DETERMINATION OF VIBRATION INPUT POWER FROM A STRUCTURE-BORNE SOURCE

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SUPERVISOR DECLARATION

"I admit to have read this report and it has followed the scope and quality in Partial Fulfillment of Requirement for the Degree of Bachelor of Mechanical Engineering (Structure and Material)"

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DECLARATION

"I hereby declare that the work in this report is my own except for summaries and quotations which have been duly acknowledged."

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DEDICATION

To My Beloved Family

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Sharifah Fauziah Bt. Syed Basri

Meor Mohd Firdaus B. Fadzil

Nur Farhana Bt. Fadzil

Nurin Mursyidah Bt. Fadzil

Meor Mursyidi B. Fadzil

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ABSTRAK

Sejak kebelakangan ini, kita sering mendengar tentang beberapa kegagalan struktur bangunan dimana ia membawa kepada bangunan runtuh. Kegagalan ini kemungkinan berpunca dari mesin berputar yang menghasilkan getaran yang kemudiannya disalurkan ke struktur bangunan tersebut. Oleh kerana itulah kuasa masukan getaran pada sktruktur bangunan mesti ditentukan melalui kajian ini. Ulasan terhadap kajian terdahulu yang berkaitan dengan tajuk kajian dilaksanakan. Objektif kajian ini adalah untuk mempamerkan kuasa masukan getaran terhadap struktur bangunan berdasarkan konsep mobiliti menggunakan kaedah plat penerimaan. Tujuan lain adalah untuk menjalankan eksperimen menggunakan kaedah plat penerimaan dan membandingkan keputusannya dengan pengukuran secara terus. Walaubagaimanapun, kajian ini terhad kepada punca yang ideal seperti plat. Perbezaan fasa juga diabaikan dan fasa daya yang dikenakan dianggap malar. Kajian merangkumi proses fabrikasi rig ujian dimana ia digunakan sebagai penerima. Sekain fabrikasi, eksperimen untuk menentukan kuasa masukan getaran juga dilaksanakan. Terdapat dua kaedah digunakan untuk mendapatkan keputusan dimana ia adalah kaedah plat penerimaan dan juga pengukuran secara terus. Kemudian, perbandingan antara kedua kaedah dilakukan untuk mengenalpasti kesahihan keputusan tersebut. Akhirnya, seluruh elemen di dalan kajian dapat disimpulkan bahawa kuasa masukan getaran dari kedua – dua kaedah hampir sama dan kaedah plat penerimaan dapat diterima pakai untuk mendapatkan kuasa masukan getaran terhadap strruktur bangunan.

ABSTRACT

Now days, we often heard about some failure in structure of a building which leads to building collapse. This failure can be cause by a sound that creates vibration from a rotating machine which then was channeled to the structure. That's why the vibration input power on a structure must be determined through the study. Reviews on the previous study of the related titles were carried out. The objective of the study is to model the vibration input power to a structure based on the mobility concepts using reception plate method. Other aims are to conduct experiment using reception plate method and to compare the result with direct measurement. However, the study is limited to an idealized receiver structure namely plate. Difference in phase excitation also might be ignored and phase from the force excitation is assumed to be uniform. The study contains the fabrication of the test rig which is used as the receiver. Besides fabrication, an experiment was carried out to obtain the input power. There are two method used which is the reception plate method and direct measurement. Therefore, a comparison between both methods was taken place to validate the data obtained. Finally, the whole elements in the study was conclude that the vibration input power from both method are almost the same and the reception plate method can be used as a valid method to determine vibration input power.

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Z	=	Impedance
Y	=	Mobility
Y_S	=	Mobility of source
Y_R	=	Mobility of receiver
v_f	=	Free velocity
k_b	=	Bending wave number
D	=	Bending stiffness per unit length
m	=	Mass per unit area
F	=	Excitation force
P	=	Vibration input power
dB	=	Decibel
ω	=	Frequency
η	=	Damping loss factor
S	=	Area

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CHAPTER I

INTRODUCTION

1.1 BACKGROUND OF STUDY

Nowadays, we often heard about some failure in structure of a building which leads to building collapse. This failure can be caused by vibration from a rotating machine which is channeled to the structure. The damage of the entire structure is due to high amplitude of vibration at resonance. The most risky structure is the industrial or factory building structure which contains many vibrating machinery. Those machines are capable of injecting high level of vibration which is hazardous not only to the structure where the machines are installed but also to the machine itself. Thus, the structural health monitoring has been introduced [1].

Such machines which causes propagation of vibrational wave into the neighboring structure is called structure-borne source. The treatment of structure-borne sound sources remains a challenging problem due to many uncertainties. For example, structural excitation to a building floor, by active components like pumps, compressors, fans and motors is an important mechanism of vibration and noise generation [2]. There is a lot interest in determining the vibration force between an installation and a building element. Determining the force between an installation and a building directly is a rather cumbersome task. Force sensors would have to be inserted between installation (source) and building element (receiver), which is difficult or even impossible for large and heavy installations. Even if it is possible, one must be careful not to alter the vibro-mechanical behavior of the source-receiver system in the frequency range of interest [3].

Thus, it is difficult to determine the structure-borne vibration than the air-borne because there is many factors need to be considered. Therefore, an accurate prediction of the injected input power from such sources is required [4].

1.1.1 Introduction on Structural Vibration

Noise or vibration is a common occupational hazard in a large number of workplaces such as the iron and steel industry, foundries, saw mills, textile mills, airports and aircraft maintenance shops, crushing mills, among many others. Structural vibration control is the most important tool to diagnose and to determine the input power of structure-borne vibration. It is defined as a method to monitor and control an input power of vibration into structure of building (structure-borne) [5].

This is actually different from vibration monitoring technique that more focusing on machine vibration and its damage that can be avoid to reduce cost of maintenance. Structural vibration control here is more focus on the strength of vibration that was injected into building element. Good prediction of input power is necessary to avoid too many vibrations in building structure [6]. Figure 1.1 below shows the vibration from machine propagating into structure.

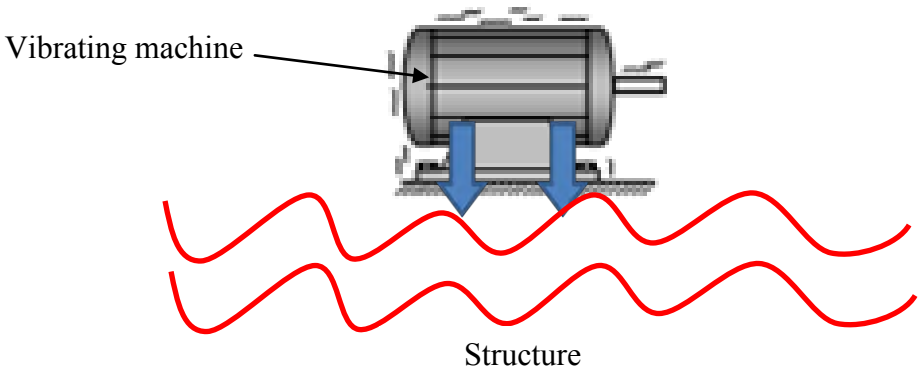


Figure 1.1: A machine propagating vibration into structure.

1.1.2 Sources of Structure-Borne Sound in Building

There are low and high frequency noise that generated from the vibrating machine. Low-frequency noise from machinery in buildings tends to be of a structure-borne nature rather than an airborne nature [7].

In vibration acoustic problem, a ‘source’ itself is defined as a machine or machine component that creates vibration, which was connected to a receiver which is in this situation, refers to a support structure of the machine [8].

Since the structure-borne noise consist of a sources and receivers, there is three situations can be generally classified. Those situations are as follows:

a. A machine (source) installed in a particular environment (receiver)
b. A machine component (source) inside a machine (receiver)
c. A sensitive piece of equipment (receiver) attached to a vibrating system (source)

In the first situation, the sources cause unwanted vibration at the source location or maybe remote from the source location. The examples of the sources are compressor in a building, exhaust fans, pumps and other rotating machines. The machine is installed directly on a structure that acts as a receiver.

The second situation is active parts inside a machine that creates vibration for example, combustion chamber inside a boiler, electrical pump in machine and many more. The third situation is often encountered in precision industrial process such as micro-electronics and other related industries [9]. Below are several types of machine that creates vibration and also noise [10]:

a. Ventilation and exhaust fans

Fans are stated as a common vibration sources. It is because the joining of the component must be tightening enough or it will vibrate. Besides the joining, the bearing of the rotating shaft is also will create vibration if it not fits enough. Another cause is the misbalancing of the propeller itself. From the vibration, it also might produce a noise [11].

b. Compressor

Compressors are definitely very noisy machines that run in high pressure. This is because the compress air that entrapped in the casing and along the pipeline will produce vibration. It happens because the high pressure volume will tend to shake the internal component and thus, it will create a vibration. From the vibration, it also radiates into the air and creates noise which is another common occupational hazard in industry.

c. Electric motors

Vibration from electric motors is originated from several sources. It may cause by bearing that were loose and it have too much space to move and this will create vibration. Other sources are due to the misalignment of the shaft. When the shaft rotates, it will cause vibration because it tends to move up and down very fast. Other than that, the joining of all the parts and even at the mounting that are not tightening enough will also generate vibration. Those internal components vibrating will cause the casing to vibrate too [12].

d. Pneumatic tools

Compressed air-powered or power tools such as drills, grinders, riveting guns, and impact guns are widely used in industries. Therefore, they are one of the vibration sources in the industry. The high pressure air flow from the tool that contact with the working surface will tend to creates vibration. Then, it also will vibrate the working bench as well. The high pressure air flow inside the tools itself will generate vibration power and this will definitely creates noise as high as 110 dB at the operator's ear [13].

1.1.3 Process of Structural Acoustic

The process of structural acoustic can be divided into four stages [14]. Those processes were shown in the figure 1.2 below. The first stage is the generation stage. The vibration will be generated at the vibrating machines and will start to affect all the internal component of the machines which then increases the vibration.

The second stage is the transmission stage. Transmission is defined as the transfer of oscillatory energy from the generating mechanism to a structure. The vibration from the source will be transmitted into receiver through the contact points.

The third stage is called the propagation process. It concerns with the energy distributed throughout the whole structure system. This is when the vibration energy affected the entire structure, not just at the contact point.

The last stage is the radiation stage. In this stage, any structural part that was in a fluid environment (air) will radiate acoustic power which often known as audible noise. This noise is usually called structure-borne noise.

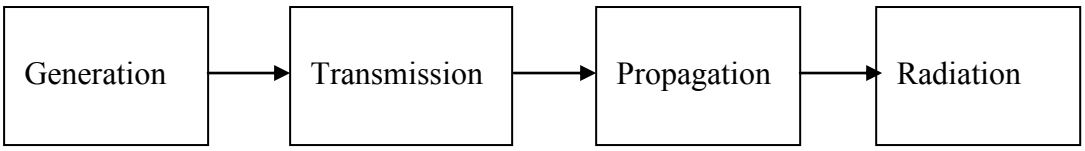


Figure 1.2: Structural acoustic process [15].

1.1.4 Importance To Know The Input Power (strength) of The Source

Vibration effect to a structure is rather vital although it is hard to see the process. The symptom before the structural damage is also sometimes not visible. That is why by knowing the input power of the vibration into structure from the sources; preliminary control measure can be planned. This will leads to a safer environment at the workplace and also cost saving [16].

From that prediction, knowledge about the condition of the supporting structure that holds the vibration sources can be obtained. Thus, a structural engineer should alert about this while planning to install any huge machine and need to ensure the support structure are strong enough to absorb potential vibration input power. This will give time to reinforce the structure or install some damper at the certain location which is at the contact points between structure and source [17].

As stated, the importance of the input power determination also to save cost of reconstruction. Determining the input power can give space for a preventive action to take place. With this action taken, the specific structure can be saved from being damage and there is no need for reconstruction. The cost needed to reinforce is much cheaper than that for reconstruction.

1.2 PROBLEM STATEMENT

The input power from vibration into a structure is rather vital especially in industries. This supports the fact that vibration from machinery in industries can deteriorate the strength of a structure if the injected power level is too high.

Vibration control measure that is widely implemented in industries is mainly focusing on machinery vibration monitoring, for example to predict the health of a machine. Prediction of source strength, for example the potential of a machine to inject vibration power to a structure is lacking.

Therefore, a prediction method is required to determine the injected input power from a structure-borne source. From this, a control measure can be designed at an early stage.

1.3 OBJECTIVE OF STUDY

The objectives to be accomplished in this study are:

a. To determine the vibration input power to a structure based on mobility concepts using reception plate method.

b. To conduct experiment using reception plate method and to compare the result with direct measurement.

1.4 METHODOLOGY

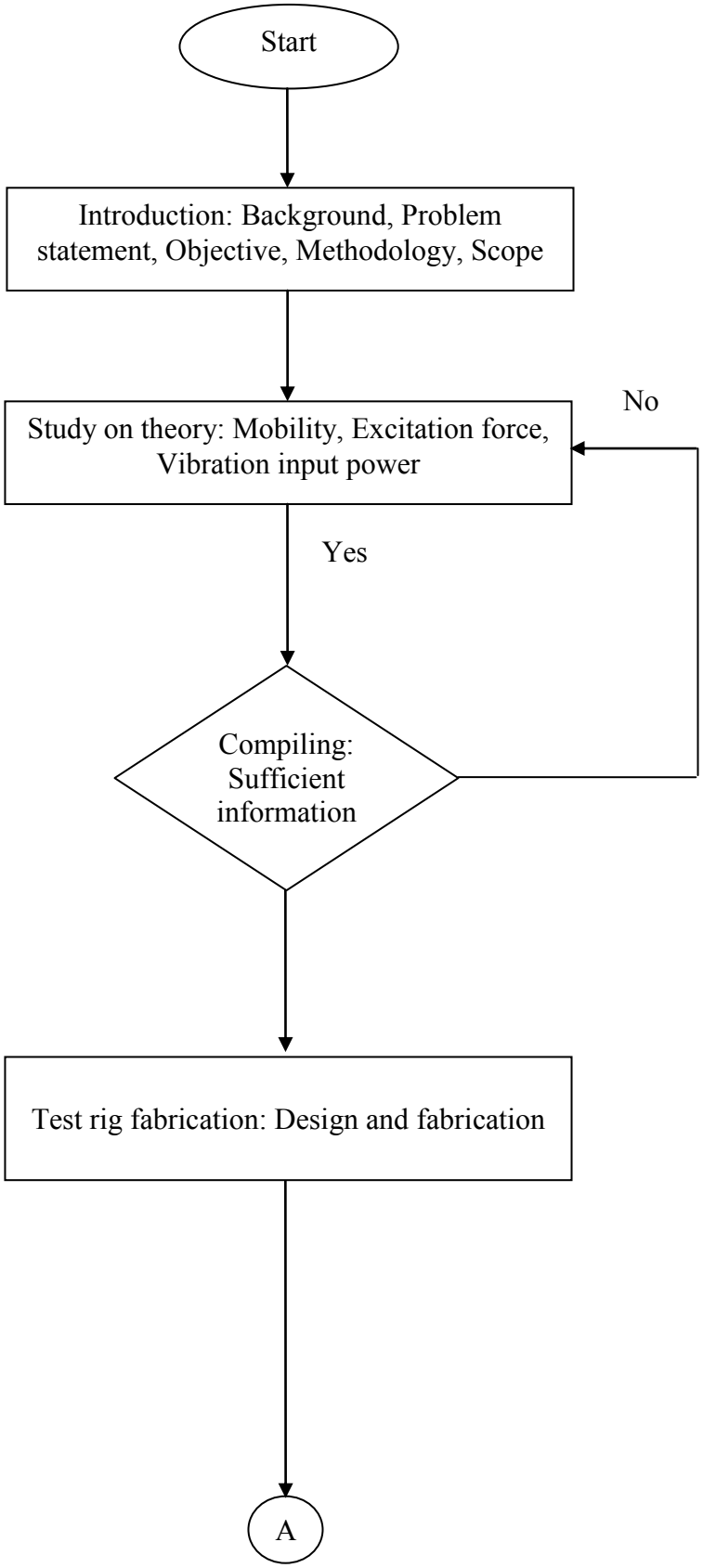
The study contains of several steps or methodology that covers both theoretical and experimental. The first step is to study the literatures that relate the theory of a vibration input power. Literature review consists of the previous researches made by other researcher from multiple sources such as journal; articles, academic books and others related references to obtain the theory.

After obtaining all the theory related, next step is the fabrication of the test rig. The rig was designed and fabricated in the workshop using appropriate materials with appropriate dimension.

The next step is to conduct an experiment according to the theory obtained. The experiment was carried out in laboratory with small machine which is a fan motor as the structure-borne source. The vibration strength represented by the free velocity was obtained from two methods namely the reception plate method and the direct measurement.

The data obtained from these two methods were then analyzed and compared. This is the important step of the study which includes accurate data analysis and discussion. Any assumption used is reviewed here.

Final step is to conclude this project into a final report. Any suggestion and recommendation for the future work were given to improve the study. Figure 1.3 summarizes the methodology into a flow chart diagram.



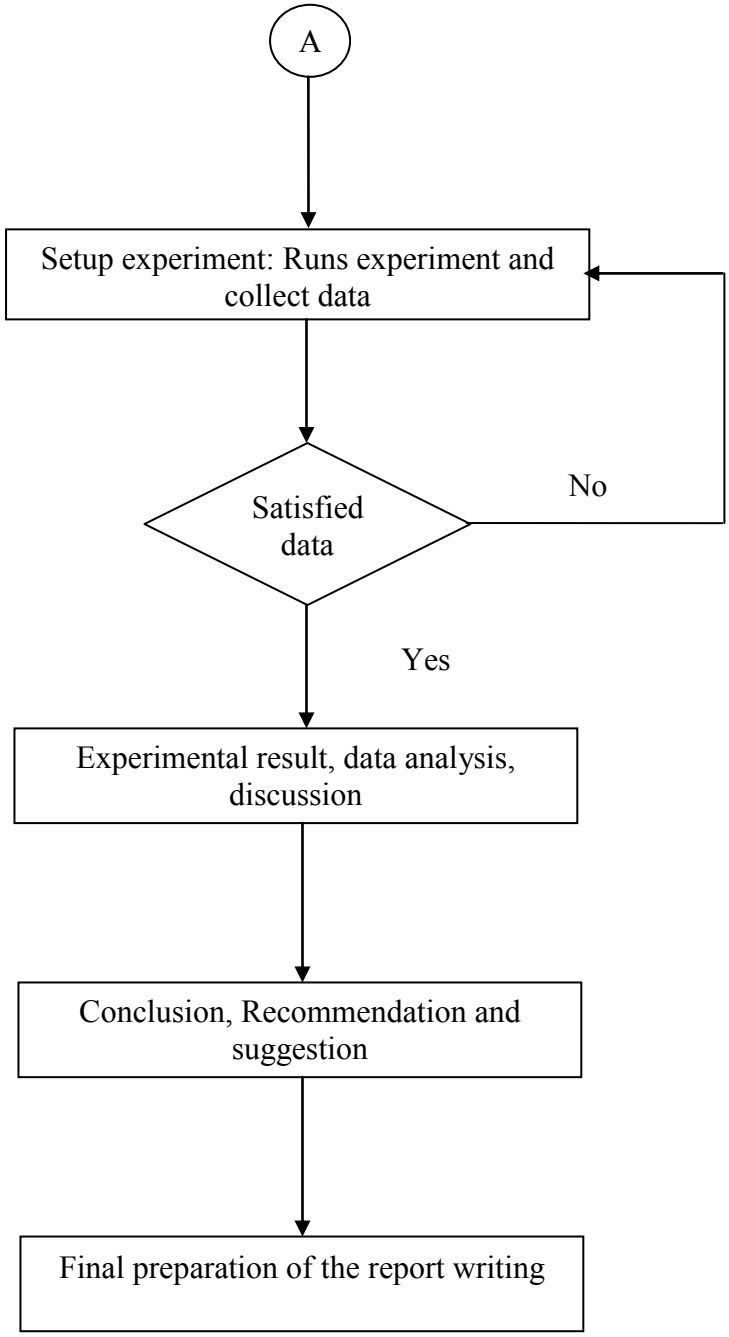


Figure 1.3: Flow chart for the whole process

1.5 SCOPE OF STUDY

There are several scopes and limitation needed to be considered in order to focus this project. The scopes represent the element that will only be covered in this study. Those elements are

a. Determination of vibration input power will be limited to an idealized receiver structures, namely plate.

b. Difference in phase excitation might be ignored. Phase from the force excitation is assumed to be uniform.