CHARACTERIZATION OF FUEL ADDITIVE FOR FUEL SAVING AND INJECTOR OPTIMIZATION

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This report is submitted in fulfillment of the requirement for the degree of Bachelor of Mechanical Engineering (Automotive)

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DECLARATION

I declare that this project report entitled "Characterization of Fuel Additive For Fuel Saving And Injector Optimization" is the result of my own work except as cited in the references.

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Date : ....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Automotive).

Signature : ....

Name of Supervisor : **PROF. MADYA DR. NOREFFENDY BIN TAMALDIN**

Date : ....

DEDICATION

Especially for my beloved mother, father and family

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ABSTRACT

V1 Booster is a fuel additive product that developed for consumers to get high quality fuel at a lower cost. This product contains 55% of Palm Olein and 45% additive formulated from R&D with the combination of nanobiotechnology from Germany. Based on the information obtained from the supplier and website, V1 Booster is functioning as a fuel saver and can improve the engine performance with less emission produced. The objectives of this experiment are to study the properties of V1 Booster and the influence of this additives on engine performance and emission release. Then, to provide a complete analysis of fuel consumption by the engine before and after using V1 Booster. The V1 Booster is tested into RON 95 and RON 97. The method used in this project is Hydrometer to measure the density, Oxygen Bomb Calorimeter to obtain energy content, engine dynamometer to analyze power, torque and brake specific fuel consumption (bsfc) and Emission Gas Analyzer to measure emission level. The result shows the density is increase after added with V1 Booster. While the energy is increase after additives is added into RON 95 but decrease for RON 97. The engine test shows the V1 Booster increase the power and torque from 2000 rpm until 3000 rpm. However, after 3000 rpm, the difference after use the additives is slightly same from the baseline RON 95 and 97 and when engine travel at high speed it performance decrease compare to the baseline petrol. It same goes to brake specific fuel consumption (BSFC). The added of V1 Booster can reduce the fuel consumption maximum about 5% for RON 95 and 22% for RON 97. But, when travel at high engine speed the V1 Booster is not saving anymore. Therefore, the use of V1 Booster is effective for low engine speed or below 3000 rpm. After 3000 rpm until the maximum 6000 rpm of engine speed, the effectiveness of V1 Booster is starting to decrease and not fixed.

ABSTRAK

V1 Booster adalah produk aditif bahan api yang dibangunkan untuk pengguna mendapatkan bahan api berkualiti tinggi pada kos yang lebih rendah. Produk ini mengandungi 55% daripada Minyak Sawit Olein dan 45% bahan aditif dirumuskan daripada R&D dengan kombinasi nanobioteknologi dari Jerman. Berdasarkan maklumat yang diperoleh daripada pembekal dan laman web, V1 Booster berfungsi sebagai penjimat bahan api dan boleh meningkatkan prestasi enjin dengan pelepasan asap dapat dikurangkan. Objektif eksperimen ini adalah untuk mengkaji sifat-sifat V1 Booster dan pengaruh aditif ini terhadap prestasi enjin dan pelepasan asap. Kemudian, menyediakan analisis lengkap penggunaan bahan api oleh enjin sebelum dan selepas menggunakan V1 Booster. V1 Booster ini diuji ke RON 95 dan RON 97. Kaedah yang digunakan dalam projek ini adalah alat Hidrometer untuk mengukur ketumpatan, Oksigen Bomb Kalorimeter untuk mendapatkan kandungan tenaga, enjin dinamometer untuk menganalisis kuasa, tork dan penggunaan bahan bakar khusus brek (bsfc) dan Pelepasan Gas Analyzer untuk mengukur tahap pelepasan asap. Hasilnya menunjukkan ketumpatan meningkat selepas ditambah dengan V1 Booster. Manakala tenaga juga meningkat selepas bahan aditif ini ditambah ke dalam RON 95 tetapi berkurangan bagi RON 97. Ujian enjin menunjukkan V1 Booster meningkatkan kuasa dan tork dari 2000 rpm sehingga 3000 rpm. Walau bagaimanapun, selepas 3000 rpm, perbezaan selepas penggunaan aditif cuma sedikit dari garis dasar RON 95 dan 97 dan apabila enjin berfungsi pada kelajuan tinggi prestasi ia menurun berbanding dengan garis dasar petrol. Begitu juga dengan bahan bakar khusus brek (BSFC). Apabila ditambah V1 Booster ia boleh mengurangkan penggunaan bahan bakar maksimum kira-kira 5% untuk RON 95 dan 22% untuk RON 97. Tetapi, apabila enjin berkelajuan tinggi Booster V1 itu tidak lagi menjimatkan. Oleh itu, penggunaan V1 Booster berkesan untuk enjin berkelajuan rendah atau di bawah 3000 rpm. Selepas 3000 rpm sehingga maksimum 6000 rpm, keberkesanan V1 Booster terhadap enjin mula berkurangan dan tidak tetap.

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W	=	Engine power
W_b	=	Brake power
Vd	=	Displacement volume
n	=	Number of revolution per cycle
N	=	Number of revolution per minute(RPM)
Nc	=	Number of cylinder
B	=	Bore size
S	=	Stroke size
$\dot{m}_f$	=	Mass flow rate of fuel
$\dot{m}_a$	=	Mass flow rate of air
ρa	=	Air density evaluated at atmospheric conditions outside the engine
η_f	=	Fuel conversion efficiency
η_c	=	Combustion efficiency
A_p	=	Piston area
mep	=	Mean effective pressure
$bmep$	=	Brake mean effective pressure
$\bar{U}_p$	=	Piston speed
T	=	Torque (Nm)
P	=	Power (kW)

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

For many decades, fuel additives have played a major role in improving engine performance and quality of fuels for use in motor vehicles, transportation, aircraft and marine vessels. Fuel additives are chemical substance or preparation added to fuel, in concentrations typically less than 1%, to impart or enhance desirable properties or to suppress undesirable properties. Some examples include combustion improvers, detergents, cold flow additives and lubricity additives. The petrol fuel additives began to be commercially introduced in 1923 to provide the octane rating needed to enable vehicle designers to increase engine compression ratios to levels which gave acceptable efficiency and performance. During 1950 and 1960, the focus of additives use was changed to automotive fuel system, because the carburetor cleanliness and efficient operation became more important. In 1980s, the used of deposit control additives rapidly increase because of emissions problem cause by the deposits and to reduce deposit build-up within the engine inlet system. Since 1923 until today, different additives and additives package have been developed and produced because of the need for petrol fuel has grown, for economic as well as legislative reasons (ATC, 2013).

For economic reasons, in the refining process, usable fuel oil is extracted from the crude oil. Crude oil reserved is limited, but the oil consumption rate is increasing continuously at an alarming rate. Reducing fuel consumption can lower expensive fuel imports and give positive impact to domestic cost balance. Nowadays, modern gasoline or petrol fuels contain more olefins and aromatics. These olefins and aromatics may worsen engine cleanliness and also increase engine deposits that lead to less stable combustion. Additives are added as a means of stabilizing and improving these fuels, bringing them to the required regulated standards (B.Duboc, 2014).

Legislation has been a major influence on the additives market in the past few years. Because of climate change and air quality have become the serious issue, there are many countries focusing on reducing emission and improving air quality. The government released the requirements to limit the emissions of carbon monoxide (CO), nitrous oxides (NO_x) and encourage the use of additives in diesel and petrol fuel. The United States was the first country to mandate the use of deposit control in its gasoline. This directive was specifically introduced to reduce emissions in United States as the test carry out by EPA clearly shows the link between deposit control and emissions. The use of deposit control additives will improve the efficiency of the engine and produce environmentally friendly vehicles (AFTON, 2015).

1.2 PROBLEM STATEMENT

Nowadays, consumers are looking for simple and inexpensive ways to lower the cost of driving. The market has responded with a plenty of devices and fuel additive products which claim to improve fuel economy and reduce emissions. There are many advertisements about using the energy from the car's battery to split water molecules into hydrogen and oxygen gas which is then burned with the fuel. Besides that, there also devices that heat, magnetize, ionize or add metals to vehicle's fuel lines and capable to increase fuel economy and reduce exhaust emissions. Furthermore, several heavily marketed devices claim to increase the fuel efficiency by creating aerodynamic properties or turbulence that improves the air-fuel mix before to combustion. One of the fuel additives brand in Malaysia is V1 Fuel Booster as shown in Figure 1.1. This fuel additive was advertised to improve fuel economy, reduce exhaust emission and keep the cleanliness of the engine as shown in Figure 1.2. However, there are still not clear analysis and no technical report to support and prove the claims.

Figure 1.1: V1 Fuel Booster

Figure 1.2: Advertisement of V1 Fuel Booster

1.3 OBJECTIVES

The objectives of this project are as follows:

1. To study the properties of V1 Booster in term of density and energy content.
2. To investigate the influence of V1 Booster fuel additive on the engine performance and emission level of Spark Ignition gasoline engine.
3. To provide a complete analysis of fuel consumption before and after using V1 Booster fuel additive.

1.4 SCOPE OF PROJECT

The scopes of this project are:

1. This project use V1 Booster as fuel additive and tested on Petronas RON 95 and 97.
2. This project involved the analysis of engine performance in term of power, torque, and brake specific fuel consumption. The emission produce by the fuel additive will be analysed as well.
3. The engine test is carry out using step test on engine dynamometer from 2000 rpm until 6000 rpm.
4. For emission test, the data obtain at two engine conditions which when engine is idling and at 6000 rpm.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Due to the competitive nature in the market, the information on the specific contents and compositions of the additives are kept confidential by the manufacturer. Only some general knowledge of additive compositions can be obtained from the patents of additive groups. The general methods of operation for the additives such as combustion improvers, fuel savers and clean emission are often known. However, the specific effects of the additives on the combustion process and efficiency of the engine are rarely available in the open literature.

2.2 FUEL ADDITIVES

In automotive field, the combustion of petroleum-based fuel in motor vehicle is a source to the emission that contains particulate and gaseous pollutants to the environment. The Clean Air Act that amended in 1970, Section 211, has recognized the potential health hazard in the combustion products from fuels and fuel additives.

This act has empowered the Environmental Protection Agency (EPA) to require manufacturers of fuel and fuel additives to register their products (Jungers et al., 1975).

The additives in the fuel have multifunctional acting such as antioxidants, metal deactivators, corrosion inhibitors, and carburetor and valve deposit detergents. These additives also ordinarily act as third party, means used to supplement the additives already present in fuel and may not blended at the refinery (Jungers et al., 1975).

2.2.1 Types of Additives in Market

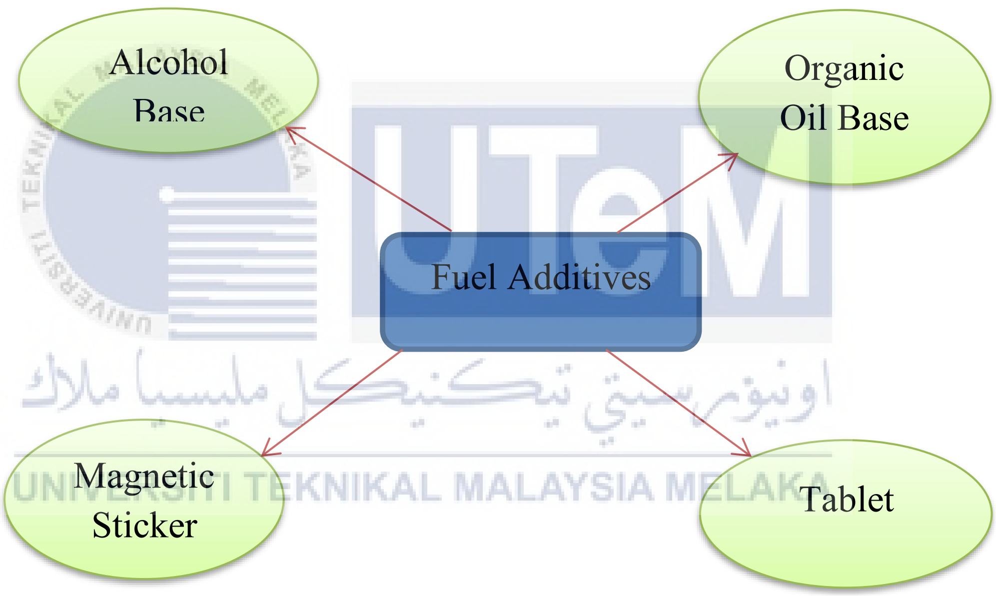

Figure 2.1: Types of Additives in Commercial Market

2.2.2 Elements in Fuel Additives

After the eighteen commercial fuel additives in the market have been analyzed by neutron activation analysis, there are several levels of elements have been found. These elements are Hg, As, V, Mn, Sb, Cr, Zn, Co, Se, Sn, Ag, Al, Fe and Sr as in table 2.1. Apparently, the predominant source of the Sn and Fe in the fuel additives may because of the solder connection in metal container. The intensive use of market additives can lead to environmental trace metal burden and increase the potential for poisoning exhaust catalytic (Jungers et al., 1975).

Table 2.1: Trace Elements in Fuel Additives (Jungers, 1975)

Element	Concentration range, μg/ml	Avg, μg/ml
Hg	<0.0002–0.002	
Cd	<0.02–0.20	
As	<0.001–0.23	
V	<0.001–0.031	
Mn	0.007–2.71	0.16
Ni	<0.013–<0.340	
Sb	<0.0005–0.0041	
Cr	<0.002–0.096	
Zn	0.032–38.0	8.8
Co	<0.0002–0.0360	
Se	<0.001–0.032	
Sn	<0.07–140	
Ag	<0.0003–0.0065	
Al	<0.01–2.30	
Fe	<0.03–560	
Sr	<0.033–37	
Br	<0.014–10	
Cl	0.5–18,200	1,334
Na	<0.01–99	
Ba	<0.02–4.2	
Ca	<17–1,900	
K	<0.7–63	

• 18 samples analyzed by neutron activation (*17*).

2.3 RESEARCH OCTANE NUMBER (RON)

The quality of the petrol is determined by the compositions and the hydrocarbons present in the mixture. Octane number is one of the characteristics in Spark Ignition (SI) engine that indicates the anti-knock of a fuel and depends on the hydrocarbon type. The octane number without additives is called as clear octane number and very dangerous to the environment. Because of this reason, the process such as alkylation have used in the refineries to improve the octane number. The common octane numbers that used in industry are Research Octane Number (RON) and Motor Octane Number (MON). The RON is tested and measured under low speed condition using ASTM D908 while MON is measured under high speed condition using ASTM D357. The lower number of RON used the easier for it to ignite in the engine. Therefore, the fuels with a higher number of RON will eliminate knocking, as it has high compression ratio and gain more power in the engine (Albahri et al., 2002).

2.3.1 Unleaded Petrol (ULP)

The petrol that has a RON number between 91 and 93 are categorized as Unleaded Petrol. Vehicles that use this type of RON need to install the catalytic converter because the gas emitted from the exhaust are high and hazardous to environment.

2.3.2 Premium Unleaded Petrol (PULP)

The Premium Unleaded Petrol is the petrol that has a RON number of 95. This PULP is a special blend of petrol created to bring high octane and knock free performance to unleaded cars. It gives more performance to the engine and run at maximum efficiency.

2.3.3 Ultimate Unleaded Petrol (UUP)

The Ultimate Unleaded Petrol (UUP) has a RON number of 98. This UUP is an advanced performance fuel designed to be better for any type or model of the vehicles. Formulated to clean the engine and reduce exhaust emissions, UUP keep the engine clean, give more performance and less harmful to the environment.

2.3.4 High Performance Petrol (HPP)

The first premium-plus petrol with 100 octane have produced by Petron and also meets the European fuel quality standard compatible with Euro 4 vehicle technology. The Petron Blaze 100 Euro 4 has extremely high octane in petrol and extraordinary engine cleaning capability to provide the powerful performance to the car. This HHP also contains organic combustion enhancer and friction modifier to provide the fuel operates efficiently. Therefore, the new Petron Blaze 100 Euro 4 is formulated to meet the European specification for cleaner, make it environment-friendly fuel.

2.4 SPRAY CHARACTERISTICS

The fuel spray and atomization play an important role to the performance and emission characteristic of the engine. The air-fuel mixture formation in the combustion chamber is affected by the characteristic of the fuel spray. The main parts of fuel spray characteristic are fuel injection pressure, cone angle, spray length and droplet size distribution. The higher fuel injection pressures encourage the engine for better fuel atomization and combustion characteristics. It also gives advantageous in terms of uniform distribution of droplets. However, the spray penetration should not hit the walls of cylinder as it may cause the problem of wall wetting and leads to uncountable loss (Prabhakara et al., 2015).

Spray cone angle is how wide the spray distribution as it comes out from the injector nozzle and penetrates the combustion chamber (Duboc, 2014). The spray has a very high velocity (typically 100 m/s) as it comes out from the injector and slowing down as the spray moves away from the nozzle. When the spray spreads out and mixing with the air gradually, the velocity reduces and the spray diverges more, as it penetrates into the combustion chamber. The spray has very high concentration of fuel in the middle and low concentration of fuel at the edges. The average range of the cone angle is 10-25˚ and if the cone angle is narrow, the spray will be denser and more localized. Therefore, narrow spray cone angle is better for the better combustion and performance.

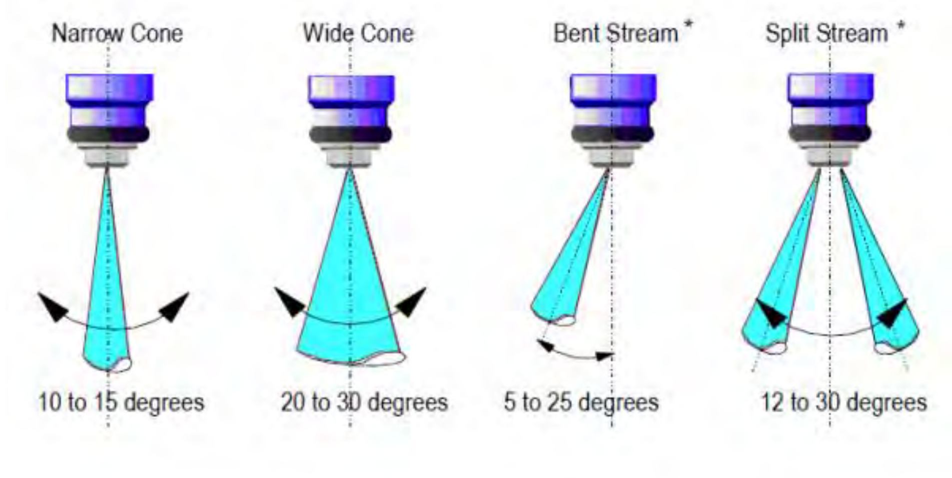

Figure 2.2: Types of spray cone angle

(Source: www.nsxprime.com)

Spray length or penetration length is the distance required for the fuel at the tip to become fully vaporized. If the spray is too long, it could impinge on and wet the piston wall which lead to instability combustion, drop the engine efficiency and increase the exhaust emissions, particularly unburnt hydrocarbons and particulates. However, if the spray is too short, it would provide insufficient mixing between the injected fuel and available air, which increasing the equivalent ratio in the combustion chamber. This has a negative impact on engine fuel efficiency and pollutant emissions.

The other characteristic of fuel spray is droplet size distribution. The literature agrees that the droplet size distribution usually measured as histogram and have single mode normal distribution (bell shaped) or bi-modal. In order to analyze the data of different spray, the droplets are assuming as the spherical. The diameters of the droplets are divided with the number of droplets to obtain the average of droplet size. However, this is not a useful average as it only controlled by the small droplets with the larger droplets are not represented well whereas those larger droplets are important as well because it hold much of the spray. Therefore, the Sauter mean diameter (SMD) is used. SMD is the diameter of the droplet that has same volume to surface area ratio of the total spray (Heywood, 1977). The SMD is often preferred mean value because the surface area is an important parameter controlling evaporation of the spray.

2.5 INTERNAL COMBUSTION ENGINE

The purpose of the engine is to convert heat into mechanical motion so that the car can move. Currently, the gasoline and diesel are use as the fuel to burn inside the engine and create motion. However, there are different types of internal combustion engine between gasoline engine and diesel engine. The gasoline engine generally use spark ignition (SI) while the diesel engine use compression ignition (CI). Basically, the working principle for SI and CI engines are practically the same, but the different is the process of the fuel combustion that occurs in both engines.

In SI engines, the spark plug located at the cylinder head will generate the spark to burn the fuel. The fuel compressed to high pressure and the combustion take place at a constant volume. While, in CI engines, the excessively high pressure in the cylinder makes the engine does not require any spark to initiate the ignition and burn the fuel. The combustion of fuel in the cylinder occurs at constant pressure for this case.

Mostly, the cars that use SI engine work on the principal of four-stroke combustion cycle to convert gasoline into motion. This four-stroke process was invented by Nikolaus Otto in 1867 and also known as the Otto cycle. The four strokes are intake stroke, compression stroke, combustion stroke and exhaust stroke (Marshall, 2000). The engine needs to go through this four-stroke principal to complete one combustion cycle.

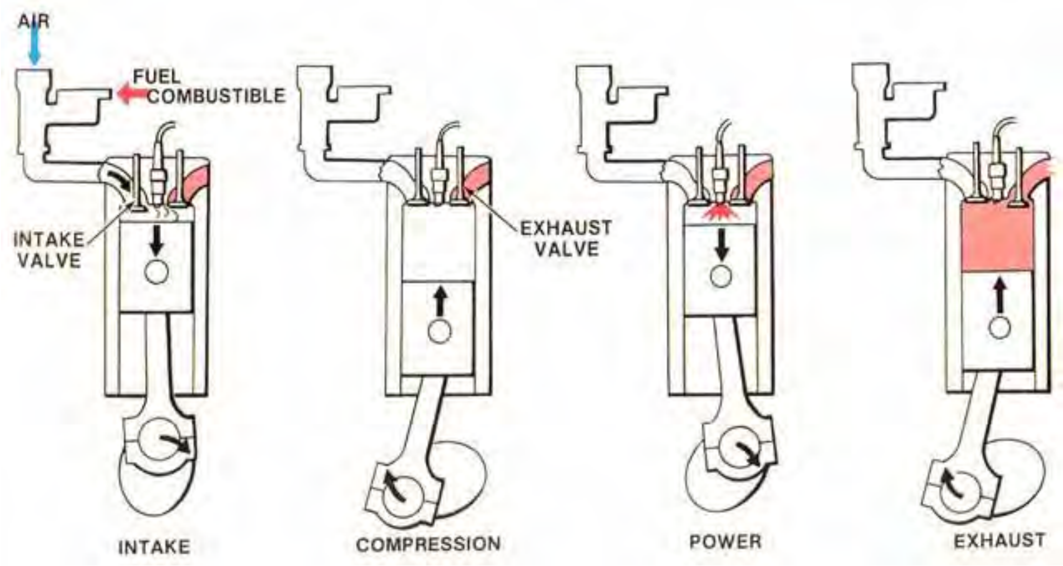

Figure 2.3: The process of four stroke cycle (AMSOIL, 2001)

Intake Stroke:

This process starts with the piston at the top, the intake valve opens and the piston moves down to let the air and gasoline enter the cylinder. Only the tiniest drop of gasoline needs to be mixed into the air.

Compression Stroke:

Then, the piston moves back upward to compress the fuel/air mixture. The compression process makes the explosion inside the cylinder more powerful.

Combustion Stroke:

When the piston reaches the top of its stroke, the spark plug emits spark to ignite the gasoline. The gasoline charge by the spark in the cylinder explodes and drives the piston down.

Exhaust Stroke:

Once the piston hits the bottom of the stroke, the exhaust valve opens and the exhaust leaves the cylinder to go out of the cylinder. Then the engine have completed one cycle of combustion and ready for the next cycle.

2.6 ENGINE PARAMETER

Engine parameters are used to determine and calculate the performance of the engine after running the test on the engine.

2.6.1 Power

The engine power is used to indicate the rate of work of the engine. The unit for power is kilowatt (kW) or horsepower (hp). (1 kW = 1.341 hp)

$$\dot{W} = \frac{WN}{n} \qquad (1)$$

$$\dot{W} = 2\pi N\tau \qquad (2)$$

$$\dot{W} = (1/2n)(mep)(Ap)(\bar{U}p) \quad (3)$$

2.6.2 Torque

The engine torque is used to measure the work done per unit rotations of the crank. It also used to indicate the ability of the engine to do work. The unit for torque is Nm.

$$\tau = bmep.Vd/2\pi n \qquad (4)$$

2.6.3 Brake Specific Fuel Consumption (BSFC)

BSFC is the ratio of the engine fuel consumption to the engine power output. The unit for BSFC is grams of fuel per kilowatt-hour (g/kWh) or pounds of fuel per brake horsepower (lb/bhp). The BSFC is depends on engine load and speed because usually BSFC is poor at low load, maximum load, idling and at high speed.

$$Bsfc = \frac{\dot{m}f}{\dot{W}b} \qquad (5)$$

2.7 TYPES OF EMISSION

Emission is the gas emitted from the exhaust produced because of the combustion of fuel inside the engine. The emission gases release through the exhaust pipe to the atmosphere which contributes to air pollution, greenhouse gases, global warming, acid rain and respiratory problems. The car manufacturers today are working on to develop and produce the cars that have less emission level and environmental friendly. For this reason, the hybrid car and electric vehicle are the choices as the alternative ways to zero emissions in the future.

2.7.1 Hydrocarbon (HC)

Hydrocarbon is the chemical compound that made up from chemical bonding between hydrogen atoms and carbon atoms. The hydrocarbon compound has different types in the gasoline, depending on the number of hydrogen and atom present, and also the way of these atoms is bonded. The hydrocarbons in gasoline inside the engine will not burn unless they are mixed with air. Therefore, when the combustion does not take place at all, the large amounts of hydrocarbons will emit through the exhaust (Dzulkifli et al, 2012).

Causes of hydrocarbons emissions are:

a) Improper ignition timing
b) Defective ignition components
c) Defective air injection components

2.7.2 Carbon Monoxide (CO)

Carbon Monoxide (CO) is forms when the carbon atoms bond with one oxygen atom. It produced from incomplete combustion and partially burned fuel in the combustion chamber. This happened when the air/fuel mixture does not have enough oxygen present during the combustion (Dzulkifli et al, 2012).

Causes of carbon monoxide are:

a) Dirty air filter
b) Faulty oxygen sensor (O_2 sensor)
c) Defective engine coolant temperature sensor (ECT sensor)

2.7.3 Nitrogen Oxides (NO_x)

Nitrogen Oxides (NO_x) is made up from nitrogen reacts with oxygen. During the combustion process, the cylinder produce high temperatures and pressure which resulting the form of Nitrogen Oxides (Dzulkifli et al, 2012).

Causes of nitrogen oxides are:

a) Defective Exhaust Gas Recirculation System (EGR)
b) Defective Catalytic Converter (CAT)
c) Engine overheating

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter describes the method used in this project to obtain the data and achieve the objectives of this project. Besides that, this is also the guidelines to accomplish the project. The flow chart of the project is shown in Figure 3.1. This project start by studying the properties of RON Petrol added with V1 Booster in terms of density and energy content. Then, this project continues with the testing using engine dynamometer to obtain the performance of the engine. The gases emit from the engine also been test using Automobile Gas Analyzer. Lastly, the main important part in this project is to analyze the fuel consumption before and after the petrol add with the additive.

3.2 PROJECT FLOW CHART

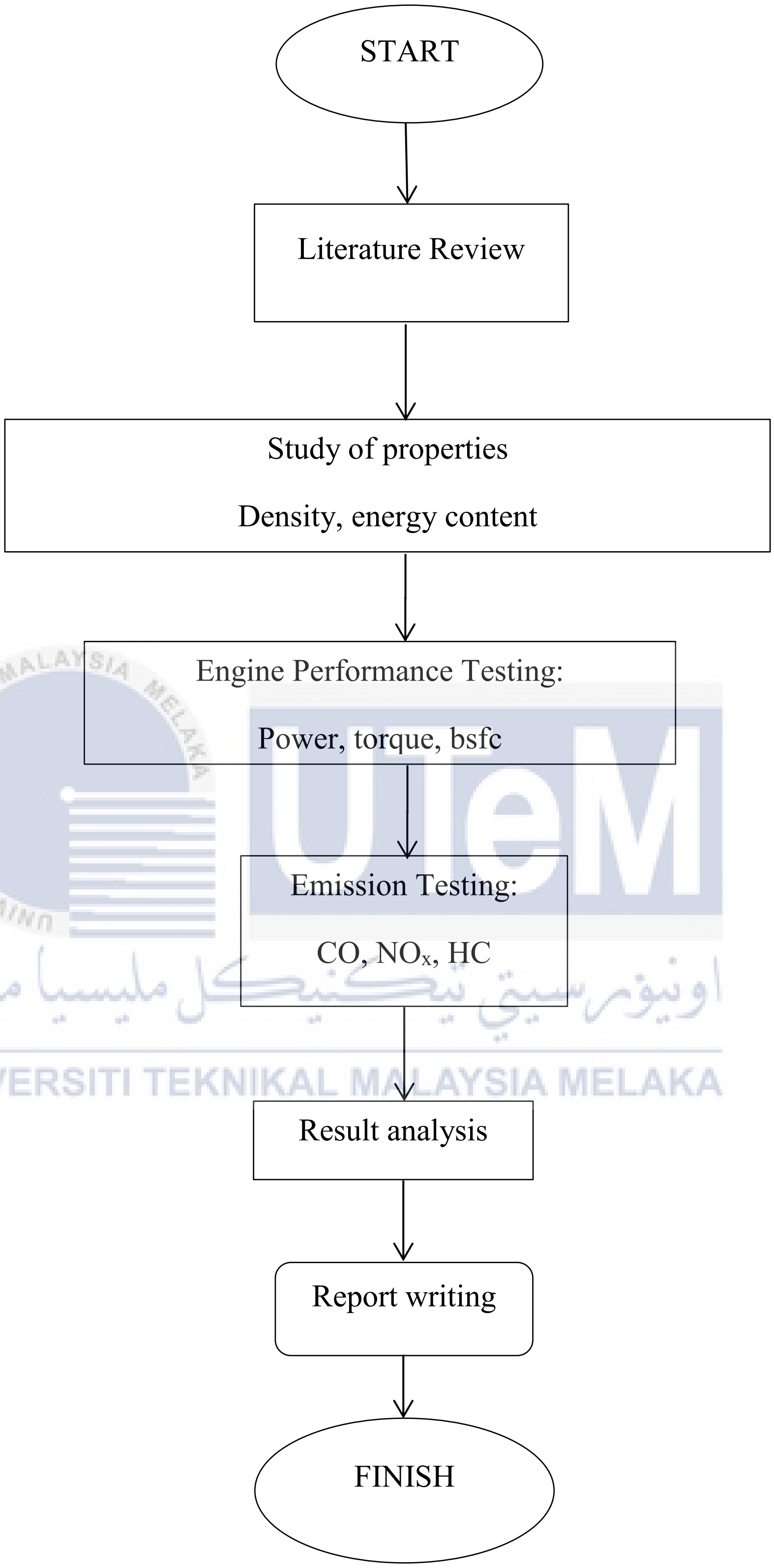

Figure 3.1: Flow chart of methodology.

3.3 EXPERIMENTAL METHOD

This section will discuss on the types of testing use in this project. There are three types of testing that been carry out. Firstly, is the testing to study the properties of fuel additives. Second is the testing to measure the performance of the engine. Third is the testing to measure the emission from the engine.

3.3.1 Properties of Fuel Additives

In this section, three experiments will be carrying out to study the properties of V1 Booster as fuel additive. This fuel additive will be added into two different grades of RON fuel which are Petronas RON 95 and Petronas RON 97. The experiment starts with the testing on Hydrometer to identify the relative density of the petrol. Then, the experiment will carry out using the oxygen bomb calorimeter to identify the energy content of the fuel added with additive.

3.3.1.1 Hydrometer

Hydrometer is an instrument that measures the relative density of the liquid. It is made of clear glass and is most often approximately 8 inches long (standard size). Hydrometers are primarily used to determine the density of an unknown liquid.

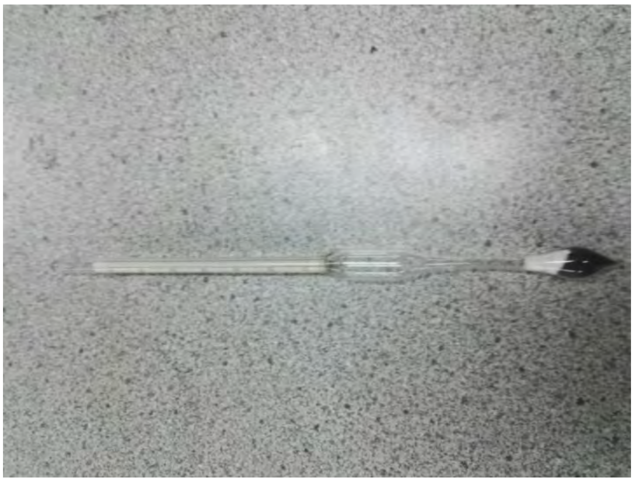

Figure 3.2: Hydrometer

3.3.1.2 Working Principle for Hydrometer

The hydrometer operates on Archimedes Principle. Archimedes, an ancient Greek mathematician, discovered that when a body lighter than a fluid is placed in that fluid, the fluid displaced by the body will equal the volume of the body as well as the mass or weight of the body. This principle is better known as buoyancy. Hydrometers consist of two parts: a stem and a bulb shown in Figure 3.3. The slender tube above the larger tube is the stem. It is hollow glass with a rounded end. The straight, cylindrical stem is calibrated by which the density or specific gravity of the test liquid is measured. The stem ends as the glass cylinder enlarges into the bulb. The bulb consists of 2 parts: the ballast and the glass bead. As the hollow bulb enlarges from the stem, its diameter increases, stabilizes, and rounds at its end in the shape of a hemisphere. This rounded end contains the ballast (small steel spheres) inside, at the end of the bulb. The small spheres are held in place by epoxy. The ballast weights the hydrometer in the liquid. Attached to the outside of the hydrometer, at the end of the bulb, is a small, glass bead. This glass bead serves to buffer the hydrometer, preventing the bulb from coming into direct contact with the bottom of the liquid's container.

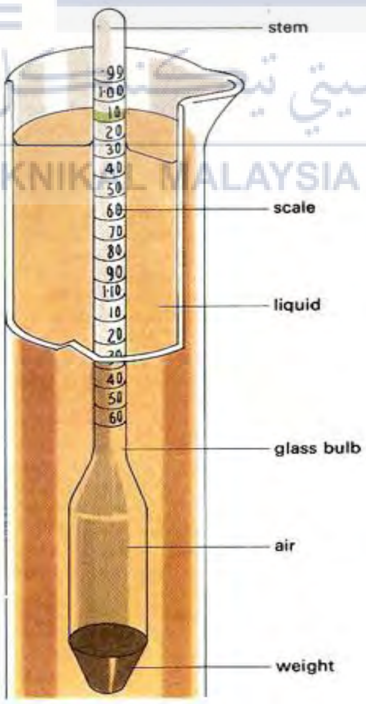

Figure 3.3: Parts of Hydrometer

(Source: www.daviddarling.info)

Procedures:

1. Clean the hydrometer by rinsing it in distilled water.
2. Hold the hydrometer by the stem so that the ballast hangs below.
3. Gradually immerse the bulb into the V1 Fuel booster until the surface level directly contacts the stem.
4. Release the stem gently.
5. Once the hydrometer is balance, read the density.
6. Record the reading.
7. Repeat the step 1 until 6 for three times.

3.3.1.3 Oxygen Bomb Calorimeter

Oxygen Bomb Calorimeter is used to determine the amount of heat released in the combustion reaction, the calorific value and sulphur content of any solid or liquid material and volatile fuels. It is known as the constant volume calorimeter because it holds constant volume and oxygen at given pressure. The sample that needs to be tested and measured is placed in a sealed vessel and ignited at a particular pressure in an atmosphere of oxygen. The resulting rise in temperature is then measured to determine the amount of heat released and energy (MJ/kg) of the sample.

Figure 3.4: Oxygen Bomb Calorimeter

3.3.1.4 Working Principle for Oxygen Bomb Calorimeter

The operating principle for this calorimeter is the same as in all bomb calorimeters. A weighed sample is burned in an oxygen-filled metal bomb while the bomb is held in a measured quantity of water within a thermal insulating jacket. By observing the temperature rise of the water and knowing the energy equivalent of the calorimeter, the amount of heat released from the sample can be calculated. Test results are commonly expressed in calories per gram (cal/g), British thermal units per pound (Btu/lb) or in the large Calorie per gram units commonly used for foods. They may also be expressed in joules per kilogram (J/kg) as used in the SI system of international units.

Procedures:

Preparing the decomposition vessel

1. Unscrew the union nut and remove the cover using the handle.
2. Attach a cotton thread to the center of the ignition wire using a loop.
3. Weigh out the substance of RON added with V1 Fuel Booster directly into the crucible with an accuracy of 0.1 mg. Note the weight using Digital Analytical Balance (see figure 3.5).

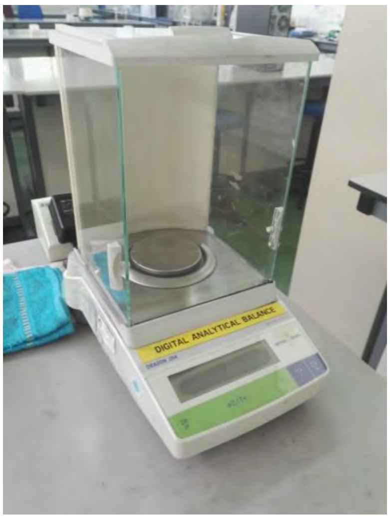

Figure 3.5: Digital Analytical Balance

4. Insert the crucible into the crucible holder.
5. Using tweezers align the cotton thread so that it hangs inside the crucible and is immersed in the sample. This will ensure that the burning thread ignites the sample during the ignition process.
6. Place the cover onto the lower section and push down until it presses against the stop piece in the lower section. Place the union nut onto the lower section and tighten by hand.
7. Fill the decomposition vessel using oxygen station.
8. Place the decomposition vessel into the inner vessel of calorimeter. The decomposition vessel must be placed between the three locating bolts.
9. Pour approximately 2L tap water maintained at a constant temperature between 18-24 °C into the tank using the measuring cup. Keep an eye on the level indicator.

Performing the measurement

1. Close the cover by moving it to the left out of the locking position until it slides down by itself. The decomposition vessel comes into contact with the igniters via the ignition adaptor. The "Fill" message will appear.
2. The inner vessel will be filled with water (approx. 70 s). The measurement process will begin as soon as it is full.
3. The measurement process is fully automatic for automatic measuring procedures. The result will appear once the measuring process is complete (see figure 3.6).

Figure 3.6: Sample result for bomb calorimeter

4. After the measurement open the cover to automatically empty the inner vessel. Remove the decomposition vessel and the ignition adaptor.
5. Open the decomposition vessel and check the crucible for signs of incomplete combustion. If combustion is incomplete, discard the test result. Repeat the test.

3.3.2 Engine Performance Testing

In this section, the experiment will be carrying out to investigate the influence of V1 Booster fuel additives on the engine performance. The V1 Booster fuel additives will be added into two different grades of RON fuel which are PETRONAS RON 95 and PETRONAS RON 97. Then, this mixture will be tested on engine dynamometer to obtain the power, torque, and brake specific fuel consumption (BSFC).

3.3.2.1 Engine Dynamometer

Engine dynamometer is a main method to measure torque, power and brake specific fuel consumption over the engine operating range of speed and load. This engine dynamometer is a perfect way to analyze the engine performance of different RON grades added with the additives.

Figure 3.7: Engine Dynamometer

Figure 3.8: Control Unit of Engine Dynamometer

3.3.2.2 Working Principle for Engine Dynamometer

In an engine dynamometer, water flow, proportional to the desired applied load, creates resistance to the engine. A controlled water flow through the inlet manifold is directed at the center of the rotor in each absorption section. This water is then expelled to the outer dynamometer body by centrifugal force. As it is directed outward, the water is accelerated into pockets on the stationary stator plates where it is decelerated. The continual acceleration and deceleration causes the dynamometer to absorb the power produced by the engine. Through this transfer of energy, the water is heated and discharged.

An integral component of a dynamometer is its data acquisition system. The system is typically consisting of two units, a Control Unit and Workstation, connected by a cable. The Control Unit, a desktop computer operated by Windows-based software, issues commands to the Workstation, a touch-screen operated unit housed in a rugged industrial enclosure. The Workstation operates the precision load and throttle control systems, collects the data, and sends it to the Control Unit to be processed, stored and analyzed.

The Workstation's success, and therefore the data acquisition system's accuracy, depends on its ability to correctly measure data in the dynamometer tests. Central to these measurements is the precision of its pressure transducers, which measure airflow in the intake manifold, oil pressure and other fluid pressures. The operator is interested in different pressures of fluids so having the capability of bringing in different pressures while running the engine is very important.

Procedures:

1. Prepare the testing engine (Mitsubishi MIVEC 1.8L) as shown in figure 3.9. Make sure the engine in good condition.
2. Enter engine parameters into the computer (Model of the engine, speed limit, mass and type of fuel).
3. Connect all data cable at Data Acquisition System port.
4. Put the cooling fan in front of the engine to prevent it from overheating.
5. Enter the sample Fuel A into the fuel tank as shown in figure 3.10.
6. Start testing by ramming the accelerator to the redline limit.
7. Observe and print out the output data.
8. Repeat step 5, use different sample of fuel (Fuel B or Fuel C or Fuel D), analyze the output data.
9. Analyze the graph of horsepower and torque vs. engine RPM and any desire output from computer.
10. Evaluate and describe the relation of the output result from the graph.
11. Each sample of fuel was tested at least three times.
12. Compare and discuss the result data.

Figure 3.9: Mitsubishi Mivec 1.8 Engine

Figure 3.10: Fuel Tank

Table 3.1: Engine specification

Engine Type	**MITSUBISHI MIVEC 1.8**
Description	4G93-DOHC
Number of cylinders	4
Total displacement dm^3	1,834
Cylinder bore mm	81.0
Piston stroke mm	89.0
Compression ratio	10.5:1
Maximum output	103 kW (140 PS; 138 bhp) @ 6,500 rpm
Maximum torque	167 N.m (123 ft.lbf) @ 5500 rpm

3.3.3 Emission Testing

In this section, the experiment will be carrying out to investigate the types of gases release from the engine and which type of fuel sample produced less emission level.

3.3.3.1 Automobile Gas Analyzer

The Automobile Gas Analyzer is a device to measure the level of emission's gases emit from the vehicle by using different type of fuel. This device can only measure three types of emission gasses, which are Hydrocarbon (HC), Carbon Monoxide (CO) and Nitrous Oxide (NO_x). The emission test was conducted in two conditions. First method is the emission test is performing when engine is running at high revolution per minute (RPM). While the second test is performed when engine is in idling condition which low rpm.

Figure 3.11: Automobile Gas Analyzer

Table 3.2: Automobile Exhaust Gas Analyzer Specification

Type	SV-5Q Automobile Exhaust Gas Analyzer
Environmental Temperature	-5 - 40°C
Measurement Scope	1. HC = 0-1000(ppm) 2. CO = 0-10(%) 3. NOx = 0-5000(ppm)
Sampling Method	Directly, Length of sampling tube = 5m, Length of probe = 900 mm
Preheat Times	10 minutes
Weight	15kg
Packing Size	610x500x330 (mm)

Procedures:

1. Switch ON analyser and wait for preheating and ‘Auto Zero’ period.
2. Enter sampling probe into the engine exhaust pipe for auto calibration as shown in figure 3.12.
3. Running the engine at least 15 minutes before make an emission test.
4. Choose a method of the measurement for ‘simple driving condition’.
5. Put cooling fan in front of the engine to avoid from overheating.
6. Press ‘measurement’ button and enter the test name.
7. Make a measurement while engine running on engine dyno or in idle condition until the red limit of rpm.
8. Observe and save manually the data record by pressing upward arrow.
9. Print out the data recorded by using printer built in analyser.

10. Compare and discuss the testing result data for all samples.

11. Each sample was tested at least three times to obtain more accurate result and consistent of data value.

12. The procedure of emission testing should take safety precaution to avoid any undesirable case.

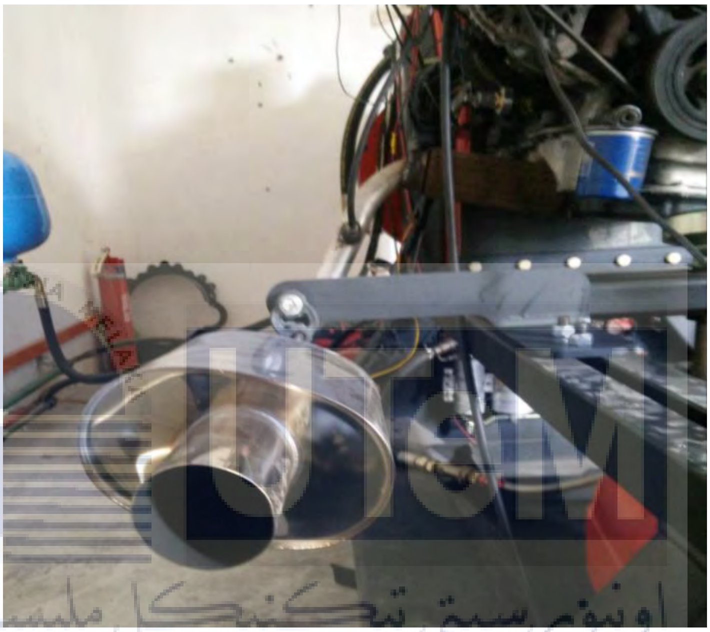

Figure 3.12: Exhaust pipe

3.3.4 Test Matrix for Engine Performance and Emission Test

Table 3.3: Test Matrix for Engine Performance and Emission Testing

Test No	Performance RON95	Emission RON95	Performance RON97	Emission RON97
1	Petronas 95	Petronas 95	Petronas 97	Petronas 97
2	Petronas 95 + V1 Booster	Petronas 95 + V1 Booster	Petronas 97 + V1 Booster	Petronas 97 + V1 Booster

Table 3.4: Comparison Matrix of Fuel RON with Additives

Test	RON 95	RON 97
Engine Performance (Torque, Power, Bsfc)	Petronas 95 vs V1 Booster	Petronas 97 vs V1 Booster
Emission Level (CO,HC,NO_x)	Petronas 95 vs V1 Booster	Petronas 97 vs V1 Booster

Test matrix for engine performance and emission testing as shown in table 3.3 and the comparison matrix of fuel RON with additive as shown in table 3.4. The data and result analysis will be shown on next chapter.

CHAPTER 4

RESULTS AND ANALYSIS

4.1 INTRODUCTION

This chapter will focus on the results obtained from the experimental testing to determine the characteristic, engine performance and emission level produce from Petronas RON 95 and 97 before and after added with V1 Fuel Booster. The detail analysis about characteristic of RON 95, RON 97 and V1 Booster in term of density and energy content will be shown in this chapter. Besides that, the analysis of power, torque, break specific fuel consumption and emission level from engine performance testing also included in this chapter.

4.2 HYDROMETER TEST

Hydrometer is an equipment to measure the density of the liquid. Hydrometer testing have been carried out in the tribology lab at Industrial Campus. The sample of the test must be kept in the refrigerator until the temperature reach 15°C before taking the reading. This is according to ASTM D1298, accurate determination of the density or API gravity of petroleum and its products is necessary for the conversion of measured volumes to volumes at the standard reference temperatures of 15°C or 60°F during custody transfer.

4.2.1 Density Results

Table 4.1: Results of Density

Sample	Density (kg/m^3)
PETRONAS RON 95	750
PETRONAS RON 95 + V1 Booster	755
PETRONAS RON 97	760
PETRONAS RON 97 + V1 Booster	762

4.3 ANALYSIS OF HYDROMETER RESULT

Based on the data recorded in Table 4.1, the result has shown that the relative density of the Petronas RON 95 added with V1 Booster is 0.67% higher than the baseline Petronas RON 95. The density of Petronas RON 97 is also higher when added with V1 Booster with the increasing value is just 0.26% compared to RON 95 with V1 Booster. This is because the V1 Booster contains 55% of Palm Olein which the density of this substance is higher than petrol.

The density of petrol has significant effect on the start of combustion and premixed and diffusion burn peak, which influence the engine performance and emission (Dobovišek, 2009). The fuel economy of vehicles also must consider the density of the petrol in the calculation to get accurate result. This is because the heating value per unit volume for petrol increase with its density. Therefore, the use of V1 Booster will increase the heating value of the petrol and increase the power and torque of the engine.

4.4 OXYGEN BOMB CALORIMETER TEST

Oxygen Bomb Calorimeter is used to determine the amount of heat released in the combustion reaction, the calorific value and Sulphur content of any solid or liquid material and volatile fuels. The resulting rise in temperature is then measured to determine the amount of heat released and energy (MJ/kg) of the sample. The samples that have been tested are Petronas RON 95, Petronas RON 97, Petronas RON 95 with V1 Booster and Petronas 97 with V1 Booster.

4.4.1 Energy Content Results

Table 4.2: Result of Energy Content

Sample	Test	
	Weight (g)	Energy (MJ/kg)
Petronas 95	0.7291	38.720
Petronas 95 + V1 Booster	0.7298	40.460
Petronas 97	0.7270	40.54
Petronas 97 + V1 Booster	0.7298	39.214

4.5 ANALYSIS OF ENERGY CONTENT RESULT

Based on the result tabulated in Table 4.2, the energy content of Petronas RON 95 shows an increasing after added with V1 Booster. Referred to the claim from the V1 Booster, the use of this additive into RON 95 can increase the quality of fuel and increase the performance of RON 95 more than RON 97. Therefore, the experiment has shown that the use of V1 Booster into RON 95 has increase the quality of fuel but it did not reach the performance of RON 97.

However, the energy content for Petronas RON 97 indicates otherwise with slightly decrease of its energy after added with V1 Booster. This shows that the V1 Booster is not suitable to be added into RON 97 because it has decrease the quality of RON 97. Theoretically, when the energy is decreased, the power produced by the engine is also decreased. This is because the unit of energy and unit of power consist of same unit which is Joule. Therefore, the use of V1 Booster into RON 97 is not only lower the energy content but it will also affect the power of the engine.

4.6 ENGINE PERFORMANCE TESTING RESULT

The results of engine performance testing are obtained from the experiment using 500 HP Liquid-Cooled Eddy-Current Engine Dynamometer. The data collected from this experiment are power, torque and brake specific fuel consumption (BSFC) against speed of engine. The engine used in this experiment is 1.8 Mitsubishi Mivec. The data have been collected using step test method when engine was running from 2000 rpm to 6000 rpm with interval at every 500.

4.6.1 Power and Torque Results

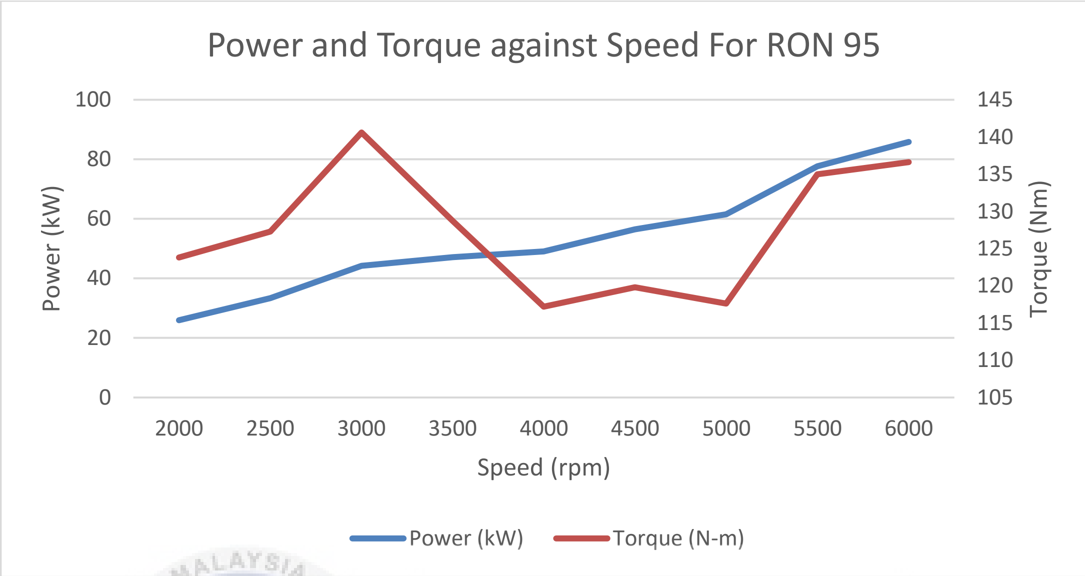

Figure 4.1: Graph of Power and Torque against Speed for RON 95

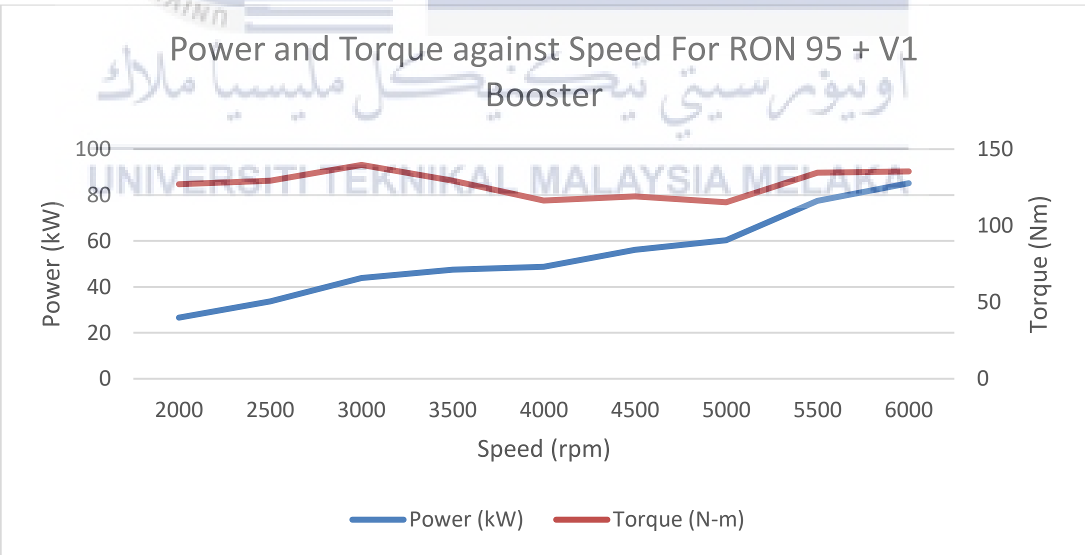

Figure 4.2: Graph of Power and Torque against Speed for RON 95 + V1 Booster

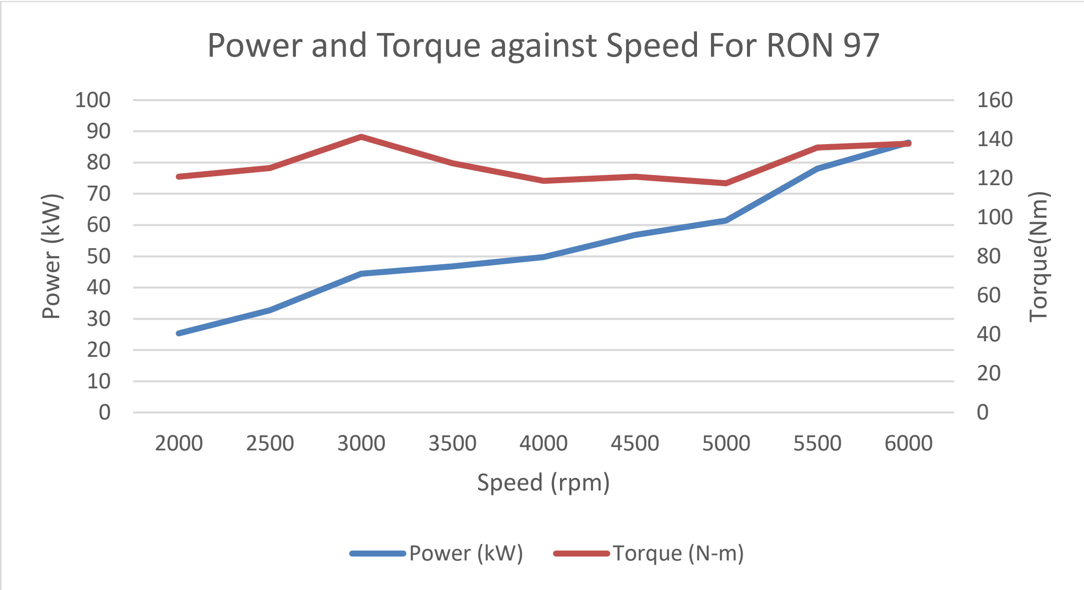

Figure 4.3: Graph of Power and Torque against Speed for RON 97

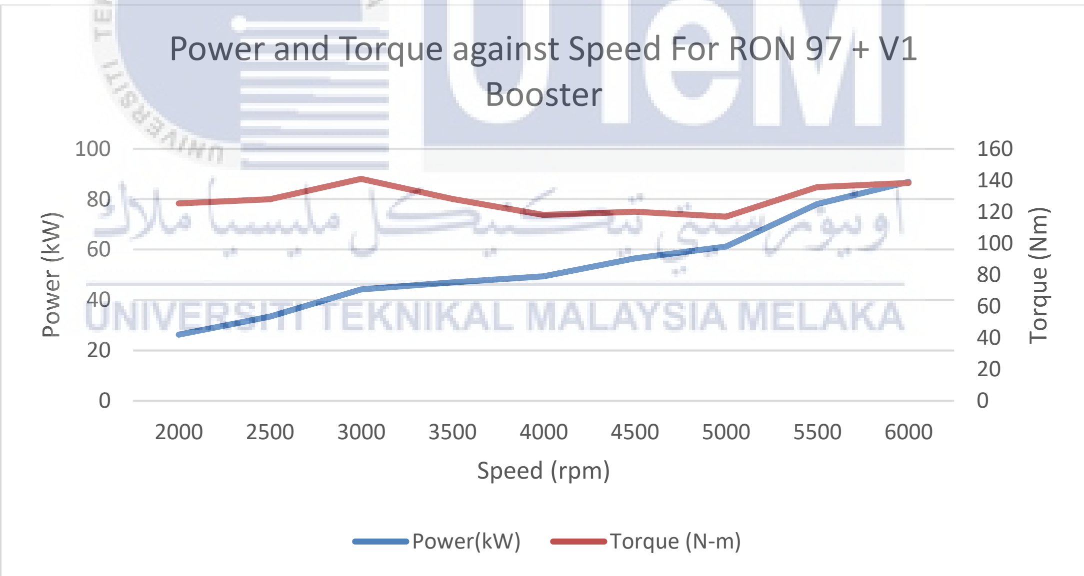

Figure 4.4: Graph of Power and Torque against Speed for RON 97 + V1 Booster

4.6.2 Brake Specific Fuel Consumption (BSFC) Results

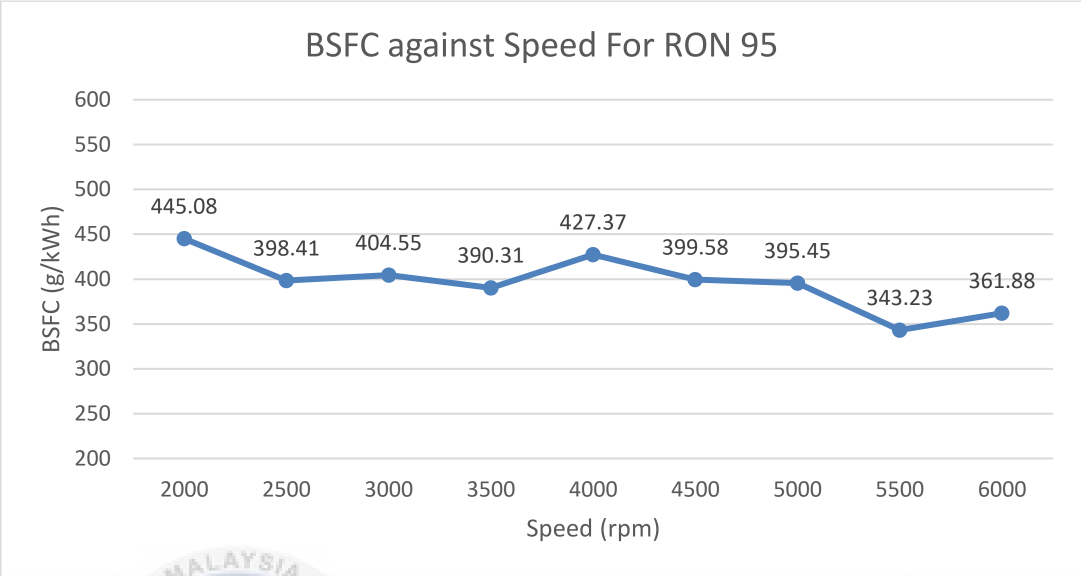

Figure 4.5: Graph of BSFC against Speed for RON 95

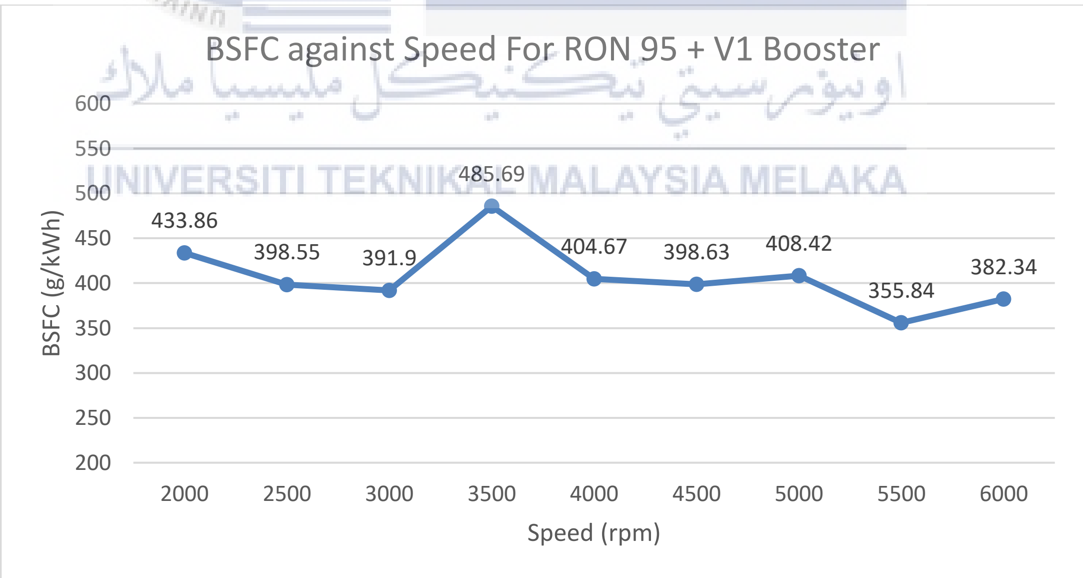

Figure 4.6: Graph of BSFC against Speed for RON 95 added with V1 Booster

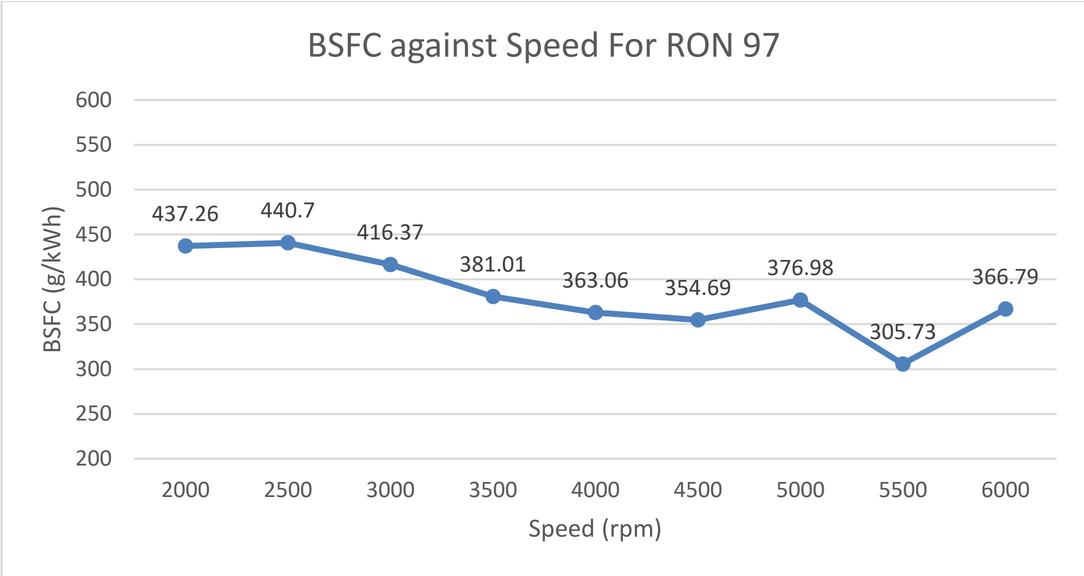

Figure 4.7: Graph of BSFC against Speed for RON 97

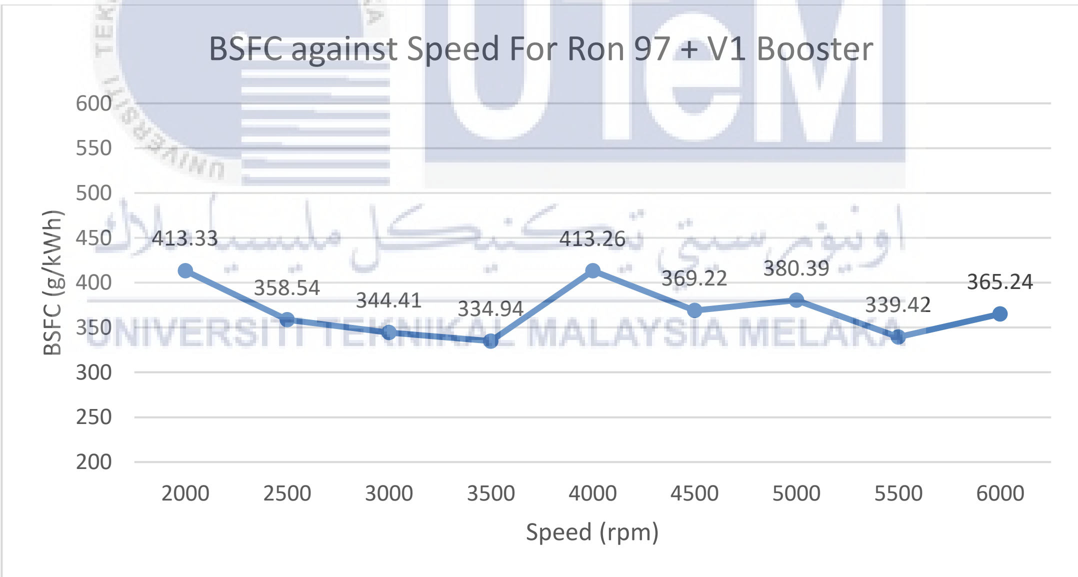

Figure 4.8: Graph of BSFC against Speed for RON 97 added with V1 Booster

4.7 ANALYSIS OF ENGINE PERFORMANCE TEST

The analysis of engine performance is divided into three which are analysis of power, analysis of torque and analysis of brake specific fuel consumption (BSFC).

4.7.1 Analysis of Power

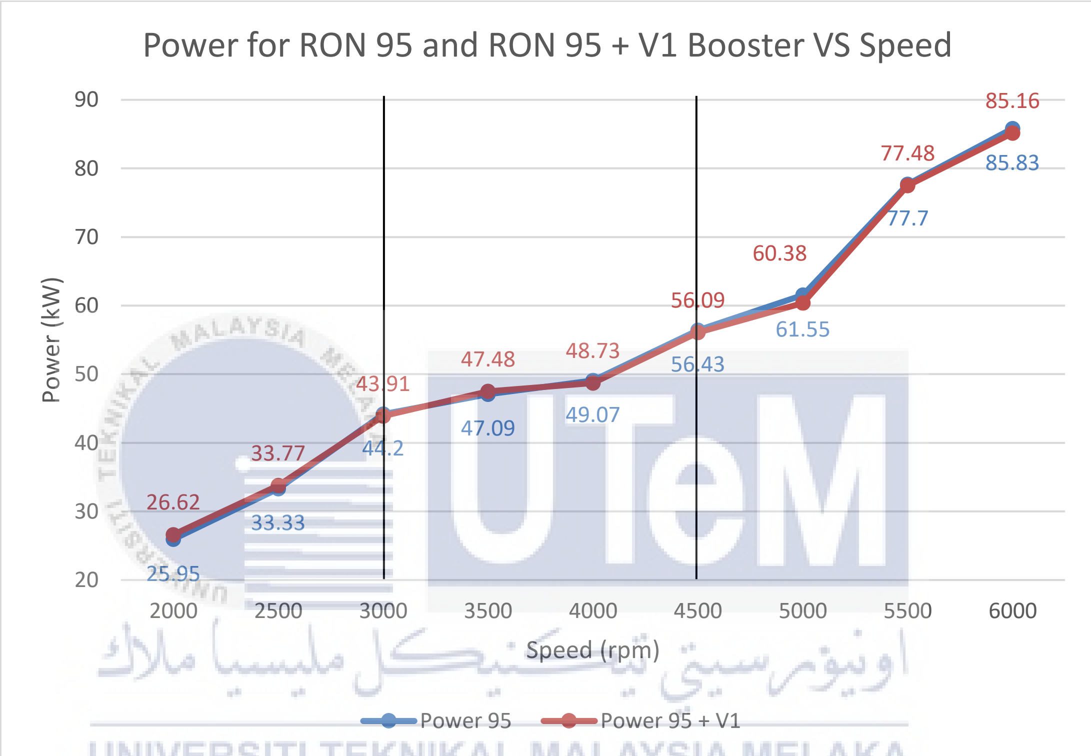

Figure 4.9: Graph of Power for RON 95 and RON 95 added with V1 Booster

Based on Figure 4.9, the graph has shown the behaviour of engine performance for RON 95 and RON 95 added with V1 Booster in term of power. The analysis for the power of the engine have been divided into three regions which are lower speed region, middle speed region and higher speed region. For lower speed region, the range of engine speed is from 2000 rpm to 3000 rpm. At this region, the power produced by V1 Booster is higher than the baseline RON 95 with about 2.6%. However, at middle speed region which from 3000 rpm until 4500 rpm, the power produced by V1 Booster is slightly same from the baseline with the difference is less than 0.4 kW. While, after 4500 rpm until 6000 rpm which in higher speed region, the power produce by the engine from the sample added with V1 Booster become lower than the baseline with decreasing about 2%.

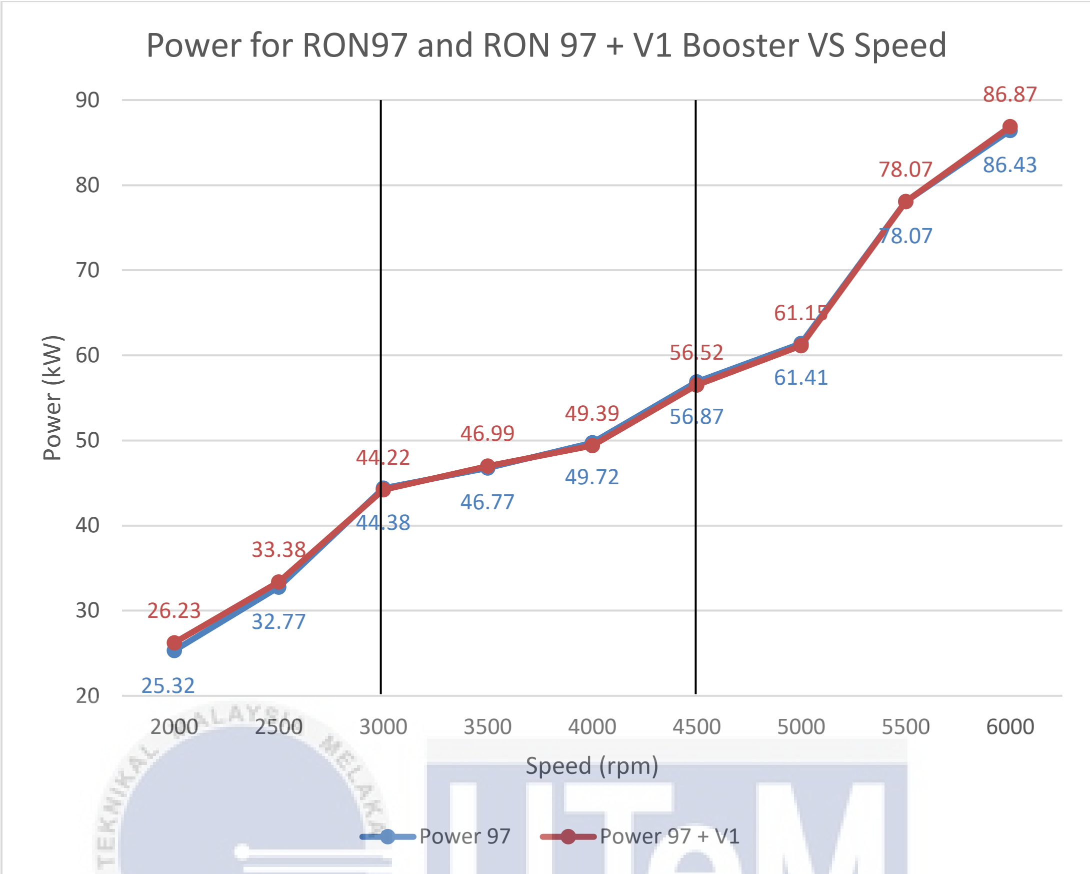

Figure 4.10: Graph of Power for RON 97 and RON 97 added with V1 Booster

While, based on Figure 4.10, the graph of power for RON 97 and RON 97 added with V1 Booster shows slightly the same trend with the graph of RON 95. At the lower speed region, the power produce by the sample added with V1 Booster is increase about 3.6% than the baseline RON 97. However, at the middle speed and higher speed regions, the use of V1 Booster did not have much effect on the power produced by the engine when compared to the baseline with the difference of the additives is 0.6% lesser than the baseline. This means the claims from V1 Booster which stated the use of this additive into the petrol can enhance engine's power and performance is only applicable for low speed region of the engine.

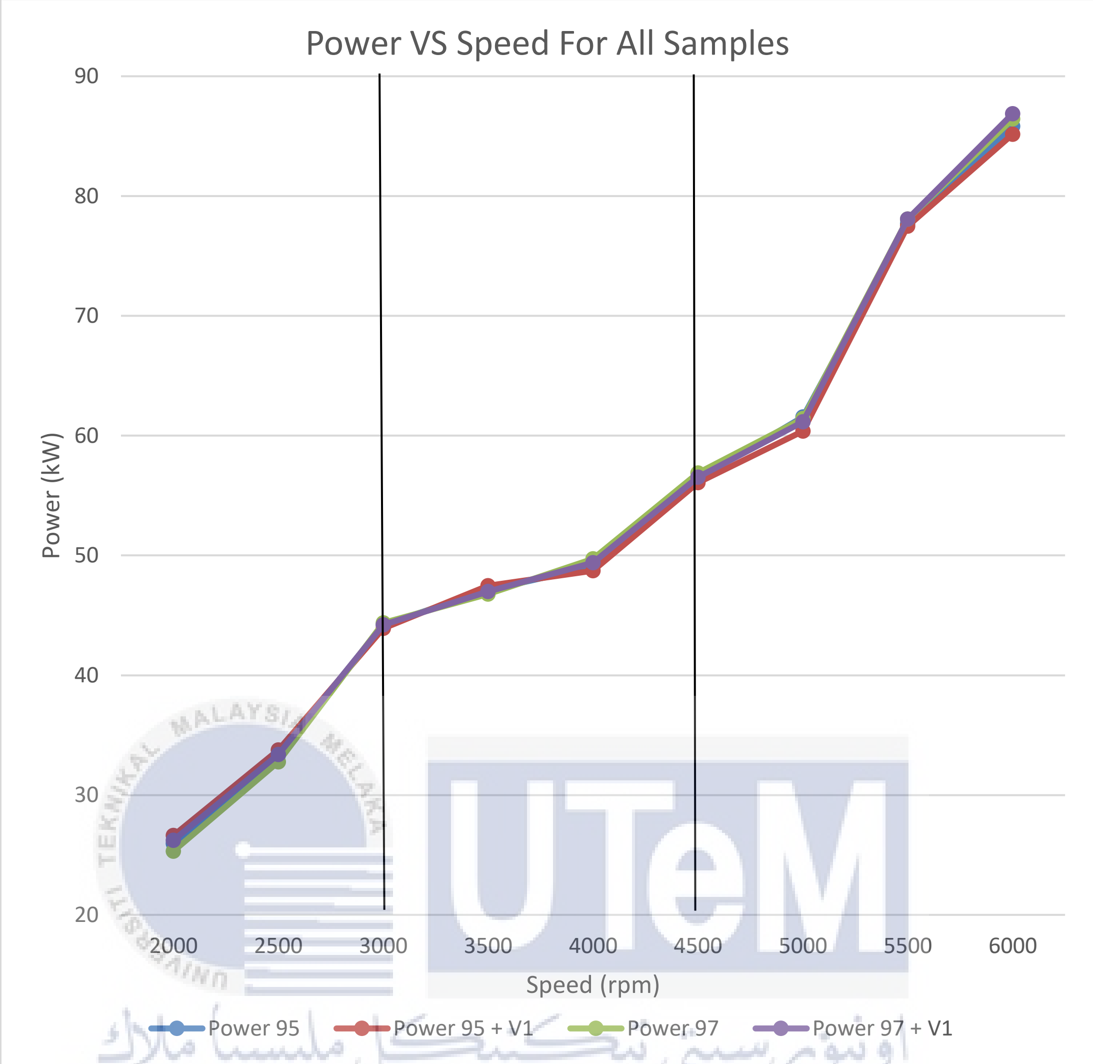

Figure 4.11: Graph of Power for RON 95 and 97 before and after added with V1 Booster

The other claims from V1 Booster is the performance of RON 95 added with V1 Booster can exceed the performance of RON 97. From the Figure 4.11, the graph shows that the highest power produced in lower speed region is V1 Booster added in RON 95 with 5.1% or 1.3 kW compare to baseline RON 97. While, at middle speed region, the power produced by all samples are slightly same with percentage different between the highest and the lowest is less than 2%. However, at higher speed region, the power produced by V1 Booster added in RON 95 is dropped 1.7% compare to RON 97. But the V1 Booster added in RON 97 produced highest power when at 6000 rpm with 0.44 kW more than baseline RON 97. Therefore, generally the claim that V1 Booster added in RON 95 can exceed the power of RON 97 can be accepted but only when the engine speed is below than 3500 rpm.

4.7.2 Analysis of Torque

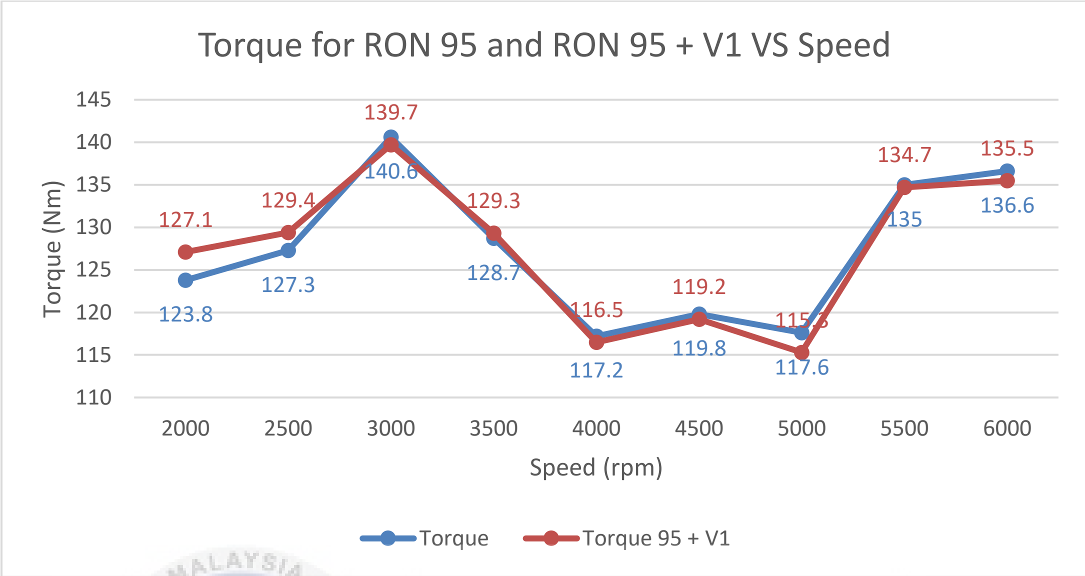

Figure 4.12: Graph of Torque for RON 95 and RON 95 added with V1 Booster

Based on Figure 4.12, the graph has been divided into three regions to show the behaviour of torque for RON 95 and RON 95 added with V1 Booster. First region or lower speed region is from 2000 rpm until 3000 rpm. The torque produced by RON 95 added with V1 Booster at this region is higher than the baseline RON 95 with 2.6%. But for middle speed region which from 3000 rpm until 4000 rpm, the V1 Booster did not give much effect on the torque of the engine with the difference is less than 0.7 Nm. Then, at 4000 rpm and above or at higher speed region, the torque produced by V1 Booster has dropped 2% from the baseline RON 95. This shows that the added of V1 Booster into the RON 95 increase the torque at lower speed region only.

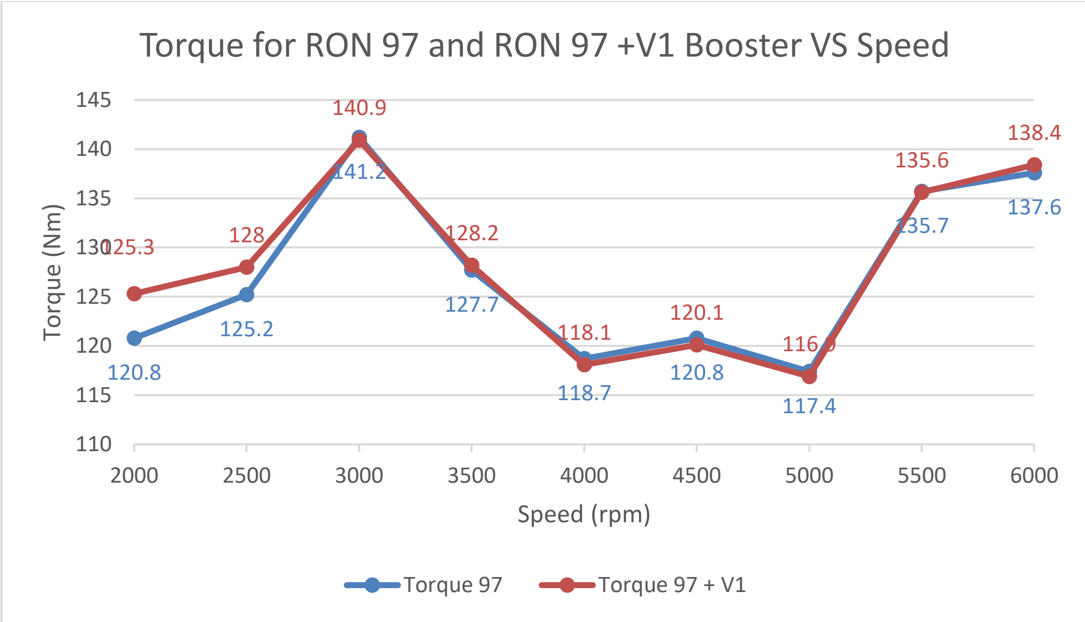

Figure 4.13: Graph of Torque for RON 97 and RON 97 added with V1 Booster

While, in Figure 4.13, the behaviour of torque for baseline RON 97 and after with V1 Booster shows slightly different. At the lower speed region, the graph shows the V1 Booster produced better engine torque than baseline RON 97 with 4.5% higher. Then, at middle speed region, the torque produced by V1 Booster is slightly same with the baseline RON 97. While, at higher speed region, the torque produced by V1 Booster has dropped 0.5% from the baseline. However, the engine torque for V1 Booster is increasing at 6000 rpm with 0.8 Nm higher than baseline. Therefore, the claims that use of V1 Booster can increase the engine performance is acceptable for lower speed region and at the maximum engine speed when added into RON 97.

4.7.3 Analysis of Brake Specific Fuel Consumption (BSFC)

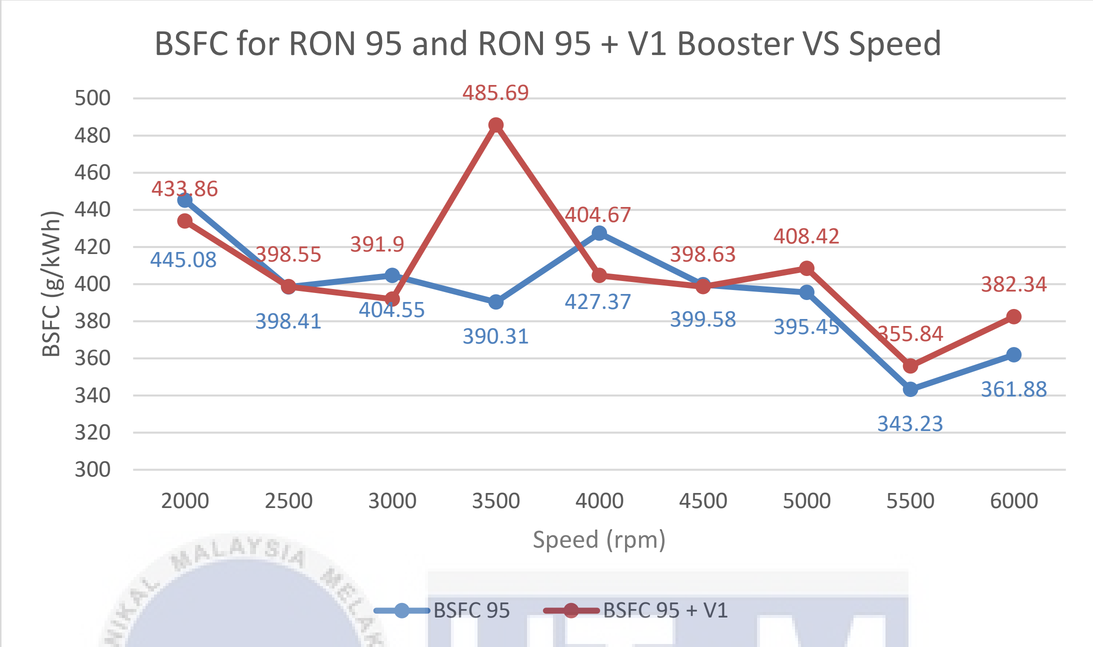

Figure 4.14: Graph of BSFC for RON 95 and RON 95 added with V1 Booster

Based on Figure 4.14, the graph for the brake specific fuel consumption (BSFC) also has been divided into three regions. For the first region which is lower speed region is from 2000 rpm until 3000 rpm. The BSFC at this region shows that V1 Booster consume less fuel up to 3.13% than the baseline RON 95. However, at middle speed region which from 3000 rpm until 4500 rpm, the BSFC for V1 Booster is drastically increase at 3500 rpm with 485.69 g/kWh while the baseline RON 95 is 390.31 g/kWh with 24% higher. But at the same region, the BSFC for V1 Booster decrease 5.3% from the baseline at 4000 rpm. Then, at the higher speed region start from 4500 rpm until 6000 rpm, the BSFC for V1 Booster consume 5.7% higher than baseline RON 95. This means the V1 Booster can save the fuel consumption of the engine up to 5.3% when the engine speed is 4000 rpm. While, the use of V1 Booster in RON 95 consumes a lot of fuel at 3500 rpm which is not save for the vehicle. Therefore, the claims by V1 Booster where the use of this additive can save the petrol more than 50% is unacceptable for RON 95.

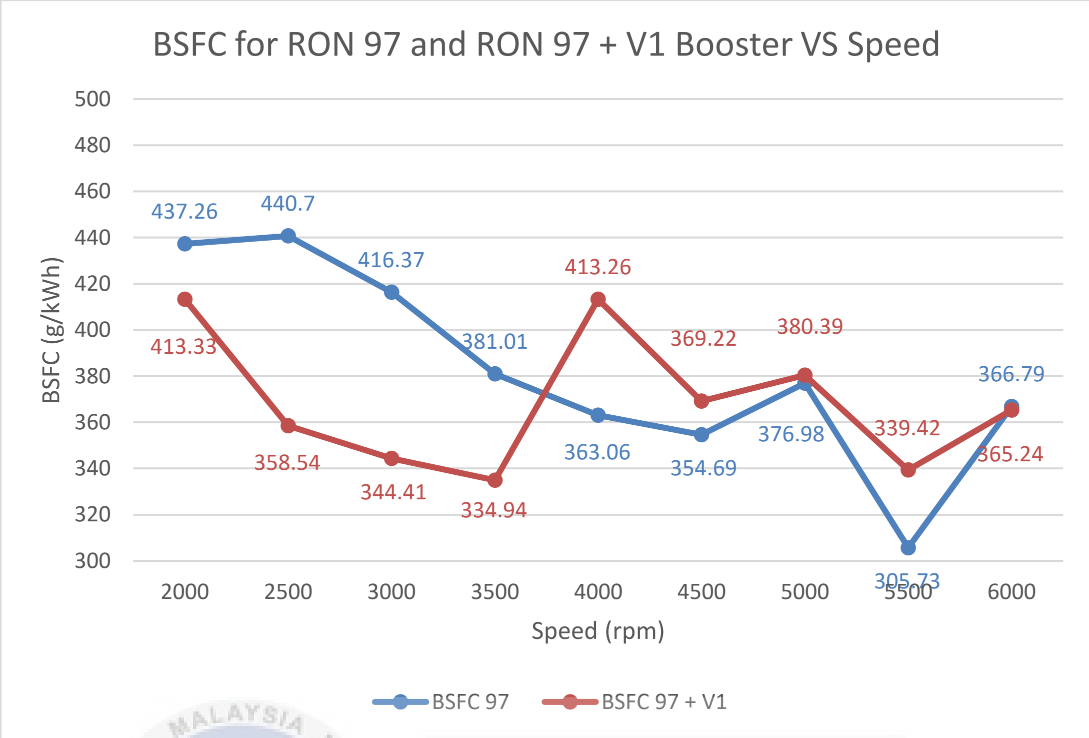

Figure 4.15: Graph of BSFC for RON 97 and RON 97 added with V1 Booster

While, the use of V1 Booster into RON 97 shows a big different compare to baseline RON 97 as in Figure 4.15. At the lower region of speed, the BSFC consume by V1 Booster is very low about 18.6% compared to baseline RON 97. However, at middle speed region, the BSFC for V1 Booster is rapidly increase at 4000 rpm with 13.8% higher than the baseline. Then, at the higher speed region, the BSFC for V1 Booster is steadily higher than the baseline RON 97 with major difference is 11% at 5500 rpm. This means that the adding of V1 Booster into RON 97 can reduce the BSFC up to 18.6% which at 2500 rpm. However, this result of BSFC for RON 97 still cannot support the claims by V1 Booster that it can save the petrol up to 50%.

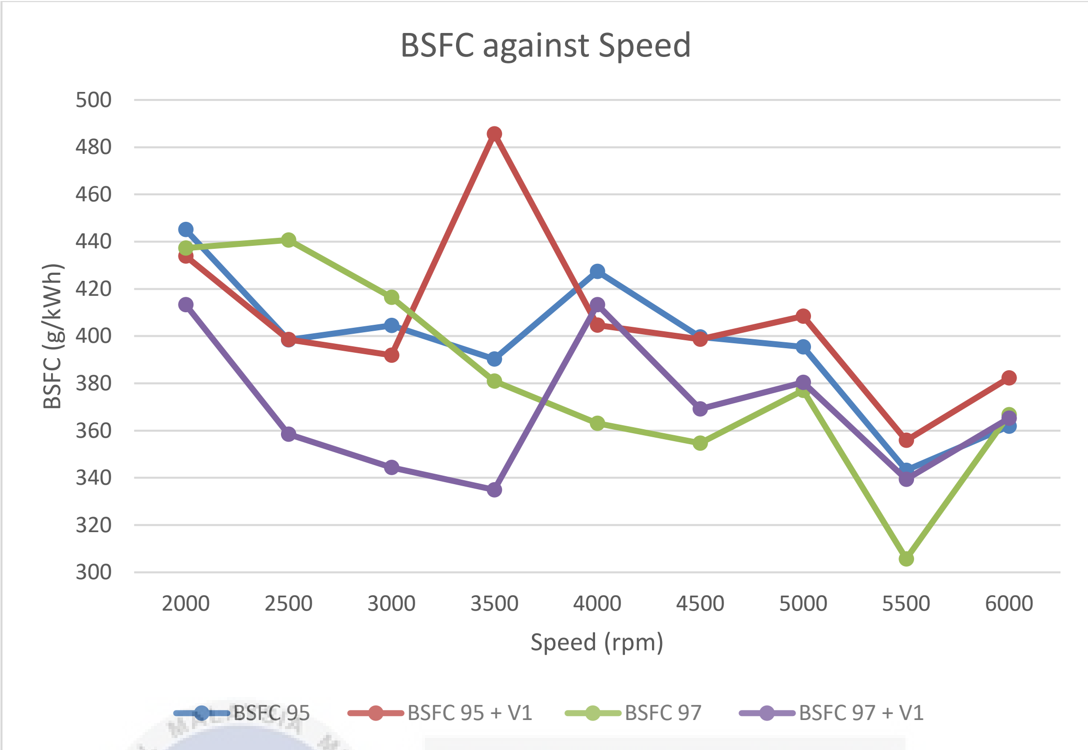

Figure 4.16: Graph of BSFC for RON 95 and 97 before and after added with V1 Booster

Overall, at lower speed region from in Figure 4.16 shows that the petrol added with V1 Booster for both RON 95 and RON 97 consume less fuel compare to baseline RON 95 with the most saving using this additive is 3.13% at 3000 rpm for RON 95 and 14.2% at 4500 rpm for RON 97. While, RON 97 consume the highest fuel at this region with 10.6 % compare to baseline RON 95 at 2500 rpm.

For middle speed region, the additives V1 Booster have the same behaviour when added into RON 95 and RON 97 where it will rapidly increase at certain engine speed. As example for V1 Booster in RON 95, it suddenly increases up to 24% higher than the baseline at 3500 rpm before it goes down after that. Same goes to V1 Booster in RON 97, the fuel consumption is quickly increase at 4000 rpm even though it still lower compare to baseline RON 95.

However, for higher speed region, the graph shows that RON 97 has the lowest fuel consumption at 5500 rpm with decreasing 11% compare to baseline RON 95 and samples added with V1 Booster. This means the V1 Booster is not saving the fuel at higher engine speed. Therefore, it can be concluded that the V1 Booster is a fuel saver and can reduce fuel consumption when travel at lower engine speed or 3000 rpm and below. However, the claim by the supplier that use V1 Booster can save up to 50% cannot be achieved because the highest reduction obtained from the experiment is only 5.3% when added into RON 95 and 18.6% when added into RON 97.

4.8 EMISSION TESTING RESULT

Emission testing results was obtained from the data collected by Automobile Gas Analyzer. The probe has been inserted into the exhaust pipe and connected to the gas analyzer. Then, the emission produced when running engine test will be detected by the probe and sent data to the gas analyzer.

The data recorded by this gas analyzer consist of three main emission gases which are Carbon Monoxides (CO), Hydrocarbon (HC) and Nitrous Oxide (NOx). The other gases that can be detected are Carbon Dioxide (CO_2) and Oxygen (O_2). The emission test was performed in two conditions. First condition is the engine in idle condition and second condition is when engine speed at 6000 rpm.

4.8.1 Automobile Gas Analyzer Results

Table 4.3: Data Emission Test for RON 95

RON 95			
Engine Condition	HC (ppm)	CO (%)	NO_x (ppm)
Idle	513	3.72	13
6000 rpm	401	4.31	25

Table 4.4: Data Emission Test for RON 95 added with V1 Booster

RON 95 + V1 Booster			
Engine Condition	HC (ppm)	CO (%)	NO_x (ppm)
Idle	261	2.43	29
6000 rpm	202	6.44	251

Table 4.5: Data Emission Test for RON 97

RON 97			
Engine Condition	HC (ppm)	CO (%)	NO_x (ppm)
Idle	355	5.15	23
6000 rpm	203	5.39	302

Table 4.6: Data Emission Test for RON 97 added with V1 Booster

RON 97 + V1 Booster			
Engine Condition	HC (ppm)	CO (%)	NO_x (ppm)
Idle	319	2.80	49
6000 rpm	170	6.09	326

4.9 ANALYSIS OF EMISSION TEST RESULTS

The analysis of emission produce by the engine is based on the data tabulated in Table 4.3, 4.4, 4.5 and 4.6. Then the data has been classified into type of emission and engine condition.

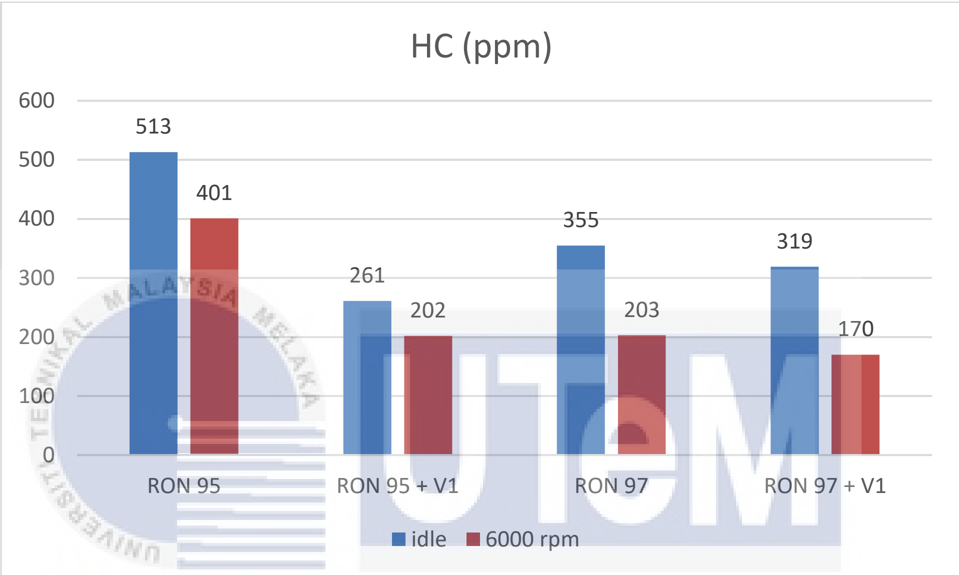

Figure 4.17: Comparison of Hydrocarbon (HC) for two engine condition

Hydrocarbons (HC) gas is basically the raw unburned fuel which produced by the engine when the combustion does not take place at all. The results for comparison of Hydrocarbons (HC) shown in Figure 4.17 indicate that RON 95 added with V1 Booster produce 49% HC gas lower than the baseline RON95 for both condition when engine is idling and at maximum speed. However, for RON 97, the samples added with V1 Booster also decrease 10% of HC gas when idle and 16.3% of HC gas when engine speed is maximum compared to baseline RON 97. This shows that the use of V1 Booster additive can decrease the Hydrocarbons gas produce by the engine and reduce poor fuel ignition.

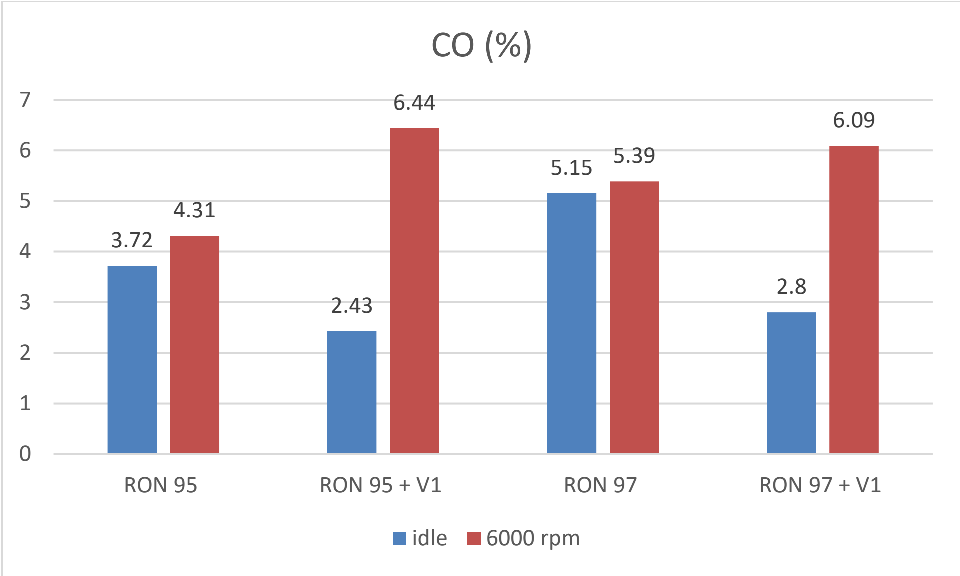

Figure 4.18: Comparison of Carbon Monoxide (CO) for two engine condition

Meanwhile, the Carbon Monoxide (CO) is the gas produced from incomplete combustion. This occurred when not enough oxygen present in the air/fuel mixture during the combustion. From the comparison of CO in Figure 4.18, the graph shows that the RON 95 added with V1 Booster produced less percentage of CO gas compared to baseline RON 95 with 1.29% lower when engine is idling. But, at 6000 rpm, the V1 Booster added into RON 95 produced the highest level of CO gas with 6.44% while the baseline RON 95 is just 4.31%. Then, the data for RON 97 also shows the same trend with RON 95. RON 97 added with V1 Booster has the lower CO gas when engine is idling with the different is 2.35%. For 6000 rpm, the baseline RON 97 produce lower CO gas than the additive with different 0.7 %. This indicate that the V1 Booster provide better mixture in combustion chamber when engine is idling but not when engine is in maximum speed. Therefore, the petrol added with V1 Booster additive can prevent from faulty oxygen sensor when idle.

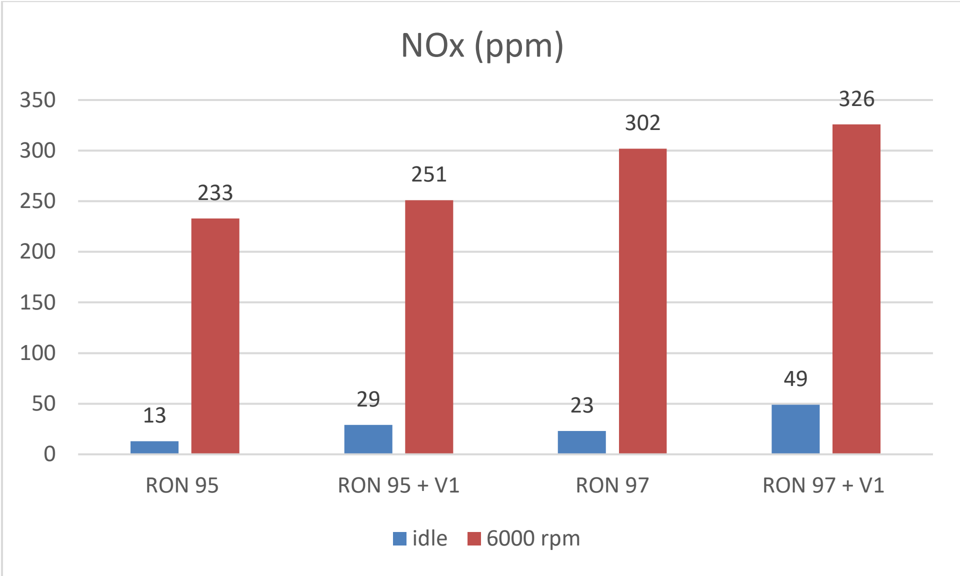

Figure 4.19: Comparison of Nitrogen Oxide (NOx) for two engine condition

The other emission gas that has been compared is Nitrogen Oxide (NOx). This gas form when the cylinder produces high temperatures and pressure. From Figure 4.19, the graph indicates the both baseline RON 95 and 97 produced the smaller amount of NOx gas when engine is idling and at 6000 rpm. This means the added of V1 Booster into RON 95 and RON 97 has increase the amount of NOx gas produced by the engine. The higher amount of NOx gas produced is not good for the engine because it could lead to engine overheating and defective Catalytic Converter (CAT). However, the increasing value of NOx for RON 95 and RON 97 after added with V1 Booster can be neglected because the difference is less than 24 ppm which is too small.

From all the analysis for emissions test that has been stated above, it can be conclude that the use of V1 Booster into the petrol did can reduce the emission gases produced by the engine generally. Even though the CO gas is increasing but it only when the engine travel at maximum speed and increasing value of NOx gas for RON 95 and RON 97 after added with V1 Booster can be neglected because the difference is less than 24 ppm which is too small. Therefore, the claim by the supplier that V1 Booster can reduce smoke emission from engine is acceptable.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATION

5.0 CONCLUSION

Based on the experiment and engine testing that have been done, the V1 Booster can be concluded as the additives that can reduce fuel consumption, increase performance of the engine and decrease emission level when engine is travel at lower speed or below 3000 rpm. After 3000 rpm until the maximum 6000 rpm of engine speed, the effectiveness of V1 Booster start to decrease and not fixed.

The experiment shows the density test has increase after added with V1 Booster for both RON 95 and 97. While, for energy content, it only increases when added into RON 95 but it decreases when added into RON 97. So, the V1 Booster is suitable for RON 95 compare to RON 97 in term of energy produced. The emission test also shows that the V1 Booster only reduce Hydrocarbon (HC) gas whereas the Carbon Monoxide (CO) gas and Nitrogen Oxide (NOx) gas increase after added with additives.

Then, the engine test proved the V1 Booster can increase the power and torque from 2000 rpm until 3000 rpm. However, after 3000 rpm, the difference after use the additives is not too big from the baseline RON 95 and 97. Even more when engine travel at high speed, the power and torque produced by the baseline RON 95 and 97 is better than the additives. It same goes to brake specific fuel consumption (BSFC). The added of V1 Booster can reduce the fuel consumption maximum about 5% for RON

95 and 22% for RON 97. But, when travel at high engine speed the V1 Booster is not saving anymore.

From the comparison between the testing results and claim from supplier, it shows that V1 Booster achieves some the expectations as it claimed such as increase performance of RON 95 more than RON 97, reduce smoke emission from engine and treat and improve fuel quality. However, the claims that it can save petrol by more than 50% is not achieved.

5.1 RECOMMENDATION

There are several steps and recommendations that can be taken to improve the data obtained and analysis for future study. For engine performance test, the petrol and additives can be tested using chassis dynamometer to gain more accurate data. This is because the chassis dynamometer has the external resistance that should be included in the data to prove the effectiveness of the additives on the vehicles. The test also can be performed on different types of engine and different types of vehicle class to obtain varieties results.

The study on the effects of the additive on the injector also can be done specifically because it will influence the performance of the engine. Besides that, the characteristic of the petrol such as octane number, composition and Reid Vapour Pressure (RVP) on the engine combustion also can be carry out to determine the effects on engine performance. To analyze the fuel saving, the test can be done on the road with how far the vehicles travel using one litre of petrol before and after added with additives.

Overall, the characterization of fuel additive for fuel saving and injector optimization using V1 Booster as the additive had performed and analyzed successfully. The further analysis and research in detail about the effect of fuel additives on engine performance and emission level is strongly recommended.

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APPENDICES

Testimoni

Ribuan pengguna V1 fuel booster telah berpuas hati diatas kehebatan dan keberkesanan produk ini didalam membantu mereka menjimatkan kos penggunaan minyak dan membuat enjin mereka lebih bertenaga dan terjaga. Dipaparkan beberapa pengalaman pengguna menggunakan V1 fuel booster untuk pelbagai jenis jentera.

En. Hassim – Kulim Kedah:

Skuter saya susah nak start, sering mati2 enjin & takda power. Setelah saya gunakan V1 Fuel booster tindakkan sebaliknya berlaku. Mudah di start, enjin dah tak mati2 macam dulu, power sangat dan minyak lebih jimat.

En. Kasim Mahmud – Sandakan, Sabah:

Selepas 9 hari menggunakan V1 fuel booster, minyak di Ex 5 ini masih ada setengah tangki lagi. Biasanya 1 minggu dah kena isi. Ternyata V1 sangat berkesan.

Rosmah Abdullah – Bintulu Sarawak.

Yes!! memang power betul V1 fuel booster. Biasa perjalanan daripada bintulu ke sarikei guna minyak 2 bar, tapi selepas guna V1 fuel booster baru 1 bar diesel saya pakai.

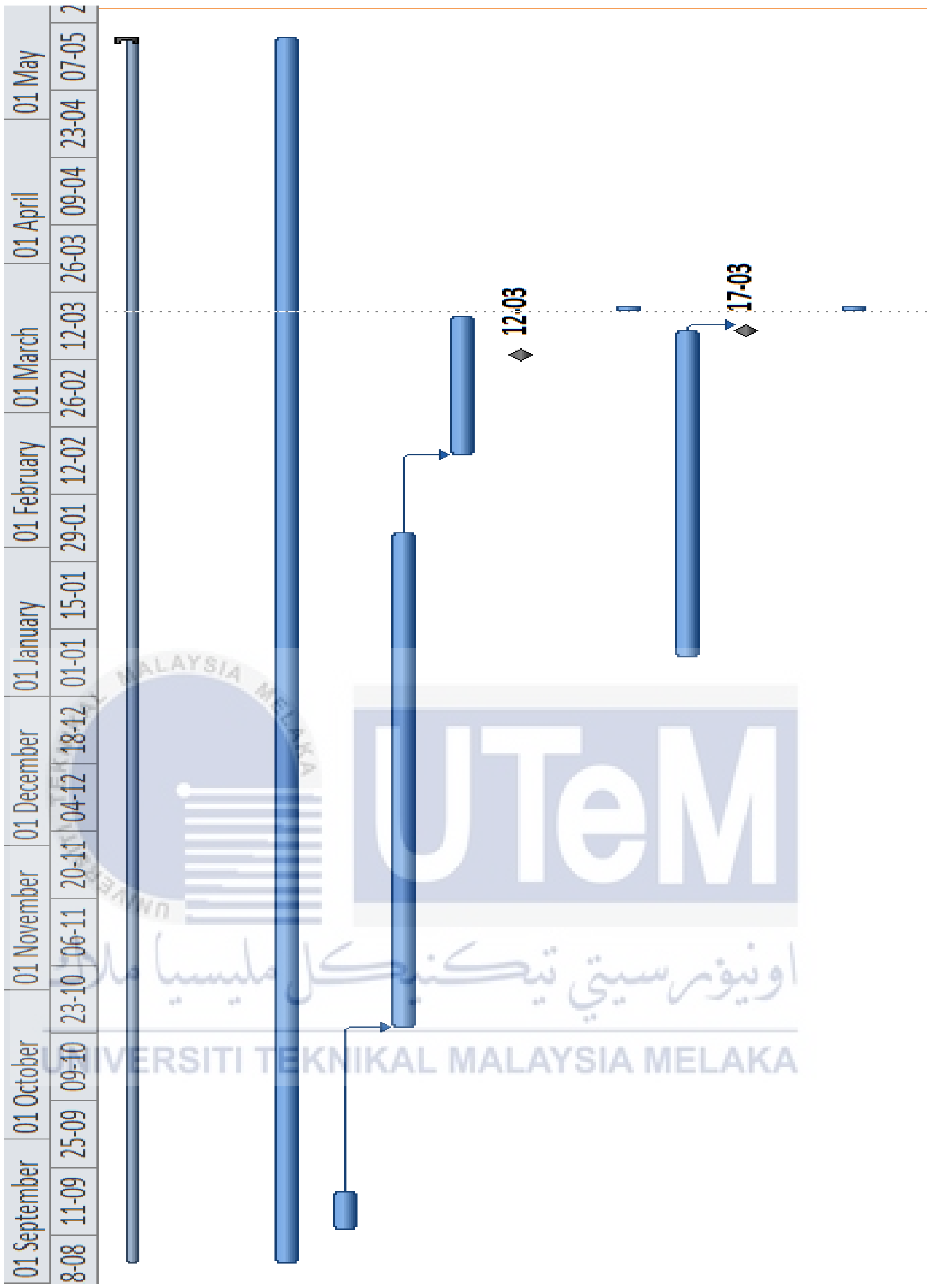
Ros Iskandar Hamdan – Melaka:

Sebelum guna V1 fuel booster, biasanya 2 hari sekali saya kena ke pam minyak untuk isi minyak, tapi lepas guna V1 fuel booster, 4 hari sekali baru isi minyak. Power jangan cerita la..

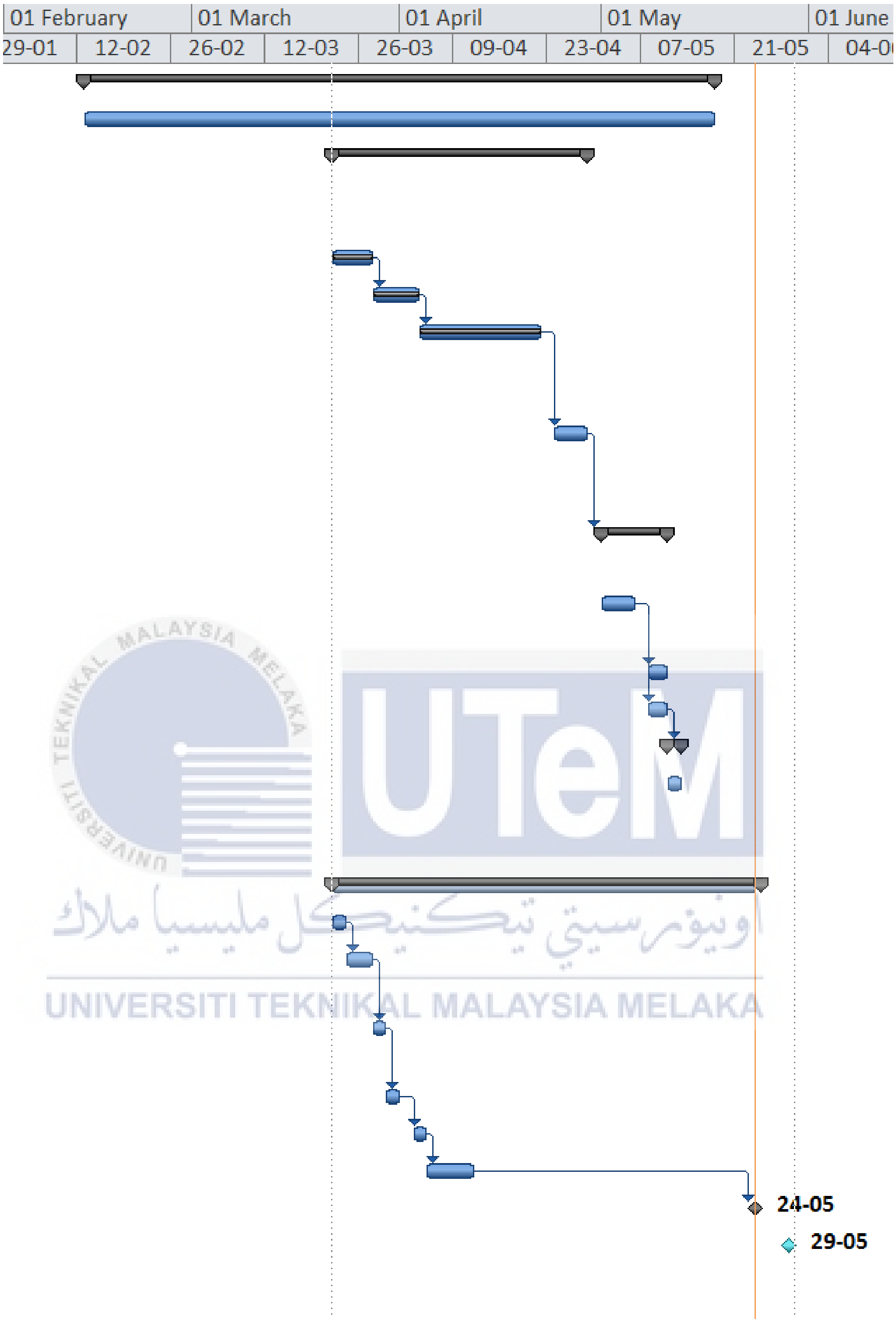
Ambotang B.Kadir – Lahad Datu,Sabah.

Mula gunakan V1 Fuel Booster bulan lalu. Sebelum guna V1 belanjakan 50lt petrol utk kerja 26 hari, tapi dengan V1 hanya perlu guna 20ltr petrol dgn masa kerja yg sama!

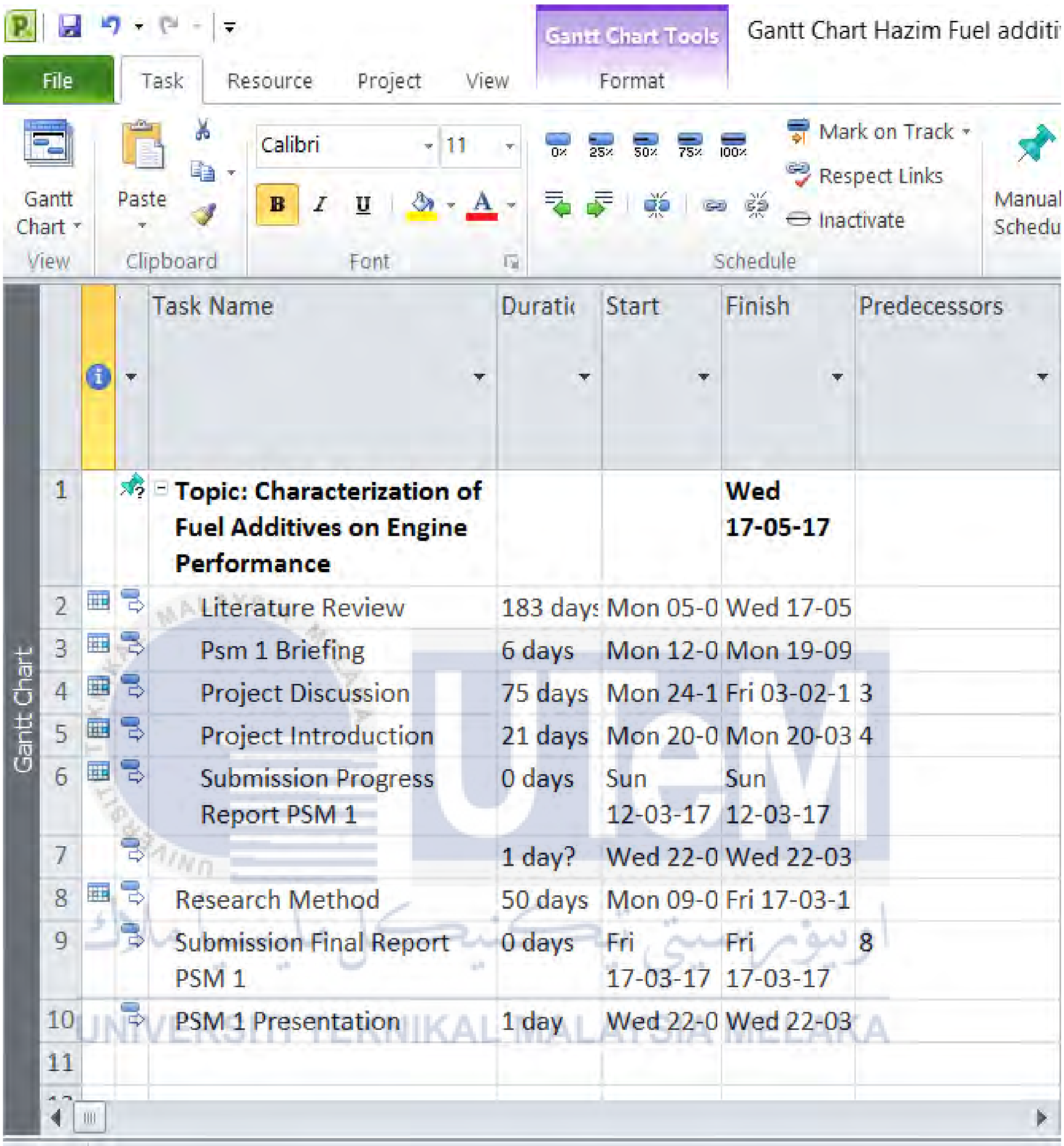
Appendix A: Testimony from Customer About V1 Booster



Appendix B: Gantt Chart PSM 1

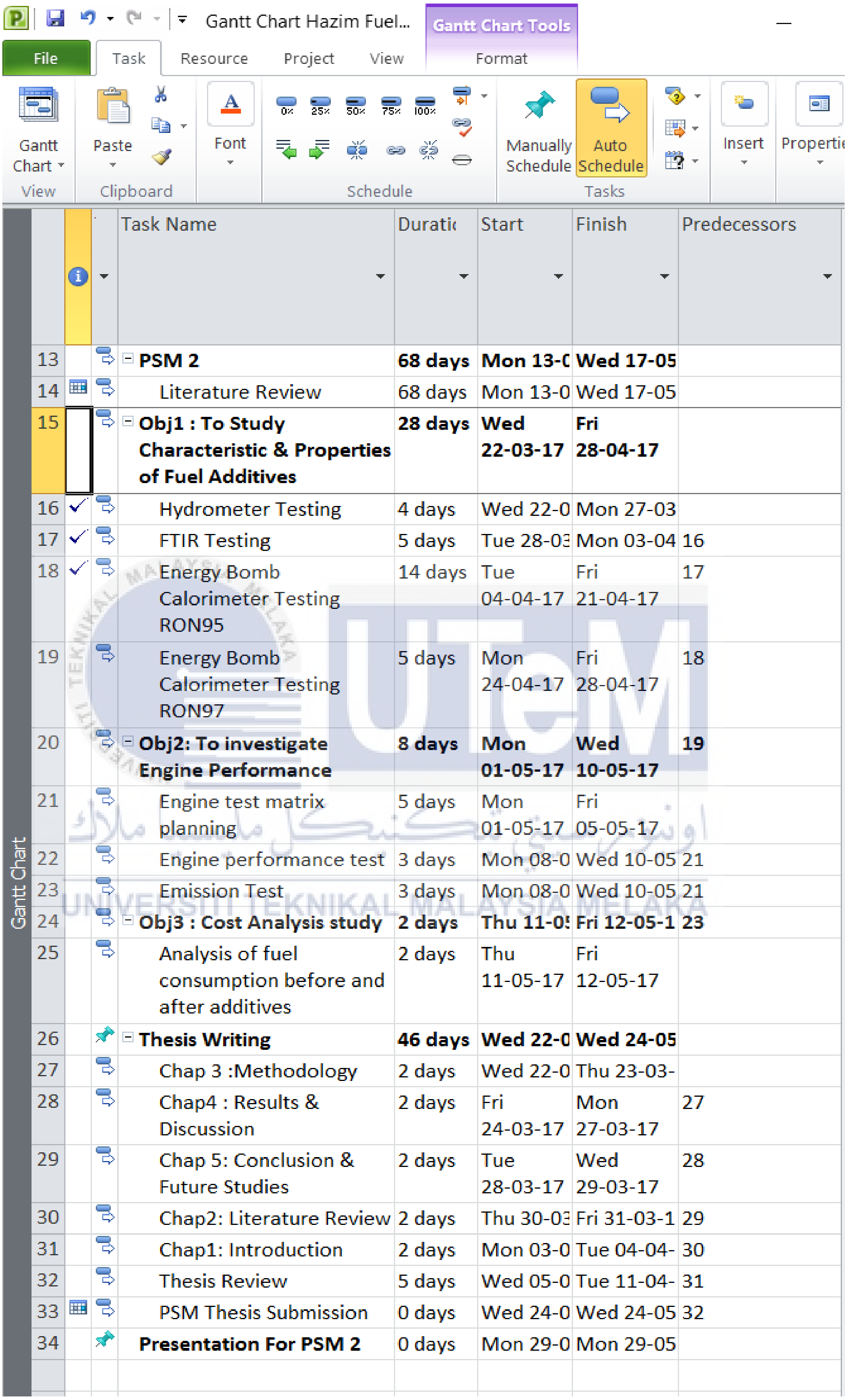


Appendix C: Gantt Chart PSM 2



	Task Name	Duratic	Start	Finish	Predecessors
1	**Topic: Characterization of Fuel Additives on Engine Performance**			**Wed 17-05-17**	
2	Literature Review	183 days	Mon 05-0	Wed 17-05	
3	Psm 1 Briefing	6 days	Mon 12-0	Mon 19-09	
4	Project Discussion	75 days	Mon 24-1	Fri 03-02-1	3
5	Project Introduction	21 days	Mon 20-0	Mon 20-03	4
6	Submission Progress Report PSM 1	0 days	Sun 12-03-17	Sun 12-03-17	
7		1 day?	Wed 22-0	Wed 22-03	
8	Research Method	50 days	Mon 09-0	Fri 17-03-1	
9	Submission Final Report PSM 1	0 days	Fri 17-03-17	Fri 17-03-17	8
10	PSM 1 Presentation	1 day	Wed 22-0	Wed 22-03	
11					

Appendix D: Task PSM 1



			Task Name	Duratic	Start	Finish	Predecessors
13			**PSM 2**	**68 days**	**Mon 13-0**	**Wed 17-05**	
14			Literature Review	68 days	Mon 13-0	Wed 17-05	
15			**Obj1 : To Study Characteristic & Properties of Fuel Additives**	**28 days**	**Wed 22-03-17**	**Fri 28-04-17**	
16	✓		Hydrometer Testing	4 days	Wed 22-0	Mon 27-03	
17	✓		FTIR Testing	5 days	Tue 28-03	Mon 03-04	16
18	✓		Energy Bomb Calorimeter Testing RON95	14 days	Tue 04-04-17	Fri 21-04-17	17
19			Energy Bomb Calorimeter Testing RON97	5 days	Mon 24-04-17	Fri 28-04-17	18
20			**Obj2: To investigate Engine Performance**	**8 days**	**Mon 01-05-17**	**Wed 10-05-17**	**19**
21			Engine test matrix planning	5 days	Mon 01-05-17	Fri 05-05-17	
22			Engine performance test	3 days	Mon 08-0	Wed 10-05	21
23			Emission Test	3 days	Mon 08-0	Wed 10-05	21
24			**Obj3 : Cost Analysis study**	**2 days**	**Thu 11-05**	**Fri 12-05-1**	**23**
25			Analysis of fuel consumption before and after additives	2 days	Thu 11-05-17	Fri 12-05-17	
26			**Thesis Writing**	**46 days**	**Wed 22-0**	**Wed 24-05**	
27			Chap 3 :Methodology	2 days	Wed 22-0	Thu 23-03-	
28			Chap4 : Results & Discussion	2 days	Fri 24-03-17	Mon 27-03-17	27
29			Chap 5: Conclusion & Future Studies	2 days	Tue 28-03-17	Wed 29-03-17	28
30			Chap2: Literature Review	2 days	Thu 30-03	Fri 31-03-1	29
31			Chap1: Introduction	2 days	Mon 03-0	Tue 04-04-	30
32			Thesis Review	5 days	Wed 05-0	Tue 11-04-	31
33			PSM Thesis Submission	0 days	Wed 24-0	Wed 24-05	32
34			**Presentation For PSM 2**	0 days	Mon 29-0	Mon 29-05	

Appendix E: Task PSM 2

RPM (RPM)	Hp (Hp)	Torque (N-m)	CO_2 (%)	AFR (A/F)	FuelMass (kg/h)	BSFC (kg/Hp-hr)	Avg-EGT (Degree F)	Blowby (CFM)	Power (kW)	BSFC (g/kWh)
2000	34.8	123.8	1	14.81	11.55	0.347	535.4	-2.441	25.95036	445.0805307
2500	44.7	127.3	1	14.82	13.28	0.311	536.9	-2.441	33.33279	398.406494
3000	59.27	140.6	1	14.82	17.88	0.316	537.4	-2.441	44.197639	404.5464963
3500	63.15	128.7	1	14.82	18.38	0.305	540.9	-2.441	47.090955	390.3084998
4000	65.8	117.2	1	14.84	20.97	0.334	546.1	-2.441	49.06706	427.3742914
4500	75.68	119.8	1	14.84	22.55	0.313	548.2	-2.441	56.434576	399.577734
5000	82.54	117.6	1	14.86	24.34	0.31	548.5	-2.441	61.550078	395.4503518
5500	104.2	135	1	14.92	26.67	0.269	548.2	-2.442	77.70194	343.2346734
6000	115.1	136.6	1	14.92	31.06	0.284	547.3	-2.442	85.83007	361.8778361

Appendix F: Engine Test Data for PETRONAS RON 95

RPM (RPM)	EGT #1 (Degree C)	E-Temp (Degree C)	Hp (Hp)	Torque (N-m)	Knock A% (%)	Fuel-A (kg/h)	Fuel-B (kg/h)	FuelMass (kg/h)	AFR (A/F)	BSFC (kg/Hp-hr)	Avg-EGT (Degree F)	Blowby (CFM)	Power (kW)	BSFC (g/kWh)
2000	72	36	35.7	127.1	2.397	137.5	125.9	11.55	14.8	0.34	544.6	-2.442	26.62149	433.8600131
2500	79	36	45.29	129.4	2.918	139.6	126.1	13.46	14.82	0.313	549.5	-2.442	33.772753	398.5461298
3000	87	37	58.89	139.7	8.839	139.6	122.4	17.21	14.82	0.308	552.5	-2.442	43.914273	391.8999183
3500	87	37	63.67	129.3	18.1	141	117.9	23.06	14.83	0.382	552.3	-2.442	47.478719	485.6912841
4000	87	37	65.35	116.5	36.64	140.8	121.1	19.72	14.83	0.318	552.3	-2.442	48.731495	404.6664277
4500	86	37	75.22	119.2	54.17	139.5	117.1	22.36	14.84	0.314	551.9	-2.442	56.091554	398.6339904
5000	87	38	80.97	115.3	121.3	137.5	112.9	24.66	14.84	0.322	552	-2.442	60.379329	408.4179206
5500	88	39	103.9	134.7	120.7	138	110.4	27.57	14.91	0.28	552.9	-2.443	77.47823	355.8418926
6000	88	41	114.2	135.5	115.5	138.8	106.3	32.56	14.92	0.301	552.8	-2.443	85.15894	382.3438854

Appendix G: Engine Test Data for Petronas RON 95 + V1 Booster

RPM (RPM)	EGT #1 (Degree C)	E-Temp (Degree C)	Hp (Hp)	Torque (N-m)	KnockA% (%)	Fuel-A (kg/h)	Fuel-B (kg/h)	FuelMass (kg/h)	AFR (A/F)	BSFC (kg/Hp-hr)	Avg-EGT (Degree F)	Blowby (CFM)	Power (kW)	BSFC (g/kWh)
2000	47	38	33.95	120.8	1.086	133.5	122.4	11.07	14.79	0.344	528.5	-2.442	25.316515	437.2639757
2500	59	39	43.94	125.2	1.784	138	123.6	14.44	14.8	0.346	534.5	-2.442	32.766058	440.6999463
3000	68	39	59.52	141.2	3.459	137.5	119	18.48	14.83	0.327	538.1	-2.442	44.384064	416.3656577
3500	76	40	62.72	127.7	6.696	135.4	117.6	17.82	14.84	0.299	541.6	-2.442	46.770304	381.0109936
4000	85	41	66.67	118.7	12.66	133.8	115.7	18.05	14.84	0.286	546.2	-2.442	49.715819	363.0635151
4500	85	41	76.26	120.8	30.13	134.4	114.2	20.17	14.82	0.279	545.9	-2.442	56.867082	354.6867413
5000	86	42	82.35	117.4	88.43	135	111.8	23.15	14.84	0.297	546.5	-2.442	61.408395	376.9842869
5500	86	42	104.7	135.7	120.6	134.8	111	23.87	14.91	0.241	545.8	-2.442	78.07479	305.7324906
6000	86	43	115.9	137.6	115.5	137.4	105.7	31.7	14.94	0.29	546.9	-2.442	86.42663	366.7850985

Appendix H: Engine Test Data for PETRONAS RON 97

RPM (RPM)	EGT #1 (Degree C)	E-Temp (Degree C)	Hp (Hp)	Torque (N-m)	KnockA% (%)	Fuel-A (kg/h)	Fuel-B (kg/h)	FuelMass (kg/h)	AFR (A/F)	BSFC (kg/Hp-hr)	Avg-EGT (Degree F)	Blowby (CFM)	Power(kW)	BSFC (g/kWh)
2000	52	45	35.17	125.3	1.292	142.4	131.6	10.84	14.79	0.327	764	-2.443	26.226269	413.3260434
2500	57	45	44.77	128	2.221	143	131	11.97	14.79	0.283	766.4	-2.443	33.384989	358.5443745
3000	70	46	59.3	140.9	5.369	141.7	126.5	15.23	14.8	0.272	771.7	-2.443	44.22001	344.4142143
3500	80	46	63.02	128.2	8.938	139.6	123.8	15.74	14.8	0.265	775.8	-2.443	46.994014	334.9362751
4000	82	47	66.23	118.1	19.77	141.5	121	20.41	14.81	0.327	776.9	-2.443	49.387711	413.2606996
4500	81	47	75.8	120.1	34.76	140.6	119.7	20.87	14.81	0.292	776.7	-2.443	56.52406	369.2233007
5000	84	47	82	116.9	85.3	141.4	118.1	23.26	14.84	0.302	779.6	-2.443	61.1474	380.3929298
5500	84	48	104.7	135.6	120.6	141.6	115.1	26.5	14.91	0.269	780	-2.443	78.074779	339.4181814
6000	83	49	116.5	138.4	115.5	141.7	110	31.73	14.91	0.29	779.3	-2.443	86.87405	365.2414041

Appendix I: Engine Test Data for PETRONAS RON 97 + V1 Booster