Review article
UDC 620
DOI: https://doi.org/10.18721/JEST.27409

P. Sutar ✉

G.H. Raisoni College of Engineering and management,
Pune, India

✉ sutarpraveen007@gmail.com

A SHORT REVIEW OF VIBRATION ISOLATION USING VARIOUS INSULATING MATERIALS

Abstract. As for the increasing dependability of man on the machine, it seems necessary to strive for improvement of the performance of machines given that the dependent inputs are not changed drastically. In mechanical engineering terms, we are accustomed to working towards increasing the efficiency of a prime mover or core machine setup by developing methods to reduce wastage of energy, and performance reducing factors can be eradicated. In machines vibration is the underlying factor that complies to carry out periodic maintenance, not working up to the full potential of the prime movers, limiting the working and output of the mechanical forces and thus resulting in reduced performances. This paper provides brief review of the effects vibration has on the performance and how isolating it can result in increased efficiency and performance.

Keywords: Vibration Isolation, Mounting material.

Citation:

P. Sutar, A short review of vibration isolation using various insulating materials, Materials Science. Power Engineering, 27 (04) (2021) 117–123, DOI: https://doi.org/10.18721/JEST.27409

Обзорная статья
DOI: https://doi.org/10.18721/JEST.27409

Сутар Правин ✉

Колледж инженерии и менеджмента Г.Х. Райзони,
Пуна, Индия

✉ sutarpraveen007@gmail.com

КРАТКИЙ ОБЗОР ВИБРОИЗОЛЯЦИИ С ИСПОЛЬЗОВАНИЕМ РАЗЛИЧНЫХ ИЗОЛЯЦИОННЫХ МАТЕРИАЛОВ

Аннотация. На фоне возрастающей зависимости человека от машины стремление улучшить производительность оборудования кажется необходимостью, так как входные данные не имеют значительных изменений. Если использовать терминологию машиностроения, мы привыкли работать над увеличением эффективности первичного двигателя или стержневой машины путем разработки методов сокращения потерь энергии, а факторы, негативно влияющие на производительность, можно устранить. В станках вибрация является основной причиной необходимости в периодическом техобслуживании, невозможности использовать полный потенциал первичных двигателей, ограничения эксплуатации и выхода механического усилия, что ведет к снижению производительности. В данной работе приводится краткий обзор эффектов, которые вибрация оказывает на производительность, а также описывается то, как виброизоляция может привести к увеличению эффективности и производительности.

Ключевые слова: виброизоляция, монтажный материал.

Для цитирования:

Сутар Правин. Краткий обзор виброизоляции с использованием различных изоляционных материалов // Материаловедение. Энергетика. 2021. Т. 27, № 4. С. 117–123. DOI: https://doi.org/10.18721/JEST.27409

Introduction. The unwanted motions of the system are always a nuisance. One of the simplest means to reduce the vibration is to use any vibration-absorbing material. Many materials are widely used for this purpose. Various passive isolation materials include pneumatic isolators, springs and dampers. Flexible materials used as sheets or pads are made of corks, felts, rubber, elastomers, etc. These stated materials are applied on heavy machinery, in building systems and various industrial applications. Flexible materials are used in common household items, vehicles and, in the context of our study, in industrial machinery as well, where they are implemented as mounting pads for the vibrating source and foundations. Using these flexible materials, we can achieve cost cuttings and get the required isolation of vibration [1]. Here, we are focusing on using sandwich pads of 2–3 materials instead of using a single one and study the output parameter transmissibility. We reviewed and sought methods and approaches for isolating the oscillations of the machine and reducing the vibration transmitted to the foundations. Vibration isolation will aim to decrease unnecessary oscillations in the setup. The transmissibility idea is related to a single DOF (Degree of Freedom) system. The focus always lies on using lightweight and low-cost materials with greater results than traditional applications for vibration isolation.

Vibration isolation systems can be classified as active or passive.

Active vibration isolation systems provide the feedback and accordingly provide opposing forces or frequencies to isolate the vibrations. Here, more vibration is found than usual.

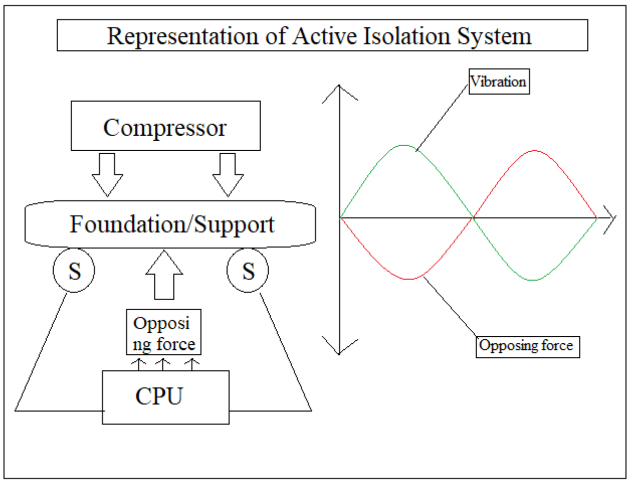

Fig. 1. Schematic representation of active vibration isolator

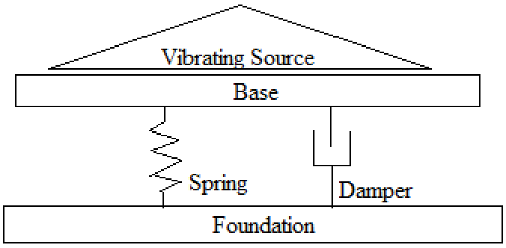

Fig. 2. Schematic representation of passive vibration isolator

Passive vibration isolation uses isolating materials like rubber pads or springs or different isolating materials [4]. We can use sandwiched composites of different materials as well, if there is a need to prepare an amount, which can provide passive isolation of the vibrating source.

Isolation is achieved at frequencies more than the square root of double the mounted resonance frequency. The area to be decided upon is a method to increase the transmissibility of the system.

For vibration isolation, the study aims to check that there is no change or modification in already used supports between vibrating source and foundation: this kind of application will have reduced weight with a possibility of stiffness control as well. Thus, we consider the effect of using such new materials like rubber, felt or copper instead of traditionally used springs and how this will impact the performance by calculating the transmissibility of vibration.

We study and compare various factors like the stiffness of materials used, damping coefficient of the materials, transmissibility of material with and without damping effects of the setup.

Hybrid isolation here stands for as a combination of passive and active types.

Problem statement and objective

The purpose of this study is to determine the vibration caused by a compressor and then to apply passive composite vibration isolators to reduce the transmissibility, i.e. vibration transmitted to the base. The combinations of rubber, felt and cork were used as isolators to reduce the vibration transmitted to the base of the compressor. The vibration is measured with and without an isolator.

Theoretical analysis

Many authors put the vibration isolation problem forth. The most discussed and easiest will be a single DOF system, with dependencies on mass, stiffness and damping. A two DOF (Degree of Freedom)

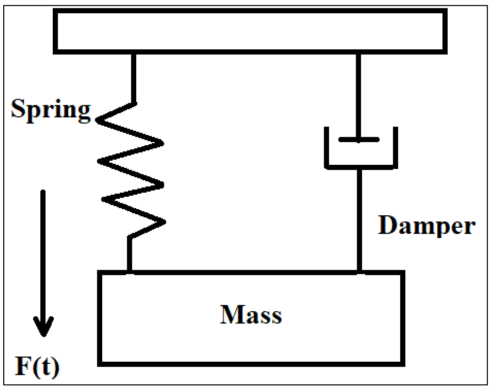

Fig. 3. Schematic diagram of vibration system

system can be devised as giving better-analysed data with fixed inputs [10]. M. Long observed that in both non-linear and linear stability theories, feedback control could be linked to improved stability [1]. Eigenvalues of the system can be used to examine results for stability of these systems and it will be stated if values found are negative.

When the damping or stiffness in the system are controlled, it is said to contain tuneable parameters [11]. Various data are available on diminishing harmonic excitations. Vibration absorbers are widely used to reduce unnecessary disturbances [1].

In this section, we study the calculation using the theoretical method proposed for identifying the effects of vibration isolation on the machine. [2]

Below is the basic equation we use for the calculation of the vibrating system [3]:

$$mx + cx + kx = F(t), \tag{1}$$

where $x(t)$ – vertical displacement; c – viscous damping; k – stiffness; $F(t)$ – excitation force; m – mass of system [3].
where M-(mass), C-(damping), and K-(stiffness) are matrices, and F (excitation force's vector) [2] .

By neglecting the damping, vertical motion occurred in the system [3].

The displacement is as below:

$$x(t) = \frac{Fo/k}{(1-r^2)} \sin \omega t, \tag{2}$$

where

$$r = \sqrt{\frac{\omega}{\omega_n}}, \tag{3}$$

$$\omega_n = \sqrt{\frac{k}{m}}. \tag{4}$$

The system has a natural frequency, here it will give larger amplitudes, for a low force of input.

Natural frequency is as follows:

$$f_n = \frac{\omega_n}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{k}{m}}. \tag{5}$$

In RPM, critical frequency is as follows:

$$RPM_{critical} = 60 f_n = \frac{60}{2\pi}\sqrt{\frac{k}{m}}. \tag{6}$$

The force transmitted is:

$$F = kx. \tag{7}$$

Transmissibility is nothing but transmitted force upon input force.

Transmissibility (T) is as below:

$$T = \left|\frac{F_t}{F_o}\right| = \left|\frac{1}{1-r^2}\right|. \tag{8}$$

The above equation can also help calculate the response of a machine X to the displacement of the foundation, Y.

The isolator's effectiveness (dB) is:

$$E = 10 \log_{10} \frac{1}{T}. \tag{9}$$

The isolator's effectiveness in percent is:

$$(1-T)*100 = Percent\ Isolation. \tag{10}$$

Michael F. Winthrop † and Richard G. Cobb proposed various vibration control elements as a practical application for space vehicles vibration isolation. These are again explained as vibration damping elements and vibration stiffness elements. They considered MR and ER fluids and piezoelectric materials as damping elements. Variable stiffness consists of shape memory alloys (SMA), piezoelectric materials, etc. [7].

This type of element is developed for automobile industries. These dampers can change their damping characteristics depending on the electricity applied [5].

Variable stiffness elements are metal alloys that regain their size after strains, when heat is applied to them. They are used to make the semi-active type of isolators.

Vibration control devices have many DOFs and can be used in space vehicle-related or ground testing-related applications [9].

Results and Discussions

Advantages of hybrid isolation:

1) Permits the transfer of static loads from the system to be isolated.

2) Reduces the power applied externally required as contrast functioning system by keeping lesser bandwidth needed.

3) Still allows some vibration isolation if the active element fails.

Disadvantage of hybrid isolation:

1) possibility of instability arises in the system due to active isolation;

2) chance of damage due to detuning of one of the isolation methods.

To change tuneable parameters, semi-active control implements a tuning scheme of passive elements of damping.

Thus, we obtained the following results:

1) reduction of the energy applied from the outside;
2) price reduction;
3) passive isolation when the active part is faulty;
4) potential of becoming as effective as feedback systems;
5) higher chance of stability when only the damping element is changed.

However, we know this change can cause further instability of the system. In reality, the setup is in need for a change of work. The variable stiffness element can be shown as a fixed element of stiffness and also as an active element of force. Due to this, semi-active control is very different from its combination as it employs more actuators and thus gets control. Combined control will not act to remove or swap the passive control [1].

Thus, in this paper, we studied and explained constant stiffness and damping elements providing a high-level understanding of active-passive damping isolation systems using different materials and methods. A trend towards using Smart Materials is observed for vibration control systems [2].

Conclusion

The study concludes that shape memory alloys that will give semi-active control are now in development. SMAs provide numerous opportunities for vibration isolation.

The review helped to state that the current vibration isolation of mechanical devices can be reduced to increase the performance of the system. It will also help to reduce the maintenance cost of the system. We identified analytical calculations necessary to evaluate and check practical applications for the single DOF type setup. The calculations can be used to compare the transmissibility of the system and decide on applying various materials (single or sandwich) to achieve low cost and better transmissibility due to better isolator effectiveness.

REFERENCES

[1] **Winthrop, Michael F., Richard G. Cobb,** Survey of state-of-the-art vibration isolation research and technology for space applications. Smart structures and materials 2003: Damping and isolation. Vol. 5052. International Society for Optics and Photonics, 2003.

[2] **Chen Yang et al.,** Study of whole-spacecraft vibration isolators based on reliability method. Chinese Journal of Aeronautics 22.2 (2009): 153–159.

[3] **C. Yilmaz, N. Kikuchi,** Analysis and design of passive band-stop filter-type vibration isolators for low-frequency applications." Journal of Sound and Vibration 291. 3-5 (2006): 1004–1028.

[4] **Urgueira Antonio P.V., Raquel A.B. Almeida, Nuno M.M. Maia,** On the use of the transmissibility concept for the evaluation of frequency response functions. Mechanical Systems and Signal Processing 25.3 (2011): 940–951.

[5] **R.A. Ibrahim,** Recent advances in nonlinear passive vibration isolators. Journal of sound and vibration 314.3-5 (2008): 371–452.

[6] **S. Gürgen, M. Alper Sofuoğlu,** Smart polymer integrated cork composites for enhanced vibration damping properties, Composite Structures (2020)

[7] A. Carrella, et al. On the design of a high-static–low-dynamic stiffness isolator using linear mechanical springs and magnets. Journal of Sound and Vibration 315.3 (2008): 712–720.

[8] **Y. Fukahori,** Use of natural rubber (NR) for vibration isolation and earthquake protection of structures. Chemistry, Manufacture and Applications of Natural Rubber. Woodhead Publishing, 2014. 371–381.

[9] **S. Santhosh et al.,** Experimental investigation and comparative analysis of rubber engine mount vibration and noise characteristics. Materials Today: Proceedings 21 (2020): 638–642.

[10] **M. Long,** (2014). Vibration and Vibration Isolation. Architectural Acoustics, 417–455.

THE AUTHOR

SUTAR Praveen – *G.H. Raisoni College of Engineering and management.*
E-mail: sutarpraveen007@gmail.com

Статья поступила в редакцию 03.06.2021; одобрена после рецензирования 09.06.2021; принята к публикации 14.08.2021.
The article was submitted 03.06.2021; approved after reviewing 09.06.2021; accepted for publication 14.08.2021.