International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 05, May - 2017

Comparative Study of Various Nonmetallic Isolators using FFT Analyzer

A. R. Lavhande
Department of Mechanical Engineering
Walchand institute of Technology, Solapur
Solapur, India

Prof. S. B. Tuljapure
Department of Mechanical Engineering
Walchand institute of Technology, Solapur
Solapur, India

***Abstract*— A body is said to vibrate when it describes an oscillating motion about a reference position. Vibration in a machine may leads to failure or maintenance of machine. By introducing isolator to vibrating body reduces the chances of failure. In this paper different nonmetallic isolators are compared for vibration isolation. The materials used for isolator consists of rubber, ribbed rubber, cork, neoprene, sagwan wood, plywood and different combinations. The test rig of gyroscope coupled to variable speed motor is used as vibrating source.**

Keywords—Vibration, Vibration Isolation, Isolator, FFT Analyze.

I. INTRODUCTION

Vibration

A body is said to vibrate when it describes an oscillating motion about a reference position. The number of times a complete motion cycle takes place during the period of one second is called as frequency and is measured in Hertz. Since man began to build machines for industrial purpose, and especially motors with higher speeds have been used to power them. Problems of vibration reduction and isolation have engaged engineers.

In practice, it is very difficult to avoid vibration. It usually occurs because of dynamic effects of manufacturing tolerances, clearances, rolling and rubbing contact between machine parts and out of balance forces in rotating and reciprocating members. Often small insignificant vibrations can excite the resonant frequencies of some other structural parts and be amplified into major vibration and noise sources.

Vibration isolation

Vibration isolation relates to bring about a reduction in a vibrating motion. A vibration isolator in its most elementary form may be considered as a resilient member connecting the equipment and foundation. The function of an isolator is to attenuate the vibrations from the vibrating system. Generally, the isolator is kept between the vibration device and the foundation to reduce the magnitude of force transmitted. Passive isolation can be done in many ways viz. equipment mounts, isolator pads, cylindrical isolators, isolators with spring, etc.

Vibration isolation is measured in percentage effectiveness of isolation and is calculated as:

$$\% \text{ Isolation} = (1 - T) \times 100 \qquad \text{Eq. 1}$$

T in the equation relates to transmissibility ratio and can be defined as the ratio of force/motion transferred to force/motion generated in the vibrating system. Mathematically, transmissibility ratio is represented as below

$$\text{T. R.} = \left|\frac{F_T}{F_O}\right| = \left|\frac{X}{Y}\right| \qquad \text{Eq. 2}$$

Where T is the Transmissibility ratio F_T is force transmitted, F_O is exciting force, X is motion transmitted, Y is motion generated by the source.

Literature review

Dr. Ashesh Tiwari et al. (2014) carried the investigation of the transmissibility of various metallic and nonmetallic materials using vibration analysis. To minimize vibration level experimental setup of vibration isolation system was developed and isolators are equipped for getting minimum transmissibility. For this purpose, different material pads were taken as isolator. The isolator materials used for work were Aluminium, Mild Steel, Cast Iron, Marble, Rubber, Wood, Nylon, and Cork.

Nikhil s. Kulkarni et al. (2014) has explained T-test approach in vibration reduction. The vibration reduction of test rig was done experimentally using different isolators. PVC sheet having varying thickness was used along with steel sheets. Five case combinations of PVC and steel sheet were included in work for comparison work. And based on the vibration magnitude (RMS Value) the T-test was done. FFT analyzer was used for the work. The accelerometer was joined at bearing support to sense the vibration. From results acquired, it is concluded that 15 mm thick plate of PVC reduced the vibration.

Mr. Viraj Bhushan Patil (2016) has done T-test on viscoelastic vibration damping. The vibration magnitude (RMS Value) of several isolators was measured and recorded using FFT Analyzer. Special vibration test rig was developed as vibration source. The vibration isolators used for work consists of Butyl Rubber sheet, Silicone Rubber sheet and PVC sheet, each of 12mm thickness. From the results obtained, it is come to know that silicone rubber sheet shows great reduction in vibration.

D. D. L. Chung (2001) took review of different materials for vibration damping. Comparison between polymers, metals, cement based materials, metal matrix and polymer matrix was tabulated and discussed in the paper. Among all the materials neoprene rubber has highest damping capacity.

Mohammad Safi A. Patan, et al (2016), has done comparative study on vibration isolators using parameter absorptivity. Different materials like wood, natural rubber, polyurethane, wood with rubber pad combination were used for damping the vibrations from test rig.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 05, May - 2017

Sagar karkhile (2015) has done the FEM based analysis of vibration reduction in rotating mechanical system by damping phenomenon. The isolator materials mentioned for the work are plain natural rubber sheet, flexible PVC sheet and corrugated rubber sheet. Modal analysis was done to see the effect of isolation over vibration amplitude. Natural frequency was checked for the comparison work. Experimental setup geometry was modeled using PRO-E software while the analysis is done using ANSYS WORKBENCH 15. From the results the flexible PVC sheet was effective for vibration isolation as compared to other two.

FFT Analyzer

FFT analyzers are used for the measurement of vibration. It consists of FFT analyzer box, accelerometer which is used as sensor. Accelerometer is connected to the vibrating base with the help of adhesive and it senses the vibratory motion, which further sent to FFT box for converting it into electrical signals. The vibration spectra can be seen at computer screen. FFT analyzers make use of the FFT (fast Fourier transform) algorithm to calculate the spectra of blocks of data. FFT analyzers produce a (complex) spectrum with a number of spectral lines equal to half the number of (real) time samples transformed.

II. EXPERIMENTATION

A. *Problem Identification*

The motor having variable speed is coupled to gyroscope is vibrating device. The speed of motor can be varied using voltage regulator. With increase in speed of the motor, the noise of vibration increases. This experimental setup has circular base which is kept on wooden table, so the vibrations generated in the system are transferred to table which is vibration receiver. The setup causes table to vibrate, which can be sensed by hand also.

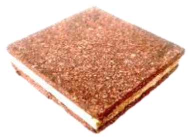
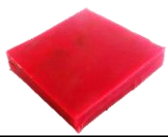
B. *Experimental Procedure*

In the work, for analyzing the isolation of different isolator, experimental setup of gyroscope coupled with variable speed motor is used. The base of the gyroscope is circular flat. The whole setup is rested on wooden table. The unbalanced forces are produced in rotating motor which further transferred to base causes base to vibrate. Different nonmetallic material pads are used as isolator to attenuate vibrations and regulator is used to vary the speed of motor. Here the gyroscope is vibrating cause and wooden table is vibration receiver. The isolator pads are kept in between them as path.

The isolator has to be analyzed for three different speeds, low medium and high speeds, viz. 1000 rpm, 1600 rpm and 2200 rpm. For each speed, vibrations transferred to table is to be recorded in two conditions which are, Firstly, without keeping isolator in between the gyroscope base and the table and secondly, keeping different isolators. Four isolator pads are kept at 90^{O} to each pad, under the base of gyroscope for the isolation purpose. The materials used for the isolator are cork, rubber, neoprene, sagwan wood, plywood, ribbed rubber and different combinations has been shown in table.

The dimensions of material for isolator are taken as same. Each isolator has 10 mm thickness and 50 mm length and width except ribbed rubber has 12.5mm. The ribbed rubber has ribs of 4 mm both sides, which is available in market. The different combinations of isolators are made and joined using special adhesive. The isolators are analyzed for three different speeds and spectrum is taken using FFT analyzer.

TABLE I. ISOLATORS AND THEIR CONFIGURATION

Sr. No.	Material of Isolator	Picture	Configuration
1	Ribbed Rubber		Having 4 mm ribs both sides
2	Rubber		Plain, 10 mm
3	Cork +wood		4 mm wood sandwiched between 3 mm pads of cork
4	Neoprene		Two 5mm neoprene pads joined to each other, 10 mm
5	Cork		Two 5mm cork pads joined to each other, 10 mm
6	Cork + Rubber		5 mm cork is joined to 5mm rubber
7	Wood		Plain sagwan wood, 10 mm
8	Rubber + wood		4 mm wood pad sandwiched between 3 mm pads of rubber
9	Rubber + Plywood		4 mm plywood pad sandwiched between 3 mm pads of rubber
10	Plywood		Plain, 10 mm

Oros NV gate 8.0 FFT analyzer is used to measure the acceleration at different speeds. The accelerometer sensor is attached to table with the help of adhesive. The experiment is carried out in two stages. In the first stage, the speed is adjusted and graph is recorded. This gives values of vibration induced in the setup. In second stage, the four isolator pads are kept between setup and the base (red dots shown in figure)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 05, May - 2017

and graph is recorded. This gives the values of vibration transmitted through rubber pad isolator to base. The gyroscope coupled to the motor is shown in fig. 1

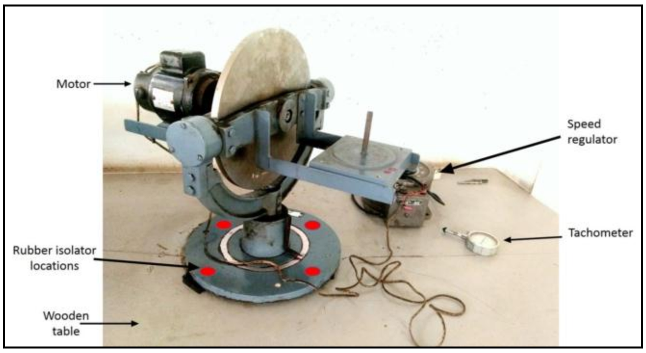


Fig. 1. Gyroscope coupled with varying speed motor experimental setup

III. RESULTS AND DISCUSSIONS

The data obtained is tabulated as follows. The transmissibility is calculated using equation 3 given above. The effectiveness of isolation values are in percentage.

TABLE II. TRANSMISSIBILITY ANALYSIS OF CORK PAD

Speed (RPM)	RMS value of Acceleration		Transmissibility Ratio, T.R.= Xt/Xo	Effectiveness of Isolation
	Without isolator {Xo}, (m/s²)	With isolator {Xt}, (m/s²)		
1000	8.50E-04	6.03E-04	0.709	29.06
1600	1.41E-03	8.45E-04	0.598	40.20
2200	1.80E-03	8.54E-04	0.473	52.66

TABLE III. TRANSMISSIBILITY ANALYSIS OF CORK+RUBBER PAD

Speed (RPM)	RMS value of Acceleration		Transmissibility Ratio, T.R.= Xt/Xo	Effectiveness of Isolation
	Without isolator {Xo}, (m/s²)	With isolator {Xt}, (m/s²)		
1000	8.50E-04	5.91E-04	0.695	30.47
1600	1.41E-03	7.41E-04	0.524	47.56
2200	1.80E-03	1.01E-03	0.562	43.85

TABLE IV. TRANSMISSIBILITY ANALYSIS OF CORK+WOOD PAD

Speed (RPM)	RMS value of Acceleration		Transmissibility Ratio, T.R.= Xt/Xo	Effectiveness of Isolation
	Without isolator {Xo}, (m/s²)	*With isolator {Xt}, (m/s²)*		
1000	8.50E-04	5.08E-04	0.598	40.24
1600	1.41E-03	7.59E-04	0.537	46.28
2200	1.80E-03	8.07E-04	0.447	55.27

TABLE V. TRANSMISSIBILITY ANALYSIS OF NEOPRENE PAD

Speed (RPM)	RMS value of Acceleration		Transmissibility Ratio, T.R.= Xt/Xo	Effectiveness of Isolation
	Without isolator {Xo}, (m/s²)	*With isolator {Xt}, (m/s²)*		
1000	8.50E-04	5.74E-04	0.675	32.47
1600	1.41E-03	6.91E-04	0.489	51.10
2200	1.80E-03	9.45E-04	0.524	47.62

TABLE VI. TRANSMISSIBILITY ANALYSIS OF PLYWOOD PAD

Speed (RPM)	RMS value of Acceleration		Transmissibility Ratio, T.R.= Xt/Xo	Effectiveness of Isolation
	Without isolator {Xo}, (m/s²)	*With isolator {Xt}, (m/s²)*		
1000	8.50E-04	7.12E-04	0.838	16.24
1600	1.41E-03	1.14E-03	0.810	19.04
2200	1.80E-03	1.26E-03	0.700	29.99

TABLE VII. TRANSMISSIBILITY ANALYSIS OF RUBBER PAD

Speed (RPM)	RMS value of Acceleration		Transmissibility Ratio, T.R.= Xt/Xo	Effectiveness of Isolation
	Without isolator {Xo}, (m/s²)	*With isolator {Xt}, (m/s²)*		
1000	8.50E-04	5.46E-04	0.642	35.76
1600	1.41E-03	6.16E-04	0.436	56.40
2200	1.80E-03	7.29E-04	0.404	59.59

TABLE VIII. TRANSMISSIBILITY ANALYSIS OF RIBBED RUBBER PAD

Speed (RPM)	RMS value of Acceleration		Transmissibility Ratio, T.R.= Xt/Xo	Effectiveness of Isolation
	Without isolator {Xo}, (m/s²)	*With isolator {Xt}, (m/s²)*		
1000	8.50E-04	4.68E-04	0.551	44.89
1600	1.41E-03	5.02E-04	0.355	64.47
2200	1.80E-03	6.66E-04	0.369	63.08

TABLE IX. TRANSMISSIBILITY ANALYSIS OF RUBBER+PLYWOOD PAD

Speed (RPM)	RMS value of Acceleration		Transmissibility Ratio, T.R.= Xt/Xo	Effectiveness of Isolation
	Without isolator {Xo}, (m/s²)	*With isolator {Xt}, (m/s²)*		
1000	8.50E-04	7.30E-04	0.859	14.12
1600	1.41E-03	9.96E-04	0.705	29.51
2200	1.80E-03	1.16E-03	0.642	35.75

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 05, May - 2017

TABLE X. TRANSMISSIBILITY ANALYSIS OF RUBBER+WOOD PAD

Speed (RPM)	RMS value of Acceleration		Transmissibility Ratio, T.R.= Xt/Xo	Effectiveness of Isolation
	Without isolator {Xo}, (m/s²)	*With isolator {Xt}, (m/s²)*		
1000	8.50E-04	6.49E-04	0.764	23.65
1600	1.41E-03	9.26E-04	0.655	34.47
2200	1.80E-03	9.38E-04	0.520	48.00

TABLE XI. Transmissibility analysis of Wood pad

Speed (RPM)	RMS value of Acceleration		Transmissibility Ratio, T.R.= Xt/Xo	Effectiveness of Isolation
	Without isolator {Xo}, (m/s²)	*With isolator {Xt}, (m/s²)*		
1000	8.50E-04	7.28E-04	0.856	14.35
1600	1.41E-03	8.47E-04	0.599	40.06
2200	1.80E-03	8.31E-04	0.461	53.94

From the data obtained, the bar chart comparing the effectiveness of isolation of different isolators at varying speeds has been shown in graph 1.

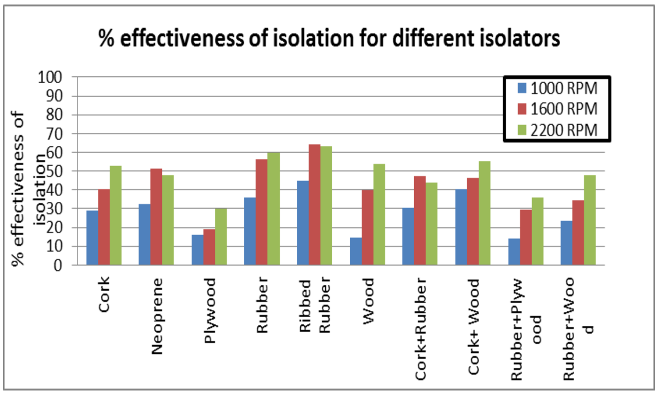


Fig. 2. Percentage effectiveness of isolation for different isolators

With increase in speed of the gyroscope coupled to variable speed motor, the vibrations also increases. From the data obtained by experimental analysis, the ribbed rubber attenuates maximum vibrations for all speed variations as compared to other isolators. For medium and high speeds ribbed rubber has effectiveness of isolation 63.08% and 64.47%, respectively, which is high amongst other isolators.

After ribbed rubber, plain rubber shows good isolation to vibration. The effectiveness of isolation at higher speed is 59.59 %; this means that the rubber isolator attenuates maximum vibrations effectively. Whereas the plywood shows minimum value of effectiveness of isolation at higher speeds which is 29.99% and at lower speed effectiveness of isolation is 16.24%.Wood shows minimum value of effectiveness of isolation at low speeds which is 14.35%, but with increase in speed, vibration isolation also increases.

Compared to all combinations used in work, the cork+wood combination attenuates maximum vibration at low to high speeds, and cork+rubber also shows effective vibration isolation whereas rubber+plywood combination have low average value of effectiveness of isolation, which is 26.46.

At high speeds i.e. 2200 rpm of motor, RMS value of acceleration is 1.80E-03 N/mm^2. At this speed, ribbed rubber attenuates 63.08% vibration. The transmissibility ratio is 0.369.

IV. CONCLUSION

It is come to know that the rubber isolates maximum vibration, so it is best suited for this vibration isolation system. Among all the materials, rubber is effective for vibration isolation. Whereas plywood isolator transfers maximum vibration to the foundation means it has the lowest effectiveness of isolation for the above mentioned vibration isolation setup. Compared to all combination, the cork+wood combination shows good isolation results.

When arranged in descending order of average value of effectiveness of isolation, the order is:
Ribbed rubber > Rubber > Cork+Wood > Neoprene > Cork > Wood > Rubber+Wood > Rubber+Plywood > Plywood.

ACKNOWLEDGMENT

I would like to express my sincere gratitude to our Principal Dr. S. A. Halkude and Dr. P. R. Kulkarni (Head of Mechanical Engineering Department) for giving me the opportunity to widen the knowledge, providing me necessary instruments and also for their constant encouragement and inspiration during project work. Also I am very thankful to my guide Prof. S. B. Tuljapure for giving much of their valuable time, precious guidance.

REFERENCES

[1] Dr. Ashesh Tiwari & Amit Chandsarkar "Analyze the transmissibility of various materials using vibration analysis", International journal of engineering sciences & research Technology, Aug 2014

[2] Nikhil S Kulkarni & Eknath R Deore "Experimental and t-test (testing hypothesis) approach in vibration reduction", International journal of mechanical engineering and robotics research, ISSN 2275-0149,Volume 3, No. 3, July 2014

[3] Mr. Viraj Bhushan Patil & Dr. Eknath Raghunath Deore "Experimentation and t-Test of Viscoelastic Vibration Damping", International Journal of Engineering Trends and Technology (IJETT) – Volume 37 Number 1- July 2016

[4] D. D. L. Chung "Review materials for vibration damping", Journal of material science 36, 5733-5737, 2001

[5] Sagar Karkhile & G B Pokale "vibration reduction validation using fem in rotating mechanical system by damping phenomenon", International Journal of Research in Engineering, Social Sciences ISSN 2249-9482, Impact Factor: 5.343, Volume 5 Issue 4, April 2015

[6] Chen Xueqian, Shen Zhanpeng, He Qinshu, Du Qiang & Liu Xinen "Influence of uncertainty and excitation amplitude on the vibration characteristics of rubber isolator", Journal of Sound and Vibration 377 (2016) 216–225,2016

[7] Mohammad Safi A Patan, Sushil Ramdas Deore & Prof. R. S. Pawar " Comparative study of vibration isolators using parameter absorptivity", international journal of advance research in science and engineering, ISSN 2319-8354, Vo. No.05, Special issue no. 02, March 2016

[8] Cyril M. Harris, Allan G. Piersol, Harris' shock and vibration handbook (McGRAW-HILL, 2002).

[9] G. K. Grover, Mechanical vibrations (Nem chand & bros, 2009)