FAULTY GEAR VIBRATION DIAGNOSTIC AND MONITORING

RUTTIRAN A/L ANBUALAGAN
B091810371

BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (MAINTENANCE TECHNOLOGY) WITH HONOURS

2022

FACULTY OF MECHANICAL AND MANUFACTURING ENGINEERING TECHNOLOGY

FAULTY GEAR VIBRATION DIAGNOSTIC AND MONITORING

RUTTIRAN A/L ANBUALAGAN

BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (MAINTENANCE TECHNOLOGY) WITH HONOURS

2022

FAULTY GEAR VIBRATION DIAGNOSTIC AND MONITORING

RUTTIRAN A/L ANBUALAGAN

A report submitted
in fulfillment of the requirements for the degree of
Bachelor Of Mechanical Engineering Technology (Maintenance Technology) With Honours

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2022

DECLARATION

I declare that this research report entitled "Faulty Gear Vibration Diagnostic And Monitoring" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	
Name	:	Ruttiran A/L Anbualagan
Date	:	18 JANUARY 2022

APPROVAL

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

Signature :

Ts Dr Nor Azazi Bin Ngatiman
Pensyarah
Fakulti Teknologi Kejuruteraan
Mekanikal & Pembuatan, UTeM

Supervisor Name : Ts. Dr. Nor Azazi Bin Ngatiman

Date : 18 JANUARY 2022

DEDICATION

To my beloved parents Anbualagan A/L Sinakaundan and Tang Siew Eng, I would be honour to dedicate this report for both of them as they are my courage, inspiration, dedication, and strength to complete my research until the end. I would also like to thanks to my brother, sister and friends because they also help me in term of financial during my year of study.

ABSTRACT

Vibrations are an inherent part of machinery. If not monitored or lowered to a safe level, the magnitude of this vibration rises over time and becomes damaging to the apparatus. Researchers worldwide are always conducting research on gear vibrations in order to enhance or suggest solutions to difficulties caused by the vibrations. Numerous components, particularly gears, can create these vibrations, which cause the machinery to shake at a specific frequency and might impair the machine's function if left unnoticed and undiagnosed. Vibrations of a high magnitude indicate that the gear is malfunctioning and should be evaluated; if left untreated, they can raise the cost of repairing the failure and shorten the machine's life. Gears typically face an increase in vibration magnitude when they sustain damage over time due to continual motion during operation. When a defective rolling element makes contact with another element's surface, impact force is generated, resulting in an impulsive gear response. Machinery performs poorly as a result of this increase in vibration magnitude. As a result, it is critical to monitor the gear's vibration status at all times and to diagnose any increase in its vibration amplitude immediately. To address this, vibration signal analysis can be used as an effective vibration monitoring technique, as demonstrated in this thesis. This thesis examines spur gear and helical gear vibrations under normal and fault conditions by conducting an experiment at speeds of 500 rpm, 1000 rpm, 1500 rpm, and 2000 rpm under four different gear conditions to determine the vibration levels associated with each condition. Vibration Statistical Analysis (VSA) was then used to examine the vibration of this gear using MATLAB and Excel tools. As a result of the results, there is an increase in the transient components, which increases in lockstep with the running speed. Additionally, the graphs demonstrate that as the speed increases, the vibration with frequency increases in amplitude. By examining the scattering of z-freq data and its coefficient. It is visible that the dots spread throughout the affix and annex frequency, indicating that the scattered data exhibits a distinct pattern when the RMS speed increases for all conditions. To summarise, time domain is less suitable for fault prediction than the R-Squared approach because the graph difference between the defective and excellent situations is similar to the graph difference between the frequency domain graphs. The RMS and R-squared values in this thesis are used to predict the condition that creates the specific vibration.
.

ABSTRAK

Getaran adalah sebahagian daripada peralatan mesin. Jika tidak dipantau atau diturunkan ke tahap yang selamat, magnitud getaran ini meningkat dari semasa ke semasa dan menjadi merosakkan radas. Penyelidik di seluruh dunia sentiasa menjalankan penyelidikan tentang getaran gear untuk meningkatkan atau mencadangkan penyelesaian kepada kesukaran yang disebabkan oleh getaran. Banyak komponen, terutamanya gear, boleh mencipta getaran ini, yang menyebabkan jentera bergegar pada frekuensi tertentu dan mungkin menjejaskan fungsi mesin jika dibiarkan tanpa disedari dan tidak didiagnosis. Getaran dengan magnitud tinggi menunjukkan bahawa gear tidak berfungsi dan harus dinilai; jika tidak dirawat, mereka boleh meningkatkan kos membaiki kegagalan dan memendekkan hayat mesin. Gear biasanya menghadapi peningkatan dalam magnitud getaran apabila ia mengalami kerosakan dari semasa ke semasa akibat gerakan berterusan semasa operasi. Apabila elemen gelek yang rosak bersentuhan dengan permukaan elemen lain, daya hentaman dijana, menghasilkan tindak balas gear impulsif. Jentera berprestasi lemah akibat peningkatan magnitud getaran ini. Akibatnya, adalah penting untuk memantau status getaran gear pada setiap masa dan untuk mendiagnosis sebarang peningkatan dalam amplitud getarannya dengan segera. Untuk menangani perkara ini, analisis isyarat getaran boleh digunakan sebagai teknik pemantauan getaran yang berkesan, seperti yang ditunjukkan dalam tesis ini. Tesis ini mengkaji getaran gear memacu dan gear heliks di bawah keadaan normal dan kerosakan dengan menjalankan eksperimen pada kelajuan 500 rpm, 1000 rpm, 1500 rpm dan 2000 rpm di bawah empat keadaan gear yang berbeza untuk menentukan tahap getaran yang berkaitan dengan setiap keadaan. Analisis Statistik Getaran (VSA) kemudiannya digunakan untuk memeriksa getaran gear ini menggunakan alat MATLAB dan Excel. Hasil daripada keputusan, terdapat peningkatan dalam komponen sementara, yang meningkat dalam lockstep dengan kelajuan berjalan. Selain itu, graf menunjukkan bahawa apabila kelajuan meningkat, getaran dengan frekuensi meningkat dalam amplitud. Dengan meneliti taburan data z-freq dan pekalinya. Kelihatan bahawa titik-titik tersebar di seluruh frekuensi imbuhan dan lampiran, menunjukkan bahawa data yang berselerak mempamerkan corak yang berbeza apabila kelajuan RMS meningkat untuk semua keadaan. Ringkasnya, domain masa kurang sesuai untuk ramalan kesalahan berbanding pendekatan R-Squared kerana perbezaan graf antara situasi rosak dan cemerlang adalah serupa dengan perbezaan graf antara graf domain frekuensi. Nilai RMS dan R kuasa dua dalam tesis ini digunakan untuk meramalkan keadaan yang mewujudkan getaran tertentu.

ACKNOWLEDGEMENTS

I'd like to express my heartfelt gratitude to everyone who contributed to my successful completion of this report. My heartfelt thanks go to my supervisor Ts. Dr. Azazi Bin Ngatiman for guiding and encouraging me from the start.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

Hz	-	Hertz
CPM	-	Cycles Per Minute
RPM	-	Revolution Per Minute
FFT	-	Fast Fourier Transform
DAQ	-	Data Acquisition
FDD	-	Fault Detection and Diagnostics
DWT	-	Discrete Wavelet Transform
ANN	-	Artificial Neural Network
AC	-	Alternating Current
FDTW	-	Fast Dynamic Time Warping
CK	-	Correlated Kurtosis
AI	-	Artificial Intelligent
R&D	-	Research And Development
RMS	-	Root Mean Squared
RMSE	-	Root Mean Squared Error
MAPE	-	Mean Absolute Percentage Error
MATLAB	-	Matrix Laboratory
LabVIEW	-	Laboratory Virtual Instrumentation Engineering Workbench
Lf	-	Large Fault
Ln	-	Large Normal
Sf	-	Small Fault
Sn	-	Small Normal

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

In engineering, Vibration is a crucial topic to examine since it occurs as a result of movement. This oscillatory movement exhibits features such as frequency, velocity, amplitude, displacement, acceleration, phase, and period. Physical vibration components include mass, stiffness, and damping, which are all comparable to acceleration, amplitude, velocity, and displacement, respectively. Vibration is classified into three types: forced vibration, free vibration, and damped/undamped vibration. Vibration are being quantified using frequency and amplitude measurements. The frequency specifies the duration of one single rotation. While amplitude can be defined as the range of motion of a weight all over a rotation. The frequencies of a vibration is measured in Hertz (Hz) units, or the number of cycles divided by time (second). The frequency of a vibration can also be expressed in cycles per minute. Additionally, cycles per minute is referred to as revolution per minute. Large or extreme vibration can have a detrimental effect on the effectiveness of a system or piece of equipment, and if not addressed or controlled, excessive vibration can result in errors. Reduced it can result in catastrophic failure, and increasing unnecessary costs (Systems & Bone, 2017).

Statistical signal process is an approach that treats signals as stochastic processes and uses their statistical features to perform signals. In signal processing applications, statistical techniques are widely used. For example, when you photograph an image you can map the probability distribution of noise and build techniques using the image model to reduce noise(Hong & Singh, 2014).

Machine learning is a type of data analytics that automates the process of developing analytical models. It is a subfield of artificial intelligence predicated on the premise that systems could exhibit intelligent behavior, recognize designs, and make decisions without much human interaction. According to advancements in information technology, modern machine learning is not comparable to previous machine learning. It was predicated on object recognition and the assumption that computers may learn to execute particular jobs without being instructed; the creators, who were concerned in artificial intelligence, sought to determine whether computers can learn from data. The iterative nature of machine learning is critical because it allows models to alter independently as they are exposed to fresh data. If prior calculations yielded dependable, reproducible results. It is not a true technology, but one that is gaining new traction. While numerous machine learning methods have existed for a long period of time, the capacity to apply sophisticated mathematical computations to large amounts of data automatically and rapidly is a relatively recent development (Szymański, 2020).

1.2 Problem Statement

Gears are a major element of rotating equipment and may be classified into three types: tooth, manufacturing method, and material. To identify a defective gear, it is nearly difficult to do so using simply human ears. Misalignment, out of position, fractures, and fractured gears are all frequent gear defects that must be detected prior to failure. When all of the machinery's parts and components are fully operational, noise and vibration may occur. In the long term, this condition may have a direct effect on the regular operation of all of the equipment.

Additionally, not everyone has access to appropriate equipment or machinery capable of tracking down a malfunctioning piece of equipment in a timely manner. Vibration Analysis (VA) is a technique that may be used to discover early failures of parts or components such as gears, shafts, bearings, and belts. Gears, on the other hand, are prone to deteriorate over time if left untreated. If the spinning machinery breaks in this situation, it may quickly result in significant injuries and jeopardise the personal safety of the employees involved. Thus, severe loss of life and property can be avoided if the rotor system's noise and vibration can be detected and analysed.

1.3 Research Objective

i). To measure the vibrations of normal and faulty gear using accelerometer sensor.

ii). To analyze the vibration data of the gears via various of vibration Statistical Analysis Methods.

iii). To verify the analysis done by R-squared and Distribution method via Z-freq.

1.4 Scope of Research

The following are the scope of this Faulty Gear Vibration Diagnostic and Monitoring research:

- Helical gears and spur gears are all utilised in this research.
- Two different gear situations were chosen for this research: a regular gear and a malfunctioning gear, in order to compare the outcomes between them.
- Create a simulation model in MATLAB.
- Conduct a vibration analysis utilising the Vibration Signal Analysis (VSA), the Fast Fourier Transform (FFT), the Time Domain, the Root Mean Square (RMS), and the Z-Freq Coefficient.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The literature review on condition monitoring and diagnostics, fault detection, signal processing, and vibration analysis will be discussed in this chapter. This study's references come from journals, books, and the internet. The goal of going over prior articles about faults in spur gear and helical gear is to obtain a better grasp of how to conduct faulty gear vibration diagnostic and monitoring.

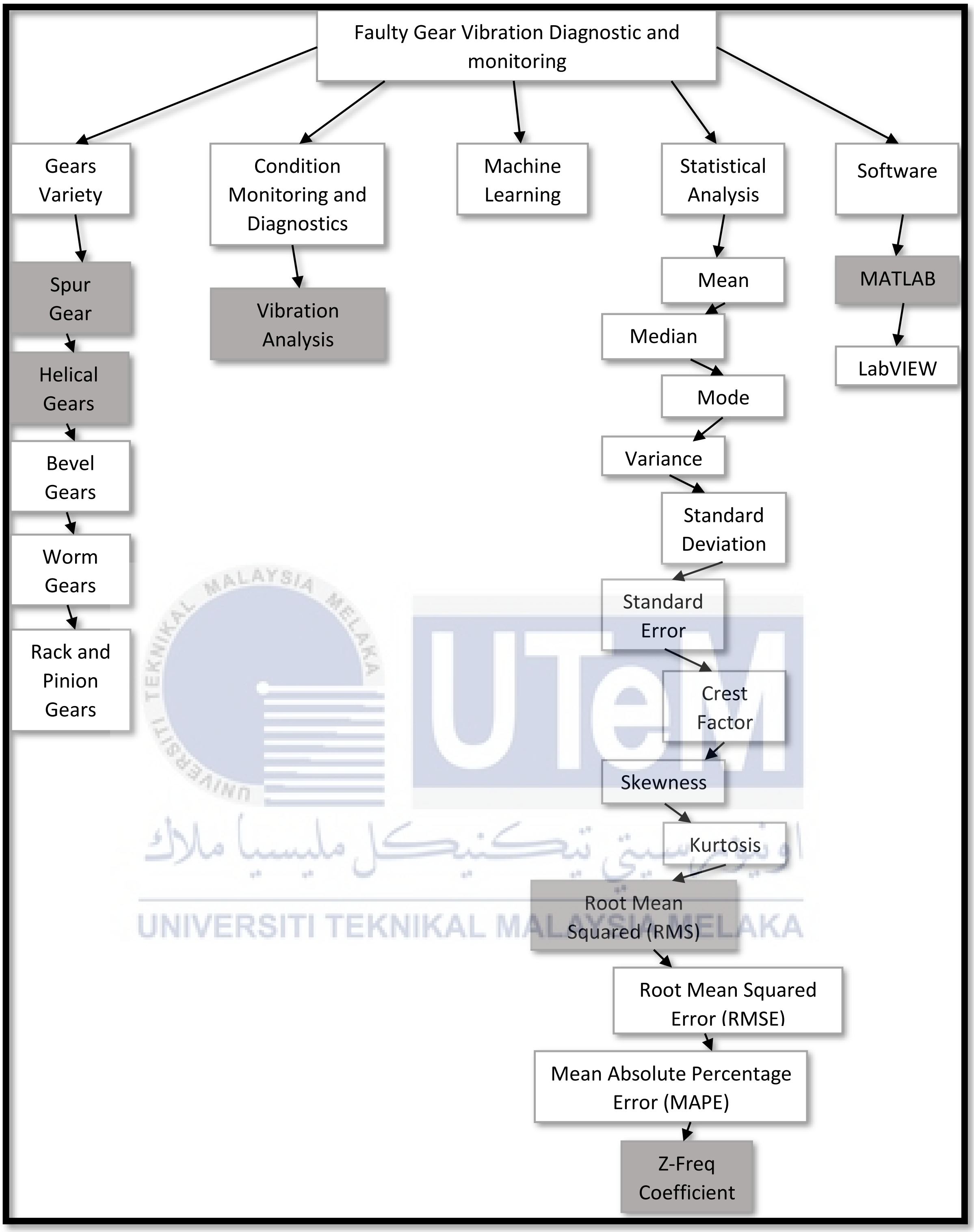

Figure 2.1 Literature Review K-Chart

2.2 Gears Variety

Gears are widely used in industrial machinery, vehicles, and a variety of other applications. Mechanics can then be used to categories gear. It is most commonly categorized by the shape and size of the teeth, as well as the manufacturing process and the substance. In addition, shifting the axis position of the gears could be used. Spur Gear, Helical Gear, Worm Gear, Bevel Gear, and Rack and Pinion Gears are the most commonly used gears.

2.2.1 Spur Gear

Gears with direct teeth are built on circular or cylindrical bodies with teeth inserted in parallel to the shaft. Transmission of motion and power is accomplished through the mating of parallel axes in matted pairs. For example, if the application is a planetary gear system or rack and pinion gear pair, then a Spur Gear can be used in conjunction with another Spur Gear, such as an internal gear (OuYang et al., 2015). Because of the spur gears' simple tooth design, they are both extremely accurate and simple to produce. Because of its simplicity, it is also one of the most commonly used gears in the manufacturing industry. For axial loads such as thrust power parallel to the shaft, high speeds and bulky maneuvers, and high efficiency ratings, spur gears are an excellent choice.

The teeth of spur gears are subjected to more stress and vibration when operating at high speeds. When operating at high speeds, spur gears produce a high-pitched squealing noise. With their multiple speed ratios (see Fig. 2.2), spur gears can be used in many mechanical applications. There are many uses for this technology, including clocks, watering systems for pumps, washers, dryers, and other pumps, as well as gear trains that can provide a higher gear reduction.

Figure 2.2 Spur Gear

2.2.2 Helical Gears

It is possible to use helical gears to drive shafts that are not parallel or intersecting, just like spur gears. Due to the fact that helical gears have teeth curved around the cylindrical transmission at an angle to its front. The teeth of the helical gear are angled in the same direction on both the right and left gears in each gear pair. Because of the helical teeth' angled design, they work differently than the significant teeth of the spur gears when paired with other gears(Wei & Lin, 2011). When helical gears make contact, the total number of tooth-to-tooth contact gradually increases rather than using the entire tooth at once. Allows the teeth to be loaded less and the operation to be smoother and smoother. Additionally, helical gears can be far more efficient than spur gears when it comes to distributing the load. They have a lower level of productivity.

Because of the helical design's complexity and the axial thrust it generates, helical gears (Figure 2.3) have a number of drawbacks, such as the need for thrust bearings in every application where a single helical gear is used. As a result, the overall cost of using helical gears is also increased. Due to helical gears' ability to handle high speeds and heavy loads,