kittur, "Experimental Study of Effect of Eccentricity on Vibration of Shafts", REST Journal on Emerging Trends in Modelling and Manufacturing Vol: 3(3), 2017, REST Publisher.

[2]. A. Laissaoui, B. Bouzouane, A. Miloudi, N. Hamzaoui, Perceptive analysis of bearing defects (Contribution to vibration monitoring) , copyright 2018 , Elsevier Ltd.

[3]. John Kubler, "Selecting Accelerometers for Modal Analysis," Kistler Instrument Corporation, IMAC XXVI, Orlando, Feb 6 2008

[4]. The piezoelectric accelerometer (vibration sensor) compression type, Source- www.sensorland.com (11/5/2019)

[5]. Vibration measurement techniques and Data acquisition system-chapter 38 http://nptel.ac.in/courses/112107088/module1/lecture38/lecture38.pdf (11/5/2019)

[6]. https://en.wikipedia.org/wiki/LabVIEW (11/5/2019)

[7]. K. M. Bhuptani, Dr. J. M. Prajapati, Friction and wear behavior analysis of different journal bearing materials, International journal of engineering research and application (IJERA), Vol. 3, Issue 4, Jul-Aug 2013

[8]. Dr. R. Tiwari, Measurements in rotating machinery, copyrights, IIT Guwahati, 2010

[9]. Christopher D. Small, Design aspects of metal-polymer bushings in compressor applications, International Compressor Engineering Conference, 2006

[10]. Patankar Rohit C, Mirza M.M, Gundale V.A, A simplified working procedure in designing the bearing bush for a 6" water-cooled submersible motor, International journal of engineering trends and technology (IJETT), Vol.30, Number 3, December 2015

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