



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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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Maintenance) with Honours. The member of the supervisory is as follow:

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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° , 30° , and -30° . 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 Paidia 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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TABLE OF CONTENTS

TABLE OF CONTENTS	ii
LIST OF TABLES	vi
LIST OF FIGURES	vii
LIST OF APPENDICES	ix
LIST OF ABBREVIATIONS	x
CHAPTER 1 INTRODUCTION	1
1.0 Introduction	1
1.1 Background of Study	1
1.2 Problem Statement	3
1.3 Objective	3
1.4 Scope	4
CHAPTER 2 LITERATURE REVIEW	5
2.1 Gear	5
2.1.1 Types of Gear	5
2.1.1.1 Spur Gears	8
2.1.1.2 Helical Gear	10
2.1.2 Dimension Specification of Gear	11
2.1.3 Surface Contact (Meshing) and Contact Ratio	12
2.1.4 Gear Failure	13

2.1.5	Operating Symptom of Gears	17
2.2	VIBRATION	18
2.2.1	Vibration Theory	18
2.2.2	Cause Vibration	19
2.2.3	Vibration severity	20
2.2.4	Vibration of Technique	22
2.2.5	Condition Monitoring/Diagnostic	23
2.2.6	Vibration Analysis	24
2.2.6.1	Spectral Analysis	25
2.2.6.2	Envelope Analysis	25
2.2.6.3	Vibration Signal Analysis	26
2.2.6.4	Time Domain	27
2.2.6.5	Frequency Domain	28
2.2.6.6	Time-frequency Domain	29
2.2.6.7	Fast Fourier Transform (FFT)	30
2.3	Misalignment	30
2.3.1	Gear Misalignment	32
2.3.2	Type of Gear Error	35
CHAPTER 3 METHODOLOGY		38
3.1	Flowchart of Project	38
		39

3.2	Apparatus Characterization	40
3.2.1	Spur Gear	40
3.2.2	Helical Gear	41
3.2.3	Motor	42
3.2.4	Coupling	44
3.2.5	Accelerometer	45
3.2.5.1	Piezo-electric Sensor	46
3.2.6	Brake and Load Unit	47
3.2.7	Center Distance	49
3.3	Configure Computer Vibration Analysis	50
3.3.1	Configure Computer Vibration Analysis Software in Computer	51
3.4	Schematic Equipment Preparation and Setup	53
3.4.1	Performing the experiment	55
	CHAPTER 4 RESULT AND DISCUSSION	59
4.0	Introduction	59
4.1	Analysis the Frequency Spectrum for Misaligned Spur and Helical Gear	59
4.2	Analysis the Effect of Load on Misaligned Angle Spur and Helical Gear	74
	CHAPTER 5 CONCLUSION AND RECOMMENDATION	88
5.0	Conclusion	88
5.1	Recommendation	89
5.2	Project Potential	89

REFERENCE	90
APPENDICES	96

LIST OF TABLES

TABLE	TITLE	PAGE
Table 3.1:	Technical data for spur and helical gear	40
Table 3.2:	Technical data of asynchronous motor	43
Table 3.3:	Technical data of elastic clew coupling	44
Table 3.4:	Technical data of brake and load unit	49
Table 3.5:	Configure Computer Vibration Analysis Software in Computer	51
Table 4.1:	Sensor 1 of spur and helical gear without load at various angle	62
Table 4.2:	Sensor 2 of spur and helical gear without load at various angle	64
Table 4.3:	Sensor 1 of spur and helical gear with load 1.7 Nm at various angle	66
Table 4.4:	Sensor 2 of spur and helical gear with load 1.7 Nm at various angle	68
Table 4.5:	Sensor 1 of spur and helical gear with load 3.4 Nm at various angle	70
Table 4.6:	Sensor 2 of spur and helical gear with load 3.4 Nm at various angle	72
Table 4.7:	Sensor 1 of spur and helical gear with 30° centre distance at various load	75
Table 4.8:	Sensor 2 of spur and helical gear with 30° centre distance at various load	77
Table 4.9:	Sensor 1 of spur and helical gear with 0° centre distance at various load	79
Table 4.10:	Sensor 2 of spur and helical gear with 0° centre distance at various load	80
Table 4.11:	Sensor 1 of spur and helical gear with -30° centre distance at various load	82
Table 4.12:	Sensor 2 of Spur and helical gear with -30° centre distance at various load	84

LIST OF FIGURES

FIGURE	TITLE	PAGE
Figure 2.1:	Example type of gears	6
Figure 2.2:	The summary and evaluation of the gears (Sheng Li, 2013)	7
Figure 2.3:	Example of spur gear	8
Figure 2.4:	Illustration of the involute profile of a spur gear tooth	9
Figure 2.5:	Picture that shows the terminology that is used for the diametric sections of a gear tooth	10
Figure 2.6:	Example of helical gear	11
Figure 2.7:	Specific gear terminology	12
Figure 2.8:	Illustration of spur gear contact ratio	13
Figure 2.9:	The crack position (J D Smith, 1993)	15
Figure 2.10:	Gear scuffing effect (Dressel, 2007)	17
Figure 2.11:	Gears out of mesh because the backlash	20
Figure 2.12:	Vibration Severity Index	21
Figure 2.13:	Vibration monitoring technique (Mitianiec and Buczek, 2008)	24
Figure 2.14:	Envelope spectrum of the defect ball bearing running with 2 rpm (Geropp, 1997)	26
Figure 2.15:	Time domain graph analysis using ultrasonic sensor (Mohd et al., 2012)	28
Figure 2.16:	Vibration signal (time domain) of healthy and faulty conditions (Moosavian et al., 2016)	28
Figure 2.17:	Frequency domain graph (Mohd et al., 2012)	29
Figure 2.18:	Shims that use at motor to reduce vibration	31
Figure 2.19:	Example of accurate equipment for the measurement and correction of misalignment motor and pump	32
Figure 2.20:	The schematic of misalignment gear (Houser D, 2006)	33
Figure 2.21:	Example of gear misalignment	34
Figure 2.23:	Example of shaft bending	36
Figure 3.1:	Flowchart of project	39
Figure 3.2:	Driven of the spur gear with 75 teeth	41
Figure 3.3:	Driver of the spur gear with 25 teeth	41
Figure 3.4:	Driven of the helical gear with 75 teeth	42

Figure 3.5:	Driver of the helical gear with 25 teeth	42
Figure 3.7:	Name plate of the induction motor	44
Figure 3.8:	Elastic claw coupling to connect the shaft	45
Figure 3.9:	Accelerometer inside parts	46
Figure 3.10:	Accelerometer uses in this project	47
Figure 3.11:	Brake and Load unit	48
Figure 3.12:	Adjusting mechanism for center distance	49
Figure 3.13:	Computer Vibration Analysis	51
Figure 3.14:	Experimental setup for vibration on gearbox	55
Figure 3.15:	Spur gearing, zero center distance, no damage, with load 3.4Nm, n = 1800rpm, acceleration sensor 1	57
Figure 3.16:	Spur gearing, zero center distance, no damage, with load 3.4Nm, n = 1800rpm, acceleration sensor 2	57
Figure 3.17:	Spur gearing, center distance (-30°), no damage, no load, n = 1800rpm, acceleration sensor 1.	58
Figure 3.18:	Spur gearing, center distance (-30°), no damage, no load, n = 1800rpm, acceleration sensor 2.	58
Figure 4.1:	Sensor 1 of spur and helical gear without load at various angle	63
Figure 4.2:	Sensor 2 of spur and helical gear without load at various angle	65
Figure 4.3:	Sensor 1 of spur and helical gear without load at various angle	67
Figure 4.4:	Sensor 2 of spur and helical gear with load 1.7 Nm at various angle	68
Figure 4.5:	Sensor 1 of spur and helical gear with load 3.4 Nm at various angle	70
Figure 4.6:	Sensor 2 of spur and helical gear with load 3.4 Nm at various angle	72
Figure 4.7:	Sensor 1 of spur and helical gear with 30° centre distance at various load	75
Figure 4.8:	Sensor 2 of spur and helical gear with 30° centre distance at various load	77
Figure 4.9:	Sensor 1 of spur and helical gear with 0° centre distance at various load	79
Figure 4.10:	Sensor 2 of spur and helical gear with 0° centre distance at various load	81
Figure 4.11:	Sensor 1 of spur and helical gear with -30° centre distance at various load	82
Table 4.12:	Sensor 2 of spur and helical gear with -30° centre distance at various load	84

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
Appendix 1:	Table the center distance using eccentric bearing flange (axis shift)	96-97
Appendix 2:	Result from graph frequency spectrum	98-119
Appendix 3:	Gantt chart for PSM 1	120
Appendix 4:	Gantt chart for PSM 2	121

LIST OF ABBREVIATIONS

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 interferometry
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 action 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 Karpal, 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.

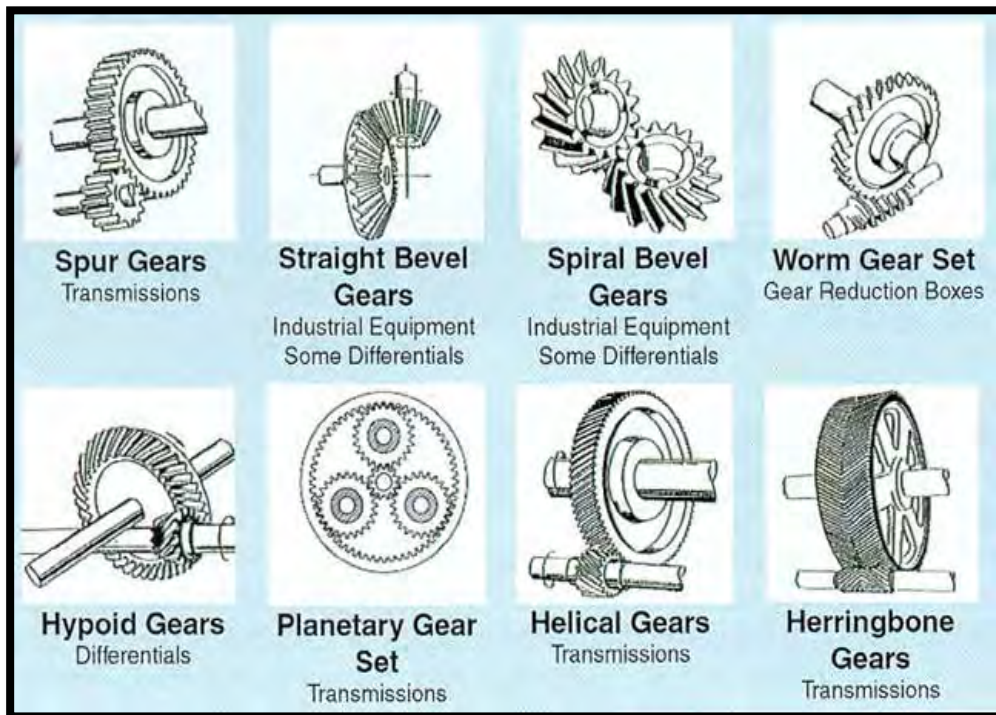


Figure 2.1: Example type of gears.
Source: www.mh.mechanicalengineering.com