A STUDY OF DIFFERENT TYPES OF ENGINE OILS ON HIGH COMPRESSION RATIO ENGINE PERFORMANCE

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in fulfilment of the requirements for the Degree of
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DECLARATION

I declare that this project report entitled "A Study of Different Types of Engine Oils on High Compression Ratio Engine Performance" is the result of my own work except as cited in the references.

Signature : 

Name : LIM JIE HAN

Date : 20 JUNE 2021

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 : 

Nameof Supervisor : DR. AHMAD KAMAL BIN MAT YAMIN

Date : 20 JUNE 2021

DEDICATION

I wholeheartedly dedicate this project to my family, friends and loved ones who actively encourage me. To my supervisor, Dr. Ahmad Kamal Bin Mat Yamin.

ABSTRACT

The objective of this study is to investigate the impact of different engine oil towards high compression ratio engine performance. The study focuses on impact of engine grades towards engine power and engine torque against engine speed, while other specifications are ignored. In this study, two different commercially distributed engine oil are chosen as the engine oil test specimen. The models are Yamalube semi-synthetic 4 stroke oil 10w-40 and Yamalube mineral 4 stroke oil 20w-50. The engine oils are tested in Yamaha XJ6 engine, and the test results are taken by using 800-Pro MC/ATV EC Dyno by DYNOmite dynamometer in DYNO-MAX 2010 software. The engine oils are tested in standard operating temperature of the engine. Environmental influence is negligible in this study. In accordance with expected behaviour, viscosity of fluid is decreasing with increasing temperature. SAE grading is used to describe the viscosity performance of engine oil. Higher SAE grading indicates that the engine oil has a higher viscosity and thus it flows slower. In general, engine oil with higher SAE grading is able to provide better lubrication and protection to the engine at high temperature and pressure as it is thicker compared to engine oil with lower SAE grading. However, higher fluid viscosity will lead to higher frictional loss as the fluid resistance is also higher. In fact, by ensuring the engine oil seal will not leak, low viscosity engine oil can decrease the rate of fuel consumption and boost the engine performance as the frictional loss caused by engine oil seal is reduced. In order to study the relationship between the different in engine SAE grading and power or torque loss of the engine, further investigation is required. In short, engine oil with higher SAE grading will give reduced power and torque compared to engine oil with lower SAE grading. The power and torque loss due to different engine oil SAE grading increase as engine speed increase. However, the percentage of power and torque loss decrease as engine speed increase.

ABSTRAK

Objektif kajian ini adalah untuk mengkaji bagaimana minyak enjin yang berbeza mengpengaruhi prestasi enjin nisbah mampatan tinggi. Kajian ini fokus pada kuasa enjin dan tork enjin terhadap kelajuan enjin, sementara spesifikasi lain tidak diambil kira. Dalam kajian ini, dua minyak enjin yang diedarkan secara komersial dipilih sebagai spesimen ujian minyak enjin. Modelnya ialah minyak 4 stroke semi-sintetik Yamalube 10w-40 dan minyak 4 stroke Yamalube mineral 20w-50. Minyak enjin tersebut diuji dalam engin Yamaha XJ6, dan hasil ujian diambil dengan menggunakan 800-Pro MC / ATV EC Dyno oleh DYNOmite dynamometer dalam DYNO-MAX 2010. Minyak enjin diuji pada suhu operasi standard enjin. Pengaruh persekitaran diabaikan dalam kajian ini. Secara umum, kelikatan bendalir menurun apabila suhu meningkat. Penggredan SAE digunakan untuk menghuraikan prestasi kelikatan minyak enjin. Penggredan SAE yang lebih tinggi menunjukkan bahawa minyak enjin mempunyai kelikatan yang lebih tinggi dan dengan itu minyak akan mengalir dengan lebih perlahan. Secara umum, minyak enjin yang menpunyai penggredan SAE yang lebih tinggi boleh memberikan pelinciran dan perlindungan yang lebih baik kepada engin pada suhu dan tekanan tinggi kerana minyak itu lebih likat jika dibandingkan dengan minyak enjin dengan penggredan SAE yang lebih rendah. Walau bagaimanapun, kelikatan cecair yang lebih tinggi akan menyebabkan ketewasn geseran yang lebih tinggi kerana rintangan bendalir juga lebih tinggi. Sebenarnya, dengan memastikan segel minyak engin tidak bocor, minyak engin dengan kelikatan rendah dapat menurunkan kadar penggunaan bahan bakar dan meningkatkan prestasi mesin kerana ketewasan geseran yang disebabkan oleh meterai minyak engin dikurangkan. Untuk mengkaji hubungan antara perbezaan dalam pengukuran SAE enjin dan kehilangan kuasa atau tork enjin, penyelidikan yang lebih lanjut diperlukan. Ringkasnya, minyak enjin dengan penggredan SAE yang lebih tinggi akan memberikan daya dan tork yang berkurang berbanding dengan minyak enjin dengan penggredan SAE yang lebih rendah. Kehilangan kuasa dan tork kerana peningkatan gred SAE minyak enjin yang berbeza seiring dengan peningkatan kelajuan enjin. Walau bagaimanapun, peratusan kehilangan kuasa dan torsi menurun seiring dengan peningkatan kelajuan mesin.

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LIST OF ABBREVIATIONS

Al_2O_3	-	Aluminium oxide
API	-	American Petroleum Institute
AW	-	Anti Wear
B/S	-	Bore to Stroke Ratio
BTE	-	Brake Thermal Efficiency
BHP	-	Brake Horsepower
CFD	-	Computational Fluids Dynamics
CI	-	Compression ignition
CR	-	Compression Ratio
DOHC	-	Dual Overhead Camshaft
EP	-	Extreme Pressure
HSDI	-	High speed direct injection
JASO	-	Japanese Automotive Standards Organization
MATLAB	-	Matrix Laboratory
MoS_2	-	Molybdenum disulphide
NO_x	-	Nitrogen oxides
NP	-	Nano Particles
PTFE	-	Polytetrafluoroethylene
SAE	-	Society of Automotive Engineers
TCP	-	Tricresyl phosphate
WHP	-	Wheel Horsepower
Wt%	-	Weight Percentage
Zn-DTP	-	Zinc dithiophosphate

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Engine oil, motor oil or as known as lubricant of engine, is lubricant that is used in internal combustion engine. Its primary features are to reduce the friction or wear in the engine, as well as clean the oil sludge and varnish. The engine oil also neutralizes acidic substance that was produced by the fuel or oxidation of lubricant. It is able to enhance the sealing of piston rings. It can also bring away the heat that was generated from the friction of the moving parts in order to cool down the engine.

Before the discovery of petroleum-based motor oil, animal fat was used to keep complex machines moving. The person that invented the earliest motor oil was Dr. John W, Ellis. Dr. Ellis was, in fact, a physician who had established practices in Massachusetts, Michigan, and Pennsylvania. He even spent several years teaching at medical schools in Ohio and New York. At age 50, Dr. Ellis's journey was just beginning. He travelled to Titusville in the early 1860s to research the properties of crude oil in hopes of implementing it for medical purposes, but he quickly realized there was no wonder tonic to be found. He did, however, notice it had vast potential for mechanical purposes. After developing his own equipment to test the crude's capabilities, Dr. Ellis discovered a new process that improved its lubricating qualities by using steam heat rather than direct heat. As fortune would have it, Dr. Ellis quickly found a way to capitalize on his newfound discovery. In 1866, Ezekiel Crocker Leonard, Dr. Ellis's wife's sister's husband, was struggling to maintain his oil refinery in Binghamton, NJ, so he consulted Dr. Ellis for assistance. This new partnership

resulted in the Continuous Oil Refining Company, whose purpose was to manufacture lubricating oil from petroleum for steam engines and other machines. (The Original Behind the Original: A Brief History of Valvoline Founder Dr. John Ellis, Sep 4, 2020)

Since the primary function of engine oil is to act as lubricant for an engine, it is necessary define the term "lubrication". Lubrication is the applications of several type of matter or object between two moving surface that was rubbing against each other to minimise the level of wear and friction. Lubrication have been utilized by nature since the appearance of animal. Animal body part such as fluid in bone joints serves the purpose of lubricating the joints and bones of animals. As wisdom of human species grow, ancient people used wet soil and reeds as simple lubricant for pulling heavy object such as timbers and rocks. As wagons are invented, friction and wear in the moving parts are inevitable. At first, animal fat and other simple lubricant are used to lubricate the wagons. This continues until petroleum industry advances in the 19th century. Crude oil was used to replace animal fat to become the primary material for making lubricants. As technology advance, the ability to lubricate of crude oil improved gradually. This is primarily because of the rising number of machines that required high level of lubrication such as the automobile vehicle, the airplane, the diesel locomotive, the turbojet, and machinery in the factory. Due to this factor, the development petroleum-based lubricants has a positive impact in accelerating the development of various industrial. (The Editors of Encyclopaedia Britannica, July 20, 1998)

For modern engine oil, viscosity is one of the main properties to differentiate between different engine oil. The value of fluid viscosity represents the thickness of the fluid or a measure of its hindrance to flow. A well performed engine oil should have low enough viscosity for it to flow freely in the engine parts under all circumstances, while at the same time having sufficient viscosity to lubricate the parts properly.

The working temperature will affect the properties of the engine oil. When a car engine is ignited, the engine often starts working at low temperature. Hence, the engine oil must flow well at low temperature, as friction and wear of the engine's moving parts can be minimised upon starting the engine. On the other hand, the engine oil should also be able to sustain high enough temperature. In fact, oil is largely composed of hydrocarbons which can be ignited. For this purpose, "flash point" is being introduced. Flash point represents the lowest temperature when the oil started to vaporise, and the vapour can be ignited. Hence, flash point of the engine oil governs its possibility to burn.

Other than that, total base number is also a property to describe an engine oil's performance. It gauges the reserve alkalinity of an oil, in other word, its ability to cancel out acidic substances. When the engine is working for a long period of time or distance, acidic substance will be formed. Hence, it is crucial to control the total base number of the engine oil for better engine efficiency and longer operating life.

From here, we can say that engine oil with different content and additives will exert different level of performance under different environment. Hence, scientist and engineer introduced single-grade oil and multi-grade oil for different working situation. In short, single-grade oil's grade only represents the viscosity of the oil when it is warm (100°C). This type of oil is expected to carry out lubrication task perfectly only at high temperature. At relatively low temperature, single-grade oil cannot flow properly. Hence, single-graded oil cannot lubricate the machine properly at low temperature. On the other hand, multi-grade oil is introduced to overcome this problem. Scientist and engineer formulate multi-grade oil by adding additive and polymer in the oil. It gives much better viscosity rating to the oil at lower temperature, while still maintaining appropriate lubricating performance by giving stable operating viscosity at higher operating temperature. Hence, multi-grade oil is expected to perform better than single-grade oil in various circumstances.

SAE Viscosity Grade	Low-Temperature (°C) Cranking Viscosity[3], mPa-s, Max	Low-Temperature (°C) Pumping Viscosity[4], mPa-s Max with No Yield Stress[4]	Low-Shear-Rate Kinematic Viscosity[5] (mm^2/s) at 100 °C, Min	Low-Shear-Rate Kinematic Viscosity[5] (mm^2/s) at 100 °C, Max	High-Shear-Rate Viscosity[6], (mPa-s) at 150 °C, Min
0W	6200 at-35	60 000 at -40	3.8		
5W	6600 at-30	60 000 at -35	3.8		
10W	7000 at -25	60 000 at -30	4.1		
15W	7000 at -20	60 000 at -25	5.6		
20W	9500 at -15	60 000 at -20	5.6		
25W	13 000 at -10	60 000 at -15	9.3		
8			4.0	<6.1	1.7
12			5.0	<7.1	2.0
16			6.1	<8.2	2.3
20			6.9	<9.3	2.6
30			9.3	<12.5	2.9
40			12.5	<16.3	3.5 (0W-40, 5W-40, and 10W-40 grades)
40			12.5	<16.3	3.7 (15W-40, 20W-40, 25W-40, 40 grades)
50			16.3	<21.9	3.7
60			21.9	<26.1	3.7

Figure 1.1: Multi-grade oil meets viscosity requirement at both high and low temperature (Internet Source, Retrieved 13 January 2021).

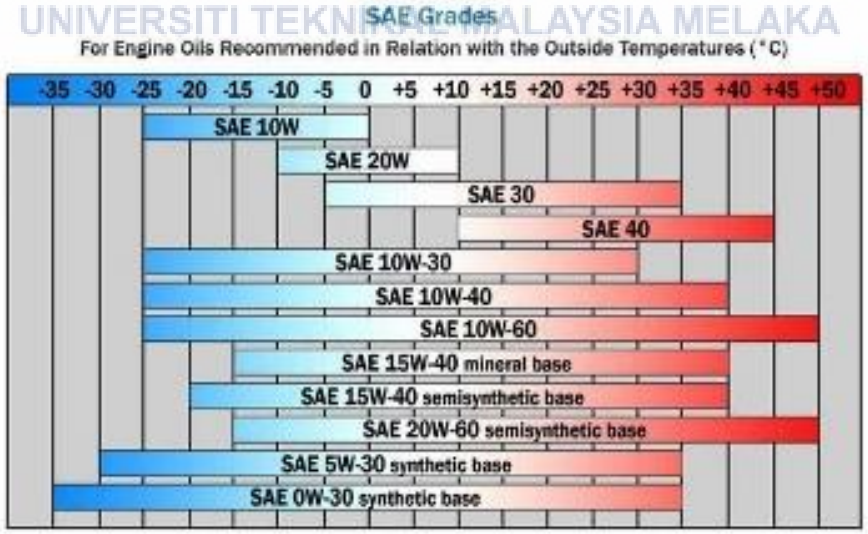

Figure 1.2: Recommended SAE graded engine oil at various temperature (Internet Source, Retrieved 13 January 2021).

In short, engine oil is one of the most important part for an engine to perform well. To meet various requirement from many different type of engine, as well as different working environment, manufacturer used additive in engine oil as high performance engine oil can only be achieved with a balanced formula. Typical engine oil usually consists of base oil, and other additives such as flow improvement additive, extreme pressure additive, anti-wear additive, detergent and dispersant as well as other components. Hence, this study was carried out to investigate how different types of engine oils will affect the performance of high compression ratio engine.

1.2 PROBLEM STATEMENT

In general, four stroke engine cycle engine work in four stages, including intake, compression, power and exhaust. Among these four, the compression stroke is related to the compression ratio of the engine. At the end of intake stroke, the drawn air-fuel mixture will be trapped in the combustion chamber of the engine when the intake valve close. The compression stroke initiate by pushing the piston upward and compressed the air-fuel mixture. The compression ratio represents the maximum cylinder volume to minimum cylinder volume ratio. Hence, high compression ratio indicates high air-fuel mixture pressure when the compression stroke end. (Kristen Lee, 2018)

In this study, an engine with high compression ratio is used as test subject to carry out our research. Since the compression ratio is high, we can expect engine will has higher operating pressure and temperature. In fact, an engine is a very complex system that contain around 30 moving parts. There is a lot of factor that could greatly affect a high compression ratio engine performance, including engine oil, fuel, working environment, condition of the moving parts, and even different technology that has been implemented in engine by different manufacturer could make two engines with similar displacement perform

differently. It is hard to determine which factor will affect an engine performance the most, so this study will focus solely on how engine oil affect high compression ratio engine.

Many drivers now a day, know very little about engine oil. They often neglect suggestion from the manufacturer and choose a cheaper engine oil as they think it performs the same. These drivers will probably suffer from low engine power, high fuel consumption and even short engine life in the future. Hence, this study also serves the purpose of showing how wrong type of engine oil can damage the engine. High compression engine ratio required a type of engine oil that suit its characteristic's for better engine performance and longer operating life. To fully understand how engine oil affect engine performance, we need to understand the design of the engine, and the content of the engine oil. Therefore, performing an experiment will show an actual results of the engine oil effect on high compression ratio engine performance. (Hall-Geisler, 2000)

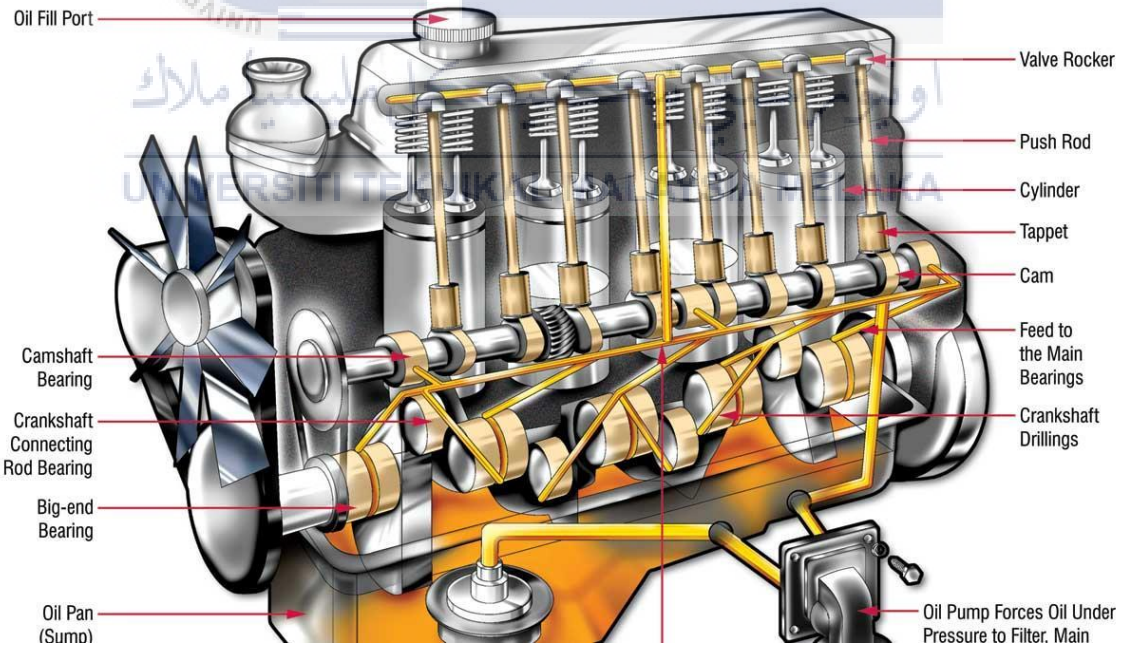

Figure 1.3 How engine oil flow in engine (Internet Source, Retrieved 13 January, 2021).

1.3 OBJECTIVE

There are several objectives in this project, the objectives are stated as below:

1. To investigate the impact of different engine oil towards the power performance of the engine.
2. To investigate the impact of different engine oil towards the torque performance of the engine.
3. To investigate the impact of environmental factor towards the properties of the engine oil.

1.4 SCOPE

There are several scopes in this project, the scopes are:

1. The test subject is engine provided by university authorities; all of the experiment will be carried out using this test subject.
2. The experimental research is focus on the engine performance, such as power, torque and RPM, while factor such as temperature, pressure, exhaust, level of vibration will not be manipulated.
3. The engine used is Yamaha XJ6S/ XJ6SA Diversion engine, the results only applicable to engine with similar arrangement, and displacement.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION TO BASIC KNOWLEDGE AND PRINCIPLE

2.1.1 WHAT IS FRICTION

Friction is the opposition force to a motion of a moving object. In fact, scientist do not consider frictional force as a fundamental force. Instead, they believe friction is caused by the intermolecular forces between the particles in the two contacting surfaces. Generally, friction can be categorised into two different type, which is static friction and kinetic friction. In short, static friction works between two surfaces of zero of same velocity. Kinetic friction will engage between two objects when they are in motion or have a velocity difference.

In liquids, fluid friction is the opposed force of the layers or particle in a fluid. In general, fluids that have higher viscosity are thicker and have higher resistance to movement. For example, honey is thicker than water, thus having higher viscosity. Besides, solid material will experience internal molecular friction as well. For instance, internal friction in a material will be created then when the solid gets pressurised or compressed. Friction is an important puzzle for completing many daily processes and activity. When two objects are rubbed against each other, a portion of the energy of motion will loss in the form of heat energy. Friction is also the main culprit for the wearing damage on basically everything including bike gears and car engine. Hence, the main task lubricants is to cut down and minimise the damages caused by friction and wear between moving parts (Ghose, 2013)

2.1.2 FRICTION AND WEAR

Friction and wear are closely related but are distinct phenomena. The mechanisms of wearing will contribute to occurrence of friction because force is applied, and energy will be consumed when wear occur. Generally, wear phenomena are referring to the damage to a solid surface. When wear occur, material will lose its weight or volume gradually. This is due to the relative movement between the two-contacting surface of the solid. In short, level of wear is determined as the volume or weight loss from solid that has a contacting surface with other solid. (Jiménez, et al, 2011)

Friction is the opposition force to the rubbing movement between two solids at the contact interface, and wear is the volume loss at the contact surfaces generated as the result of repeated friction. Wear is caused as the result of fracture in the contact region for mechanical wear or the removal of products grown on the contact surfaces by tribo-chemical reaction and/or corrosion for tribo-chemical wear. (Kato, 2011)

2.1.3 TYPE OF LUBRICANTS

Lubricants can be categorised into 4 main types, which is gaseous lubricants, liquid lubricants, semi-liquid/plastic lubricants or solid lubricants. (Kumar, et al, 2015)

Solid lubricants operate by introducing a layer consist of low shear strength substance in the volume between two contacting surfaces. Lubricating solids can be used in various method, the basic principle is similar. Low friction medium or layer will be deposited on the contacting surfaces to minimise the friction wear under dry conditions. Solid lubricants are frequently utilised when there is problem of containment caused by liquid. Sometimes, liquid or gaseous lubricants will fail in extreme environment such as vacuum, high temperature, or high radiation The examples of solid lubricants included