



**SIGNAL DETECTION FOR GEAR DEFECT OF PUMP SYSTEM
USING SIGNAL ANALYSIS OF DATA ACQUISITION**



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

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**Faculty of Mechanical and Manufacturing Engineering
Technology**



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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2023

DECLARATION

I declare that this Choose an item. entitled “Signal detection for gear defect of pump system using signal analysis of data acquisition” 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.

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Date

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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.

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DEDICATION

I declare that this thesis is an original report of my research, has been written by me. The experimental work is almost entirely my own work with the guidance of my supervisor.

All supporting literature and resources have been adequately referenced.



ABSTRACT

The signal detection method is a type of predictive maintenance which monitor the health, performance, and reliability of a mechanical unit. By this, signal detection is categorized as a condition-based maintenance method under predictive maintenance. In this project report, the gear pump system is selected as the subject for the signal detection to detect the condition of the system. The gear pump is selected because the gear pump system is widely used in the industrial application making it a reasonable subject to be used in this project report. There are many types of fault detections in the gear pump system due to the mechanical rotating part, high-pressure conditions and chemical fluid exposure. There for, condition-based maintenance has an important role in the system so that it can be monitored closely. Firstly, data collection for the gear pump in different conditions would be collected. By this, the data would be processed and to be analyse which later compare the normal and abnormal state of the gear pump. With this, the average signal would be set to familiarize both conditions of the gear pump. Secondly, a new development of a new integrated analytical method for detecting an abnormal behaviour is presented by using a normal microphone as the source to monitor the condition of the gear pump and damage level. After obtaining both vibration and sound/audio signals, the signal would be processed using an integrated analytical method and I-Kaz for visual data spread. For the result of the research, it is concluded as a successful study. This is because by this research the finding for both signal analysis technique in short use for diagnosing and monitoring the status of mechanical systems and equipment. Vibration analysis is well-known for its great sensitivity, non-destructive nature, and versatility, but it also necessitates the use of specialised equipment and skilled staff. Sound analysis is a reasonably simple, quick, and cost-effective procedure, although it has a limited scope and is susceptible to background noise. Both methods have benefits and drawbacks, and the optimum strategy would be determined by the individual application, the equipment or machinery being monitored, the experience of the personnel performing the analysis, and the available resources.

ABSTRAK

Kaedah pengesanan isyarat ialah sejenis penyelenggaraan Ramalan yang memantau kesihatan, prestasi dan kebolehpercayaan unit mekanikal. Dengan ini, pengesanan isyarat dikategorikan sebagai kaedah penyelenggaraan Berdasarkan Keadaan di bawah penyelenggaraan ramalan. Dalam laporan projek ini, sistem pam Gear dipilih sebagai subjek untuk pengesanan isyarat untuk mengesan keadaan sistem. Pam gear dipilih kerana sistem pam gear digunakan secara liar dalam aplikasi industri menjadikannya subjek yang munasabah untuk digunakan dalam laporan projek ini. Terdapat banyak jenis pengesanan kerosakan dalam sistem pam gear disebabkan oleh bahagian berputar mekanikal, keadaan tekanan tinggi dan pendedahan cecair kimia. Oleh itu, penyelenggaraan berasaskan keadaan mempunyai peranan penting dalam sistem supaya ia boleh dipantau dengan teliti. Pertama, pengumpulan data untuk pam gear dalam keadaan berbeza akan di kumpul. Melalui ini, data akan diproses dan dianalisis yang kemudiannya membandingkan keadaan normal dan abnormal pam gear. Dengan ini, isyarat purata akan ditetapkan untuk membiasakan kedua-dua keadaan pam gear. Kedua, pembangunan baharu kaedah analisis bersepadu baharu untuk mengesan tingkah laku abnormal dipersembahkan dengan menggunakan mikrofon biasa sebagai sumber untuk memantau keadaan pam gear dan tahap kerosakan. Selepas mendapat kedua-dua isyarat getaran dan bunyi/audio, isyarat akan diproses menggunakan kaedah analisis bersepadu dan I-Kaz untuk penyebaran data visual. Seterusnya, keputusan akan disahkan dan dibandingkan dengan kedua-dua keputusan. Dengan ini, kedua-dua kaedah analisis isyarat akan menentukan kelebihan dan kekurangan kedua-dua kaedah tersebut. Untuk hasil penyelidikan, ia disimpulkan sebagai kajian yang berjaya. Ini kerana melalui penyelidikan ini, penemuan untuk kedua-dua teknik analisis isyarat digunakan secara ringkas untuk mendiagnosis dan memantau status sistem dan peralatan mekanikal. Analisis getaran terkenal dengan sensitiviti yang hebat, sifat tidak merosakkan dan serba boleh, tetapi ia juga memerlukan penggunaan peralatan khusus dan kakitangan mahir. Analisis bunyi ialah prosedur yang agak mudah, cepat dan menjimatkan kos, walaupun ia mempunyai skop terhad dan terdedah kepada bunyi latar belakang. Kedua-dua kaedah mempunyai faedah dan kelemahan, dan strategi optimum akan ditentukan oleh aplikasi individu, peralatan atau jentera yang dipantau, pengalaman kakitangan yang melakukan analisis, dan sumber yang ada.

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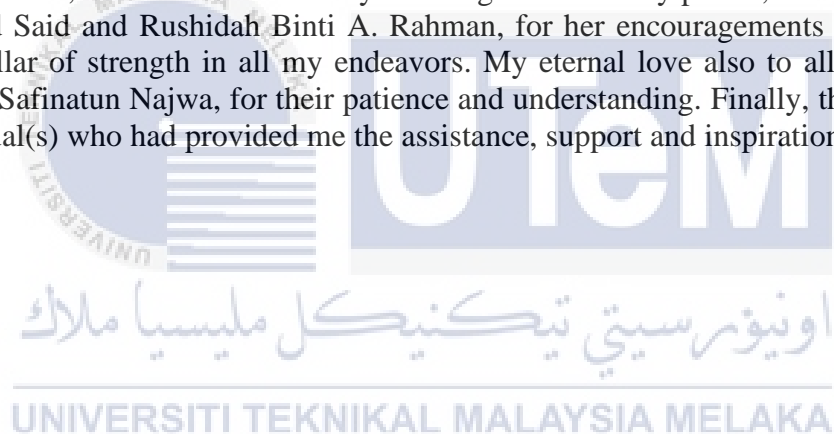


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LIST OF SYMBOLS AND ABBREVIATIONS

DAS	-	Data Acquisition System
CBM	-	Condition Base Maintenance
FFT	-	Fast Fourier Transformation
f	-	Frequency
ω	-	Angular Frequency
σ^2	-	Variance
	-	
	-	



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CHAPTER 1

INTRODUCTION

1.1 Background

Gear Pump is a type of pumping system used to convey fluids (liquids or gases), and occasionally slurries. The role of a pump is to mechanically convey a fluid by transferring a specific volume with overlapping gears or cogs and pumping it continuously. Additionally, it generates a continuous stream that is proportional to the rate in which its gears turn. So, most of the system is applied in industrial work where water piping systems or hydraulic fluid power is applied. In the Gear Pump system, an internal or external spur gear part is used to pump a chemical or non-chemical type of chemical in a liquid or gas form with high viscosity.

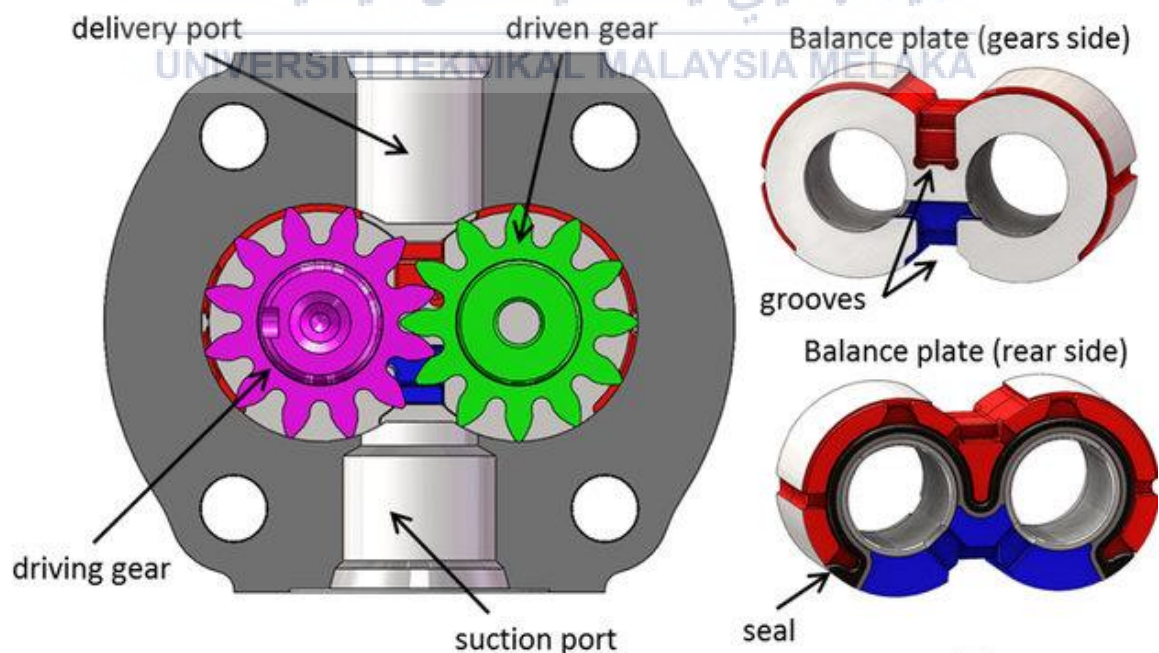


Figure 1.1 Example of an external gear pump system by Massimo Rundo

Many industrial applications need the use of gear pumps. The gear pump's abrupt failure might have a severe impact on its performance. So commonly the gear pump system will produce a defect and slowly perform. The major type of defect for gear pump is internal component for example the spur gear part causing a scratch. For the major defect to had happen, the problem may arise on the failed on the minor component. Usually, the minor component problem is broken or wear seal, torn or break gear bushes. This problem may be cause on long time usage, poor monitoring and unplanned maintenance on the component. As a result, gear problem diagnostics has been the focus. (Osman, 2019). Many studied found that the common defect for gear pump system is caused by poor maintenance or monitoring system. (Pietkiewicz, 2009). By this gear pump system had to be well maintain for performance and economic wise. This is due to the fact that the unit operates at a higher operating pressure, which raises the stream density of the transmitted energy and, thus, increases system efficiency.

The most common failures that arise on the gear pump is the wear friction produce by the gear to the cover. This is because the wear produces by the friction as the motor rotate will overtime turn into erosion. This problem is common let along the gear pump function with the high pressure and volume making any technical instrument that detect the problem could profit from such research. Such an experiment may be difficult to carry out in the case of complex mechanical systems. (Pietkiewicz, 2009). If the Gear Pump System go on this will cause a performance issued. And if its sill been used ignoring the defect, an unexpected breakdown may occur on the system and replacing the gear pump on the system may be the only option.

In one of the journals, one of a sea gear pump system is underperformance. When the system was put through a reliability test in the lab the entire load, it failed. A reduction in seawater pressure and an increase in vibration velocity were documented by the condition monitoring and fault diagnostic system (CMFDS). The tooth root area of three teeth of the seawater pump gear were cracked and fragmented. The remaining teeth were severely abraded. The bearing bracket was also severely damaged, with only a small section left. The remaining gears in the gearbox showed several wear scratches as well. (Zhilong Gao, 2019)

For that reason, an early detection is crucial for this complex system. This is because avoid unneeded expend for the industry company is unwise. Therefore, many industry tents to decrease their spending using various many method. For this scenarios Predictive maintenance can help with the unplanned downtime, maintenance costs, and using maximum value in the assets.

The are many methods of diagnostic or monitoring system that can be used for gear pump system. The most common method is by using vibration to analysis in the system. Vibration analysis method as for now is wide used in industry and not only used in a gear pump system. This is because now day vibration analysis for machine monitoring and diagnostics has become increasingly affordable because to advances in data gathering technology and signal processing techniques, including the instrument used. But there are some drawbacks on using vibration analysis only. By this, the other method that has potential on using is by using sound signal along with vibration. This is because by using both the data can develop a new solution that can detect the behavior for the gear pump system. By this, the new solution in theory can be archive because of the advancement technology.

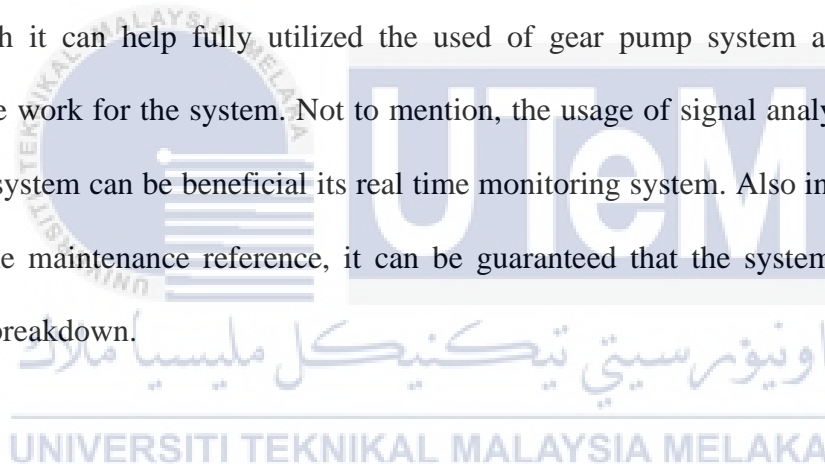
1.2 Problem Statement

Gear Pump system is widely used for industrial and consider the main component for hydraulics system, water piping system and any fluid nor gas system. Unfortunately, as the gear pump become crucial in a system, the component itself had some flaw that need to be taking care or monitor. In a study by Zhilong Gao (2019), Gear failures in gear pump system can occur for a variety of reasons, including a small fillet of the tooth root or top transition, an insufficient safety factor, an insufficient gear module and pressure angle, and issues with heat treatment and assembly quality. There for, to prevent this problem to enlarge, engineer try to come with method of maintenance on the component.

There are many variations of maintenance method for the system to be maintain as the technology is adapt to the solution. For example, the basic method of maintenance is to do a regular a regular observation and checklist. This included tearing the system apart to do the observation. This can bring a long downtime for the system when doing maintenance work. Beside this is using predictive maintenance type, condition-based maintenance method. This method is widely use because of its future that monitor the system health and performance using a signal analysis. With this, it improves the manual maintenance because the method can be done when the machine is still on running mode.

Following by this, the new integrated method can develop a new solution that can bring more beneficial, reliable, and precise data that can improve the previous solution. To do this, first need differentiate the signal behavior produce by normal and abnormal gear pump. By this the data need to familiarize the overview of the gear pump condition when problem is added. After that the next step will try to develop a new solution for the following system to detect an abnormal behavior using microphone signal wave. By this all the data for each method need compare the result if it can bring an improvement the existing vibration analysis method that been used.

In Conclusion, this studied is important to help the mechanical modern world. With this research it can help fully utilized the used of gear pump system and control the maintenance work for the system. Not to mention, the usage of signal analysis toward the gear pump system can be beneficial its real time monitoring system. Also include by using sound as the maintenance reference, it can be guaranteed that the system chance to be unplanned breakdown.



1.3 Research Objective

The main aim of this research is to determinant signal detection for gear defect of pump system using signal analysis of data acquisition. Specifically, the objectives are as follows:

- i) To characterize the gear pump signal behaviors between normal and abnormal condition of gear pump system.
- ii) To develop a new integrated analytical method on detect an abnormal behaviors of signal analysis using microphone and computer software
- iii) To Validate of integrated analytical method between Vibration and Sound/Audio signal.

1.4 Scope of Research

The scope of this research is to specifies the extent to which the research field would be investigated in the work and the parameters that would be used in the investigation. Below are as follows:

- The effect that produces by normal and abnormal signal behaviours
- the different between Time and Frequency domain of signal behaviours
- Using a MATLAB software to interact with the vibrational and Audio/Sound signal
- For the vibrational signal data, it is prioritised by using a maintenance based vibratory diagnosis MBP 011 for specimen
- For the Sound signal decision been made to try to use a regular everyday microphone

1.5 Hypothesis

A hypothesis is a statement that outlines your research's expectations and rational argument "informed guess" as to how your scientific tests will turn out. A good hypothesis is carefully stated as a key aspect of the scientific method, yet even the simplest ones can be difficult to express. For this title the hypothesis is as below.

- If the signal behaviours between normal and abnormal condition of gear pump system become crucial for the studied, then it can bring a necessary change in the system that can bring benefit evidence toward the studied
- By bringing a develop new solution on how to detect an abnormal behaviour of signal analysis using microphone and computer software, it is hope that the new solution would be implemented in the mechanical world as a new method of predictive maintenance
- Whether the data analysis get by comparing the vibrational signal and sound signal in fault detection method un unsuccessful or impactful, then it would be improvising with our studied to meet the standard and resourceful for other studied

1.6 Importance of The Study

This study is made with an aim to provide a crucial precise information, data and knowledge so that it can bring beneficial to the society regard of its outcome. This thesis may have a flaw or bound to the scope of research, but the potential for the new method is as follow.

- Economic improvement

The previous vibrational technique is a technique that require a widely use in the industry application. The technique requires a many equipment need to be uses and setup. For that reason, that can be a downside for the system. By this, the implementation techniques costs are generally high.

- Comparison between Signal analysis

Signal analysis had variety use in our technology world. This is because as the technology in the world keep growing, with respect of more signal is used. By this vibrational signal analysis had been long implemented in the CBM monitoring system, the system flaw maybe can be improved by the new type of signal analysis.

- Sound signal analysis have a potential

Sound analysis is a type of technique in signal analysis. This is because sound produce a noise that can be collect for data signal analysis. Thou it is yet to be use or implement in the industry; sound analysis can be used same as vibrational analysis for condition monitoring system for maintenance.