VIBRATION ANALYSIS OF CORDLESS IMPACT WRENCH MECHANICAL SYSTEM USING STATISTICAL ANALYSIS METHOD

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**A thesis submitted
in fulfillment of the requirements for the degree of
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DECLARATION

I declare that this thesis entitled " VIBRATION ANALYSIS OF CORDLESS IMPACT WRENCH MECHANICAL SYSTEM USING STATISTICAL ANALYSIS METHOD " is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : HAIQAL DZARIF BIN RAMLI

Date : 9 JANUARY 2023

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 : ....

Supervisor Name : TS. DR. MOHD IRMAN BIN RAMLI

Date : 9 JANUARY 2023

DEDICATION

This thesis is dedicated to my beloved family for thier patience, absolutely everything with love and for their continuous support and encouragement, while I have been away from home

ABSTRACT

Condition monitoring through vibration analysis can detect and identify the faulty from rotating machine. Thus, improve the safety, productivity and reduces maintenance costs while increases reliability. The literature study shows there many previous studies on condition monitoring through vibration analysis of bearing, gear and shaft. Vibration signal analysis (VSA) is one of the mostly used method of condition monitoring because through VSA, the type of defect and the severity of defect can be detected at early stage which can help to reduce massive breakdown risk. In this study, the vibration signal analysis of cordless impact wrench will be studied and analyzed.

The cordless impact wrench itself has a natural frequency vibration but it faulty condition, the excess vibration caused will give user a bad experience in term of comfortability and quality of work. Therefore, a study about it can help to understand the vibration signal characteristic. For this study, the vibration signal will be recorded using accelerometer transducer and data acquisition (DAQ) device. Then, the data will be filtered and processed by MATLAB and Microsoft Excel to extract the required vibration signal from time domain spectrum. Thus, statistical data such as root mean square (RMS) presented in the form of graph can be compared based on the normal and abnormal condition. Vibration spectrum of frequency domain from normal and abnormal condition can be analyzed to study and compare the pattern of the spectrum if there is any faulty in the cordless impact wrench.

ABSTRAK

Pemantauan keadaan melalui analisis getaran dapat mengesan dan mengenal pasti kerosakan dari mesin berputar. Oleh itu, tingkatkan keselamatan, produktiviti dan kurangkan kos penyelenggaraan sambil meningkatkan kebolehpercayaan. Kajian literatur menunjukkan terdapat banyak kajian sebelumnya mengenai pemantauan keadaan melalui analisis getaran galas, gear dan poros. Analisis isyarat getaran (VSA) adalah salah satu kaedah pemantauan keadaan yang paling banyak digunakan kerana melalui VSA, jenis kecacatan dan keparahan kecacatan dapat dikesan pada peringkat awal yang dapat membantu mengurangkan risiko kerosakan besar-besaran. Dalam kajian ini, analisis isyarat getaran sepana hentam nirwayar akan dikaji dan dianalisis.

Perengkuh tanpa wayar itu sendiri mempunyai getaran frekuensi semula jadi tetapi keadaannya rosak, getaran berlebihan yang disebabkan akan memberi pengguna pengalaman buruk dari segi keselesaan dan kualiti kerja. Oleh itu, kajian mengenainya dapat membantu memahami ciri isyarat getaran. Untuk kajian ini, isyarat getaran akan direkodkan menggunakan transduser akselerometer dan peranti akuisisi data (DAQ). Kemudian, data akan disaring dan diproses oleh MATLAB dan Microsoft Excel untuk mengekstrak isyarat getaran yang diperlukan dari spektrum domain masa. Oleh itu, data statistik seperti punca min kuasa dua (RMS) yang ditunjukkan dalam bentuk grafik dapat dibandingkan berdasarkan keadaan normal dan tidak normal. Spektrum getaran domain frekuensi dari keadaan normal dan tidak normal dapat dianalisis untuk mengkaji dan membandingkan corak spektrum jika terdapat kerosakan pada sepana hentam nirwayar.

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LIST OF SYMBOLS AND ABBREVIATIONS

RMS	-	Root Mean Square
DAQ	-	Data Acquisition
MATLAB	-	Matrix Laboratory
Nm	-	Newton-meter
m/s^2	-	Meter per second square
g	-	Amplitude gravitational unit
Hz	-	Hertz
MEMS	-	Micro-electromechanical systems
VSA	-	Vibration signal analysis
FFT	-	Fast Fourier Transform
mm	-	Milimeter
Ft-lb	-	Foot-pound

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CHAPTER 1

INTRODUCTION

1.1 Background

A significant number of modern industries rely on various rotating machine such as motor pump, compressor, generator, etc. All rotating equipment generates vibration and have its own unique vibration signal. Vibration is referred as mechanical system's oscillatory (Leonard Meirovitch, 2001) . It can happen naturally or by exerting force on things around us. Vibration not only happen on machine that has moving parts, but it can happen on building, plants, human, even air and water particle vibrates. Excess vibration will cause difficulty in a variety of disciplines, including mechanical, civil, and electrical engineering. Therefore, condition monotoring is required to prevent them from happening. The most popular monitoring techniques are vibration analysis, lubricant analysis, infrared thermography, electrical monitoring, and sound (acoustic) emissions (Rao et al., 1996). Condition monitoring on rotating machines is important so that naintenance can be planned well in advance of the machinery failing (Nandi et al., 2005). Vibration signal analysis is one of the most accurate method to analyse the state of equipment beside its reliability (Rao et al., 1996). From vibration analysis, the structure damage detection and identification can be obtained.

In cordless impact wrench, vibration is a normal behaviour where there is no faulty. When there is a damage occur in cordless impact wrench, it make users feel uncomfortable due to excessive vibration. Motor, bearing and planetary gear set inside cordless impact wrench is the main component thus play a big role in determining the work quality. The excessive vibration is usually caused by an uneven or poorly condition of components. Alternatively, the vibration could indicate that the bearings are worn out or deterioration. Therefore, it is necessary to study the vibration signal from the faulty component so that prevention step can be taken. There are several method and tools of analysing the vibration signal and spectrum of cordless impact wrench. It is important to have a precise and detailed data to understand the characteristic of the vibration. The vibration of a machine is calculated by attaching an accelerometer and measuring the increasing accelerations caused by the vibration. The accelerometer is a sensor that monitors a physical tool's dynamic acceleration which affect the change in voltage (H.N Norton et al., 1989) and (S. Xianzhiong et al., 2005). Accelerometers are full-touch transducers that are frequently installed on high-frequency components, such as rolling-element bearings, motor housing, etc. The accelerometer data depicts the system's vibration response in time domain. Vibration data in the time domain can provide the maximum amplitude and period of a vibration. However, it is impossible to precisely identify the nature of machine's defects using only time domain data. As a result, the vibration data is evaluated in the frequency domain using signal processing methods. The Fast Fourier Transform (FFT) is the most widely used signal processing approach. The FFT method was proposed by Patel et al. (2018) as an analysis tool for monitoring a rotating machine, and important problems like misalignment and bearing can be tracked in this way FFT spectra contain information that can be used to identify the source and cause of an issue. Then, FFT spectrum from the accelerometer sensor that appear in the data acquisition tool will be filtered by the computer aided data processing system known as MATrix LABoratory (MATLAB). MATLAB is a programming software that was created with the goal of making scientific calculations as simple as possible. To process the data of vibration signal, the MATLAB software and Microsoft Excel is used.

1.2 Problem Statement

Cordless impact wrench nowadays is becoming modern and simple on its electrical and mechanical system. Motor, bearing, planetary gear are the main component in modern cordless impact wrench. When motor can not perform at it best performance, it might affect the quality of work. Beside motor, the breakdown of the bearing will give the user uncomfortable grip due to the excessive vibration caused by inner ring or outer ring damage, rolling element defect, and severe damage. In order to analyse the fault, vibration signal analysis method is used. For this study, a statistical analysis and spectrum analysis method will be used to obtain the best presentable and precise data regarding to the analysis fault on the cordless impact wrench bearing.

1.3 Research Objective

The main aim of this study is to analyse the characteristic of the cordless impact wrench's vibration signal with and without faulty on the system . Specifically, the objectives are as follows:

a) To study paramater to be measured on cordless impact wrench when tested at 90 Nm, 100 Nm and 110 Nm of torque.

b) To investigate the normal and abnormal data using vibration spectrum and statistical analysis method from MATLAB and Microsoft Excel.

1.4 Scope of Research

This project will be focused on cordless impact wrench bearing faulty diagnostic. This project involves three phase which are laboratory experimental activities, signal data analysis and result validation. Accelerometer will be used as vibration signal sensor detection. The signal are process by DAQ (Data Aquisition) by using accelerometer as the transducer. Then, MATLAB and Microsoft Excel are assigned to filter, process and analyze the vibration spectrum and produce the graph of statistical method chosen. The data will be represented by using FFT and Vibration Signal Analysis (VSA).

Using the proposed signal processing methods, the impacts of various failures and the frequency spectrum on the system's vibration response are explored. Ways to reduce machine vibrations will be suggested. To categorise the system's defect, various statistical methodologies are used. The statistical methodology and the spectrum analysis are used to reach the final conclusion.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter provides an overview of previous research and study on knowledge that related to this study. It introduces the framework for the case study that comprises the obejctives of the study stated in Chapter 1 in this thesis. It is important to set the context of the literature review by providing an explanation of its specific purpose for this particular case study. The main purpose of the literature review work was to survey previous studies on knowledge sharing and layout the framework where equipment details discussed first, then condition monitoring, vibration analysis, signal processing, advanced statistical analysis followed by data aquisition (tranducers) and fault recogntion techinique based on artificial intelligence (AI).

2.2 Cordless impact wrench

Maintenance and construction sector nowadays use a lot of modern tools to help engineer, technician, and maintenance crew to solve a work in a short time and to do heavy work easily. One of it is cordless impact wrench or also called as torque gun. It is designed to transmit high torque output with minimal effort. A sudden high force supplied by its brushless motor contain high intensity of twisting motion to a fastener (nut) through shaft in a very short time. This motion can be set into forward and reverse motion (loosening or tightening) and this tool can be used to assemble and disassemble works.

For this study, a cordless impact wrench will be tested to study it vibration characteristic with normal and abnormal condition.

Figure 2.1: Cordless Impact Wrench.

Table 2.1: Cordless Impact Wrench specification.

Features	**Specification / Type**
Brand	KEELAT
Model	KID004
Type	Cordless
Motor	Brushless
Battery model	21V (40000 mAh)
Maximum torque	420 Nm
Maximum speed	4200 RPM
Impact rate	0~6200 per minute
Wrench head size	1/2-inch

2.2.1 Internal parts of the cordless impact wrench

In order to understand deeper about the cordless impact wrench, the internal part of it needs to be recognized to enhance our understanding of the mechanical system and electrical system in this tool.

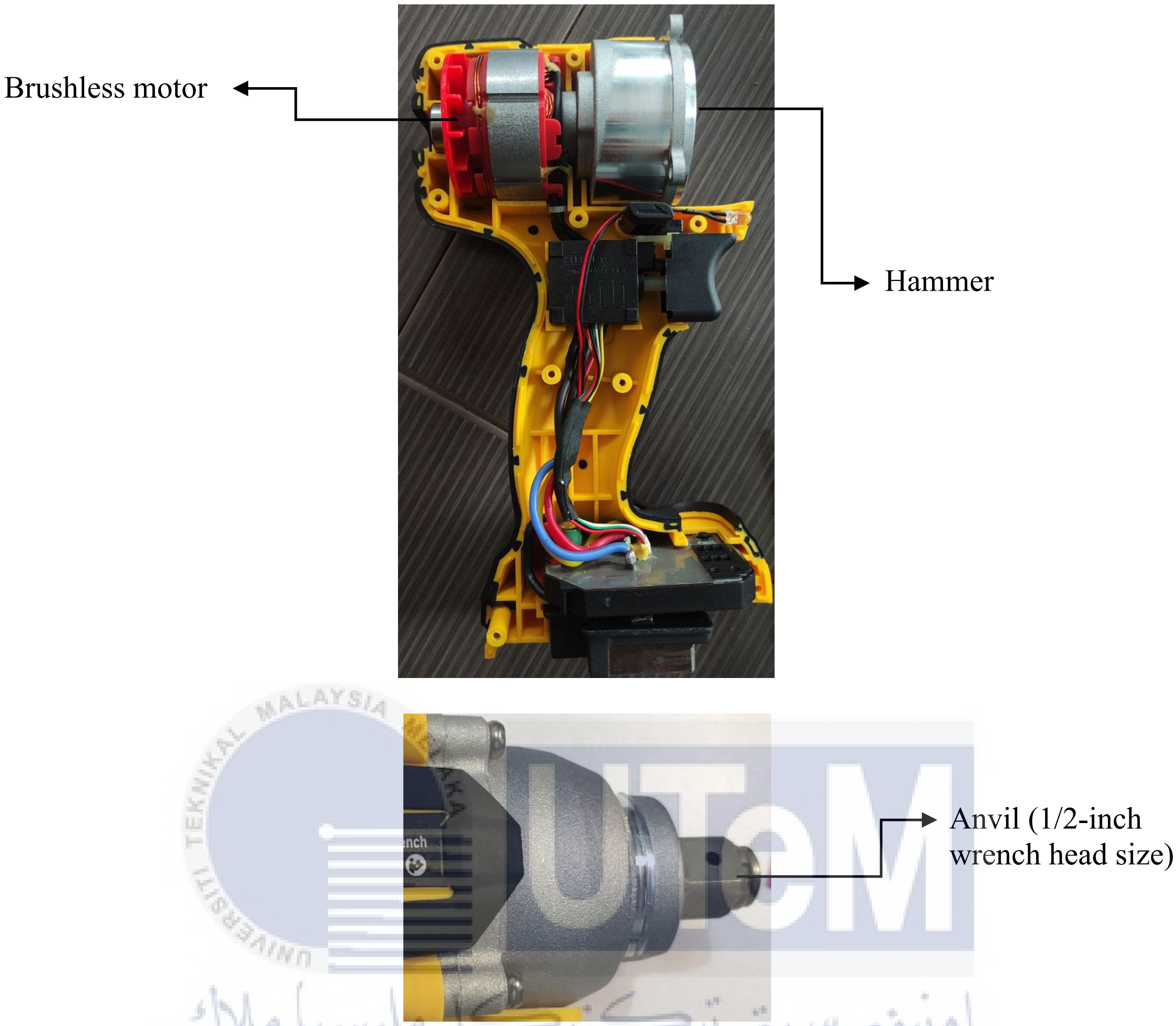

Figure 2.2: Internal parts of cordless impact wrench

2.2.2 Bearing

There are several types of bearing such as ball bearing, roller bearing, and cylinder bearing. Bearing main function is to reduce the friction between moving parts and to hold rotating parts such as shafts, wheels, gears, and rotors so that they can rotate smoothly. There are several main parts of bearing such as inner ring, outer ring, cage and rolling element. Figure 2.3 shows the main parts in bearing.

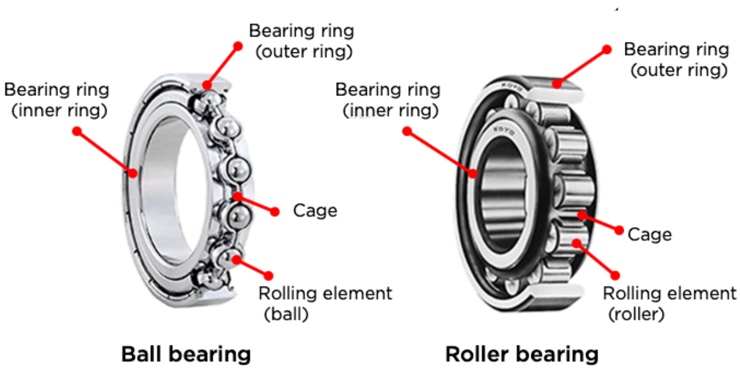

Figure 2.3: Bearing parts.

Source: https://koyo.jtekt.co.jp/en/2019/08/column01-03.html

Bearing is a core component of frictionless transmission for every rotating machine. Therefore, bearing condition monitoring become more crucial as it play a particularly important role. Bearing can give benefits as it maintained regularly. In other way, bearing can give massive downtime if it is not maintained well. Figure 2.4 below shows the ball bearing inside the cordless impact wrench. It is located inside the hammer system placed in between the planetary gear set and the brushless motor.

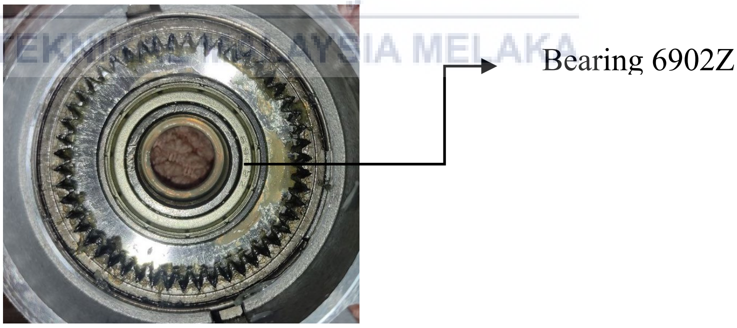

Figure 2.4: Bearing 6902Z

Bearing with model number 6902Z is used in this cordless impact wrench with dimension as follow.

Table 2.2: Bearing specification

Bearing model	Dimension (mm)
6902Z	15 x 28 x 7