VIBRATION ISOLATION OF A ROTATING MACHINE

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VIBRATION ISOLATION OF A ROTATING MOTOR

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DECLARATION

I declare that this project report entitled “Vibration Isolation of A Rotating Machine” is the result of my own work except as cited in the references

Signature : ……

Name : ……

Date : ……

APPROVAL

I hereby declare that I have read this project report and in my option this report is sufficient in term of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Plant & Maintenance).

Signature :……

Supervisor's Name ……

Date :……

DEDICATION

To my beloved Ibu, Boboy, Fazli, Ijoy and Faiz

Thank you for your love, care and support.

ABSTRACT

Vibration isolator is widely used in industrial fields as vibration insulation in rotating machinery. It helps to isolate the vibration of the motor from spreading to other places. Many studies have been conducted on vibration isolators. Most of the research is isolating the vibration signals in one direction either vertical direction or horizontal direction only. The study in multi-direction vibration isolation is still lacking. The purpose of this project is to study the characteristic of vibration isolator. In addition, to investigate the performance of vibration isolator and its operating deflection shape (ODS). There are a number of experiments were conducted to compare the transmissibility of two different types of vibration isolator. An experiment was conducted by using a frame; a rotating motor and some attachment of unbalance mass of the rotor. First, the experiment begun to measure the transmissibility at the frame and motor only, Then continued to frame, motor and rotor only. Next, it was continued to frame, motor, rotor and addition of unbalance mass. The present of unbalance mass actually is to produce vibrations in the system. Then, two types of vibration isolator are installed between the motor and the frame and the performance of both vibration isolator was tested. The movement of operating deflection shape (ODS) while studying the two types of vibration isolator was viewed and compared. The ODS was taken when the system is in resonance state. So that, the performance of both vibration isolator can be visualised either it is performed in a single direction or multi direction. Based on the experiment, it shows that both vibration isolator was isolated the vibration well. Besides, it shows that multi-direction type of vibration isolator isolate better than the single direction type of vibration isolator. It was proven in the both experiments either in the transmissibility performance or ODS. The ability of multi-directional vibration isolation can help reduce vibration from spreading to other places. Vibration generated from the defect machine should be isolated so that the vibrations do not cause damage.

ABSTRAK

Penebat getaran banyak digunakan di dalam bidang perindustrian sebagai penebat getaran pada mesin yang berputar. Ianya membantu untuk menyekat getaran motor daripada merebak ke tempat lain. Banyak kajian mengenai penebat getaran telah dijalankan. Kebanyakan kajian adalah menebat getaran dalam satu arah sama ada arah mencancang ataupun arah mengufuk sahaja. Kajian terhadap penebatan getaran dari pelbagai arah masih kurang. Tujuan projek ini dijalankan adalah untuk mengkaji sifat penebat getaran. Selain itu, untuk menyiasat perlaksanaan penebat getaran dan menggambarkan kendalian bentuk pesongan tersebut. Terdapat beberapa eksperimen telah dijalankan untuk membandingkan tahap kebolehpindahan dua jenis penebat getaran yang berbeza. Eksperimen dijalankan dengan menggunakan rangka besi, motor yang berputar dan terdapat alat tambahan tidak seimbang yang diletakkan pada rotor tersebut. Pertama, eksperimen mula mengukur kebolehpindahan pada bingkai dan motor sahaja, Kemudian diteruskan bingkai, motor dan pemutar sahaja. Seterusnya, ia diteruskan dengan bingkai, motor, rotor dan penambahan massa tidak seimbang. Kehadiran massa ketidakseimbangan sebenarnya adalah untuk menghasilkan getaran dalam sistem. Seterusnya, dua jenis penebat getaran tersebut telah dipasang di antara motor dan rangka besi tersebut. Pergerakan kendalian bentuk pesongan semasa mengkaji kedua-dua jenis penebat getaran juga dapat dilihat dan dibandingkan. ODS telah diambil apabila sistem berada dalam keadaan resonans. Supaya, prestasi kedua-dua pengasing getaran boleh dilihat sama ada ia dilakukan dalam satu arah atau arah multi. Berdasarkan eksperimen, ia menunjukkan bahawa kedua-dua penebat getaran telah menebat getaran dengan baik. Selain itu, ia menunjukkan bahawa jenis penebat getaran multi-arah menebat getaran lebih baik daripada jenis satu arah penebat getaran. Ia telah terbukti dalam kedua-dua eksperimen sama ada dalam prestasi kebolehpindahan atau ODS. Kebolehan Penebatan getaran dari pelbagai arah dapat membantu mengurangkan getaran daripada merebak ke tempat lain. Getaran yang terhasil dari pada mesin yang rosak hendaklah di tebat dengan sebaik-baiknya supaya getaran tersebut tidak mengakibatkan kerosakan.

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I perceive as this opportunity as a big milestone in my future career development. I will strive to use gained skills and knowledge in the best possible way, and I will continue to work on their improvement, in order to attain desired future career objectives. Thank you.

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T	Transmissibility
ODS	Operating Deflection Shape

LIST OF SYMBOL

c	=	Damping coefficient
ξ	=	Damping ratio
F_e	=	Excitation force
F_t	=	Force transmitted
i	=	$\sqrt{-1}$
m	=	Mass
k	=	Spring stiffness
ω	=	Operating frequency
ω_n	=	Natural frequency
T_f	=	Transmissibility
x	=	Displacement
$\dot{x}$	=	First derivatives of x
$\ddot{x}$	=	Second derivatives of x

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Figure 1.1 Various types of vibration isolators.

Nowadays, there are many types of vibration isolator as shown in Figure 1.1 that has been used and required in various industrial sectors or everyday objects in order to reduce the vibration transmission, such as in pumps, motors, HVAC systems, isolation of civil engineering structures, base isolation, sensitive laboratory equipment and valuable statuary. Besides, vibration isolators are also widely used in machinery as vibration insulation, which blocks the vibration waves from transfers to the floor. As the machine, continuously operating in a long period of time, under a high speed and carry heavy loads; indirectly it will cause a critically damaged. The problem is getting worse when, the vibration waves are transmitted to the other machine that stay next to the machine produced vibrations.

The vibration phenomenon might be occurred due to the problems inside the operating machine. The unbalance and misalignment of existing components of the machines might be one of the several reasons that lead to a high vibration of the machine component and can cause the machine breakdown. Thus, the vibration waves produced from the machine is not properly isolated. It will transmit to the floor. From the floor, it will transmit to the machines that stay next to the problem machine. In this case, it produces another problem to the machine next to it. As the result, it might affect the performance of the machine to operate. The operation of the machine will be decreased and could be a danger for user to run the machine. Thus, the maintenance cost would be higher if there is a critical damage or broken part of the machine component.

As the solution to this problem, vibration insulation is required to isolate the machine in order to reduce the vibration waves from transmit to another part. The present of vibration isolator on the machine, will block or decreases the vibration waves from transmitting to others part. As a result, it will produce another problem to the machine that stays next to it. Thus, this vibration problem will contribute to the decreasing performance of the machine. The machine could be dangerous to the user while running the machine and cause the machinery breakdown. As we know, currently the maintenance cost would be high when critical damage or broken part of the machine component. To avoid this problem to become worse, we need to isolate the vibrations that produce from the defect machine.

1.2 PROBLEM STATEMENT

Nowadays, there are need to isolate the vibration waves that are produced from the defect machine. But, currently there are so many vibration isolators that isolate the vertical vibration of the machine were produced. The problem occurs when, current vibration isolators does not work in multi-degree of freedom which is only work in one direction and unable to work more than one direction. We know that, when the machine is defected, it will vibrate not in single degree of freedom (one direction). The machine will vibrate in multi-degree of freedom various directions which are mostly in vertical and lateral direction. Currently, most of the isolators produced are effective in one direction, such as vertical vibration. Thus, only few numbers of isolator are effective in overcoming the lateral direction. The problem occurs when the lateral vibration is damaging as much as the vertical direction as well. So that, there are need to take care of this vibration problem.

1.3 OBJECTIVE

The objectives of this project are as follows:

1. To study the characteristic of vibration isolator.
2. To measure the performance of vibration isolator using measured data.
3. To visualize the effect of vibration isolator on the motor vibration Operating Deflection State (ODS)

1.4 SCOPE OF PROJECT

The scopes of this project are:

1. Obtain the characteristic of vibration isolator by conducting analytical studies.
2. Do the experimental work in order to measure the performance of two types of vibration isolators of input and output as well as to measure data by using accelerometer sensor.
3. Obtain the motor vibration ODS (Operating Deflection State) pattern and visualize the effect of two different types of vibration isolator by using VibShape Software.

1.5 GENERAL METHODOLOGY

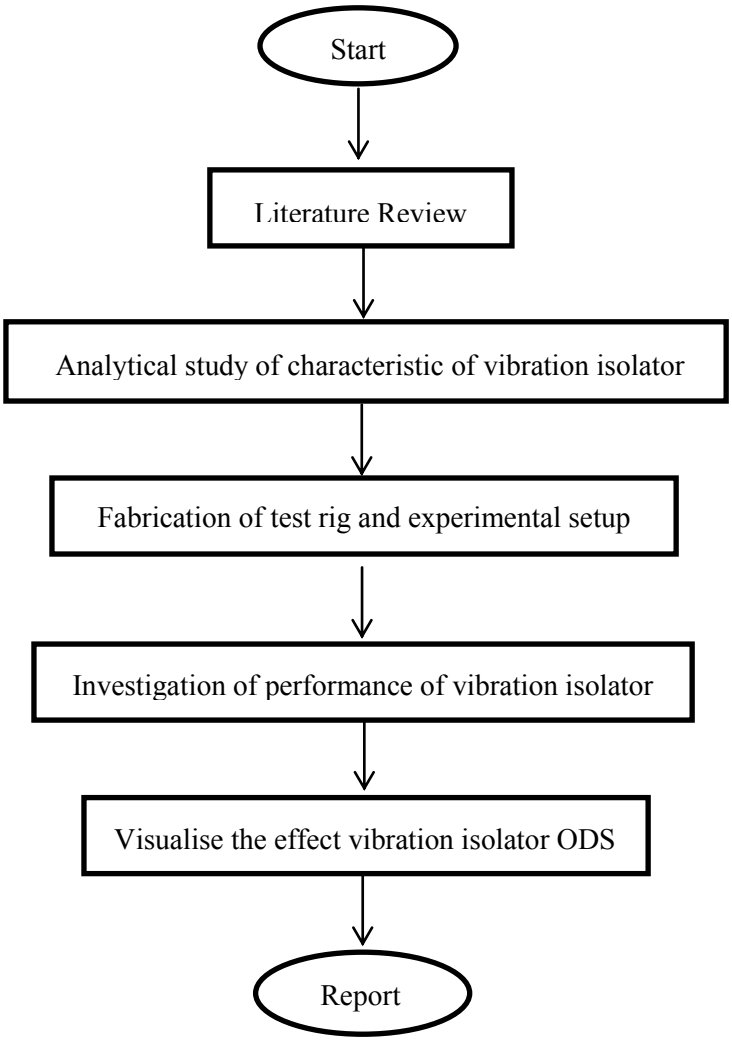

Figure 1.2 General Methodology

CHAPTER 2

LITERATURE REVIEW

2.1 Characterizations of Vibration Isolator

Vibration isolators are used in many applications to minimize the transfer of vibrations from machines to foundations. This is always the case in domestic appliances, a typical example being refrigerators where vibration isolators are used to minimize the structural borne noise due to the vibrations of the compressor. According to Levent and Sanliturk (2003) for this particular case compressor grommets are the vibration isolators which are used to minimize the transfer of vibrations from compressor to refrigerator body. However, the optimization of vibration isolators is a difficult process mainly due to inherent dependency of the properties of viscoelastic materials to many factors, including temperature, frequency and strain.

In addition, Naibiou (2011) stated that, vibration isolator is one of the vibration suppression methods. There are two kinds of vibration isolation which are to isolate a vibration source from its support and to isolate a base excitation from a device (Coppola, 2010). Furthermore, a simplest vibration isolator consists of a spring and a damper arranged in parallel. The spring plays a dual role which is to support the weight of the device and to isolate the base motion. Meanwhile, for a linear spring isolator, vibration isolation occurs when the natural frequency of the isolator system is smaller than the frequency of the base motion or exciting frequency. According to Carrella et al. (2008)

stated that to increase the isolation region, the stiffness of the isolator spring should be made as low as possible. However, lowering the isolator's stiffness results in a large static deflection that is undesirable. To overcome this problem, a high-static-low-dynamic stiffness (HSLDS) spring can be used. The HSLDS isolator is capable of supporting a large static load while possessing a low natural frequency.

Figure 2.1 Cooling Tower

Lamancusa (2002) stated that, by referring to the Figure 2.1 it shows a common example the vibration sources with a large reciprocating air conditioning compressor weighing 20,000 pounds, mounted on a roof. The loud noise levels at multiples of the compressor rotational frequency, predominantly 60 and 120 Hz, were measured in the rooms directly below the compressor.

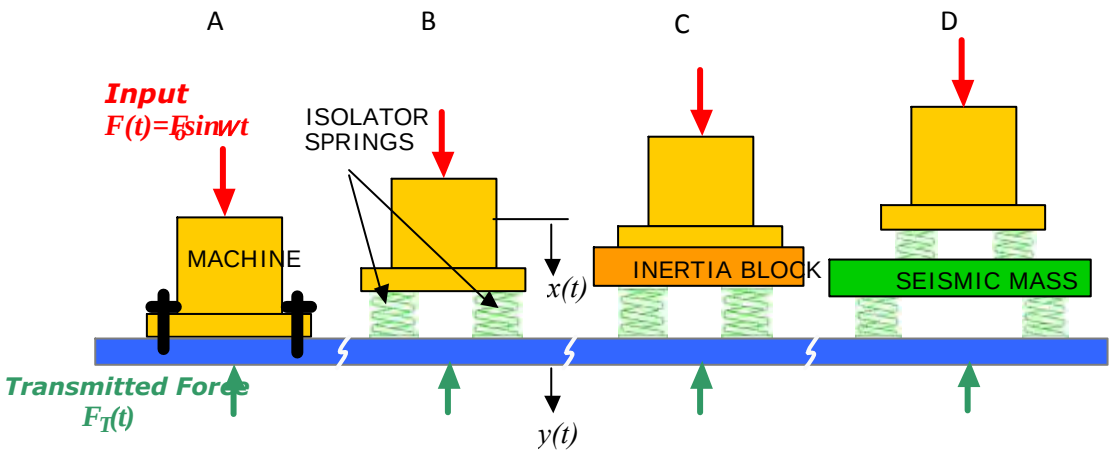

Figure 2.2 Vibration isolation systems

Based on Figure 2.2, there are four systems which are

A) Machine bolted to a rigid foundation

B) Supported on isolation springs, rigid foundation

C) Machine attached to an inertia block

D) Supported on isolation springs, non-rigid foundation (such as a floor); or a machine of isolation springs, seismic mass and second level of isolator springs

According to Figure 2.2, B is the force transmitted to the floor is equal to the force generated in the machine. The transmitted force can be decreased by adding a suspension and damping elements are known as vibration isolators. Based on Figure 2.2, C by adding an inertia block, a large mass which is a block of cast concrete, will directly attach to the machine. According to Figure 2.2, D another option is to add an additional level of mass or known as a seismic mass, again a block of cast concrete and suspension (Lamancusa, 2002).