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VALIDATION OF BAR VIBRATION BY USING FEA

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This report was submitted in accordance with the partial requirements for the honor of Bachelor of Mechanical Engineering (Automotive)

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"I verify that this report is my own except summary and extract that every one of it I have clarify the resource"

Signature	: ....
Author's Name	: ....
Date	: ....

Dedicated

To my beloved Mum and Dad,

To my respectful Supervisor,

To my honorable Lecturers,

&

To my fellow Friends.

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ABSTRAK

Analisis getaran sering dijalankan untuk menentukan sifat dinamik sesebuah struktur yang juga dikenali sebagai modal parameter struktur. Elemen di dalam modal parameter adalah frekuensi tabii, penyerap dan bentuk mod. Walaubagaimanapun, hanya frekuensi tabii dan bentuk mod yang difokuskan di dalam kajian ini. Modal parameter boleh ditentukan secara teori (Analisis Unsur Terhingga) atau secara eksperimen. Analisis unsur terhingga merupakan cara termudah dan terpantas bagi menentukan parameter modal dengan dibantu oleh perisian analisis unsur terhingga. Di dalam pendekatan eksperimen, pengukuran respons frekuensi telah dijalankan. Keputusan yang dicapai dari pelbagai cara telah dibandingkan dan dibincangkan.

ABSTRACT

Vibration analysis is often carried out to determine the structural dynamic properties or also known as modal parameters. Element of the modal parameters are natural frequency, mode shapes and damping. However, only mode shapes and natural frequencies are being focus in this research. Modal parameters can be determined either theoretically (Finite Element Analysis) or by experimental modal analysis. FEA is the easiest and fastest method to determine modal parameters with the assistance of FEA software. In experiment approach, frequency response measurement was carried out. Results from different methods were compared and discussed.

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A	=	cross section area, m^2
a	=	acceleration, ms^{-2}
B	=	width, m
c	=	damping constant
E	=	Young's Modulus, GPa
F	=	force, Nm
F_d	=	damping force
F_s	=	spring force, Nm
f_d	=	damped natural frequency, rad/s
f_n	=	natural frequency, Hz
h	=	thickness, m
I	=	2D moment of beam, m^4
K	=	spring constant, Nm
L	=	length, m
r	=	ratio of harmonic force frequency over undamped natural frequency
v	=	velocity, ms^{-1}
X	=	amplitude of vibration
π	=	pie, 3.142
ζ	=	damping ratio
ρ	=	density, kg/cm^3
λ_n	=	coefficient of vibration
φ	=	phase shift
ω_n	=	frequency, rad/s

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CHAPTER I

INTRODUCTION

Vibration phenomena are broad and wide to discuss. Understanding vibrations enables engineers to design product and eliminate unwanted vibrations, and to harness vibrations for useful purposes. Much research effort has been spent on various structural monitoring techniques in order to develop a reliable, efficient and economical approach to increase the safety and reduce the maintenance cost of manufacturing process. Vibrations analysis must start with a mathematical model of the dynamic of the system under study, and the model must be simple enough to be amenable to analysis yet detailed enough to describe the pertinent behavior of the system. This requires a firm foundation dynamics, and practice in developing system models. The most important parameter in vibration study is natural frequencies and mode shapes. A mode shape describes the expected curvature (or displacement) of a surface vibrating at a particular mode while natural frequency is the frequency at which a system naturally vibrates once it has been set into motion. To determine those two, many methods have been developed either by experimental, calculation or using computer software (FEA). Experiments have been conducted by many past researchers which have helped us enhance our understanding in this field. FEA is a numerical technique that can be used to approximate the structural dynamic characteristics of vibrating mechanical systems. The Finite Element technique can be used for structural dynamic studies of existing equipment or to evaluate the dynamic characteristics of machines and structures prior to fabrication.

1.1 Objective

The objective of this project is to validate by using Finite Element Analysis (FEA) the testing of bar vibration.

1.2 Scopes

These project scopes consist of the following:

1. Literature research on vibration
2. Determination of the natural frequencies and mode shapes by testing
3. Finite Element Analysis (FEA) simulation
4. Validation of testing results by FEA
5. Report writing

1.3 Problem Statement

The study of vibration is mostly concern to oscillatory motions of bodies and forces that associated with them. Any bodies possessing mass and elasticity are capable to vibrate. Hence, most engineering structures experience vibration to some degree, and their design requires consideration of their oscillatory behavior. In this research, a bar will be tested to determine its vibration, natural frequencies, and mode shapes. Then, the result will be validated using FEA software. Lots of methods have been used to determine its natural frequency and mode shapes. The most frequently use method is by using FEA software because it has wide application. However, experimental testing offers more realistic approaches for existing product because the bar will be tested on its real condition. Results (natural frequencies and mode shapes) differences are expected from both methods. By comparing both results, we will be able to compare both results and discussed it.

CHAPTER II

LITERATURE REVIEW

2.1 Background

In order to measure and validate bar vibration, it is essential to understand theories of vibration. Hence, information and data gathered from previous study was studied deeply. In addition, collected information from internet, books and other sources were used as guidance and reference.

Mass-spring system was used to illustrate vibration. These two elements, mass and springs were the most basic building blocks for vibration analysis. Even though the mass has some degree of internal flexibility, the model is considered to be infinitely rigid. Similarly, although the spring has clearly have a mass of its own, it will be assumed as weightless which will be neglected.

2.3 Theories of Vibration

The study of vibration has started long times ago by many investigators. Pythagoras, who was born in 582 B.C, studied the music produced by the vibration of strings. Galileo, who was born in A.D 1564, also investigated stringed musical instruments as well as pendulum oscillations. According to Palm III (2007), electrical circuits can have oscillatory voltages or currents, but these are not called vibratory system, and their study is not called vibration. Air pressure oscillation is called sound, but the study of sound is called acoustics, not vibration.

The term vibration is usually used to describe the motion of mechanical objects that oscillate or have the potential to oscillate. Figure 2.3 shows vibration data from a vibrating object. Oscillation or vibration of a mechanical object is caused by a force or moment that tries to return the object to an equilibrium or rest position. Vibration is commonly expressed in terms of frequency such as cycles per second (cps), Hertz (Hz), cycles per minute (cpm) or (rpm) and strokes per minute (spm). The vibration of a system involves the transfer of its potential energy to kinetic energy and kinetic energy to potential energy, alternately.

The most important element in vibration is elasticity and mass. In order to vibrate, the system must have both. This means that all solids are capable of vibrating under the right condition because solids possessed both elasticity and mass.

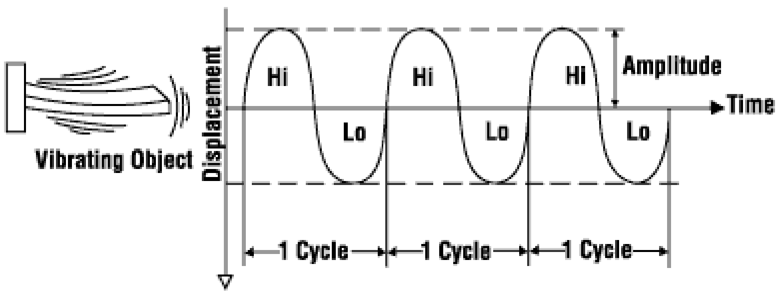

Figure 2.3: Representation of the measured vibration exposure

(Source:

http://www.ccohs.ca/oshanswers/phys_agents/vibration/vibration_intro.html)

2.4 Types of Vibration

Vibration can be divided into 2 main groups either free vibration or forced vibration.

2.4.1 Free Vibration

A free vibration could be defined as a repetitive motion of a body that takes place about its static equilibrium position (Fertis, 1995). The motion is performed under the action of forces inherent in the system itself and without the benefit of fluctuating external forces of any kind. It means that it will vibrate when given a small displacement or deformation and then being released. Restoring force tends to move the mass of the body toward its neutral position. From this statement, any freely vibration motion must possess both masses and some kind of restoring force.

2.4.1.1 Free Undamped vibration

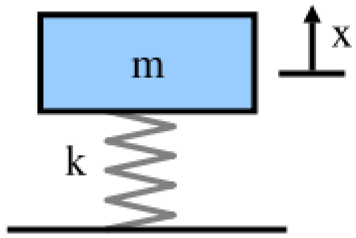

Figure 2.4.1.1: Mass-spring-system of free undamped vibration

(Source: http://en.wikipedia.org/wiki/Vibration)

Assume the damping is negligible and that there is no external force applied to the mass. The force applied to the mass by the spring is proportional to the amount the spring is stretched "x" (assume the spring is already compressed due to the weight of the mass). The proportionality constant, k, is the stiffness of the spring and has units of force/distance.

$$F_s = -kx.$$

The force generated by the mass is proportional to the acceleration of the mass as given by Newton's second law of motion.

$$\Sigma\ F = ma = m\ddot{x} = m\frac{d^2x}{dt^2}.$$

The sum of the forces on the mass then generates this ordinary differential equation:

$$m\ddot{x} + kx = 0.$$

If we assume that we start the system to vibrate by stretching the spring by the distance of *A* and letting go, the solution to the above equation that describes the motion of mass is: