UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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VIBRATION STATISTICAL ANALYSIS (VSA) OF GASOLINE ENGINE'S ABNORMAL VALVE CRACK BY ACCELEROMETER

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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Sesi Pengajian: 2019

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I hereby, declared this report entitled VIBRATION STATISTICAL ANALYSIS (VSA) OF GASOLINE ENGINE'S ABNORMAL VALVE CRACK BY ACCELEROMETER is the results of my own research except as cited in references.

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APPROVAL

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ABSTRAK

Analisis getaran menggunakan statistik (VSA) adalah salah satu teknik pemantauan keadaan (CM) dan diagnosis mesin yang bergerak maju dan berputar seperti enjin pembakaran dalaman (ICE) yang mempunyai rangkaian injap. Pemantauan keadaan boleh meningkatkan keboleharapan mesin dan mengurangkan kos penyelenggaraan. Dengan melakukan CM, kesalahan dalam ICE dapat dikesan dengan lebih awal. Injap yang tidak normal digunakan sebagai set percubaan dalam enjin petrol. Objektif penyelidikan ini adalah menumpukan perhatian khusus untuk mengukur isyarat getaran yang dihasilkan oleh kerosakan injap ekzos dalam enjin petrol menggunakan sensor pecutan dan menganalisis ia menggunakan VSA. Keputusan eksperimen dan analisis menunjukkan bahawa VSA adalah kaedah yang berkesan untuk menentukan isyarat getaran dari injap yang tidak normal. Hasilnya menunjukkan teknik statistik yang dicadangkan berkesan dalam diagnosis kerosakan dalam eksperimen ini, dan ini dianggap sebagai pendekatan yang unik untuk memantau prestasi injap dalam enjin petrol.

ABSTRAK

Vibration statistical analysis (VSA) is one of technique for condition monitoring (CM) and diagnosis of reciprocating and rotating machines such as internal combustion engines (ICEs) valve train. Condition monitoring can improved machine reliability and decrease maintenance cost. By perform CM, fault in ICE can be detect early. Abnormal valve crack was used as the experimental set-up in gasoline engine. The objective of this research is focused specifically on measuring vibration signal produce by exhaust valve crack fault in gasoline engine using accelerometer sensors and analysis it using VSA. The experimental results and analysis showed that VSA is an effective method to determine vibration signal of abnormal valve crack. The results indicated the proposed statistical technique is effective in fault diagnosis for experimental cases, and this is considered to be a unique approach to condition monitoring of valve performance in engine.

DEDICATION

To my beloved mother Selomah Binti Saidin and all my friends

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LIST OF SYMBOLS

°	-	Degree
±	-	Tolerance
%	-	Percentage
cc	-	Cubic centimetre
$\mathbf{E_C}$	-	Energy constant
g	-	Gram
HP	-	Horse power
Hz	-	Hertz
$\mathbf{K_U}$	-	Kurtosis
kW	-	Kilowatt
$\mathbf{m/s^2}$	-	Meter per second square
mm	-	Millimetre
mV	-	Millivolt
N	-	Number of Samples
Nm	-	Newton meter
oz	-	Ounce
pk	-	Peak value
$\mathbf{R^2}$	-	R-square
S	-	Standard Deviation

S_K	-	Skewness
$\bar{X}$	-	Mean Value of Sample
X_i	-	Individual Sample
σ	-	Standard Deviation
σ^2	-	Variance
Z^{∞}	-	I-kaz

LIST OF ABREVIATIONS

4GL	Fourth Generation Language
CBM	Condition Based Monitioring
CI	Compression Ignition
CM	Condition Monitoring
DAQ	Data Acquisition
dB	Decibel
DFT	Discrete Fourier Transform
EMD	Empirical Mode Decomposition
FFT	Fast Fourier Transform
HHT	Hibert Huang Transform
HOS	Higher Order Statistic
IC	Internal Combustion
IIR	Infinite Impulse Response
ISO	International Organization of Standardization
LabView	Laboratory Virtual Instrumentation Engineering Workbench
MatLab	Matrix Laboratory
MFC	Macrofiber Composite
rad	Radian
RMS	Root Mean Square

RMSE	Root Mean Square Error
rpm	Revolution Per minute
SOHC	Single Overhead Cam
SI	Spark Ignition
STFT	Short Time Fast Fourier
VI	Virtual Instrument
VSA	Vibration Statistical Analysis
WT	Wavelet Transform
WVD	Winger-Ville Distribution

CHAPTER 1

INTRODUCTION

1.0 Background of Study

Vibration is oscillation or repetitive motion of an object around an equilibrium position. In vibration, four main physical components of vibration which is mass (store of kinetic energy), stiffness (store of potential energy), damping (dissipate energy), and force (provide energy). There are few types of vibration in engineering that is free vibration, force vibration, damped or undamped vibration, and random vibration. Vibration tends to have a lot of advantages and disadvantages, stirring up engineer global to put a lot effort to use its benefits and curtail its disadvantages. Invariably the whole lot vibrates in the world, some vibrations are appropriate and useful, some are actually negligible, and some are tolerable, some disturbing and the rest fall below the unsafe category. Vibration always occurs in engineering and will keep happening even after performing a good maintenance process such as vibration in cars engine, aircraft engine, machinery, and fan motor.

Nowadays, there are many types of engine uses in cars application. The common type of engine uses in car application is gasoline engine or also known as spark ignition (SI) engine. Most of these engines are 4-stroke cycle engines, which means the piston had to circulate four strokes to complete a combustion cycle. The cycle includes four different processes: intake, compression, combustion, power stroke, and exhaust.

During intake process in IC engine of a gasoline engine, the mixture fuel with air then will be inducted into the cylinder. The spark will ignite it after the piston compresses the fuel-air mixture and causing combustion. During the combustion process, vibration will occur in the engine due to repetitive movement of pistons, valves, connecting rod and other moving components in the engine. The level of vibration occurs in the engine can be defined by the condition of the engine itself. The longer used of car engine the larger vibration occurs and vice versa to a new engine. Excessive vibration can occur in engine causes by defects happened in engine components such as defect pistons, defect valves, defect connecting rods or defect bearings. But, the vibrations in the engine can be reduced by performing maintenance such as overhaul the engine.

An engine fault can be defined as the failure of the engine to achieve its optimum performance. These affecting the efficiency of power produced by the engine and can decrease the fuel efficiency. Engine faults also can lead to pollution such as air and noise pollution. The common engine faults are bad fuel mix, lack of compression, and lack of spark. Some cause of a fault in the engine is defected on parts of Internal Combustion (IC) Engines such as abnormal valve condition, piston scuffing or scratching, piston ring broken, and others basic part of the engine.

In IC Engine, there is two type of valves included in this system which is intake valves and exhaust valves. The main function of intake and exhaust valve is to control gases flow in IC engine. They are open and close to inlet gas into combustion chamber and outlet the gases into exhaust pipe. Meanwhile, they are used to seal the combustion chamber to traps the air-fuel mixture during compression stroke which both intake and

exhaust valve in close condition. There are many types of valve, but for IC engine the poppet valve is commonly used.

Any type of valve failure will affect the engine performance consequently making it obligatory to give due significance to failure analysis of IC engine valves. Possible modes of valves failure are fatigue failure, thermal fatigue, carbon deposits on valves, wear failure, erosion or corrosion of valves, valve face recession, and overheating of valves.

Condition Monitoring (CM) or Condition Based Monitoring (CBM) is described as the continuous assessment of the health of the plant and equipment throughout its service life. It is important to be able to detect faults while they are still developing. This is referred to as incipient failure detection (Elamin, 2014). Meanwhile, failure is the termination of the ability to perform the required function and, the fault is defined as a situation, which exists after a failure (Elamin et al., 2010). The incipient detection of diesel engine failures also offers a protected working environment and becoming an increasing number of essential to use comprehensive CM schemes for continuous assessment of the combustion and mechanical conditions of reciprocating machineries (Gu et al., 2006). The incipient detection of diesel engine failures also offers a protected working environment and becoming an increasing number of essential to use comprehensive CM schemes for continuous assessment of the combustion and mechanical conditions of reciprocating machineries (Lamaris et al., 2010).