UNIVERSITI TEKNIKAL MALAYSIA MELAKA

A STUDY ON GASOLINE ENGINE FUEL OCTANE NUMBERS USING ACCELEROMETER ANALYZING WITH MULTI STATISTICAL TECHNIQUES

This report submitted in accordance with requirements of the University Technical Malaysia Melaka (UTeM) for the Bachelor's Degree in Mechanical Engineering Technology (Maintenance) (Hons.)

by

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This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Maintenance) with Honours. The member of the supervisory is as follow:

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ABSTRACT

Octane numbers are considered as one of the most important things element in fuel to ensure the performance of the engine. Octane numbers are also can be the cause of failure to the engine. This study present the performances of the engine that relates to the octane numbers and compression ratio. The experimental procedure was performed by using three specimen fuels which is RON95, RON97, and RON100 within the specific range of speed at the engine. Data acquisition involved the vibration signal recorded by the accelerometer sensor. The vibration signal that produced by dynamic response of combustion engine has been analyzed using Fast Fourier Transform (FFT). All the data recorded are filtered using the MATLAB to get the valid data. The data obtained from the experiment were analyzed using statistical analysis method to make the interpretation of the data obtained. As a result, verification of the correlation was done and the calculated error using mean absolute percentage error and root mean square error has been showing the suitable fuel for the engine N43B20. Correlation process has been proved that it can be used as a standard for determining the suitable fuel for the engine through statistical analysis which is non-destructive, low cost and efficient method.

ABSTRAK

Nombor oktana dianggap sebagai salah satu elemen yang penting di dalam bahan api untuk memastikan prestasi enjin yang baik. Nombor oktana juga boleh menjadi punca kepada kegagalan enjin. Kajian ini membentangkan perkaitan di antara nombor oktana dan nisbah mampatan terhadap prestasi enjin. Prosedur eksperimen ini telah dilaksanakan menggunakan tiga jenis bahan api iaitu RON95, RON97 dan R0N100 dengan purata kelajuan yang khusus terhadap enjin. Perolehan data melibatkan isyarat getaran yang direkodkan oleh sensor pecutan. Isyarat getaran yang dihasilkan melalui tindak balas dinamik oleh enjin pembakaran telah di analisa menggunakan Transformasi Fourier Pantas (FFT). Kesemua data yang direkodkan telah ditapis menggunakan MATLAB untuk mendapatkan data yang sah. Data yang diperolehi dari eksperimen telah dianalisis menggunakan kaedah analisis statistik untuk membuat tafsiran data yang diperolehi. Sebagai hasil, pengesahan korelasi telah dilakukan dan pengiraan ralat menggunakan purata ralat peratusan mutlak (MAPE) dan ralat kudrat rata akar (RMSE) telah menunjukkan bahan api yang sesuai untuk enjin N43B20. Proses korelasi telah membuktikan ianya boleh digunakan sebagai piawai bagi mengenalpasti bahan api yang sesuai untuk enjin melalui analisis statistik dimana merupakan kaedah yang tidak memusnahkan, cekap dan kos yang rendah.

DEDICATION

To my beloved parents and family members.

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RON	Research Octane Number
MATLAB	Matrix Laboratory
RMS	Root Mean Square
STDDEV	Standard Deviation
G-code	Graphical code

CHAPTER 1

INTRODUCTION

1.0 Introduction

Vibration can put as a natural thing that happens in any moving objects. Vibration is not only on the machine, but it can happen on the bridge, building, human, tools, and plants. The problem that involves vibration will occur in many courses such as areas of mechanical, civil and electric engineering. As an example, wave at offshore platforms, noise in cabin aircraft, quake, hanging bridge, the highest buildings, and machine tools operation. Vibration is a thing that cannot be avoided but it can be reduced to make sure something worst does not happen. Usually, vibration can be produced because of the movement effects such as tolerances, clearances, rolling and many more between machine parts and contact surface in rotating and reciprocating members. Vibration also can detect the type of damage that occurs on condition structure.

In a vehicle, vibration can happen in overall body part especially engine. The gasoline engine is the type of internal combustion engine that almost all vehicle used on road compared to the electrical engine. The concept of a gasoline engine burns gasoline for fuel to generate energy. The gasoline engine is also referred to as a petrol engine. When the vehicle starts to run, it can produce a vibration on the engine. Unexpected vibration can generate a fault in the engine. Many faults in the engine can be listed, one of that is clogged radiator which is the engine will close to overheat if the radiator is produced a dirty coolant. In others, the fault in the vehicle is dirty oil. Dirty oil can produce and leave the molecules on vehicle components

like spark plugs, valves, and combustion chambers. It also damages a car bearing by leaving a dirty molecule or oil that can become embedded in the oil filter to having a clogged. Usually, the possibility of engine fault because of the component that always operated in-vehicle systems such as pistons, clogged injector, bearings, gaskets, cracks rings, and many more. All these possibilities can occur because of spark knock and it can be detected by using vibration analysis. Spark knock called as premature ignition that happened because of poor fuel used to the engine. Unexpected fault in the engine can make the higher cost for corrective maintenance. To find and eliminate the fault, there have several methods can be used to diagnose in detailed technical condition of the engine.

Condition monitoring is a regular observation and record all the data in the report. It is also a part of analyzing and identifying the failure/problem that occurs and tries to find the solutions. Condition monitoring is an essential technique to monitor the condition and performance of machining. In-vehicle system, condition monitoring is the best way to avoid engine failures before it becomes worth. It is the process of determining the condition of the engine while in operation. In condition monitoring, there have three major steps to detect a failure which is data acquisition, signal processing, and features. All of these steps are determining as a current state to condition monitoring to get the effectiveness data. It does not only help to reduce the chance of harmful failure; however, it is additionally easier to order components ahead, schedule workforce, and arrange alternative repairs throughout the surprising downtime.

Condition monitoring can be used in multi-techniques such as Global Statistical Analysis, Integral Kurtosis Algorithm Z-notch (I-KAZ) and many more techniques that have been done by researches. These techniques having their own

advantages and suitability to detect the failure and analyze the performance of the engine. All this method can be used to measure the characteristics and condition of the engine.

1.1 Problem statement

The engine is the main element to move a car. When an engine system cannot perform as new as build and it is system cannot be longer used anymore, the diagnoses should be taken to troubleshoot the problem. A "prevention is better than cure" can be used to diagnosing the car to avoid something bad happen. It is better to prevent the fault rather than to try to find the cures for fault after breakdown.

In order to define the performance of engine and fault, several techniques and fuel octane numbers will be a study on literature review and the comparison are recommended to choose the best fuel for the engine N43B20.

1.2 Objectives

i) To measure three random octane numbers fuel using piezo-based sensor (accelerometer)

ii) To analyze fuel performance using vibration statistical analysis on acquired data

iii) To determine the suitable fuel for gasoline engine N43B20 using percentage error techniques

1.3 Scope

In relation to the objectives of the study, the scopes of study are:

i) To focus on internal combustion of a gasoline engine

ii) To using three types of fuel octane number apply at engine the N43B20

iii) To measure the fuel performance by using vibration statistical analysis

CHAPTER 2

LITERATURE REVIEW

2.0 Vibration

Vibration can be an effective tool to diagnose and measure the performance of the engine and some of the early failure on machine and equipment. According to Feng et.al, (2016) generated vibration signal at planet bearing is to identify the fault characteristics. These claim can be supported by similar research done by Zarei et.al, (2014) where using the vibration signal is to detect the bearing defects of conduction motors. As studied by Wang et.al, (2016) condition-based maintenance via vibration signal is to detect and diagnose a fault in a rotating machine. Furthermore, in an observation-based study by Moosavian et.al, (2016) using vibration signal is to measure the effect of piston scuffing on engine performance. Vibration is the system that can oscillate naturally without applied any forces. In an engineering system, vibration can produce minor or serious fault and it is also can give a prediction problem. As studied by Verstraete et.al, (2017) using time frequencies in the vibration signal can predict the fault in rolling element bearing. This can be supported by Chen and Rand, 2016 in their journal, applied vibration signal to the internal combustion engine can predict the bearing knock fault. According to Kulkarni and Wadkar, (2016), using a vibration signal can presence the defect causes in rolling element bearing of rotating machinery.

2.0.1 Vibration application

The accelerometer is one of the sensors that mostly used by technical to measure the performance and detect the failure on the engine. According to Hushim, (2015) in his studied, accelerometer sensor is used to collect the vibration signal to measure the performance of the engine. In another study by Chen and Bond Randall, (2015), the accelerometer is used to record the vibration on the surface of the engine block to diagnose the misfire. As studied by Shatnawi and Al-khassaweneh, (2014) using the accelerometer to capture the vibration in an internal combustion engine is the effective ways to diagnose the fault. An accelerometer consists of an internal force that connected with a measuring load cell like a piezoelectric by a spring that gives a preload. The accelerometer typically is a crystal and therefore lists only compress loads, then a spring having a force will stay in compression.

The transducer has three types which are velocity, acceleration, and displacement. The function of the transducer or sensor is to monitor the vibration in machine movement or rotating. The transducer will convert the vibration to the normal signal condition. According to Zhao et.al, (2017), the acceleration transducer used to transform the vibration into the normal signal to measure the combustion parameter. As studied by Szymański and Tomaszewski, (2016), the transducer is used to measure the vibration of the valve clearance in a combustion engine. In placing more emphasis, Somashekar and Ab, (2013), accelerometer and transducer sensor used to measure the absolute vibration in an internal combustion engine to detect and diagnose the incipient failures.

2.0.2 Vibration technique

According to Mahmood, (2014), vibrations analysis technique is not a limit to condition monitoring only. However, it can be utilized in the diagnostic plan. Indeed, it will consider a main diagnostic device for the best troubleshoot in producing or assembling the product. The dependability and achievement of the plan will be improved by achieving a variation of non-destructive measurement that applies the vibrations analysis method. According to Hong and Singh, (2014), the vibration technique is used to diagnose the fault that happened in the gearbox. As studied by Kumaresan, (2016), vibration analysis is to diagnose the engine cylinder block to detect the misfire.

2.1 Internal Combustion Engine (Gasoline Engine)

Internal Combustion can be understood as a burning gasoline in an engine. It is the element in chemical change of release the power of fuel and air mixture. As studied by Moosavian, (2017), Internal combustion (IC) engines are the major element in powertrains that produced the power required for vehicles. Internal combustion engine (ICE) is produced the explosion in the combustion of the fuel happens among the engine, then the engine will convert the power from the combustion to performance. The engine consists about the fixed cylinder and piston movement. The internal combustion engine is developing the gases to push the piston when the operation is successive, it will rotate the crankshaft. Finally, when the system is completely function gears in powertrain will drive the vehicle's wheels.

Fuel properties and compression ratio can affect the performance of the internal combustion engine. According to Leone et.al, 2015 the compression ratio is related to the knocking sound. Using higher compression ratio can improve efficiency to reduce the knock but it can give an effect to the high temperature and pressure for unburned mix fuel-air which can lead to the more knock at high load. As studied by Rankovic and Bourhis, (2015) spark ignition is related to research octane number (RON) and motor octane number (MON). Fuel resistance is linked with the auto-ignition that can produce a carbon in an internal combustion engine. When the carbon is developed, the performance of the engine can be reduced. It has two types of ICE that are presently in manufacturing which is spark ignition for the gasoline engine and the other one is compression ignition for a diesel engine. Mostly those ICE is four-stroke operation engines, which means there has a four-movement are required in a completed cycle which is intake, compression, combustion, and power and lastly is exhaust.

The explosion spark in gasoline and explosion compression in diesel is completely different in the process of transmitting and explode the fuel. In a spark explosion gasoline engine, the fuel needs to mix with air and move to the cylinder throughout the intake mechanism. When the piston is compressing the mixture of fuel-air, the explosion will occur then it will be causing the combustion. The process of the mixture combustion gases has pushed the piston during the power stroke. But for the diesel engine process, only air is absorbing into the engine for compression. After that, diesel engines will spray the fuel into the hot compressed gas during operation to produce the explosion.