



**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**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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**2019**

**BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA**

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

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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

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

## ACKNOWLEDGEMENTS

Praise to Allah SWT the Almighty for his blessing in giving me the strength, ideas, determination and patience in completing this last semester project paper in which to graduation requirement of Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours.

In addition, this project would not have materialized without guidance, assistant and encouragement from people surrounding. Thus, I would like to give my deepest gratitude to Ts Mohd Irman Bin Ramli as my supervisor and Mr. Nor Azazi Bin Ngatiman as my advisor for his guidance and constructive comments as well as his suggestion in helping me to improve the quality of this project.



## TABLE OF CONTENTS

	<b>PAGE</b>
<b>TABLE OF CONTENTS</b>	<b>viii</b>
<b>LIST OF TABLES</b>	<b>xii</b>
<b>LIST OF FIGURES</b>	<b>xiii</b>
<b>LIST OF SYMBOLS</b>	<b>xvii</b>
<b>LIST OF ABBREVIATIONS</b>	<b>xix</b>
<b>CHAPTER 1      INTRODUCTION</b>	<b>1</b>
1.0    Background of Study	1
1.1    Problem Statement	4
1.2    Objective	5
1.3    Scope	5
<b>CHAPTER 2      LITERATURE REVIEW</b>	<b>6</b>
2.0    Framework of Literature Review	6
2.1    Introduction to Gasoline Engine Vibration	7
2.1.1    Mechanical vibration	7
2.1.2    Classification of vibration	8
2.1.3    Elementary parts of Vibration Systems	9

2.1.4	Vibration in Vehicle	10
2.2	Introduction to Automobile	11
2.2.1	Engine	11
2.2.2	Basic Engine Parts	12
2.2.2.1	Cylinder block	13
2.2.2.2	Cylinder Head	14
2.2.2.3	Piston	15
2.2.2.4	Piston Ring	16
2.2.2.5	Crankshaft	17
2.2.2.6	Valves	18
2.2.2.7	Spark Plug	19
2.2.2.8	Camshaft	21
2.2.3	Gasoline Engine	22
2.2.3.1	Four Stroke Cycle	22
2.2.4	Common Defect in IC Engine	24
2.2.5	Valve Crack	25
2.3	Condition Monitoring	27
2.3.1	Vibration Analysis	28
2.3.2	Statistical Analysis	34
2.3.2.1	Advance Statistical Analysis (I-Kaz)	36

2.3.3	Decision Tree Model	37
2.3.4	Vibration Sensors	39
2.3.4.1	Accelerometer Sensor	40
2.3.5	Software	42
2.3.6	Signal Filtering	44
2.3.7	Fault Diagnosis	47
<b>CHAPTER 3</b>	<b>METHODOLOGY</b>	<b>49</b>
3.0	Introduction	49
3.1	Flow Chart	50
3.2	Experiment setup	51
3.2.1	Valve Setup	52
3.3	Sensors Installation on the Surface Engine Block	53
3.4	Test rig procedure	54
3.5	Data Processing and Data Analyzing	55
3.6	Signal Analysis	56
<b>CHAPTER 4</b>	<b>RESULT AND DISCUSSION</b>	<b>57</b>
4.0	International Organization for Standardization	57
4.1	Sensors Calibration	57

4.2	Vibration signal for the normal engine	58
4.3	Vibration signal of exhaust valve crack	60
4.4	Analysis of Vibration Statistical Analysis (VSA)	63
4.4.1	Comparison between the different size of valve crack	67
4.4.2	Comparison healthy and defect valve	70
4.4.3	Analysis on RMS values	72
4.4.4	The effect of speed on Kurtosis	73
4.5	R-square	76
4.6	Data prediction error	78
<b>CHAPTER 5</b>	<b>CONCLUSION AND RECOMMENDATION</b>	<b>82</b>
5.0	Conclusion	82
5.1	Recommendation	83
<b>REFERENCE</b>		<b>84</b>
<b>APPENDIX</b>		<b>90</b>

## LIST OF TABLES

<b>TABLE</b>	<b>TITLE</b>	<b>PAGE</b>
Table 3.1:	The technical specifications of the engine under study	51
Table 3.2:	Exhaust Valve Properties	52
Table 3.3:	Exhaust Valve Crack Faults Dimensions	53
Table 3.4:	Accelerometer specification	53
Table 4.1:	Table of RMS for Different Size of Exhaust Valve Crack	67
Table 4.2:	Comparison of the Prediction Error at Speed 650 rpm	79
Table 4.3:	Comparison of the Prediction Error at Speed 1000 rpm	79
Table 4.4:	Comparison of the prediction Error at Speed 1500 rpm	80
Table 4.5:	Comparison of the Prediction Error at Speed 2000 rpm	80

## LIST OF FIGURES

FIGURE	TITLE	PAGE
Figure 2.1:	Framework of Literature Review	7
Figure 2.2:	A Deterministic (periodic) Excitation	8
Figure 2.3:	Random excitation	9
Figure 2.4:	Elementary Parts of Vibrating Systems	10
Figure 2.5:	Illustration of the Vehicle Engine	12
Figure 2.6:	Illustration of Basic Engine Part in One-cylinder	13
Figure 2.7:	Cylinder Block Engine	14
Figure 2.8:	Cylinder head block	15
Figure 2.9:	Piston	16
Figure 2.10:	Piston Ring	17
Figure 2.11:	Crankshaft	18
Figure 2.12:	Valves	19
Figure 2.13:	Spark Plug	20
Figure 2.14:	Camshaft	21
Figure 2.15:	Illustration of Four-stroke Cycle in a Gasoline Engine	24
Figure 2.16:	The Basic Nomenclature of Engine Valve	25

Figure 2.17:	Exhaust Valve Crack	26
Figure 2.18:	Vibration Monitoring Technique	28
Figure 2.19:	Time Domain Graph Analysis	30
Figure 2.20:	Vibration Signal (time domain) of Healthy and Faulty Conditions	31
Figure 2.21:	Frequency Domain	32
Figure 2.22:	FFT of Car Engine during Idle	33
Figure 2.23:	A Typical Decision Tree Classifier	38
Figure 2.24:	The Basic Measurement Principle of Vibration Sensor	40
Figure 2.25:	Accelerometer Transducer	40
Figure 2.26:	Vibration Measurement System	41
Figure 2.27:	Block Diagram Integration of the LabView and MatLab for Acquiring Data from Accelerometer	43
Figure 2.28:	If Sampled at 100 Hz, a 60 Hz Sinus Wave may Erroneously make the Vibration Profile look like a 40 Hz Signal.	45
Figure 2.29:	Superimposed Graphs of the Butterworth Filter Frequency (phase) Response with Increased Cut-off Frequency	47
Figure 3.1:	Flow Chart	50
Figure 3.2:	Exhaust valve crack	52
Figure 3.3:	Sensors Attachment	54
Figure 3.4:	Engine Speed Monitoring	55

Figure 3.5:	Experimental Activity Diagram	56
Figure 4.1:	Time Domain and Frequency Domain Graph for Accelerometer Calibration	58
Figure 4.2:	RMS graph for Engine with Healthy Exhaust Valve	59
Figure 4.3:	Time domain and Frequency Domain Graph	60
Figure 4.4:	Time Domain and Frequency Domain Graphs for Speed 650 rpm (a) Abnormal Valve Crack (b) Healthy Valve	61
Figure 4.5:	Time domain and Frequency Domain graphs for Speed 1000 rpm (a) Abnormal Valve Crack (b) Healthy Valve	62
Figure 4.6:	Time domain and Frequency Domain Graphs for Speed 1500 rpm (a) Abnormal Valve Crack (b) Healthy Valve	62
Figure 4.7:	Time domain and Frequency Domain Graphs for Speed 2000 rpm (a) Abnormal Valve Crack (b) Healthy Valve	63
Figure 4.8:	RMS Graphs for all Engine Condition with Speed 650 rpm	65
Figure 4.9:	RMS Graphs for all Engine Condition with Speed 1000 rpm	65
Figure 4.10:	RMS Graphs for all Engine Condition with Speed 1500 rpm	66
Figure 4.11:	RMS Graphs for all Engine Condition with Speed 2000 rpm	66
Figure 4.12:	RMS Graph for Exhaust Valve Crack 0.25mm	68
Figure 4.13:	RMS Graph for Exhaust Valve Crack 0.5mm	69
Figure 4.14:	RMS Graph for Exhaust Valve Crack 1.0mm	69



Figure 4.15:	Differences Graph of RMS at Speed 650 rpm	70
Figure 4.16:	Differences Graph of RMS at Speed 1000 rpm	71
Figure 4.17:	Differences Graph of RMS at Speed 1500 rpm	71
Figure 4.18:	Differences Graph of RMS at Speed 2000 rpm	72
Figure 4.19:	Average RMS for each Engine Condition	73
Figure 4. 20:	Kurtosis Graphs for Exhaust Valve Crack 0.25mm with Different Speed	74
Figure 4.21:	Kurtosis Graphs for Exhaust Valve Crack 0.5mm with Different Speed	74
Figure 4.22:	Kurtosis Graphs for Exhaust Valve Crack 1.0mm with Different Speed	75
Figure 4.23:	Kurtosis Graphs for Healthy Exhaust Valve with Different Speed	75
Figure 4.24:	R-squared Graph for Healthy Exhaust Valve	76
Figure 4.25:	R-squared Graph for Exhaust Valve Crack 0.25mm	77
Figure 4.26:	R-squared Graph for Exhaust Valve Crack 0.5mm	77
Figure 4.27:	R-Squared Graph for Exhaust Valve Crack 1.0mm	78

## LIST OF SYMBOLS

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

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

## LIST OF ABBREVIATIONS

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

<b>RMSE</b>	Root Mean Square Error
<b>rpm</b>	Revolution Per minute
<b>SOHC</b>	Single Overhead Cam
<b>SI</b>	Spark Ignition
<b>STFT</b>	Short Time Fast Fourier
<b>VI</b>	Virtual Instrument
<b>VSA</b>	Vibration Statistical Analysis
<b>WT</b>	Wavelet Transform
<b>WVD</b>	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).