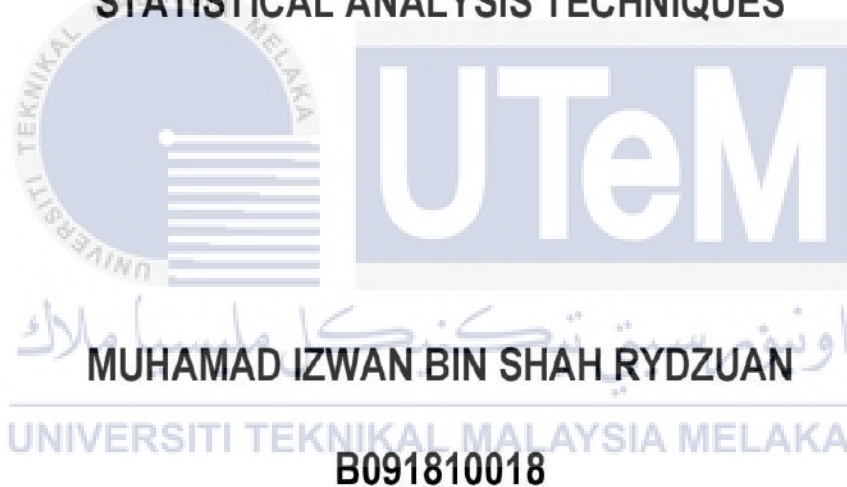




**A STUDY OF MOTOR BEARING VIBRATION USING  
STATISTICAL ANALYSIS TECHNIQUES**

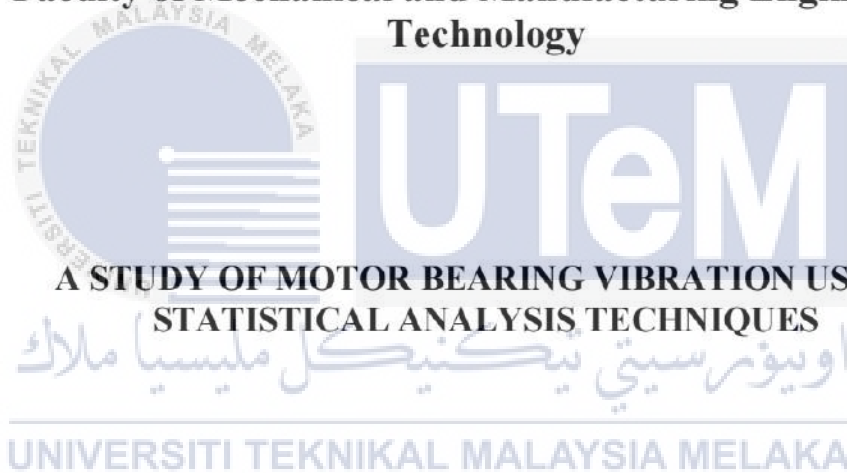


**BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY  
(MAINTENANCE TECHNOLOGY) WITH HONOURS**

**2022**



**Faculty of Mechanical and Manufacturing Engineering  
Technology**



**Muhamad Izwan Bin Shah Rydzuan**

**Bachelor of Mechanical Engineering Technology (Maintenance Technology) with  
Honours**

**2022**

**A STUDY OF MOTOR BEARING VIBRATION USING  
STATISTICAL ANALYSIS TECHNIQUES**

**MUHAMAD IZWAN BIN SHAH RYDZUAN**



**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**2022**

## DECLARATION

I declare that this Choose an item. entitled “A Study of Motor Bearing Vibration Using Statistical Analysis Techniques” is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature



Name

*Muhamad Izwan Bin Shah Rydzuan*

Date

17 January 2022

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## APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology ((Maintenance Technology) with Honours.

Signature

*irman*

Supervisor Name

: *Ts. Dr Mohd Irman Bin Ramli*

Date

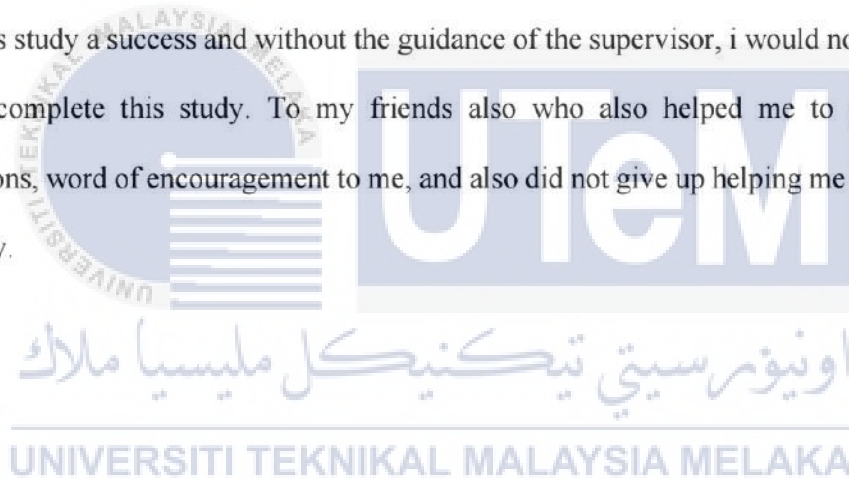
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## DEDICATION

I dedicate this study to my beloved parents, Puan Norsiah Binti Abku Khairi and Encik Shah Rydzuan Bin Hashim, because they always advices me, give moral support, inspiration, spiritual, strength and financial support for me to success in this study. To my supervisor Ts. Dr. Mohd Irman Bin Ramli thank you for helping me a lot and giving me guidance to make this study a success and without the guidance of the supervisor, i would not have been able to complete this study. To my friends also who also helped me to give views, suggestions, word of encouragement to me, and also did not give up helping me to complete this study.



## ABSTRACT

Bearings are one of the important elements in engineering machinery such as those used in electric motors. Bearings can also be a cause of failure on electric motors. This study presents the relationship between vibration and bearings on electric motors. This experimental procedure was carried out using vibration applications to analyse the vibrations on bearings. Data acquisition involves vibration signals recorded by acceleration sensors. The vibration signal generated through the dynamic response by the electric motor was analysed using Fast Fourier Transformation (FFT). All recorded data were filtered using the to obtain valid data. The data obtained from the experiments were analysed using statistical analysis methods to make interpretations of the data. As a result, correlation verification has been performed and the Root Mean Square (RMS) has indicated that the source of the resulting vibration is from the bearing. The correlation process has proven that it can be used as a standard to identify fault bearing vibrations through statistical analysis which is a non -destructive and more efficient method.



## **ABSTRAK**

Galas merupakan salah satu elemen yang penting di dalam penggunaan jentera kejuruteaan seperti yang digunakan di dalam motor elektrik. Galas juga boleh menjadi punca kepada kegagalan pada motor elektrik. Kajian ini membentangkan perkaitan di antara getaran dan galas pada motor elektrik. Prosedur eksperimen ini telah dilaksanakan menggunakan aplikasi getaran untuk menganalisis getaran pada galas. Perolehan data melibatkan isyarat getaran direkodkan oleh sensor pecutan. Isyarat getaran yang dihasilkan melalui tindak balas dinamik oleh motor elektrik telah dianalisa menggunakan Transformasi Fourier Pantas (FFT). Kesemua data yang direkodkan telah ditapis menggunakan Sistem Getaran Sejangat untuk mendapatkan data yang sah. Data yang diperolehi dari eksperimen telah dianalisis menggunakan kaedah analisis statistik untuk membuat tafsiran data. Pengesahan korelasi telah dilakukan dan kudrat rata akar (RMS) telah menunjukkan punca getaran terhasil adalah dari galas. Proses korelasi telah membuktikan ianya boleh digunakan sebagai piawai bagi mengenalpasti getaran galas yang telah rosak melalui analisis statistik iaitu kaedah yang tidak memusnahkan dan lebih cekap.





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Last but not least, from the bottom of my heart a gratitude to my beloved family and friends, for her encouragements and who have been the pillar of strength in all my endeavors. To my friend, Fahrul Asyraf Bin Saharudin, Amirul Aiman Bin Fadzil, Aizuddin Husaini Bin Baharen and Muhammad Ariff Bin Noor Salleh for their patience and understanding. I would also like to thank my beloved parents for their endless support, love and prayers. Finally, thank you to all the individuals who had provided me the assistance, support and inspiration to embark on my study.

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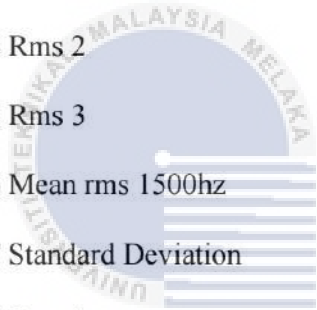


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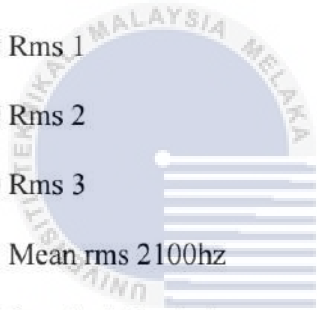
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## LIST OF SYMBOLS AND ABBREVIATIONS

$f_D$	-	Speed Shaft
$f_c$	-	Damage Frequency Cage
$f_k$	-	Damage Frequency Balls
$f_i$	-	Damage Frequency Inner Bearing



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## CHAPTER 1

### INTRODUCTION

#### 1.1 Background

Vibration often occurs under any circumstances on a directly moving object. Vibration is produced in various forms such as on machine tools, bridge structures and buildings, humans and nature. An example that can be seen in terms of nature, can also be felt is like an earthquake which is a phenomenon of movement of the earth's surface by a sudden movement on the rocky surface of the earth. Earthquakes produce vibrations that occur during energy stored in the earth, usually in the form of rock friction.

In mechanical terms is the movement of an object around an equilibrium point. The swinging motion of a pendulum or the movement of a tyre travel on an off-balance road are both instances of vibration. Vibration often occurs in any situation that occurs on a moving object or even naturally. Vibration is produced in various forms such as on machine tools, bridge structures, buildings, humans and nature.

In the field of engineering, vibrations can be seen in operating machines such as vehicle engines, AC and DC motors, turbines, suspension bridges, and machine tool operation. Each machine produces normal vibration, but for abnormal vibrations can be avoided to ensure the smooth operation of the machine.

Vibrations can occur on the entire moving part of the motor especially the bearings. A bearing is a type of part that helps the rotation of an object that supports a rotating rod in a

machine. When the motor is turned on, vibration will be produced on the machine. Abnormal vibrations can give signs of damage to the machine. Bearing damage is typically caused by maintenance that is not performed on a regular basis. These abnormal vibrations can be detected using vibration analysis. Unexpected damage to the machine can create higher costs for corrective maintenance. To detect vibration, several methods can be used to diagnose the condition of the machine in more detail.

Stressed machines often show unusual vibrations or changes in vibration patterns. To detect vibration changes. There are several ways to analysis the vibrations and be able to see the actual performance of the parameters. Among the steps used to analysis vibration is to use instrumentation such as transducers, vibration meters, accelerometers, and analysis software. All of these modes are components of different vibration frequency but are able to collect the data needed to detect the cause of damage and produce abnormal vibrations.

Monitoring of the situation is the best measure to prevent unwanted damage to the machine. In addition, by analysing and identifying failures on the machine, the cause of the problem that occurs and more efficient measures to ensure the smooth running of the machine during operations can be found.

## **1.2 Problem Statement**

Bearings are machine elements that are easy to move and reduce friction between moving parts. In the engineering industry, bearings are often adopted in every part of the movement mechanism used for rotating or linear shaft applications, for case in motors and to ensure the smooth movement of the mechanism.

Besides that, if the bearing is already damaged, these signs can be seen like the performance of a motor or machine will decrease. A damaged bearing will also produce a noise, and it

also a sign of bearing damage. It is possible that the bearing already broken but still forced to operate. Therefore, bad vibrations result is because the rolling of the bearing element is no longer as perfect as the original condition. Machines will be disrupted if this matter is not overcome as soon as possible and will also disrupt the production output.

Bearings need to be monitored and are an important technique to guide machine performance. The smooth operation of the machine will be disturbed due to damaged bearings. Preventive maintenance should be performed to allow the machine to run smoothly without any problems. To identify any damage to the motor bearings, several techniques are used to detect damage that will occur on the bearing which will be a study on a literature review and also recommendations to maintain and extend the life of the bearings.

### **1.3 Research Objective (Two or three objectives for study scope completed in two semesters)**

The objectives of this study are as follows:

- a) To determine the vibration level on a motor by using accelerometer sensor.
- b) To apply vibration statistical analysis to detect vibration caused by bearing.

### **1.4 Scope of Research**

The scope of study are related to the objectives of the study:

- Accelerometer sensors are developed with various types following the suitability of functions and conditions whether on-site or off-site.
- Investigation of bearings on motors that produce vibrations and determine the form of vibrations generated due to bearing failure.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Introduction

Vibration is a normal condition while a machine is operating and also a best way to detect something abnormal happening to the machine. According to Zhao et al. 2016, the traditional signal analysis methods are unsatisfactory for analyzing the non-smooth and strange signal in the high-frequency band. These studied can be claimed from Zhao et al. 2016, the vibration signal of motor bearing is selected as the research object, the wave let transform and approximate entropy is introduced into the vibration signal analysis in order to propose a new vibration signal analysis. Furthermore, vibration is the best solution to determine the fault condition of machines. When using vibration to observe machine health, the objective is to correlate noticeable vibration with typical wear-out mechanisms, these studied can be related to Wszolek et al. 2020. A studied by Zarei et al. 2014, for the vibration signal is used for fault classification rather than common methods that use directly vibration signal. According to Rastegari & Bengtsson. 2015, two of the main online condition monitoring technique, namely vibration analysis and Shock Pulse Method (SPM) have been implemented and tested on electric motors to monitor bearing conditions. Extracting the failure related information from vibration signals is a very important aspect of vibration-based fault detection for rolling bearing, based on the studied from Zheng et al. 2021. Vibration is widely regarded as the best operational parameter for assessing dynamic conditions such as a ball bearing defect, unbalance shaft and lubrication.

## 2.2 Vibration Application

Technically, applications that can be used to detect fault vibration and also know the performance of a machine, example is the accelerometer. An accelerometer uses piezoelectric crystals to convert mechanical energy into electrical energy (signals). Therefore, this method is considered to be the best method for determining the force generated by the vibration of the machines. According to Guru Manikandan et al. 2020, accelerometers are used for measuring the acceleration of the vibrating system. Furthermore, accelerometer is the best way to detect the vibration on the bearing motor. As studied by Baek et al. 2020, continue to apply the method to extract accelerometer signal patterns to detect abnormal vibrations in the bearing-shaft system. Accelerometer has limitations, if sufficient heat is allowed to radiate into the crystal, it can be damaged or destroyed. An accelerometer is capable of detecting the unusual vibrations produced by the motor bearing. A ball bearing before complete failure may result in the eccentric running of the shaft which will start generating noise and produce vibrations in the machine or in some components of the machine, these studied can be supported from Mongia et al. 2021. In another study by Mongia et al. 2021, this device detects the frequency vibration ( $>1$  kHz) better because a piezoelectric accelerometer is considered as a standard device for measuring the vibration of machines.

A vibration meter is another application to measure the level of vibration. A vibration meter is an equipment that monitors the level of vibration in industrial machinery. According to Reliability Direct. 2021, a vibration meter can be used to monitor and diagnose problems in bearings, machines, engines and more. These studied can be supported by Adash. 2021, Vibration meter or analyzer is an electronic device which is able to process vibration signals. Vibration meter frequency is sensitive to attempt displacement, velocity, and acceleration

features. These is a great instrument for tracking overall vibration value in process equipment. According to Vibration Meters. 2021, mainly vibration meters are used in many installations and machines as well as in the development of products, such as tools or components, to measure vibrations and oscillations.

### **2.2.1 Vibration Technique**

Among the techniques used to determine whether a vibration is normal or not, by way of observation of the situation. This method can detect something abnormal in the state of the motor that is working. According to Payne & Geist. 2007, Vibration monitoring of machinery or components has been recognized as a way to prevent premature or catastrophic failures. These studied can be supported by Sutar et al. 2018, Vibration monitoring reveals knowledge of machines condition and its rate of change, which can be ascertained by selecting a suitable parameter for measuring deterioration and recording its value at on a routine or continuous basis. An example, that can be seen is when the motor that is working produces unusual vibrations causing the fastening screws on the motor base plate to become loose and if this is left then will invite more dangerous conditions and motor performance will also decrease. Besides that, bad vibration can be increases because of misalignment, unbalancing, structural compromises, and other issues. With regular observation of the condition of the motor, it is the best way to detect the initial problem of bearing. These studied can be supported by Payne & Geist. 2007, Large centrifugal chillers have been using vibration monitoring and analysis to determine when bearings should be replaced or when rotor components were failing. Based studied by Tiple. 2021, They are majorly used for vibration monitoring and diagnostic checks of mechanical installations in industrial plants. The health of the machine is checked by routine or continuous vibration monitoring with sophisticated instruments, which will give you an early indication of the failure and can take countermeasures to avoid catastrophic failure, according to Sutar et al. 2018.