ON THE PERFORMANCE OF THE MOTORCYCLE ENGINE USING USED LUBRICANT OIL

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JUNE 2017

This dissertation is submitted to

Universiti Sains Malaysia

As partial fulfilment of the requirement to graduate with honors degree in

BACHELOR DEGREE OF ENGINEERING

(MECHANICAL ENGINEERING)

School of Mechanical Engineering
Engineering Campus
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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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Bibliography references are appended.

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ACKNOWLEDGEMENTS

Firstly, I am grateful to The Almighty God for establishing me to complete this thesis and project. I am grateful also for His blessings for providing me the strength, guidance and path to continuously work hard on this thesis writing. I would like to express our deepest gratitude for my EMD452 Final Year Project supervisor, Mr. Abdul Yamin Saad for his generous assistance, guidance and dedicated involvement throughout the decision and until the final phase. Besides that, I would also like to take this opportunity say thank you to the lab technicians and other lectures for their cordial support, valuable information and guidance which helped me in completing this task through various stages. There are still a lot to be of people that I would like to say thank you, especially people that involved in contributing me the used oils to conduct the experiment, including my project supervisor, Ir Dr Nadiahnor binti Yusop, Saparuddinf Nuddin and mechanic at motorcycle workshop. Not to forget, many thanks to my course mates which have made valuable comments and suggestions which give me an inspiration to improve our design. Furthermore I do appreciate the help and advice on the preparation of the engine from the school technician especially Mr.Zalmi and Mr.Baharom who suggested on how the variables of the experiment can be arranged in the manner that would be easy for me to conduct and continue my experiment in near future. Plus, he have been really supportive by giving valuable information and suggestions which give me an inspiration and idea to improvise my project. I also would like to expand our deepest gratitude to all those who have directly or indirectly guided me in this final year project. Thank you.

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ABSTRAK

Keperluan pesat dalam industri automotif menyebabkan pengeluaran minyak pelincir begitu banyak di pasaran. Syarikat pengeluaran pembuatan minyak pelincir bersikap inovatif dalam mendapatkan ramuan dan formula khas mendapatkan teknologi yang berbeza seperti bahan tambahan (aditif) dan campuran. Disebabkan oleh pasaran yang sangat kompetitif, hal ini telah menyebabkan peningkatan harga minyak enjin yang mendadak sehingga menyebabkan banyak pengeluar bersaing untuk menjual produk mereka. Pada masa yang sama, kos penyelenggaraan kenderaan telah menjadi beban kepada pengguna. Oleh itu, kebanyakan pengguna cuba untuk mencari kaedah untuk mengurangkan kos penyelenggaraan kenderaan mereka.

Dalam kajian ini, minyak enjin yang telah digunakan untuk beberapa perbatuan akan digunakan untuk mengkaji kesan ke atas prestasi enjin motosikal, terutamanya tork dan kuasa enjin. Kesannya akan dianalisis sama ada ia selamat atau tidak untuk digunakan semula minyak untuk melincirkan enjin. Enjin yang dilincirkan menggunakan pelbagai jenis minyak telah dihidupkan dan prosedur yang digunakan untuk eksperimen ini adalah ketika enjin pada Wide Open Throttle (WOT). Tahap graf prestasi oleh semua jenis minyak pelincir yang telah digunakan akan dibandingkan dengan minyak enjin asas (baseline oil).

Keputusan menunjukkan terdapat sedikit penurunan dalam prestasi yang tork adalah dalam lingkungan sekitar 0.1-3.58% manakala kuasa kuda adalah dalam julat antara 0.01 - 3.8%. Ini adalah disebabkan oleh penurunan keberkesanan minyak enjin digunakan. Komposisi minyak enjin yang digunakan juga boleh menjejaskan penurunan prestasi. Ini kerana keadaan operasi enjin telah terkumpul dengan deposit karbon, yang seterusnya memberi kesan kepada kecekapan juga.

Walau bagaimanapun, dalam aspek ekonomi, kaedah ini boleh memberi manfaat kepada ramai kenderaan pengguna bagi membolehkan mereka untuk mengurangkan kos penyelenggaraan mereka. Berdasarkan beberapa sampel pengiraan, pengguna boleh menyimpan sehingga 50% daripada kos penyelenggaraan mereka menggunakan minyak semula atau dengan melanjutkan perkhidmatan perbatuan selang.

x

ABSTRAK

Due to the rapid need in automotive industries, the production of lubricant oil is so abundant in the market, Manufacturers seek different technologies such as additives and blend. Due to highly competitive market, this however, increases the price of engine oil keep arising as many manufacturer competing to sell their product. The cost of vehicle maintenance thus become a burden to the users. Users then try to discover methods in order to reduce the maintenance cost of their vehicle.

In this study, the engine oil that has been used for several mileage will be reused in order to study the effect on the engine performance, particularly the torque and power of the engine. The effect will be analysed whether it is practically safe or not to reused the oil to lubricate the engine. The engine was run using different types of used oil at Wide Open Throttle (WOT). The performance graph will be compared with base engine oil.

Result showed that there were slight drop in performance which are the torque is in the range of around 0.1 - 3.58 % whereas the horsepower is in the range between 0.01 - 3.8 %. This is due to drop in effectiveness of the used engine oil. The composition of the used engine oil may also affect the performance drop. This is because the operating condition of the engine has accumulated with carbon deposit, which consequently affect the efficiency too.

However, in the economical aspect, this method could benefit many vehicle user in order for them to reduce their maintenance cost. Based on few sample of calculation Users could save up to 50% of their maintenance cost using reused oil or by extending the mileage interval service.

CHAPTER 1: INTRODUCTION

1.1 Introduction

Servicing and doing the maintenance works on your vehicle, no matter a car or motorcycle, is essential to ensure the condition and performance of the car is at optimum level. The reason behind the change of lubricant oil is that to reduce the friction and wear in the engine. Basically, when the engine is running, all the mechanical parts of the engine is suffering of a friction. Friction will wearing out the engine parts which eventually damaging the engine parts. To be specific, there are actually hundreds of moving parts that occur in the car's or motorcycle's engine such as the pistons pump up and down in the cylinders, the crankshaft spins, the gears race round at the top speed and many more. Every one of them rub against one another as it moves which eventually making a noise, losing energy to friction, and gradually wearing out.

By referring to the Figure 1.1, the upper part of figure showed that between those two solids are not lubricated which a perfect example that the friction is very high. They will move roughly between one another and eventually will lose a lot of energy due to the friction. However, for the bottom part of the figure showed that the oil is lubricated both solids. This will benefit both solids as it will cushions and smooths the movement between these two solids. The oil is very helpful because due to its liquid properties, it can easily change the shape and flow. Ideally, it will flow in perfect layers and the layers will slide freely past another, thus helping the friction to be reduced.

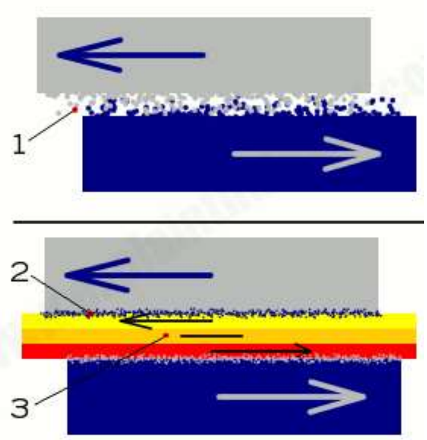


Figure 1.1: Unlubricated and lubricated solid (sources: explainthatstuff.com)

In fact, the friction factor is only one of the reason while we lubricates the engine. Another good thing of lubricating the engine is also it can reduce heat that produce by the friction from the moving parts. For an easy example, if you rub you hand, this means friction is occur, and what else happened? You will feel a slight warmer that before. So, friction generally will generate heat. Heat generated can be very problematic to the engine of the vehicle. So, it is very crucial to lubricate the engine while properly selected the type of lubricant to use because if it is wrong, then, surely catastrophic failure may result in the future. Therefore, we lubricated our machinery to minimize the resistance to movement and as a result, it can reduced the amount of heat produced. The heat generated by the machinery movement is transferred to the oil so that it may be removed by a lube oil cooler.

1.1.1 Significance of lubricating the engine

Many people believe that a lubricant is simply used to make things slippery and smoothing the movement of the machinery. It is also reduces the amount of wear that occurs during operation. It is because the oil will lubricate and moving around the parts which literally speaks, it will cover up the contact between one parts to another. This will assist the parts to moving accordingly and smoothly as the result of the reduced in friction. In fact, by lubricating the engine, it will reduces operating temperatures too. This is closely related to the reduced in friction too. It is because, as the friction is reduced, the temperature also will reduced too because the friction energy between the moving parts is minimized. Other than that, the significance of lubricating the engine also is it can minimizes the corrosion of metal surfaces of the engine, and assists in keeping contaminants out of the system. Oil can hold the burr or contaminants formed in the engine so that it would not damaging the engine. It is because burr formed can reduced the efficiency of the engine which eventually the carbon formed will get thicker until it become a sludge.

Lubricants have many properties that can be mixed and matched to meet your operating needs. For example, there are different chemicals that can be added to allow a machine to efficiently run at extreme temperatures. We can also make a lubricant more effective in protecting machine surfaces under extreme pressures. By looking at the demands of the machine, you can properly identify the type of lubricant best suited for its proper function. So a lubricant is a substance that reduces friction, heat, and wear when introduced as a film between solid surfaces. Using the correct lubricant helps maximize the life of your bearings and machinery, therefore saving money, time, and manpower, thus making operations more efficient and more reliable.

1.1.2 What makes a good lubricating oil

Lubricant oil comes with many different types. It is also served to certain purpose. For example, if the engine is using petroleum-based oils, but you lubricate your engine using synthetic oil, it will end up by damaging your engine car. Many vehicles begin to use oil if the regular oil is switched with synthetic. Using or burning oil means that it gets by the pistons and into combustion chamber where it burned off. Thus, it will produce a white smoke. Synthetic oil does provide many advantages if your car is designed to use it. This type of oil doesn't react to differences in temperature and creates better fuel economy. It also provides reduced friction on the engine parts over petroleum-based oil. The engine will last longer and require less maintenance, which means more savings for the owner. So what makes a good lubricating oil?

Basically, oil is measured by its viscosity, which is considered the thickness of the oil. In general, oil must be thick enough to lubricate the machinery parts while thin enough for the oil to flowing through the machinery parts of the engine. The outside temperature also impacts the viscosity of the oil, and it must be able to maintain proper flow even in low temperature. Lubricants are much like any other substance. The colder it get, the harder, more solid they become. Sometimes, that means they work less effectively. So, the poorer performance of lubricants at lower temperature is one of the reasons why engines and transmissions are less efficient before they have properly warmed up.

1.1.3 Project background

People acknowledge that servicing their vehicle, no matter a car or motorcycle, is essential to ensure the condition and performance of the car is at optimum level. Typically, vehicle user will be ask to send their vehicle for servicing purposes by the car manufacturer to the service centre. The basic services including the change of oil lubricant engine and oil filter for every 5000km (depend on the oil type). The benefits of change the engine oil are it could saving energy consumption, improving operation efficiency and reducing noise & vibration. Concerning the chemical compositions of lubricating oils, they typically consist of about 90% base oils (petroleum fraction) and less than 10% chemical additives and other components. Due to the exhaustion of chemical additives and the contamination from metallic materials, the lubricant degradation will come out after a service time. Eventually, it becomes physically and chemically unsuitable for further service use and must be replaced. However, problem arise is what actually happened to the oil that have been flush out from the engine?

The used engine oil will be collected for recycling purposes. Based on American Petroleum Institute website, it stated that used oil can be re-refined into base stock for lubricating oil which in returns it could benefits many people. Just imagine, if we can recycle two gallons of oil, it can generate enough electricity to run the average household for almost 24 hours. Although it gets dirty, used oil can still be cleaned and re-used. In fact, recycled used oil can be used as an industrial burner fuel, hydraulic oil, incorporated into other products or re-refined back into new lubricating oil.

So, after we know that used lubricant oil can be recycled and re-refined into new lubricating oil, what will happen if this used oil is directly utilized back in another engine without undergoes some process of cleaning and re-refined it? Logically speaks, of course used oil will get dirty and contained with burr and metal powder, and to fill it back into the engine would definitely damage the engine once it runs. It is because the used oil is already degraded and oxidized by a previous heating process in the engine. So, to use it back and fill into another engine would surely affect the performance of engine as it would not be as efficient as before. It could affect the friction in the engine, wear and tear of the engine and caused catastrophically vibration.

Therefore, this project is all about the study of the performance of the engine using used oil. Parameters such as power and torque will be determined due to the effect of using used oil as a lubricant in the engine.

1.2 Problem statement

Generally, engine oil will be flush out of the engine when it has been used for certain kilometres that required the owner to change the engine oil. The flushed oil will be collected by the mechanic for recycling purpose. Typically, many car's manufacturer will notify their customer to send their vehicle for servicing when the mileage has reached to 5000KM (may differ between car's engines) or three months old, whichever is earlier. However, there are many cases where the engine oil that has been flushed out is still good and can be use due to a certain reason. This surely would cost and burden the owner. Quality asides, this act also could be understand as the way of automotive industries doing their business. People will be forced out to change the engine oil although the vehicle is rarely used which impossible for the engine oil to be degraded. In another cases, although the vehicle is frequently used, where its mileage has reached to the point which the engine oil has to be replace due to the oil has been degraded by contaminants in the engine, there are some question whether is there any possibilities that the engine oil still can be use and might not do any harm to the engine or not. Thus, this project is to measures certain effects on the engine when the use of oil that have already degraded and oxidized such as performance of the engine motorcycle which includes the power and torque of the engine. In fact, this project also would highlight the benefit in terms of economical to the people.

1.3 Objectives

The objective of this study are:-

- To determine the effect of using used lubricant oil on engine's power
- To determine the effect of using used lubricant oil on engine's torque
- To determine the economical aspect of using recycle engine oil to the user

1.4 Scopes and outline of project

This project is mainly focused on the effect of using used lubricant oil to the performance of engine motorcycle. The engine will be lubricate using various type of grade of oil from mineral type to fully synthetic type. As stated previously, a different type of oil will give a different kind of output. Performance graph or torque and power will be compared to one another and the differences will be discussed.

This project also involved the use of dynamometer as shown in figure below and controller. Dynamometer with 20KW coupled with the motorcycle engine and the speed was controlled using a controller. Basically, the controller displayed the value of torque, engine speed, dyno speed and load. Dynamometer speed was calculated and set at the controller. The calculation as shown as follow:

$$Dynamometer\ Speed = \frac{Actual\ engine\ RPM}{Primary\ Reduction\ Ratio \times gear\ teeth} \quad (1)$$

$$Primary\ reduction\ ratio = 3.048\ (\frac{64}{21}) \quad (2)$$

Given:

Gear teeth of dynamometer = 66/60

Gear ratio of Modenas Kriss 110CC = 64/21

The value of dyno speed is set at the controller and the throttle will be operating at WOT (Wide Open Throttle) until the engine is at constant speed. The value of engine speed is set at various point with interval of 500 which starts from 1000RPM to 5000RPM. Then, as all the value of torque is compiled, the value for the power is calculates using formula as shown in equation 3.

$$Power = 2\pi NT$$

Where:

N = Engine speed in rev/second (RPS)

T = Torque of the engine

Figure 1.2: 20kW eddy current dynamometer

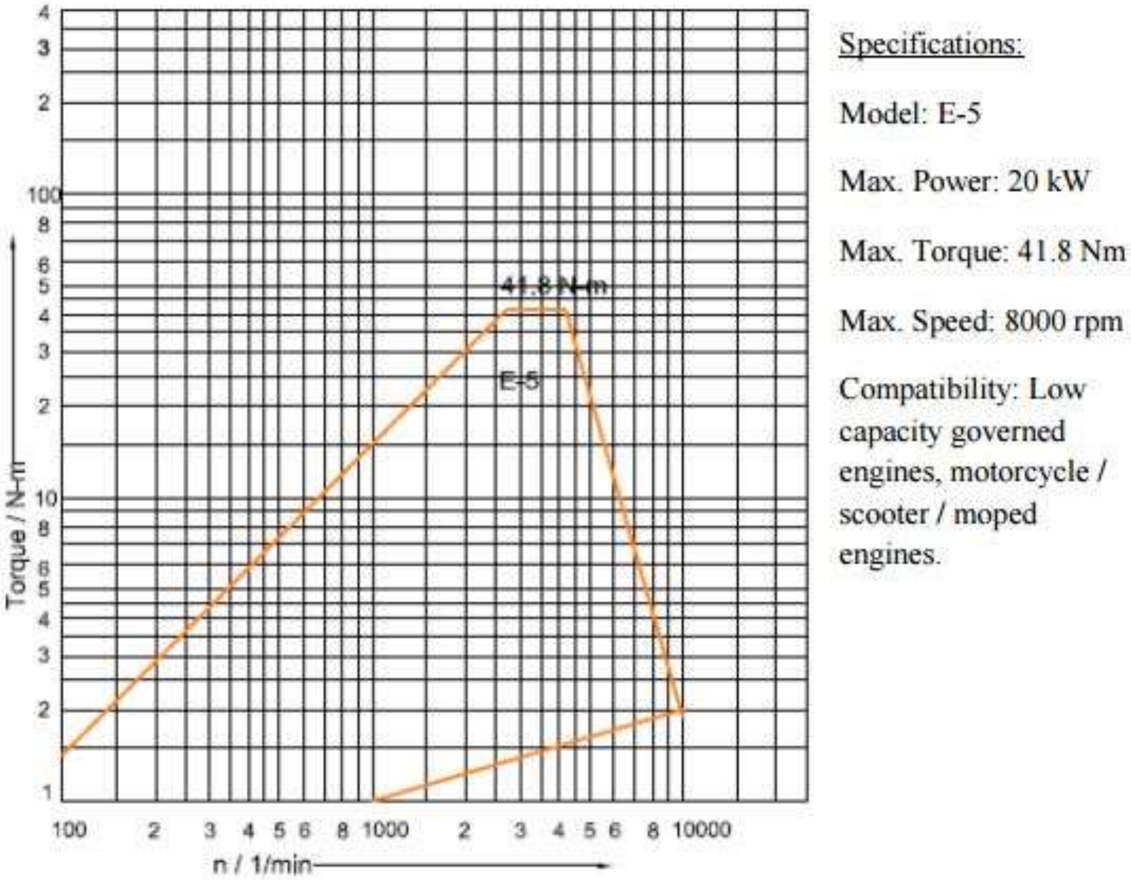


Figure 1.3: Graph of eddy current dynamometer performance

1.5 Outlines report

In this report consists of five chapter that explained the overall information and details from the introduction to conclusion of this project. Chapter 1 is the introduction of the project to the research background, problem statement, objectives and scope of the project.

Chapter 2 is about the literature review and mainly about the research related to this project from the past journal, articles, books and webpages as references. Detail explanation about the research are describe in this chapter.

In chapter 3, methodology for carried out the project in discussed here for more detail. The procedure, experiment and calculations will be explained briefly on how they conducted and needed to be included in the project. Chapter 4 is discussed about the results and the discussion have been obtained after complete chapter 3.

Lastly, the chapter 5 is the conclusion of the project. The summary of the project implementation and achievement are included. The limitation of this project also included for next research to improve this system to be better in future.

CHAPTER 2: LITERATURE REVIEW

2.1 Basic working principle of four-stroke engine

There are two types of internal combustion engine, most typically are two-stroke and four stroke engine. Both have different working principle. Four stroke engine required four distinct piston movement where it goes with the following orders of intake, compression, power and exhaust [1]. Intake stroke is where the mixture of air and fuel is introduced in the combustion chamber. At this point, the piston position moves from TDC to BDC and intake valve will open. The second stages is where the compression of the mixture is occur where piston move back up via the counterweight on the crankshaft to compress the mixture. Then, the ignition stages occur where the compressed mixture is ignited by the spark plug causing a detonation in the combustion chamber. Consequently, the piston will move downward as result of the detonation. The last stage is where the exhaust stroke occur. At this stage, the exhaust valve will open and releasing the product of combustion of mixture of air and fuel. However, the different between four-stroke and two-stroke engine is in the method of filling the mixture and removing the product of combustion from the combustion chamber. The combustion cycle is completed in a single piston stroke as oppose to two piston strokes [1].

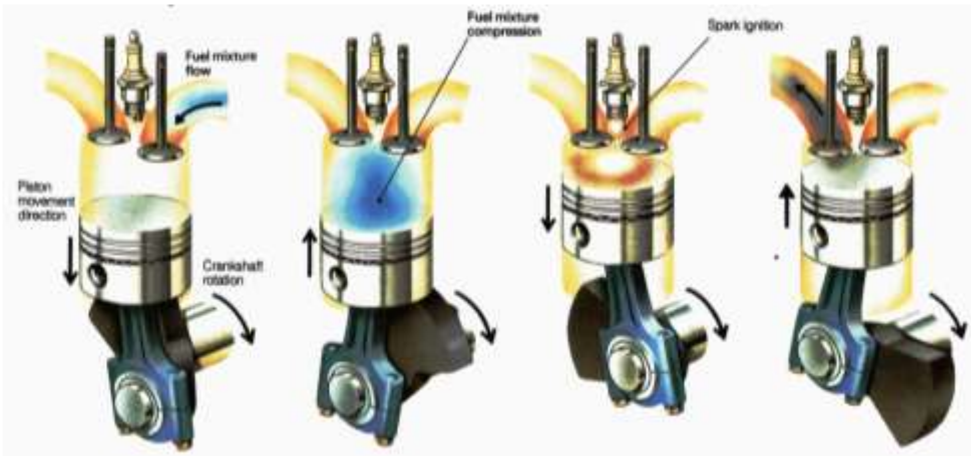


Figure 2.1: (a) intake, (b) compression, (c) ignition, (d) exhaust [1]

2.2 The significant of lubricating the engine

Hence, there are a lot of movements of the mechanical part in the engine itself which brings the essential of lubricating the engine. The movement of many parts in cylinder lead to a friction occur between the parts which consequently produced a thermal energy which typically heat up the engine. This could potentially affect the performance and mechanical efficiency of the engine. It is well known that the reduction of engine mechanical friction increases the engine efficiency [2]. Many researcher also conducted experiments to determine the effect of the friction and temperature on the engine. Plus, when there is a large friction between the cylinder and the piston, it would lead to the vibration too. Engine will be vibrate as the piston moving upward and downward when there is no enough lubrication on the piston [3]. This statement also was supported by many researcher as a torsional vibration of engines is possible [4, 5, 6]. Besides that, the engine friction also could affect the fuel efficiency of the engine too. There were many experiments and researches on this matter. The reason why the friction in the engine can affects the fuel efficiency is because as the engine was not lubricated enough, then the friction will be high because the engine is working effectively as it has to be [7]. In fact, there is also a research which conducted to determine whether the engine's fuel economy could be affected as a result of the friction in the engine. The fact that the experiment were conducted in the diesel engine, it still proved that if the friction in the cylinder were not eliminated, the consequences of reduce in performance and increase in fuel economy is possible [11].

The experiment mentioned earlier was conducted on two different Diesel engine specifically Heavy-Duty Diesel engine and Light-Duty Diesel engine. Both were used to investigate the effect of the lubricant oil viscosity on friction characteristics and fuel consumption of the engine. The measurement of outcome experiment were measured using appropriated eddy current dynamometers and instrumented with fuel consumption measurement unit, pressure sensor, angle encoder, speed sensor, temperature indicators, data acquisition system and many more [11]. Two engine lubricants were selected for both types of engine in such a way that both lubricants were of same performance category but having different viscosity grade. For DI diesel engine SAE 20W-50 and SAE 10W-30 engine lubricant complying with API CG-4 were chosen, whereas for IDI diesel engine SAE 15W-40 and SAE 5W-30 engine lubricants complying with API CF-4 were selected. It is to be noted that recommended engine oil was taken as baseline lubricant for the friction and fuel consumption study. Test results in terms of friction mean effective pressure (FMEP), friction power, fuel consumption (g/kWh) were analysed for DI heavy duty diesel engine for both engine lubricants. Whereas test results in terms of fuel consumption and Fuel Efficiency (%FE) for the light duty IDI diesel engine were analysed for both engine lubricants.

On top of that, it is not only will affect the performance and fuel consumption of the engine, a good lubricant oil also could help preserve the nature by ensure the emission of the combustion is not harmful to the environment. The research presents the treatment of waste engine oil and studying the performance, combustion and emission characteristics of blends of recycled engine oil with diesel in a diesel engine [7]. The recycled oil will be treated first by using acid and clay treatment which is more cost effective method compared to the other advanced method which requires higher investment. After the blends were prepare, it will be test using the diesel engine. The performance of the engine is studied and in returns, the results indicate an increase of brake thermal efficiency, exhaust gas temperature when compared with that of diesel. Also there is a decrease of brake specific fuel consumption and emissions of NOx and HC. Hence the blend of recycled engine oil with diesel reduces the consumption of diesel and also minimizes the disposal problems of engine oil. Plus, the properties of the engine oils can affect the engine emissions in many ways [13]. Heavy hydrocarbon derived from the engine oil are a known significant contributor to the soluble organic fraction or organic carbon portion of diesel particularly [13]. Engine oil hydrocarbon could affect the nuclei mode SOF, which consequently affect the emission particle produced. Plus, high molecular mass polymers in engine oil also could contribute to this problem. But it can be controlled by lowering the amount of oil consumed by the engine. This can be done through the engine design or modifying oil properties, such as lower vitality, better seal compatibility to minimize the leakage, and better detergency or oxidative stability to minimize cylinder deposits [13].

2.3 Engine oil and its significant

2.3.1 Engine oil

Engine oil is primarily used for lubricating the internal combustion engine. It can protects the engine from suffer from a big friction, high operating temperature and many more. It also helps the minimisation of exposure to oxygen which in return the oxidation at higher temperature also decrease. Engine oil is primarily a product from petroleum which commonly called mineral oil. It consists of variety formula of hydrocarbon molecules which differentiate their behaviour responds to heat, pressure and engine operating factors [14]. Given the variations of characteristics and qualities of the lube oils, the American Petroleum Institute (API) has developed the specification to define the standard engine oil performance. There are two type of classifications of oil that are recognised by API performance standard; S-Series oils are designed to meet performances standard for Spark Ignition (SI) engine system while C-Series oils meet with Compression Ignition (CI) engine performance requirements.

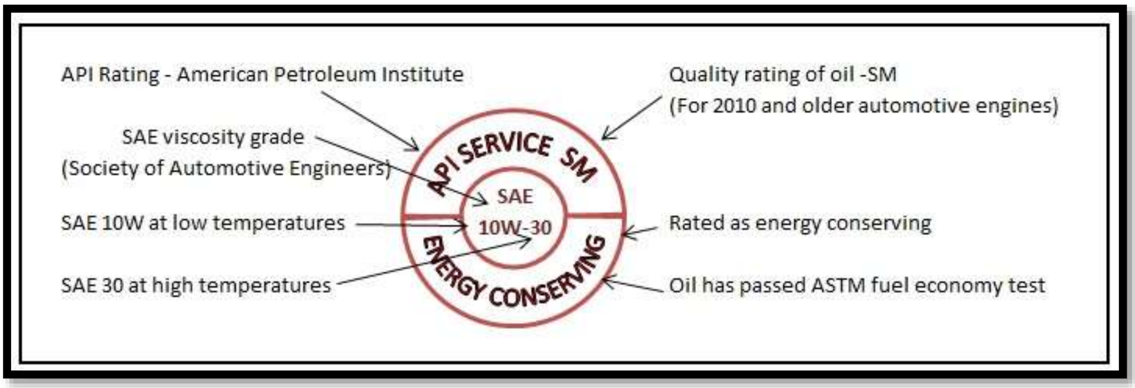


Figure 2.2: API service symbol (pic courtesy of Machinery Lubrication Magazine)

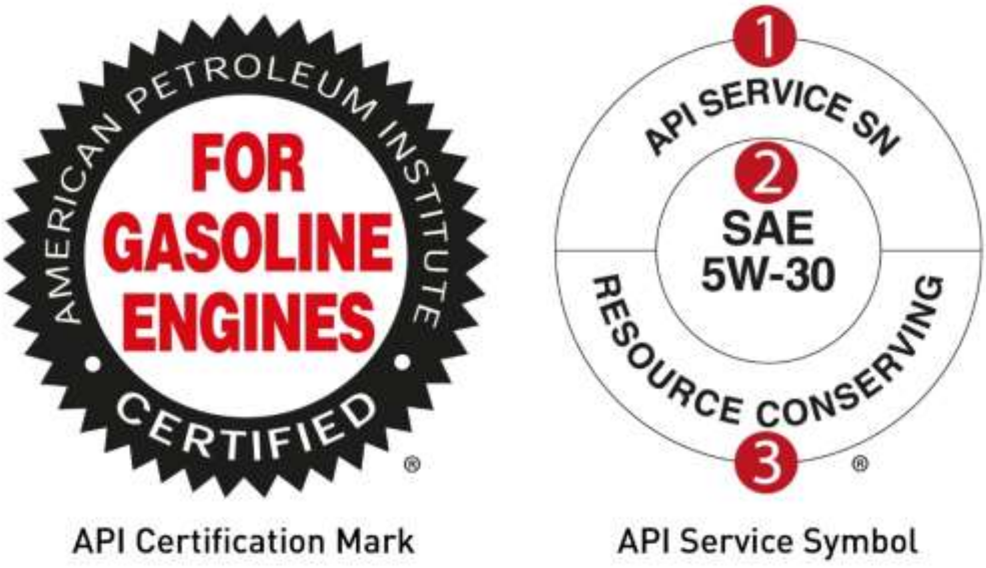


Figure 2.3: API service symbol and API certification mark

Based on Figure 2.3, both are the symbol designates the performance standard oil meets according to the API specifications. Engine oil carrying the API symbol must be certified after undergoes specialized testing to determine whether it meets with the API standard. The symbol is divided into three parts which as shown in Figure 9 and the symbol is commonly called as donut symbol. The upper part which numbered with 1 is designates the oil's performance standard. The part numbered with 2 or the centre part identifies the viscosity of the oil which is a standard defined by the Society of Automotive Engineers (SAE). Basically, viscosity is a measure of an oil's flow characteristics at certain temperatures. The part numbered with 3 is a fuel economy. It is often marked with 'Energy Conserving' which implies the energy conserving properties in a standard test in comparison to reference oil. The use of energy conserving oil is expected to result in improved of fuel economy of the vehicle. Moreover, for the API certification symbol, it identifies an engine oil as recommended for a specific applications such as diesel or gasoline use. The lube oil will only qualifies to have the starburst certification symbol only if it meets the most current standard specification set up by the API.

Below shows the current and previous API standard that have been used across the world. Owner of the vehicle should follow the manufacturer's recommendation on the performance level of their vehicle:

Table 2.1: API Service Classification for Gasoline-powered vehicle (Source: "Motor Oil Guide: Which oil is right for you" extract from AMERICAN PETROLEUM INSTITUTE, Engine oil licensing and certifications system

NAME	STATUS	SERVICE
SN	CURRENT	Introduced in October 2010 for 2011 and older vehicles, designed to provide improved high temperature deposit protection for pistons, more stringent sludge control, and seal compatibility. API SN with Resources Conserving, matches ILSAC GF-5 by combining API SN performance with improved fuel economy, turbocharger protection, emission control system compatibility, and protection of engines operating on ethanol-containing fuels up to E85
SM	CURRENT	For 2010 and older automotive engines
SL	CURRENT	For 2004 and older automotive engines
SJ	CURRENT	For 2001 and older automotive engines
SH	OBSOLETE	-
SG	OBSOLETE	-
SF	OBSOLETE	-
SE	OBSOLETE	CAUTION: Not suitable for use in gasoline-powered automotive engine built after 1979
SD	OBSOLETE	CAUTION: Not suitable for use in gasoline powered automotive engines built after 1971. Use in more modern engine may cause unsatisfactory performance or equipment harm

Table 2.2: API Service Classification for Diesel-powered vehicle (Source: "Motor Oil Guide: Which oil is right for you" extract from AMERICAN PETROLEUM INSTITUTE, Engine oil licensing and certifications system

CATEGORY	STATUS	SERVICE
CJ-4	CURRENT	For high speed four-stroke cycle diesel engines designed to meet 2010 model year on-highway and Tier 4 nonroad exhaust emission standard as well as for previous model year diesel engines. These oils are formulated for use in all applications with diesel fuels ranging in sulfur content up to 500 ppm. However, the use of these oils with greater tah 15 ppm sulfur fuel may impact exhaust aftertreatment system durability and/or drain interval. CJ-4 oils are effective at sustaining emission control system durability where particulates filters

		and other advanced aftertreatment system are used. API CJ-4 oils exceed the performance criteria of API CI-4 with CI-4 PLUS, CI-4, CH-4, CG-4 and CF-4 and can effectively lubricate the engine calling for those API service categories.
CI-4	CURRENT	Introduced in 2002. For high speed, four stroke engiens designed to meet 2004 exhaust emission standards implemented in 2002. CI-4 oils are formulated to sustain engine durability where exhaust gas recirculation (EGR) I sused and are intended for use with diesel fuels ranging in sulfur content up to 0.5% weight.
CH-4	CURRENT	Introduced in 1998. For high speed, four stroke engines designed to meet 1998 exhaust emission standard. CH-4 oils are specifically compounded for use with diesel fule ranging in sulfur content up to 0.5% weight.
CG-4	OBSOLETE	Introduced in 1995. For severe duty, high speed, four stroke engines using fuel with less than 0.5% weight sulfur. CG-4 oils are required for engines meeting 1994 emission standards. Can be used in places CD, CE and CF-4 oils
CF-4	OBSOLETE	Introduced in 1990. For high speed, four stroke, naturally aspirated and turbocharged engines. Can be used in place of CD and CE oils

Apart from API regulations, there are also ILSAC regulations which stand for International Lubricants Standardization and Approval Committee where it is formed by AAMA (American Automobile Manufacturers Association). Basically, the organization is mainly about to define the need, parameters, licensing and administration of lubricant specifications. However, the similarities between ILSAC and API is both of the oils is carry the API service symbol including the Energy Conserving designation as shown in figure 9. Listed below is the ILSAC regulations that are currently used.

Table 2.3: International Lubricant Standardization and Approval Committee, Engine oil viscosity classifications (Handbook)

ILSAC GF-1	This indicates the oil meets both API SH and Energy Conserving II (EC-II) requirements. It was created in 1990 and upgraded in 1992 and became the minimum requirements for oil used in American and Japanese automobiles.
ILSAC GF-2	This regulations replaced GF-1 in 1996. The oil must meet both API SJ and EC-II requirements. The GF-2 standards requires 0W-30, 0W-40, 5W-20, 5W-30, 5W-40, 5W-50, 10W-30, 10W-40 and 10W-50 motor oils to meet stringent requirements for phosphorus content, low temperature operation, high temperature deposits and foam control
ILSAC GF-3	The oil must meet both API SL and the EC-11 requirements. The GF-3 standard has more stringent parameters regarding long term effects of the oil on the vehicle emission system, improved fuel economy and improved volatility, deposit control, and viscosity performance. The standard also requires less additive degradation and reduced oil consumption rates over the service life of the oil.
ILSAC GF-4	This is similar to the API SM service category but it requires an additional sequence VIB Fule Economy Test (ASTM D6837)
ILSAC GF-5	Introduced in October 2010 for 2011 and older vehicles, designed to provide improved high temperature deposit protection for pistons and turbochargers, more stringent sludge control, improved fuel economy, enhanced emission control system compatibility, seal compatibility, and protection of engines operating on ethanol-containing fuels up to E85.

2.3.1 Types and grades of lubricant oil

It is safely to say that the lubricant also play a vital role in order to ensure the engine working effectively. There are various type of engine oil and it is varies with the viscosity and properties of the oil behaving in certain temperature [8]. As published by the Automotive Lubricant References Book, 2nd edition, John Wiley and Sons Ltd, engine oil performs many function and its play a vital role in lubricating the engine cylinder from grinding and tearing between the metal components in the cylinder. Plus, it can transfers the heat produced away from the combustion cycle in which consequently could help the mixture of air and fuel from pre-ignition as the pressure and temperature build up in the cylinder. The characteristics of the engine oil is as they get hotter, the oil become thinner. That is why there are numerous of grades of engine oils which it will show different behaviour as the oils heats up. As example, 10W-30 grade oil. This type of oil behaves like a 10-rated single grade oil when cold, but it does not thin any more than a 30-rated single grade oil when hot. W is stands for winter, the lower the W number, the easier the engine will turn over when starting in cold climates. The number after W is hot viscosity rating whereas the number before W is cold viscosity rating.

Table 2.4: Quick guide for variety of engine oils (source: carbibles.com)

Fully synthetic	**Characteristics**
0W-30 **0W-40** **5W-40**	• Fuel economy savings • Enhances engine performances and power • Ensure engine is protected from wear and deposit build up • Ensure good cold starting and quick circulation in freezing temperature • Gets to moving parts of the engine quickly
Semi-synthetic	Characteristics
5W-30 **10W-40** **15W-40**	• Better protection • Good protection within the first 10 minutes after starting out • Roughly three times better at reducing engine wear • Increased oil change intervals – don’t need to change it quite so often
Mineral	Characteristics
10W-40 **15W-40**	• Basic protection for a variety of engines • Oils needs to be changed more often

As the engine oil gets thicker, the engine has to work to push the oil throughout the engine components, the vehicle pulls on your fuel supply to help power the engine and keep it running [9]. The harder the engine has to work to move oil through different parts, the more fuel the vehicle uses, So the thinner your engine oil, the better your fuel efficiency is, However, many people specifically look for high viscosity oil to provide the fullest protection to their engine. Plus, high viscosity of engine oil could also improve the thermal or waste heat produces by the engine, thus operating temperature of the car also get decrease [10]. This significantly can increase the lifespan of many components in the engine. However, the engine oil could not be as thinner as the user wanted. It is because the engine oil still has to be thick enough to protect the engine components from in contact with each other which could lead to wear and damage of the engine parts.

CHAPTER 3: METHODOLOGY

3.1 Flowchart outline of the project

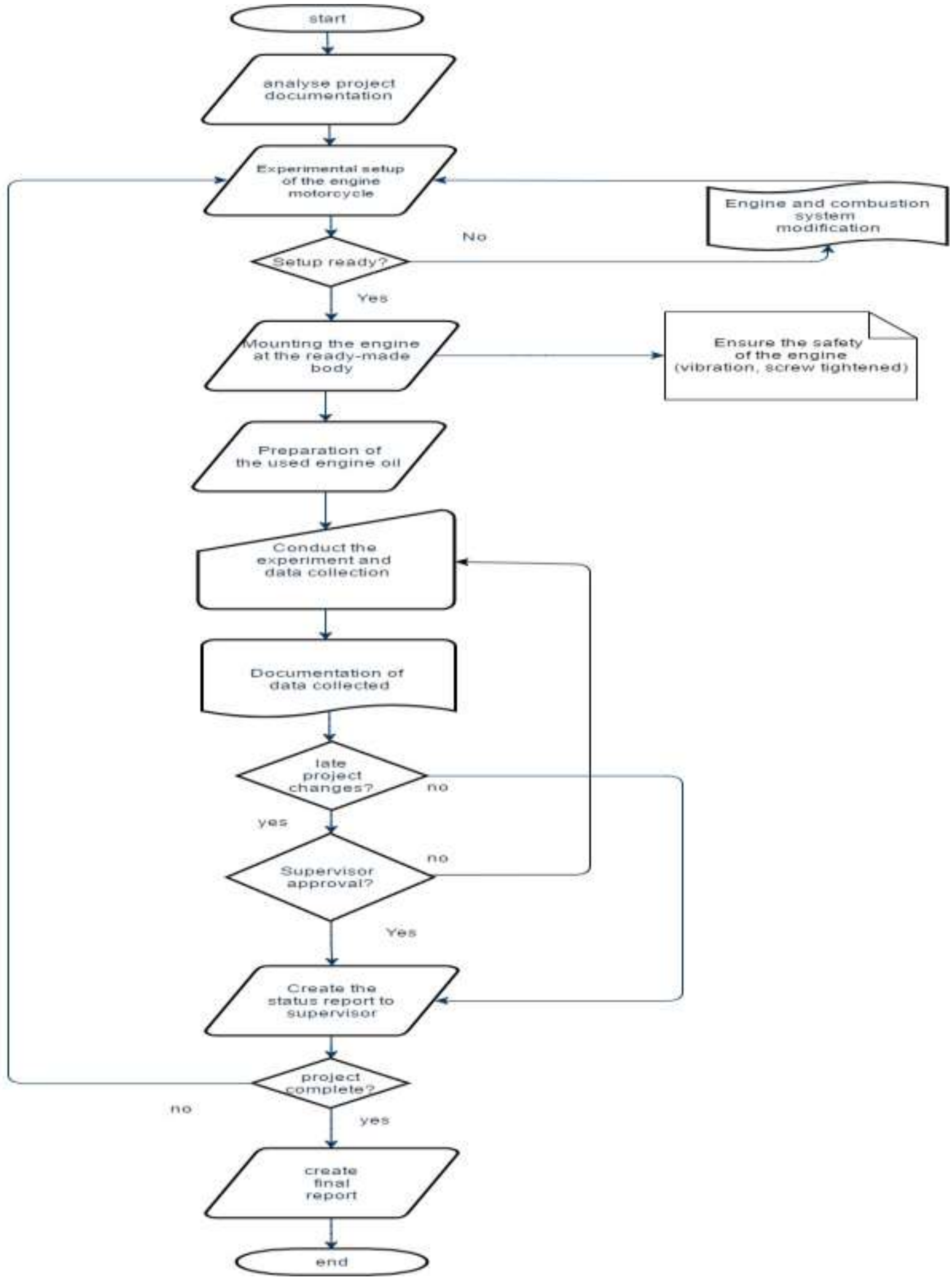
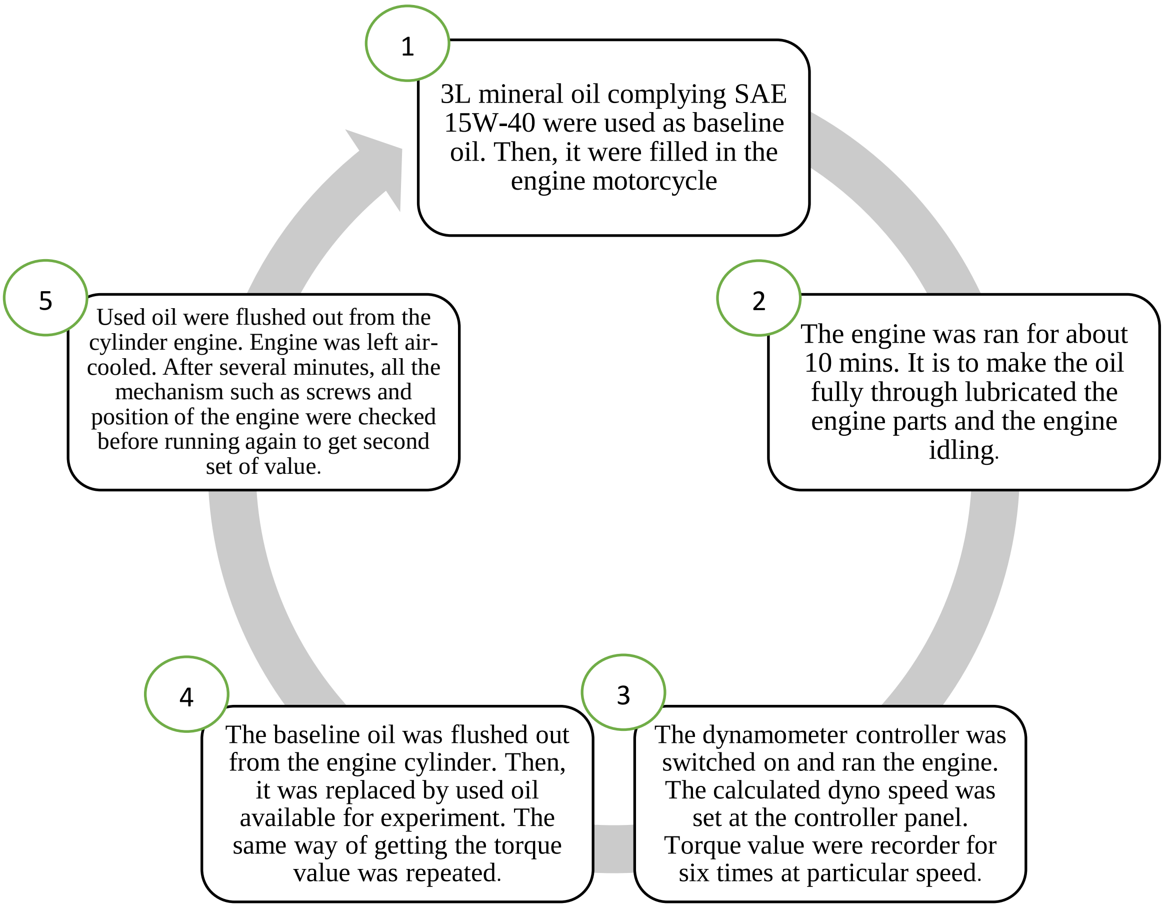


Figure 3.1: Flowchart outline of the project

3.2 Work flow of the experiment



Firstly, the mineral oil complying under SAE 15W-40 were filled in the engine cylinder. The oil used is the brand new oil. It is consider as baseline oil. Meaning to say, for every variables of recycled oil use results' will be compared to the baseline performance curve. Then, the engine will start to fire and was left for around 10 minutes. It is because just to make sure the oil is fully lubricated the engine parts and engine speed is at constant speed where it is idling around 600 RPM. Then, the dynamometer was ran and the calculated dyno speed which equivalence to engine speed was set up at the controller of the dyno. The experiment conducted was similar as standard procedure of wide open throttle torque curve and it is started at engine was ran with 1000 RPM of engine speed and then incremented by 500 for each step until it reached 5000 RPM. The reason of the speed range 1000 RPM and 5000 RPM were used is it is consider as typical speed run by motorcycle user which not intentionally for high-performance speed. Then, after the baseline performance data were recorded, the baseline oil were replaced with used oil derived from vehicle user and workshop nearby. The type of used oil available for experiment are SAE 10W-30, SAE 5W-40, SAE 5W-30, SAE 10W-40, SAE 0W-20 and SAE 20W-50. The same procedure was conducted to get the torque data and it was recorded. For every type of used oil, the experiment were done three times to get the average results so that the data is around the accurate value. For every type of oil used, after the experiment were finished, the engine oil will be flushed out and left for air cooled until all the oil in the cylinder is extract from it. The mounting screws, engine body, and bolts were checked before running the engine for another type of oil to avoid any bad consequences during the experiment conducting.

3.3 Engine motorcycle specifications

As previously mentioned, the engine motorcycle used to conduct the experiment is by using the engine from Modenas, which the first national motorcycle ever made. The model was named Modenas Kriss until today. The engine specifications are listed as shown below.

Figure 3.2: Modenas Kriss 110

Table 3.1: Modenas Kriss 110 engine specification

Type	Four stroke, Single cylinder
Cooling system	Air-cooled
Bore and stroke	53.0 x 50.6 mm
Displacement	111 mL
Compression ratio	9:3:1

Max Horsepower	6.6 kW @ 8500 RPM
Max Torque	9.3 Nm @ 4000 RPM
Carburetion system	Carburator, KEIHIN PB18
Starting system	Primary kick, Electric starter
Ignition system	Magneto CDI
Lubrication system	Forced lubrication (wet sump)

3.4 Dynamometer and its controller

Figure 3.3: Engine Dynamometer

As shown in Figure 3.3, type of dynamometer use was eddy current dynamometer which have the maximum power input of 20kW. The dynamometer which held at USM Engine Lab are basically use for various engine testing. Basically, a dynamometer is a load device used to measure an engines torque and speed by using some procedure which can be adjusted using the controller. In the context of this experiment, the standard procedure of Wide Open Throttle (WOT) is used to get the performance curve. The type of dynamometer used is engine dynamometer where the output of the dyno is coupled directly to the transmission of gear box of the engine motorcycle. The coupling mechanism use is 'Quick-connect' coupling where it connected to the sprocket of motorcycle as shown in Figure 3.4.

Figure 3.4: Quick-connect coupling

This type of coupling was already available in the Engine Lab USM, it fits perfectly but by physically observed, the coupling was a bit older and there are some obvious corrosion on the surface of it. But most crucial part is where the metal ‘fingers’ that are placed between the teeth of the gear. The ‘fingers’ is still strongly attached to the rod, thus this coupling is safe to be use. As shown if figure 3.5. The completed setup between the dyno and engine motorcycle is shown.

Figure 3.5: Experiment setup completed between engine and dyno

In terms of the controller used, the model of the controller is Focus Applied Technology D2ACP Dyno Controller Unit as shown in Figure 3.6. The controller is basically used to control the load. The set point (engine speed) can be setup manually or electronically generated. The controller have 3 modes of operating which is open loop, speed control and torque control. In terms of this experiment, the modes used was speed control modes. The controller continuously measures the speed and adjusts the load of the dynamometer to maintain speed at desired set point. Plus, the controller is generally a full PID controller which makes it important to tune it for the appropriate engine-dyno combination.

Figure 3.6: Focus Applied Technology D2ACP Dyno Controller Unit

Basically, the controller displayed the value of torque, engine speed, dyno speed and load. Dynamometer speed was calculated and set at the controller. The calculation as shown as follow:

$$Dynamometer\ Speed = \frac{Actual\ engine\ RPM}{Primary\ Reduction\ Ratio \times gear\ teeth} \quad (1)$$

$$Primary\ reduction\ ratio = 3.048\ (\frac{64}{21}) \quad (2)$$

Given:

Gear teeth of dynamometer = 66/60

Gear ratio of Modenas Kriss 110CC = 64/21