# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

# VIBRATION ANALYSIS FOR MISALIGNMENT ON SPUR AND HELICAL GEAR

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Maintenance) with Honours.

by

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## ABSTRAK

Hampir semua jenis mesin yang biasa digunakan dalam industri melibatkan komponen mekanikal dan gear. Sementara itu, gear akan memberikan getaran apabila penjajaran berlaku terhadap gear. Gigi yang berlebihan boleh menjejaskan komponen lain kerana paras getaran tinggi akan menyebabkan kerosakan kepada mesin. Oleh itu, kajian ini memberi tumpuan kepada analisis getaran dua jenis gear iaitu gear merangsang dan heliks yang disebabkan oleh "misalignment" dengan menggunakan spektrum frekuensi. Di samping itu, kajian ini juga memberi tumpuan kepada perubahan beban yang dikenakan pada gear. Beban yang digunakan dalam kajian ini ialah 0 Nm, 1.7 Nm dan 3.4 Nm. Beban yang dikenakan merujuk kepada buku manual Gunt Hamburg. Jarak pusat yang digunakan dalam kajian adalah 0°, 30°, dan -30°. Getaran diukur dengan menggunakan sensor pecutan yang terletak di dua lokasi berbeza untuk melihat kecenderungan getaran. Masa yang diambil untuk operasi mesin selama 20 minit dan kelajuan motor yang dinyatakan ialah 1800 rpm bersamaan dengan 30Hz. Setiap sudut kesilapan gear dan beban kombinasi yang digunakan akan mempengaruhi getaran yang dihasilkan pada gear, semakin besar bebannya, semakin tinggi nilai getaran yang terjadi pada gear.

## ABSTRACT

Almost all types of machine commonly used in the industry involve mechanical components and gear. In the meantime, the gear will provide vibration when the alignment occurs against the gear. Excessive gear could affect other components as high vibration level will lead to damage to a machine. Therefore, this study focuses on vibration analysis of two types of gear namely spur and helical gear caused by "misalignment" by using frequency spectrum. In addition, this study also focuses on the change in load applied to the gear. The load applied in this study was 0 Nm, 1.7 Nm and 3.4 Nm. The load imposed refer to Gunt Hamburg manual book. The central distance applied in the study was $0^o$, $30^o$, and $-30^o$. Vibration is measured by using acceleration sensors located at two different locations to observe vibration tendency. The time taken for a machine operation for 20 minutes and the specified motor speed is 1800 rpm equivalent to 30 Hz. Each angle of gear misalignment and load applied combination will influence the vibration produced on the gear, the greater the load it, the higher the vibration value that occurs on the gear.

## DEDICATION

I dedicate my work to my family and other friends. Realize that every of challenging work is needed self-efforts as well as helps and guidance from elders and friends. Also, special feeling of gratitude to my beloved parents, Amir Bin Patawari and Paida Binti Rusli whose words of encouragement and pushed, prayers of the day and night. I also dedicate my work to my supervisor and co-supervisor who have guided me to do the real of work-self until finish. From this supporter, I can handle the work even the challenger that very hard to face. Encouragement and advice from them I are able to get such a success.

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Besides that, I would like to acknowledge and give a special thanks to my friends, Ahmad Firdaus Bin Sulong for giving me some share of knowledge an vibration and gives some help. Lastly, I would like to thanks to all my lecturers who has taught me throughout in my study at Universiti Teknikal Malaysia Melaka.

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| | |
|---|---|
| **RPM** | Revolution per minute |
| **DP** | Diametral pitch |
| **CP** | Circular pitch |
| **M** | Module |
| **OD** | Outside diameter |
| **HCR** | High contact ratio |
| **LCR** | Low contact ratio |
| **TE** | Transmission error |
| **HP** | Horsepower |
| **KW** | Kilowatt |
| **ESPI** | Electronic speckle pattern interfometry |
| **SEA** | Statistical energy analysis |
| **CM** | Condition monitoring |
| **CK** | Correlated kurtosis |
| **FFT** | Fast Fourier transform |
| **HOS** | High order statistics |
| **STFT** | Short Fourier transformation |
| **WT** | Wavelet transform |
| **WVD** | Wigner-ville distribution |
| **RMS** | Root-mean square |
| **HHT** | Hilbert Huang transform |
| **DFT** | Discrete Fourier transform |
| **AGMA** | American Gear Manufactures Association |

| | |
|---|---|
| **HL** | Hydrodynamic lubrication |
| **EHL** | Elastohydrodynamic lubrication |
| **BL** | Boundary lubrication |

# CHAPTER 1

# INTRODUCTION

## 1.0 Introduction

This chapter will cover subtopic of background, problem statements, objectives and scope of the study.

## 1.1 Background of Study

In the process of transmitting torque, gear is a rotating part of the machine that have a cogs or teeth where it meshes with another gear part of the machine. The term gear can be traced back to 350 BC where Aristotle who was one of Greek philosophers wrote description about gear. After hundred years later, the diagram of hoist was drawn by a Hellenistic mathematician whose name was Archimedes. He drew the diagram consists of a set of worm and worm wheel. In power sources, all the devices of gear can change the speed, torque and the direction. This is because, gears almost produce the changes in torque by creates a mechanical advantage. One of its advantages was through a gear ratio that may be considered a simple machine. On the meshing gear, all the cogs or teeth having a same shape that will working together by working in a sequence where called as a gear train or transmission. Rack is the process where gear can mesh with a part of linear tooth and producing a translation instead a rotation. In a crossed belt pulley system, the gears transmission is an analogue to the wheels. The advantage is it can prevent a gear slippage. Gears is complicated machine but important component like a clock to mill drive system

and large kiln. Hence, gears is an essential mechanical part to various automobiles and machines to get suitable different speeds based on vehicle load.

Vibration is a term often associated with rotating machinery. Vibrations that cannot be controlled will cause damage to a machine. Therefore, it is important to control the vibrations in a reasonable limit. Most rotating machines used many types of gear to support the shaft when rotating by bringing something off the burden. The use of gear in an industry will play a very important role to reduce the friction of the engine's performance.

Gear that is often used is discussed enough to give mechanical millwright or with basic information that will be required to perform installation and maintenance work to be carried out. According to Aherwar when it is often faults, this can be detected by applying the physical examination of the components, using methods and techniques such as microscopy, dye penetrates, X-ray, magnetic rubber, and others (Aherwar, 2012). The gears failure that have error can be catastrophic. A piece of tooth can douse the teeth and will cause significant damage. It is common for gear to continue operating under adverse conditions such as inadequate overload and inadequate lubricant for a relatively long period of time. However, at one point, the failure will occur. The goal of the vibration analyzer is to track down any failures before they occur.

Common causes of gear vibrations are misalignment, imbalance, excessive tooth reaction, broken teeth, tooth gear and tooth flakes. Misalignment is one of the major causes of vibration in the gear vibration. It often happens when gear conditions are not aligned with the diameter. The detailed work in this report will be performed on the 'Computerized Vibration Analyzer' and 'Damage to Gear Kit' to measure the gear defect that vibrates from the wrong alignment.

## 1.2 Problem Statement

Misalignment in gear will affect the performance of the machine and cause deterioration on gear in long term. The easiest countermeasure acion is by changing of whole gearbox, but this method is very expensive and will cause production downtime which increase the total cost of maintenance. With the arise of condition-based maintenance (CBM) in industry, vibration can use as a method to monitor the condition of gear and misalignment included. The basic cause of misalignment at the gears is inadequate lubrication, overload, contaminants, moisture and lubricant breakdown. Vibration analysis on the misalignment occurred in gear and reduce the estimated maintenance cost of a machine regard to gear misalignment problem. According to Donald R. Houser, (2006), he stated that factor of misalignment is shaft bending deflection effect with the gear, this will apply for a single gear on the shaft, deflection will occur along the line of action, but when an extra gear and other external forces imposed on the shaft deflection and will take a general instructions, this is important because the misalignment is linear with the load, therefore, when the load is at an increased level, the misalignment will also increase.

## 1.3 Objective

An objective is defined as the purposes or target of the project:

i. To analyze the frequency spectrum for misaligned spur and helical gear.
ii. To determine the effect of load on misaligned angle to spur and helical gear.

## 1.4 Scope

This investigation project focus on the misalignment of spur and helical gears with number of small teeth is gear 25 and large gear teeth is 75. The misalignment data of the gear will be recorded to frequency spectrum with 1800 rpm. Besides that, the data at frequency spectrum on this project focus to 3 different angle of center distance which are 0°, 30°, and -30°.In addition, this project was run with 3 different load which are 0 Nm, 1.7 Nm and 3.4 Nm. This project will run on 'Damage to Gear' machine on Diagnostic and Vibration laboratory FTKMP UTeM.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Gear

A gear is a disk or wheel with teeth around its periphery either on the inside edge or on the outside edge. A gear is used for the purpose of providing a positive means of power transmission. This transmission is affected by the teeth on one gear meshing with the teeth on another gear or rack. Meshing teeth formed with special cutters provide a much more compact drive than either belts or chain drives and can operate at higher speeds and power.

### 2.1.1 Types of Gear

Gears work on the same functions those found in automobiles, aircrafts and turbines. They are required to reduce the shaft power of the motor and convert it into controllable revolution per minute (RPM) required to drive the axle of a car and to rotate the propeller of an aircraft. The number and size of gears is referred to as a gearing ratio and determines the final power output being delivered by the motor after the motor has been transferred through the gears. Over the last two decades, some researchers have learned how to get gear improvements that require long-term goals aimed at minimizing disability and maximize efficiency over performance. The gear is a rotating component to convey the power and motion to change the speed with gear ratio that involves between two gear meshing. According to Karpat, Dogan, Yuce, and Ekwaro-Osire, the gear is an

important element in transmission systems used for power transmission. Torque is also an important factor when considering gearing ratios as larger gears provide more torque to overcome inertial forces, gear can arranged at the different situations based on the type of delivery that can be accounted for, example if it is a linear or a manual transmissions planet (Karpat, Dogan, Yuce, & Ekwaro-Osire, 2017). Examples of the different equipment that occur in the delivery of any is gear spur gears, helical, ring gear and bevel gear. Various type of gears exists to meet the requirements of different applications. Figure 2.1 shows the type of gears that are commonly used in industry and automotive application. Figure 2.2 shows the summary and evaluations of gear types.

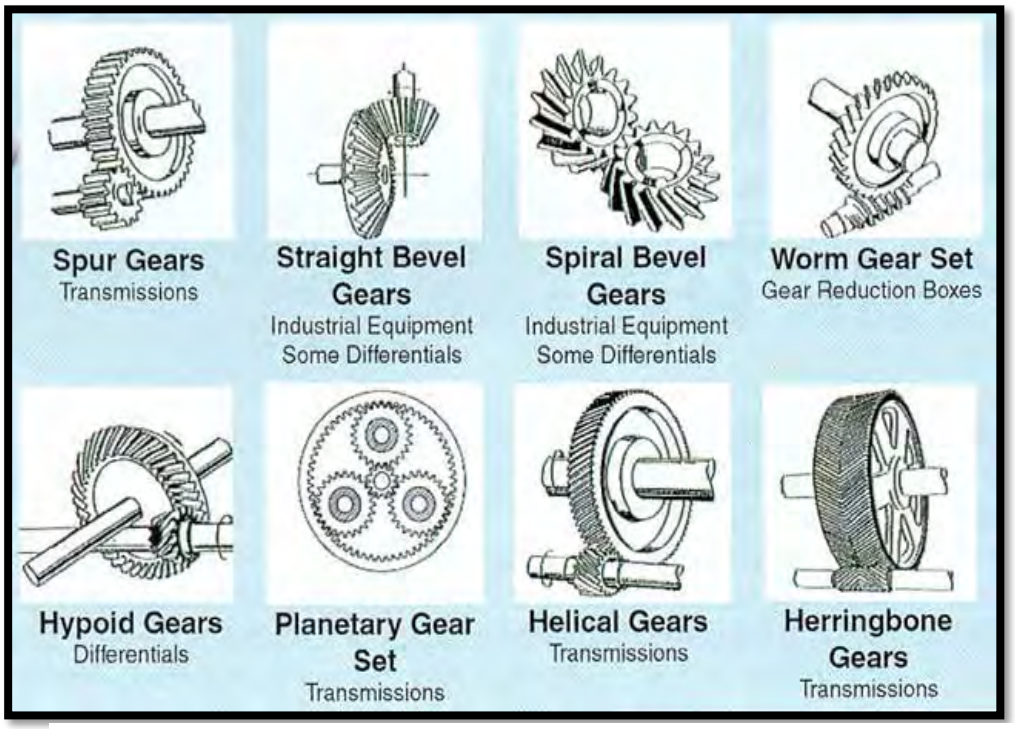


**Figure 2.1: Example type of gears.**
**Source: www.mh.mechanicalengineering.com**