GASOLINE QUALITY MONITORING VIA VEHICLE OBD DATA ANALYSIS

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DECLARATION

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

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LIST OF ABBREVIATIONS

ASTM	**A**merican **S**ociety for **T**esting and **M**aterials
BTDC	**B**efore **T**op **D**ead **C**entre
CLS	**C**omplex **L**ogarithm **S**pectrum
DTC	**D**iagnostic **T**rouble **C**ode
ECU	**E**ngine **C**ontrol **U**nit
FFT	**F**ast **F**ourier **T**ransform
GCI	**G**asoline **C**ompression **I**gnition
GHG	**G**reen**h**ouse **G**as
GPS	**G**lobal **P**ositioning **S**ystem
HCCI	**H**omogenous **C**harge **C**ompression **I**gnition
IDT	**I**gnition **D**elay **T**ime
MIL	**M**alfunction **I**ndicator **L**amp
MON	**M**otor **O**ctane **N**umber
MPRR	**M**aximum **P**ressure **R**ise **R**ate
NIR	**N**ear **I**nfra**R**ed
OBD	**O**n-**B**oard **D**iagnostic
OPAH	**O**xygenated **P**olycyclic **A**romatic **H**ydrocarbons
PCA	**P**rincipal **C**omponent **A**nalysis
PLS-DA	**P**artial **L**east **S**quares **D**iscriminant **A**nalysis
PRF	**P**rimary **R**eference **F**uel
RON	**R**esearch **O**ctane **N**umber
SI	**S**park **I**gnition
USB	**U**niversal **S**eries **B**us

NOMENCLATURES

CO_2	Carbon Dioxide

PEMANTAUAN KUALITI GASOLIN MELALUI ANALISIS DATA OBD KENDERAAN

ABSTRAK

Nombor oktana penyelidikan menentukan kualiti mengetuk ketahanan bahan api dalam enjin pencucuran. Di Malaysia, jenis bahan api petrol yang paling biasa dijumpai adalah RON95 dan RON97. Salah satu objektif projek penyelidikan ini adalah untuk membandingkan prestasi enjin kenderaan dengan mengkaji pencucuhan mesin enjin apabila didorong dengan bahan api petrol dari nombor oktana yang berlainan dan dari stesen minyak yang berbeza. Analisis komparatif memancarkan masa pemajuan dengan nombor oktana penyelidikan (RON) 95, dan 97 telah dijalankan pada Perodua Myvi SE 2017 menggunakan pelbagai jenis bahan api petrol yang terdapat di bandar Parit Buntar. Bahan bakar minyak yang digunakan terdiri daripada Caltex, Petron, Petronas dan Shell. Keputusan menunjukkan corak khas untuk setiap RON bahan api; corak-corak ini diperolehi dengan menggunakan masa pendahuluan pencucuhan, pendikit / beban yang dikenakan kepada kenderaan dan kelajuan kenderaan dyang digunakan. Hasilnya kemudian dibuktikan lagi dengan tester oktana SHATOX SX-200 untuk membaca bacaan RON sebenar sampel bahan bakar minyak. Stesen minyak yang berbeza mengubah bahan api mereka secara berbeza. Ini menjelaskan bacaan yang berbeza yang diperolehi sebagai bahan api petrol diuji dengan penguji oktana mudah alih.

GASOLINE QUALITY MONITORING VIA VEHICLE OBD DATA ANALYSIS

ABSTRACT

Research octane number (RON) determines the quality of knocking resistance of a fuel in a spark ignition (SI) engine. In Malaysia, the most commonly found petrol fuel types are RON95 and RON97. One of the objectives of this research project is to compare the engine performance of the vehicle by studying the spark ignition of the engine when it is fuelled with gasoline fuel of different octane number and from the different petrol station. The comparative analysis spark advance timing with research octane number (RON) 95, and 97 was carried out on a Perodua Myvi SE 2017 under different types of gasoline fuels available in the Parit Buntar town. The different gasoline fuels consist of Caltex, Petron, Petronas and Shell. The results showed a special pattern for each fuel RON; these patterns were obtained using the spark advance timing, throttle/ load applied to the vehicle and the speed the vehicle is driven. The results are then further proved with SHATOX SX-200 portable octane tester to read the actual RON reading of the sample of the gasoline fuels. Different petrol stations alter their fuel differently. This explains the different reading obtained as the gasoline fuels are tested with the portable octane tester.

CHAPTER 1

INTRODUCTION

1.1 Overview

Research octane number (RON) determines the quality of knocking resistance of a fuel in a spark ignition (SI) engine. In Malaysia, the most commonly found petrol fuel types are RON95 and RON97. The fuel with higher octane rating allows a higher level of compression before igniting. A higher level of compression gives an engine a higher brake thermal efficiency. Generally, engines with a higher compression ratio require fuels with a higher-octane rating. More energy will be released from the fuel resulted from the high compression during the combustion process in the combustion chambers. A vehicle filled with a lower octane rating fuel than the one specified by the car manufacturer will experience pre-ignition, in which it will damage the car engine in the long-run. In Malaysia, most cars are built to run on RON95 petrol fuel. The newly developed engine technology has enabled some high compression modern engines to also run on RON95.

Before this, in Malaysia, the petrol prices were regulated by the ex-government where the petrol price would be announced weekly on Wednesday night effective since March 2017 [1] following the removal of fuel subsidies. After the 14th General Election on the 9th of May 2018, the new government announced that the present fixed petrol prices will stay and that there will be no increase in the petrol prices. They also claimed that if there would be an increase in the petrol prices, the government will subsidize. Based on an article as referred in [2], Malaysians are spending 23.9 percent of their monthly disposable income on petrol and another 14.6 percent on transport. With the rising living cost in Malaysia, these numbers can be further reduced if Malaysians spend their money on petrol and transport in a smarter way. There are issues raised questioning the quality of petrol fuel supplied by different petrol stations. It has been long debated that for the same octane number of the fuel, each petrol station will supply different quality. The primary difference is the additives and the octane booster. Octane booster additives are used to increase the octane rating of gasoline fuel. Each petrol station blends their petrol fuel with a mixture of different petroleum component. The additives are different, but the base fuel is the same for all petrol stations. These additives are the extra ingredients that clean the engine and hence improve the lubrication inside the engine cylinders.

Onboard Diagnostic (OBD) system was first designed to reduce emissions as the vehicle owner or repair technician can monitor the performance of main engine components. A basic OBD system consists of an engine control unit (ECU) which uses input from various sensors to control the actuators to get the desired performance. Starting from the year 1996, all vehicles manufactured are required to install OBD-II port inside the vehicle [3]. This port will allow any electronic device compatible with OBD-II to be plugged in and read information about the vehicle [4]. In this experiment, an OBD-II adapter is used because it is inexpensive and readily available. The OBD-II adapter will be connected to the ECU of the car. Hence, no new sensors need to be installed to conduct the experiment. ECU is the main part of a vehicle. It controls the actuators on the internal combustion engine so that the vehicle is functioning at their optimum performance. Hence, by refueling the vehicle used in this experiment with the different octane number of petrol from the different petrol station allow the objective of this study to be satisfied. In this work, the knock retard of engine spark ignition timing will be recorded via connection of OBD-II scanner with the ECU.

1.2 Project Background

The experiment of this project will be conducted on a Perodua Myvi car. The car will be refueled with the different octane number of petrol fuel of the different petrol station. The results will then be compared by observing and measuring the performance of the engine of the car. The project will investigate the quality of the same fuel octane number from the different petrol station. It will resolve the long-debated issues of the differences of the same octane number of petrol fuel from the different petrol station. This will enable the drivers to choose which petrol station supplies the best quality of fuel. The petrol fuel used in the experiment will also be tested of their actual octane rating using SHATOX SX-200. This equipment is a portable octane tester, used to measure the octane level. An OBD-II connector will be connected to the ECU of the car and to a laptop which has a LabVIEW setup which will display the results of the experiment. With the three connections, the laptop will be able to become a very detailed scan tool. OBD system is an advanced system which will monitor the engine performance, ignition system, emission system operation and transmission operation. This approach is relevant to the current time as the OBD-II is heavily used by professional mechanics to monitor the performance of main engine components and to identify the issues or problems faced by the car by reading the diagnostic trouble code (DTC).

1.3 Problem Statement

After reviewing all other journals and articles, there are very limited literature focusing on monitoring gasoline quality via vehicle OBD data analysis. The number of experiment to test the quality of gasoline fuel using SHATOX SX-200 is also limited. Therefore, the main objective of the present study is to investigate the quality of the same octane number fuel from the different petrol station by using SHATOX SX-200 portable octane tester and hence compare the engine performance of the vehicle by studying the spark ignition of the engine when fuelled with gasoline fuel of different octane number and from the different petrol station.

1.4 Scope of Work

The scope of work for this study are as follow:

Experimental

1. The experiment is conducted by using a Perodua Myvi SE (Special Edition) 2017 car with a city driving cycle.
2. Refuel Myvi car with RON95 and RON97 from Shell, Caltex, Petron and PETRONAS.
3. Test gasoline quality with SHATOX SX-200 portable octane tester.
4. Connect the ECU of the car with an OBD adapter to read information from the car using a laptop which has a LabVIEW set-up.

Simulation

1. The following data are logged in the LabVIEW setup
    1. Engine speed (rpm)
    2. Vehicle speed (km/h)
    3. Ignition timing advance (ºBTDC)
    4. Distance traveled (km)
    5. Runtime engine (s)
    6. Body control module (V)
    7. The temperature of the coolant (ºC)
    8. The temperature of the intake air (ºC)
    9. The temperature of the engine oil (ºC)
2. The logged-in data are read in MATLAB software.
3. 3D graphs are constructed relative to engine speed (rpm), throttle position (%) and ignition timing advance (ºBTDC) in MATLAB.

1.5 Objectives

The objectives of this study are as follow:

1. To investigate the quality of the same octane number fuel from the different petrol station by using SHATOX SX-200 portable octane tester.
2. To compare the engine performance of the vehicle by studying the spark ignition of the engine when fuelled with gasoline fuel of different octane number and from the different petrol station.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter reflects the extensive review done relating to this research project. The importance of the different quality of the gasoline fuel to the transportation industry and in the mechanical engineering. This chapter discussed the effect of the knocking combustion on the fuel consumption and how the different quality of the gasoline fuel affects them. Besides that, the different types of gasoline fuel blends used in the industry and for research purpose are discussed. The use of the OBD system is also discussed in this chapter.

2.2 Knocking Combustion and Characterization

Knocking combustion can affect fuel consumption, engine durability, noise, emission performance and power density. In the SI engine and gasoline compression ignition (GCI) engine, knocking combustion constrain engine performance and thermal efficiency [1]. GCI engine can sustain the high efficiency and low pollutant emissions but under certain operating conditions, knocking combustion causes damage to the engine. The end-gas auto-ignition causes the raising of the compression ratio to be limited to improve thermal efficiency on a conventional knock in SI engine. Even though the basic characteristics of the conventional combustion are made clear throughout years of study, many still do not understand how the fuel chemistry and knock index are related. They question the relationship between heat transfer and pressure oscillations and auto-ignition front propagation. In contrast, the researches conducted in knocking combustion in homogeneous charge compression ignition (HCCI) engines are much lesser. For HCCI engine, Fast Fourier Transformation (FFT) was used to calculate the complex logarithm spectrum (CLS) in which it was found that the load and the engine speed affect the harmonic characteristics of knocking combustion. The increment in the engine speed and the load increases the knocking intensity [2]. However, earlier this year, a new method was proposed to improve the knock detection in which the method distinguishes the difference between the autoignition and the combustion of the end gas [3], where low-knocking detection is allowed in the new definition of knocking event.

RON can define gasoline anti-knock quality, which is important to increase SI engine efficiency. Even though a right number of blending components can increase the gasoline knock resistance [4], the engine can go through a dangerous knocking regime during high loads operation [5]. Ethanol has been commonly used as the blending agent with gasoline fuels because it is produced from bio-derived resources. Spark timing is retarded and lower compression ratio and boost are needed in order to prevent knocking from happening [6]. The researcher explored the oxidation behaviour and the ignition delay times of Haltermann Solutions (RON91) and Coryton Advanced Fuels (RON97). These two samples were tested in a high-pressure shock tube and in a rapid compression machine at a wide range of temperatures, equivalence ratios and pressures. The reactions of the two types of gasoline were compared and based on observation, RON91 exhibited a much slower ignition delay time as compared to RON97. These results showed that the effects of fuel octane number and fuel composition on ignition characteristics are strongest in the intermediate temperature (negative temperature coefficient) region. Higher RON values enhance the fuel’s anti-knock quality [7].

2.3 Autoignition Studies

Fuel octane numbers are directly related to the autoignition properties of fuel/air mixtures in a spark ignition engine. In the previous years, many kinds of research are done to study about the ignition of the low-octane types of gasolines, ranging from RON50 to RON70. These low-octane types of gasolines are mainly used for GCI internal combustion engine [8]. It is a smart substitute for traditional spark ignition engines. By using low-octane fuels and the GCI technology, life cycle analysis can be improved thus reducing the effect of the fuels on the environment by neutralizing the use of diesel fuel in compression ignition engines. As the injection timing was gradually delayed, it was observed that the importance of the differences in physical properties slowly increases and rationalized by analysis of mixture stratification patterns [9]. This was concluded after different physical properties were injected to low-octane fuels. For this matter, fuel sensitivity for direct injection engine is related to the amount of non-paraffinic components. It is further revealed that fuel sensitivity strongly affects the dependency of the temperature of ignition characteristics in both diesel sprays and homogenous mixtures [10]. Combustion modeling for direct injection engines requires a fuel surrogate, a simple mixture of pure fuel components that will be able to imitate the chemical and physical characteristics of the gasoline fuel [11]. A higher number of surrogates are able to imitate the ignition delay times of gasoline more precisely compared to a lower number of surrogates [12]. One of the most popular surrogates is the iso-octane-based surrogate. Iso-Octane (2,2,4-trimethylpentane) is a main reference fuel and a significant constituent of gasoline fuels [13]. Its autoignition characteristics would probably help to optimize the combustion issues related to controlled autoignition or spark-ignition engine knocking [14]. Under low-temperature combustion (LCT) conditions, fuel surrogates should be properly formulated in order to model autoignition of fuel [15]. Not only the mixtures of the surrogate are able to imitate the ignition delay times, the surrogate mixtures are also able to imitate the thermochemical, chemical kinetic properties and the thermophysical of the real fuel [16]. The fundamental experiments and predictive simulations can be conducted with these simulations. Besides that, applying great pressure while injecting the fuels extended the combustion delay for gasoline-type fuels but not for diesel because diesel has a higher maximum pressure rise rate (MPRR) compared to gasoline-type fuels. However, due to the short combustion duration at a high injection pressure, these gasoline-type fuels have the highest efficiency [17]. The emissivity of soot decreases with the increasing pressure of injection because the nucleation mode increases, thus decreasing the accumulation mode, producing low soot and a low number of particle emissions. Hence this proved that, in terms of emission, for a compression ignition engine, the low-octane gasoline fuels are more suitable to be used compared to diesel. This finding is further verified in [18], as the authors proved that as the ratio of the gasoline increases, the soot emissions are relatively low at only $0.0015 g/kW.h$ at a lower load. Additionally, in a medium and high load, the injection number should be doubled as it retards the first injection timing and hence effectively reduce the pressure rise rate. The application of low-octane gasoline on GCI engines reduces energy consumption and greenhouse gas (GHG) emissions. These reductions can be further reduced by producing a much better configuration of low-octane gasoline [19].

There is also research done in which the authors study the ignition process in two terms which are, ignition delay time and in-cylinder pressure profiles to build a very reduced kinetics mechanism of n-heptane. The authors experimented with the whole range of engine operations. With two schemes developed of different number of reactions and species, the end results showed that the scheme with the lower number of reactions and species is more accurate as the window of engine operation were controlled

[20]. Other than RON, motor octane number (MON) is also a relatively important value in the gasoline fuel field. MON usually is lower than RON. There is a work to estimate the RON and MON from homogeneous gas-phase ignition delay time (IDT) data calculated at various pressures and temperatures. An early hypothesis was made which stated that fuels with IDT identical to that of a primary reference fuel (PRF) would have similar octane rating under the specific conditions of pressure and temperature [21]. The end results showed that the measurement using the standard American Society for Testing and Materials (ASTM) and blending rule, the predicted RON and MON displayed a reasonable accuracy.

2.4 Gasoline Fuel Blends

Researchers are currently active in searching and developing for cleaner alternative fuels. Butanol if blended with gasoline would be a much cleaner alternative fuel. After experimenting with the Butanol-gasoline composition on an SI engine at a full throttle condition within 1000-5000 rpm speed engine, the results showed that the brake power, engine torque, brake specific fuel consumption and the emission of carbon dioxide increases with regards to pure types of gasoline [22]. At higher engine speeds, the butanol isomers-gasoline blends produced higher exhaust gas temperature and brake thermal efficiency and this type of blends produce lower nitric oxide emissions.

Other than butanol, ethanol is also one of the popular alcohol blends with gasoline fuels. Ethanol has a cooling effect, a factor that will restrain engine knocking during the standard RON test. However, generally the unidentified intermolecular interactions in the ethanol-gasoline mixtures made the octane responses of the mixtures not well understood [23]. Since ethanol has no aromatic compounds and lower carbon content than gasoline [24], ethanol blends decrease particulate emissions, where nano-sized particles are released rarely. In another research in [25], the authors deny the absence of the aromatic compound in ethanol, instead, they proved that the aromatic compound decrease and the sizes of polycyclic aromatic hydrocarbons also decrease with the increase of the ethanol components in the ethanol blends. Not only that, the rate of soot production also decreased. This is due to the increase in the oxidative reactivity of soot from the blended fuels [25]. Even though in the previous years, research suggested that the content of the ethanol fuel did not affect the trend of the carbon dioxide emission, instead it reduced the emission of nitrogen oxide [26]. Besides that, at a relatively low engine speed, the engine torque output can be enhanced with the appropriate ethanol-gasoline mixing ratio [27]. The brake thermal efficiency is maximum when the engine operates at 58–73% of wide open throttle with an engine speed of 2000–2500 rpm. At the knock-limited engine loads, splash blended ethanol fuels with a higher ethanol percentage enabled higher engine thermal efficiency through allowing more advanced combustion phasing and less fuel enrichment for limiting the exhaust gas temperature under the upper limit of 850°C [7]. Ethanol has a low energy density, which can reduce the vehicle mileage partially or/and fully offset by upgraded efficiency when adapted compression ratio and turbo-changing are used [28]. In an optimized turbocharged engine, the lifecycle of the carbon dioxide emission can be reduced when using sugarcane-based types of gasoline as compared to using corn-based ethanol gasoline. This is due to the ethanol content, octane sensitivity, the lifecycle of carbon dioxide emissions and RON [29]. The ethanol blends do not only increase carbon dioxide and nitrogen oxide emissions as claimed in previous research, it also increases the emissions of both oxygenated polycyclic aromatic hydrocarbons (OPAHs) and PAHs as claimed in the latest study in [30] but at cold engine start conditions. It is further proved in the latest study in [31], that with ethanol blends exhaust emissions will decrease as compared to commercial gasoline and this is far cleaner and good alternative fuel for SI engines. OPAHs are important contaminants that should be considered during risk assessment and remediation of sites because unhealthy exposure to OPAHs and PAHs could lead to cardiovascular disease and poor fetal development. Other than butanol and ethanol blends, there is also the latest research using propanol blend to test the performance of a gasoline engine. In this research, the authors studied and relate the propanol blends on the engine fuel consumption and the pollutant emissions the propanol blends produced. The result of the experiment stated that this type of blend does reduce the pollutants emission of the vehicle engine and not only that, it also improves the fuel economy by 2.84% [32].

All the studies combining alcohol with fuels showed that alcohol blends fuel burn cleaner than unleaded gasoline in the SI engines. It can be concluded that fuel with alcohol blends would be a good fuel alternative for SI engines as these types of blends produce low unhealthy gas emissions from vehicle and thus it is environment and nature-friendly. Other than that, there is also a research combining diesel, gasoline and ethanol fuel blends which have higher combustion stability. These three blends, having the emulsifying properties are able to increase the octane rating of the fuel and enable the engine to run with a higher fraction of premixed flame [33]. There is also a blend of biodiesel fuel, in which this type of blend has a more stable autoignition and combustion as a direct injection is applied to the compression ignition engine. The biodiesel component in the blend greatly affect the autoignition delay time and with the increasing number of biodiesel fraction in the blend, it shortens the ignition delay time. The flammability of a biodiesel is better than the flammability of a pure gasoline [34].

2.5 Detection and the Usage of Adulterants

Adulterants are additives that are added to the fuel to lower the quality of the fuel illegally. Adulterations of the gasoline fuel are done mainly to increase the profit margin for distributors and fuel service stations [35]. Gasoline fuel of RON95 is often adulterate with cheaper RON91. This lowers the octane number of the RON95 gasoline fuel. In a recent study, RON91 can be detected and quantify in the adulterated RON95 using a new Near Infrared (NIR) spectroscopy combined with multivariate analysis. However, since the results using this method has a lower limit of detection less than 1.5% level for RON91 adulteration, the method should be changed to a much simpler, more rapid and more sensitive method to detect the presence of one petroleum product in another [36].

Besides that, another method that can be used to detect adulteration is using the distillation curves combined with PCA (Principal Component Analysis) and PLS-DA (Partial Least Squares Discriminant Analysis) [37]. The authors proved that by using this method, a model is produced which has a good sensitivity to distinguish between adulterated and unadulterated gasoline fuel samples. By using this method, various assays are not required, hence the analytical process can be sped up. This is due to the possibility to apply the results of the distillation curves to routine analysis (ASTM D86), therefore not requiring various assays, speeding up the analytical process.

2.6 On-Board Diagnostic (OBD) Systems

OBD systems were developed to monitor and diagnose electric component problems as the engines become more complex. OBD monitors certain engine components that provide vehicle operational information and it is an additional computer software that also monitors the emission control and emission-related components/systems. To make it short, OBD is a system that enables the ECU of the car to communicate with external electronic devices. With these features, the presence of a malfunction or deterioration which will affect the emissions can be determined. Hence, an OBD is made up of the combinations of the malfunction indicator lamp (MIL) on the dashboard, the various emission control and the diagnostic computer software. Devices that connect to OBD-II have been used widely to store driving information data [38]. However, the weakness is that the information received by the devices from the OBD-II network is unique.

CHAPTER 3

METHODOLOGY

3.1 Overview

In this chapter, the methodology discussed consists of (i) experimental method; (ii) experimental equipment and tools. The methodology applied for this experiment is discussed in details and the required information of the equipment and tool used in this experiment is also discussed.

3.2 Test Procedure

The apparatus to be used are set up in accordance in Figure 3.1.

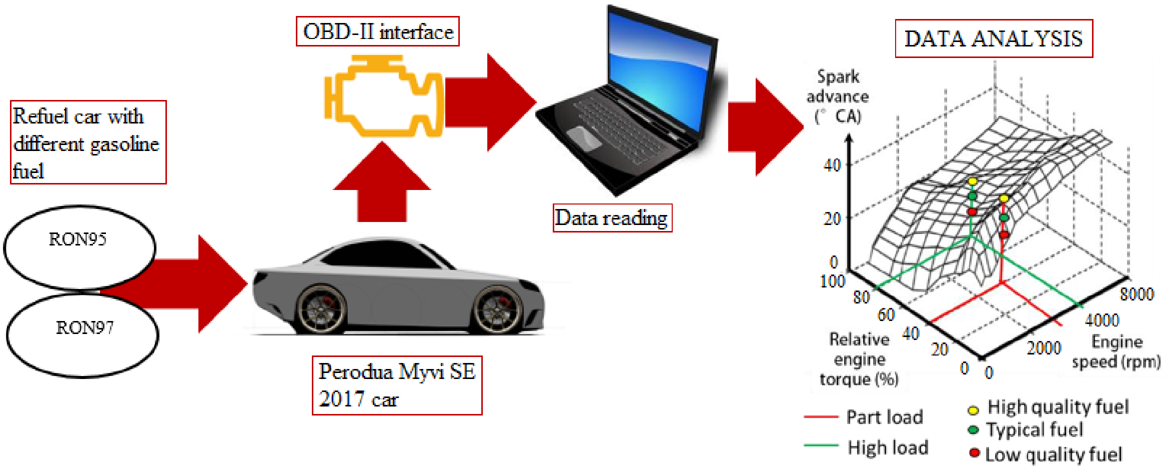


Figure 3.1: Apparatus setup in different stages

Firstly, a Perodua Myvi SE 2017 car with an OBD port is used for this experiment. Then the car will be refuelled with the different RON of gasoline fuel from the different available gas station in Parit Buntar town which are Caltex, Petron, PETRONAS and Shell. The name of the gasoline fuel stations, the date the car is refuelled, the RON of gasoline fuel used and the volume of gasoline fuel refuelled are recorded. After that, a laptop with a pre-setup LabVIEW system is then switched on inside the car. This LabVIEW system is the system that will read the data produced by the vehicle as it is driven around the town. It acts as the medium that collects and interprets data from the ECU of the car. The vehicle is then driven around the town with a city-driving style at a radius of 50km from the campus. The USB port of the laptop will be connected with the OBD-II port of the vehicle via the OBD-II connector. The data read will be stored inside the laptop. Then, the data will be processed and analysed to determine the performance of the vehicle which is done by measuring spark advance under a certain engine operating conditions (i.e. low engine speed and high load) in which the knock might be expected to occur. The data is then interpreted into a 3-D graph using MATLAB analysis. The stages of the experiment are shown in Figure 3.1. Besides that, the actual RON of the gasoline fuel will be tested using SHATOX SX-200 portable octane tester. Some correlation can be observed by comparing the spark advance data with the octane tester.

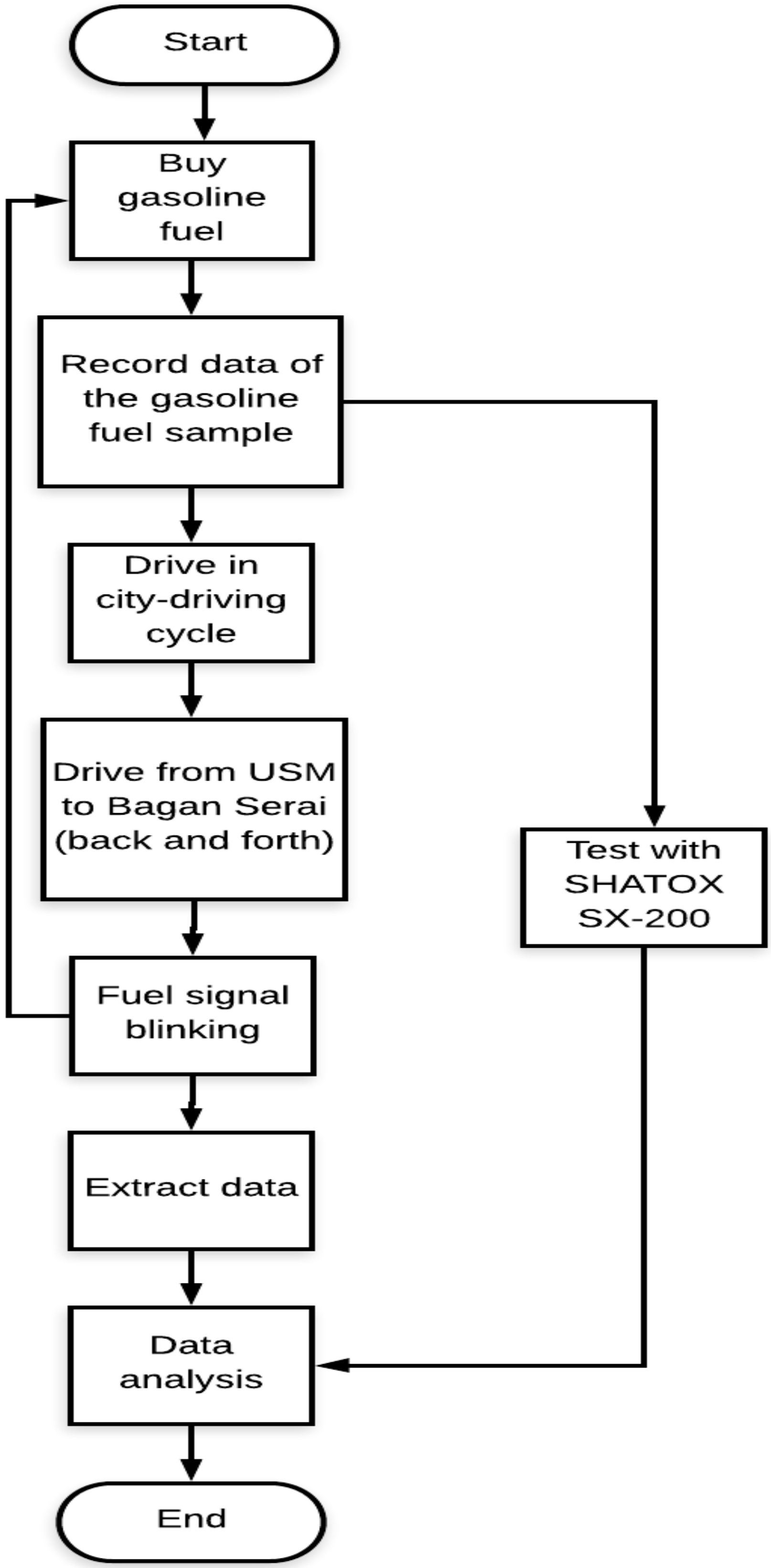


Figure 3.2: Flow chart of the experimental methodology

3.3 Experimental Equipment and Tools

The most important equipment in this experiment is the Perodua Myvi SE 2017. This vehicle has been used to test the performance after refuelling with the different types of the gasoline fuels. The vehicle that is used for this experiment has already travelled exceeding 20,000 km. The Table 3.1 below showed the basic specifications of the Perodua Myvi SE 2017 as obtained from Perodua website.

Table 3.1: Perodua Myvi SE 2017 Specifications obtained from [39]

Powertrain			
Engine Tech		16-valve DOHC, naturally-aspirated with variable valve timing	
Capacity	1,495 cc	Horsepower	102 hp at 6,000 rpm
Arrangement	Inline 4	Torque	136 Nm at 4,400 rpm
Bore x Stroke	72 mm x 91.8 mm	Compression Ratio	10:1
Fuel	Petrol		
Drivetrain			
Type	Conventional Automatic	Transmission Name	4E-AT
Ratios	4	Manufacturer	Akashi Kikai
Driveline		Front Wheel Drive	
Performance and Efficiency			
Rated Economy		6.5 L/ 100km (Internal)	

Besides having the vehicle, the SHATOX SX-200 portable octane tester is also one of the most important equipment in this experiment. This device determines the Pump Octane Number (AKI), RON and MON of the tested gasoline fuels. It displays the results in less than 20 seconds. It functions by using near-infrared (NIR) transmission spectroscopy utilizing 14 near-infrared emitting diodes with narrow bandpass filters, a silicon detector system, and a fully integrated microprocessor. To operate this device, the analyser should first be pre-calibrated before proceeding with these required three steps which are:

1. Sampling a background signal
2. Acquiring two absorption spectra of the gasoline fuel sample
3. Acquiring a second background signal

The analyser is small, lightweight, and operates on "AA" batteries or AC. Before each reading, the unit standardizes itself to assure accuracy. The octane number is printed with time and date on the built-in printer. The SHATOX SX-200 portable octane tester is shown in Figure 3.3.

Figure 3.3: SHATOX SX-200

The components of the SHATOX SX-200 portable octane tester is marked and named as below in Table 3.2.

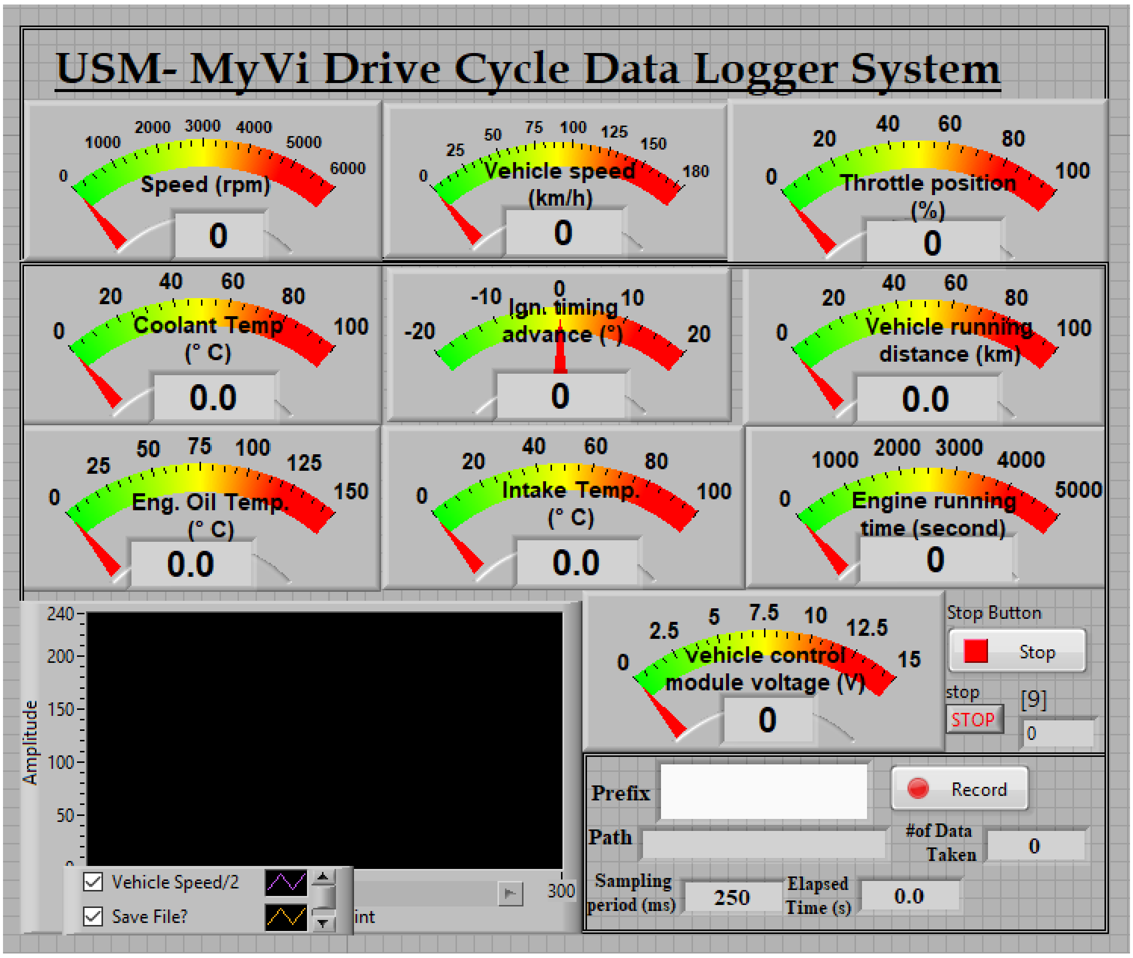
Table 3.2: The components of SHATOX SX-200 portable octane tester and its function

Number	Component	Function
1	Octane meter	Displays gasoline octane numbers by research (RON) and motor (MON) methods and antiknock index AKI (RON+MON)/2 simultaneously
2	RS232 Cable	Connects the octane meter with the octane meter detector
3	Octane meter detector	To be filled with investigated fuel sample

Other than that, the petrol used to refuel the car are also kept inside a fuel bottle. The petrol will then be sent to the engine laboratory in School of Mechanical Engineering to be tested for their quality. The gasoline quality test will be done using SHATOX SX-200 portable octane tester. This test is important to make sure the quality of the gasoline will be tally with the results analysed using MATLAB software. The setup to test the quality of each sample of the gasoline fuel is presented in Figure 3.4.

Figure 3.4: Experimental setup using SHATOX SX-200 portable octane tester

Figure 3.5 shows the setup of the LabVIEW in the laptop that is used to collect data from the ECU of the car. As observed from the setup, there will be 9 types of data that will be recorded and stored in the laptop. The speed of the car as I drive the Myvi car in city-driving style will be recorded in both rpm and km/h units. The throttle position will be recorded in percent. When the accelerator pedal is pushed, the throttle position sensor will monitor the opening of the throttle valve. The throttle position controls the amount of air flow into the intake manifold of the engine. The coolant temperature will be recorded in degree Celsius. The coolant temperature will be measured by the coolant temperature sensor. This sensor will measure the temperature of the coolant in the cooling system. Besides that, the ignition timing advance will be recorded in the unit of degree. The ignition timing changes as we drive and the number of degrees before top dead centre (BTDC) is called advance. Advance increase with the engine speed and decreases as the engine goes under a load. The vehicle running distance in km is also recorded. This is important as we will measure how far the car will be able to travel when petrol fuel is kept constant every time, and hence enable us to determine the performance of the engine's vehicle.



USM- MyVi Drive Cycle Data Logger System

Speed (rpm) 0

Vehicle speed (km/h) 0

Throttle position (%) 0

Coolant Temp (° C) 0.0

Ign. timing advance (°) 0

Vehicle running distance (km) 0.0

Eng. Oil Temp. (° C) 0.0

Intake Temp. (° C) 0.0

Engine running time (second) 0

Vehicle control module voltage (V) 0

☑ Vehicle Speed/2

☑ Save File?

Prefix

Path

Sampling period (ms) 250

Elapsed Time (s) 0.0

#of Data Taken 0

Figure 3.5: Data collection with LabVIEW program

Figure 3.6 shows the route where the vehicle is driven. The route is marked with blue colour line. During the experiment, the vehicle travelled 23 km per way. Hence, per experiment, the vehicle travelled 46 km in average. Besides that, before driving the car, the LabVIEW is turned on and the record button is clicked to make sure that the data is recorded. As the car is driven, the meters in the LabVIEW setup can be seen moving and tally with the car’s meters. After the experiment is done, stop button is clicked indicating that no more data is going to be collected.

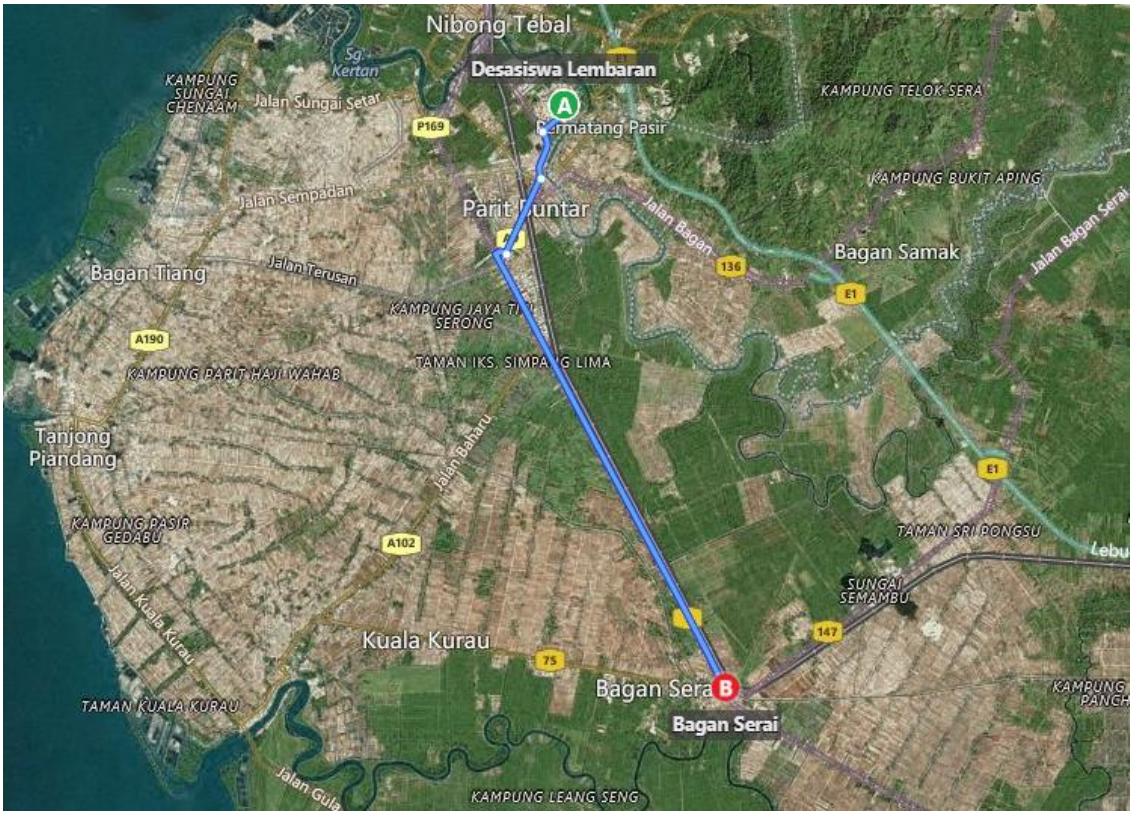


Figure 3.6: The route taken to drive the vehicle

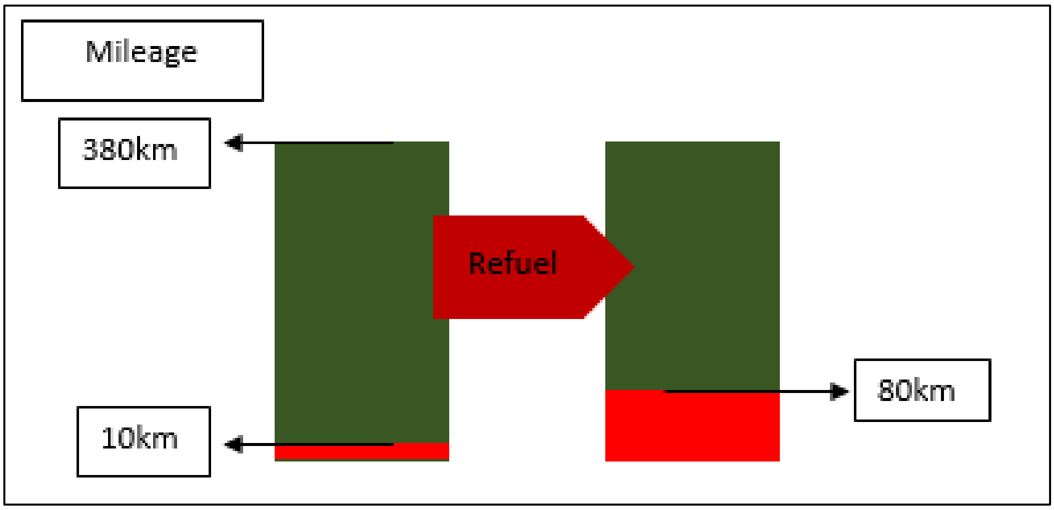


Figure 3.7: Refueling chart

To refuel the car with another petrol, the petrol inside the car is made sure to be the lowest possible amount to drive the car around, where the empty petrol sign would blink. The petrol sign is as circled in white in Figure 3.8 will blink repeatedly. In average, the petrol sign will blink when there is enough petrol to drive another 10km as can be seen in Figure 3.7. The full capacity of a Myvi tank is at the average of 23.75 litres which is equal to the 380km worth of mileage on average. At only 10km mileage, the car is refuelled with another petrol worth of RM10 which is estimated to be 75km in mileage.

Figure 3.8: Speedometer in the Perodua Myvi SE 2017