UNIVERSITI TEKNIKAL MALAYSIA MELAKA

A STUDY ON GASOLINE ENGINE ABNORMAL VALVE CLEARANCE USING ACCELEROMETER ANALYZED BY VIBRATION SIGNATURE ANALYSIS

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

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ABSTRAK

Kecacatan akan berlaku dalam sistem mekanikal dalam tempoh waktu yang panjang. Kecacatan boleh berubah menjadi kegagalan dari masa ke masa dan menjejaskan prestasi sistem jika ia tidak dikesan dan penyelenggaraan yang betul. tidak dilakukan Sebaik sahaja kegagalan berlaku, ia akan meningkatkan kos penyelenggaraan, mengurangkan jangka hayat, dan kecekapan akan jatuh. Analisis isyarat getaran adalah teknik yang boleh menjadi alat yang berguna untuk pemantauan sistem getaran mekanik berputar dan saling balas. Teknik pemantauan keadaan ini merupakan pendekatan untuk meningkatkan ketersediaan dan kebolehpercayaan sistem. Pengesanan kecacatan dalam enjin adalah kajian biasa dan berterusan yang dilakukan oleh penyelidik untuk memperbaik penyelesaian awal untuk menyelesaikan masalah yang berkaitan dengan jenis sistem mekanik ini. Dalam makalah ini, analisis telah dijalankan pada enjin kenderaan petrol. Tujuan kajian ini adalah untuk mengkaji keberkesanan teknik analisis getaran isyarat pada sistem injap. Kelonggaran yang tidak normal untuk injap diselaraskan kepada 0 mm, 0.2 mm, dan 0.3 mm untuk memerhatikan kesan keadaan simulasi terhadap keberkesanan teknik statistik yang dicadangkan. Hasil kerja eksperimen menunjukkan bahawa teknik yang dicadangkan adalah petunjuk yang baik untuk mengesan kecacatan pada injap. Ini juga akan menjadi alat yang berguna untuk pemantauan keadaan injap pada enjin.

ABSTRACT

Faults will likely to happen in a mechanical system over a period of time due to many factors. Fault can turn into a failure over a time and affect the performance of a system if it is not detected and execute a proper maintenance. Once failure occur, it will increase the cost of maintenance, reduce lifetime, and the efficiency will drop. Vibration signature analysis (VSA) is a technique that can be a useful tool for vibration monitoring of a rotating and reciprocating mechanical systems. This type of condition monitoring (CM) technique is an approach for increasing the availability and reliability of a system. Fault detection in internal combustion engine (ICE) is a common and continuous studies performed by researchers in order to improve to an advance solution for solving the related problem to this type of mechanical system. In this paper, an analysis was carried out on ICE of an engine vehicle with overhead valve (OHV) single overhead cam (SOHC) petrol engine. The purpose of this study is to investigate the effectiveness of VSA on a valve train system with simulated condition (normal clearance and abnormal clearance) at the intake valve. The abnormal clearance for the valve was adjusted to 0 mm, 0.2 mm, and 0.3 mm to observe the effects of the simulated condition towards the effectiveness of the proposed statistical technique. The results of the experimental work reveal that the proposed technique is a good indicator to diagnose the simulated fault. This also will be a useful tool for condition monitoring of valve clearance in ICE.

DEDICATION

To my beloved parents Farid Waradi Bin Hj. Hamidi and Siti Salmiah Binti Hj. Mohd Zain, I would be honour to dedicate this thesis for both of them as they are my courage, inspiration, dedication, and strength to complete my project until the end. I would also like to thanks to my sisters because they also help me in term of financial during my year of study.

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LIST OF ABBREVIATIONS

AC	Alternating Current
AI	Artificial Intelligent
ANN	Artificial Neural Network
CI	Compression Ignition
CK	Correlated Kurtosis
CM	Condition Monitoring
CPM	Cycle Per Minute
CWT	Continuous Wavelet Transform
DAQ	Data Acquisition
DWT	Discrete Wavelet Transform
FDD	Fault Detection Diagnosis
FDTW	Fast Dynamic Time Warping
FFT	Fast Fourier Transform
HHT	Hilbert-Huang Transform
Hz	Hertz
ICE	Internal Combustion Engine
LabVIEW	Laboratory Virtual Instrumentation Engineering Workbench
MAPE	Mean Absolute Percentage Error
MATLAB	Matrix Laboratory
MEMS	Microelectromechanical
MSC	Morlet Scalogram

NDT	Non-Destructive Technique
PdM	Predictive Maintenance
R&D	Research And Development
RMS	Root Mean Square
RMSE	Root Mean Square Error
RPM	Revolution Per Minute
SI	Spark Ignition
SOHC	Single Over Head Cam
STFT	Short Time Fourier Transform
TFR	Time-Frequency Domain
VSA	Vibration Signature Analysis
WT	Wavelet Transform

CHAPTER 1

INTRODUCTION

1.1 Background

In engineering, vibration is one of the main subjects need to be study because vibrations occur when there is movement. The typical features in this oscillatory movement are amplitude, displacement, frequency, period, phase, velocity, and acceleration (Fallis, 2013). Physical components of vibration consists of mass, stiffness, and damping which all of these is related to acceleration, velocity, and displacement respectively (Brown, 2014). Vibration have three types which is free vibration, forced vibration, and damped/undamped vibration.

Measurement of vibration can be performed by utilizing tools such as frequency, and amplitude. Frequency is the time needed for one complete cycle. While amplitude can be described as how high and low a weight travels on its journey around the circle. Frequency of a vibration has units which called as Hertz (Hz) or to be more detail, it is the number of cycles divide by time (second).

Cycle per minute (CPM) also can be used for frequency of a vibration. Other than that, CPM also known as revolution per minute (RPM). High or excessive vibration can affect the reliability of system or equipment and if excessive vibration not treated or reduced it can cause catastrophic failure thus will increase unnecessary cost. Most vehicles on the road are powered by internal combustion engines (ICE). The most common ICE for vehicles are fueled with petrol or diesel.

Mainly, ICE is a four stroke engines as shown in Figure 1.1 which have four processes to make a complete combustion process. This process called “stroke” which in ICE there are four stroke consists of intake stroke, compression stroke, power stroke, and exhaust stroke. Gasoline engine means that type of fuel that used in ICE is petrol (Mary, 2017). Gasoline engine also known as spark ignition (SI) engine. Gasoline engine labor via sucking a combination over gas yet breeze among a cylinder, compressing it together with a piston, yet igniting that together with a spark. The resulting burst drives the piston downwards, producing power permanency (Aaron, 2017).

A little year ahead around 1876, Nicolaus Otto invented the first four-stroke internal combustion engine called the “Otto Cycle Engine”. Then, the Otto’s previous idea of ICE was taken into an improvement by Gottlieb Daimler and Wilhelm Maybach. They implemented a new system in the engine which is gasoline-injected carburetor.

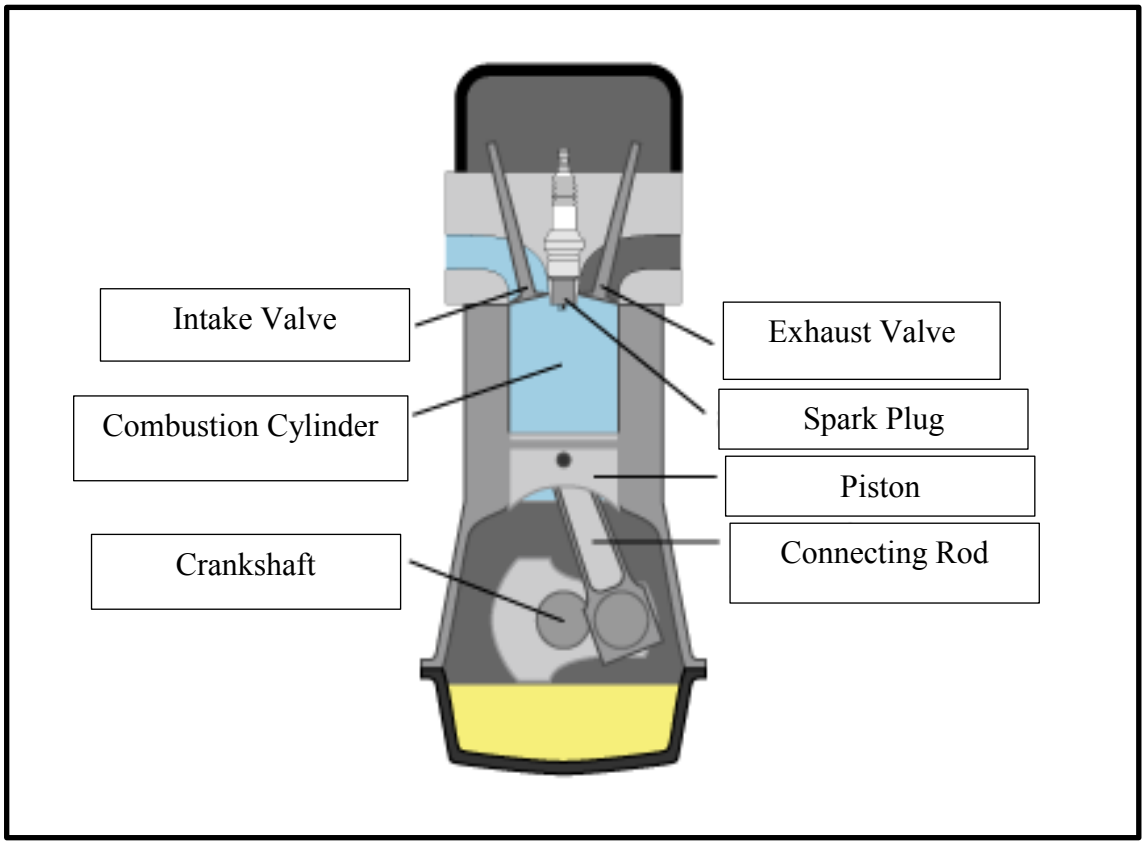

Figure 1.1: Example of four stroke engine

Valves in ICE controls the flow of air and fuel in and out of the cylinders. In ICE, valves are driven by way of the intake camshaft then the exhaust camshaft. There are two types of engine valves used in ICE which includes intake valve and exhaust valve. The intake valve allows the air and fuel to enter the combustion chamber while exhaust valve lets the combusted mixture out from the combustion chamber. The valves correspond of a round head, a stem or a groove at the pinnacle concerning the valve. The head regarding the valve is the larger end that opens and closes the passageway to and from the combustion chamber. The stem courses the valve up and down or supports the valve spring. The groove at the top of the valve stem holds the valve spring within region with a retainer lock. The valves need to open and close for the air-and-fuel blending in imitation of enter, then exit, the combustion chamber. Proper timing about the opening and closing over the valves is required for the engine to drive smoothly. Common engine valve failure is bent or broken, burnt, noise, valve seal worn out.

Fault can be defined as an abnormal condition of a component, equipment, sub-system level which may lead to a failure or malfunction (Sinnasamy et al., 2017). Engines such as internal combustion engine are widely used in automotive industries. A serious care of ICE must be taken into account to avoid fault because catastrophic failure may occur which can lead to loss of production or accident involving human (Jiang et al, 2017).

Common faults that occurred in engine mainly include abnormal fuel injection, misfiring, abnormal valve clearance, broken rocker arm, and piston ring fault (Sinnasamy et al., 2017). These problems can be solved by implementing diagnostic measure or conduct condition monitoring on the engine.

Diagnostic is the techniques of diagnosis while diagnosis can be described as identification of fault through the judgement and conclusion (Syah Lubis, 2017). Deterministic and stochastic (statistic) approaches for the remaining useful life of a machine or equipment or component or sub-system level are one of tools that used in diagnostic for diagnosing faults. Nowadays, the application of condition monitoring in industries have been applied, particularly to identify the presence of symptoms of incipient faults and eventually prevents catastrophic failures on critical machineries. Common techniques applied in condition monitoring are vibration analysis and diagnostic, acoustic emission, lubricant analysis, thermography, etc.

1.2 Statement of the Purpose

The purpose of this study is to analyse the simulated faults on internal combustion engine where the valve train clearance is artificially adjusted to certain conditions. The analysis is focusses on vibration signature analysis and statistical method to find what is the best technique for diagnosing the implemented faults.

1.3 Problem Statement

Engine is the main component in a vehicle as it works as a power source for the vehicle to move on the road. Over the time, an engine may have fault occurrence on parts of the engine. This fault can lead to a malfunction or failure in the engine which then degrading the engine's performance and life time. One of many faults that occurred in an engine is the abnormal valve clearance. Valve clearance concerning the gap between the rocker arm and valve cap. Many researches have been employed regarding the abnormal valve clearance in order to find the best method to rectify the problem and making an

improvement for performance and reliability of an engine Thus, this paper will perform an analysis on the stated problem in order to provide the best technique for diagnosing the fault of valve in internal combustion engine.

1.4 Objective

i) To conduct a vibration analysis on valve train in a gasoline engine using vibration signature analysis.

ii) To investigate the best statistical method for fault detection and diagnosis.

iii) To compare the performance of engine between healthy and abnormal valve clearance.

1.5 Project Scope and Limitation

In this project, the analysis of valve clearance will be performed on Proton Iswara 4G13 12 valve-carburetor 4-cylinder SOHC gasoline engine. The type of sensor used in this project is piezoelectric accelerometer. The software that will be used for analyzing the data is MATLAB through the Fast Fourier Transform (FFT). Data acquisition (DAQ) used during signal measurement. Other than that, vibration signature analysis (VSA) method is the technique that will be used for signal analysis. Statistical method will be used for comparing the performance of the engine and finding the best technique for detecting and diagnosing faults. Only intake valve that will be diagnose by implementing fault condition at the rocker arm and valve cap.

1.6 Significance of Study

The main purpose is to diagnose valve clearance on a gasoline engine. By using vibration analysis and statistical method, the characteristic of the vibration will be compared to choose the best technique for condition monitoring. Besides, this study will provide a new knowledge in the future especially for diagnostic and condition monitoring method on gasoline engine because most of research from previous are more to diesel engine.