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Tribological Study of Engine Oil Lubricant Characteristics and its Performance on 660cc Engine

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Abstract

This paper presents analysis on engine lubricant characteristic and investigation on different engine oil lubricant effect, P1 and P2, in reducing fuel consumption of a 660cc engine. Four-ball tester machine was used to study the friction and wear response with variable speed and temperature. Optical microscope was used to measure the wear scar diameter and capture the image for analysis. The result obtained from this experiment showed that the engine oil P1 contributed to more friction and wear compared to engine oil P2 due to the P2 film characteristics and anti-wear additive characteristics. Fuel consumption experiment was carried out to investigate the engine oil P1 and engine oil P2 lubricant effect in reducing fuel consumption. Based on the result, P2 engine oil showed a better lubricant characteristics compared P1 engine oil in term of fuel consumption based on maximum mileage it could travel using two litre of fuel.

Keywords: Tribology, fourball tester, fuel consumption

1. INTRODUCTION

Engine oil can be divided into four basic varieties which are synthetic oil, synthetic blends, high mileage oil and conventional oil. Synthetic motor oil is a laboratory synthesis of precisely controlled ingredients created by oil engineers, scientists and chemists. When combined with a high-performance additive package, this results in an oil with the highest level of lubrication and engine protection, generally offering better protection at start-up, better cleansing qualities, enhanced durability and better protection against heat build-up [1]. Secondly is the synthetic blend motor oils, which contain a mixture of synthetic and conventional base oils for added resistance to oxidation (compared to conventional oil) and to provide excellent low temperature properties. Synthetic blend motor oils are recommended for cars, trucks, vans and SUVs that regularly carry heavy loads, tow trailers and/or operate frequently at high RPMs.

Most engine oils are made from a heavier, thicker petroleum hydrocarbon base stock derived from crude oil, with additives to improve certain properties. The bulk of typical engine oil consists of hydrocarbons with between 18 and 34 carbon atoms per molecule. One of the most important properties of engine oil in maintaining a lubricating film between moving parts is its viscosity. The viscosity of a liquid can be defined as its "thickness" or a measure of its resistance to flow. The viscosity must be high enough to maintain a lubricating film, but low enough that the oil can flow around the engine parts under all conditions [1]. Viscosity index is a measure of how much the oil's viscosity changes as temperature changes. A higher viscosity index indicates less viscosity changes with temperature than a lower viscosity index. There are four categories of oil viscosity measurements that affect engine operation [2].

Fuel consumption can be defined as the amount of fuel used per unit distance. In other words, the lower the value of fuel consumption, more economical the vehicle is. In lubrication system, it is very important to reduce power loss due to friction and wear [3]. Hence, it is required to reduce the friction and power loss as much as possible in the lubrication system. Lubricant plays an important role in reducing fuel consumption. Reducing viscosity across the high-to-low temperature range can improve fuel economy by 1.1 %. Using low viscosity engine oil also improves automotive fuel economy, not only because it lowers the frictional loss of the engine oil seal, but also because leak free performance is essential for efficient engine function [4].

2. EXPERIMENT

In this experiment, a four-ball tester machine was used to analyse the engine lubricant tribological characteristics. American Standard Testing Material (ASTM) D4172 was chosen since it is the standard used to evaluate the lubricating fluid or oil characteristic [5]. The wear scar diameter was evaluated by using optical microscope. Two engine oils that were used in this experiment were labelled P1 (from Helix 10W-30) and P2 (from Petronas Mach 5 10W-30). Speed and the temperature were denoted as variables in this experiment. The speed was varied from 1200 rpm to 2000 rpm with gradual increment of 400 rpm. The temperature was also gradually increased by 10 °C, beginning from 70 °C to 100 °C. A 660cc Perodua Kancil car engine was used to study the effect of two different engine oils on fuel consumption. Each engine oil was used and tested for analysing their tribological effects. The car was driven at 30 km/h, 40 km/h and 50 km/h by using two litres of each fuel, while speed and maximum mileage reading were taken to analyse their data. Before the experiment was carried out, all the properties of engine oil must be known. This study aims to investigate the different engine oil lubricant effect in reducing fuel consumption on 660cc engine. The oil viscosity value was measured by using viscometer, as shown in Figure 1, while the values of other properties were taken from Shell and Petronas technical data sheet as shown in Table 1.

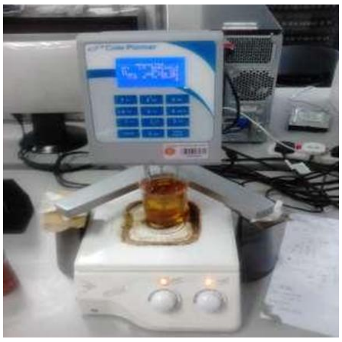

Figure 1. Viscometer

Table 1. Properties of Engine Oils

Properties	P1 – (Shell Helix HX5 10W-30)	P2 - (Petronas Mach5 10W-30)
Viscosity @ 40 °C, cSt	70.0	73.0
Viscosity @ 100 °C, cSt	14.36	16.37
Viscosity Index	161	145
Density @ 15 °C	0.862	0.864
Flash Point, °C	226	228
Pour Point	-35	-33

3. RESULTS AND DISCUSSIONS

3.1 Friction Torque

From the experiment carried out, several data had been collected including friction torque, coefficient of friction, wear scar diameter and maximum mileage travelled. Relationships between oil friction torque at various speeds are given in Figure 2. The figure shows that the force value of P1 was higher compared to P2 at 1200 rpm to 2000 rpm. At 2000 rpm, the trend of P1 friction torque recorded a higher value compared to P2 friction torque. At that point, the surface films became thinner. This led to the breakdown of fluid film of the engine oil and the increment of value of friction torque [6].

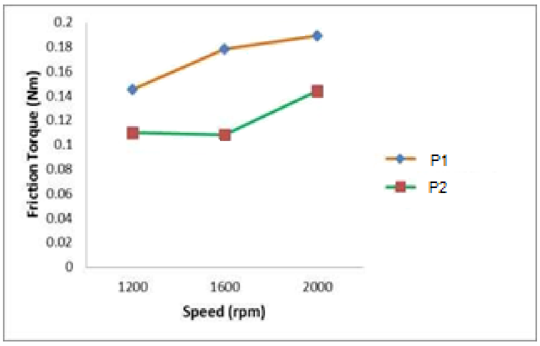

Figure 2. Friction torque variation with speed at 90 ˚C

3.2 Coefficient of Friction

Variation of friction coefficient at various temperatures is shown in Figure 3. The results showed that the engine oil P1 and engine oil P2 had the same value of coefficient of friction at 70 ˚C. At 80 ˚C and 90 ˚C, the coefficient of friction of engine oil P2 showed a descending trend, whereas the coefficient of friction of engine oil P1 showed an ascending trend. The coefficient of friction of engine oil P1 was higher than the coefficient of friction of engine oil P2 at 100 ˚C. The film thickness of P1 engine oil was very small and boundary lubrication occurred at this point [7].

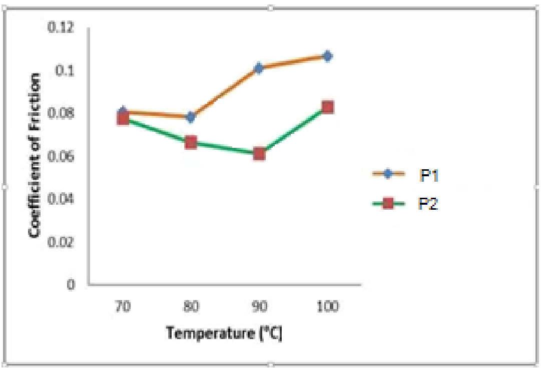

Figure 3. Graph of coefficient of friction variation with temperature at 1600 rpm

3.3 Wear Scar Diameter

Figure 4 shows the wear scar diameter due to the use of the two engine oil at 70 °C and 2000 rpm. It was observed that the size of wear scar diameter of engine oil P2 was bigger than the size of wear scar diameter of engine oil P1 against speed and temperature. According to the hydrodynamic lubrication, lower viscosity oil would give lower friction [8]. This has been proven as in Table 1 that shows the properties of engine oil of P1 had lower viscosity compared to viscosity of engine oil P2. Hence, the wear scar diameter of engine oil P2 was bigger compared to engine oil P1 due to higher value of viscosity.

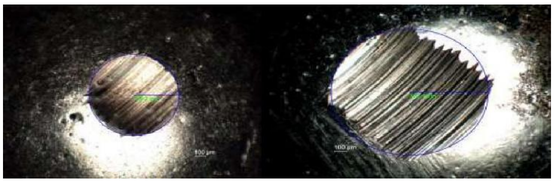

Figure 4. Wear scar of P1 (left) and P2 (right) at 70 °C and 2000 rpm

3.4 Maximum Mileage

As seen in Figure 5, it was observed that engine oil P1 had higher maximum mileage travelled than engine oil P2 at 30 km/h and 40 km/h of the car speed. At these speeds, the friction and heat between engine rotating parts and wear were assumed to be higher by using engine oil P2 compared to engine oil P1. Engine oil P1 had higher value of maximum mileage travelled compared to engine oil P2 at speed 30 km/h and 40 km/h due to lesser power loss. However, at speed of 50 km/h, P1 engine oil had lower maximum mileage travelled compared to P2 probably due to the increase in friction, heat and thus its viscosity.

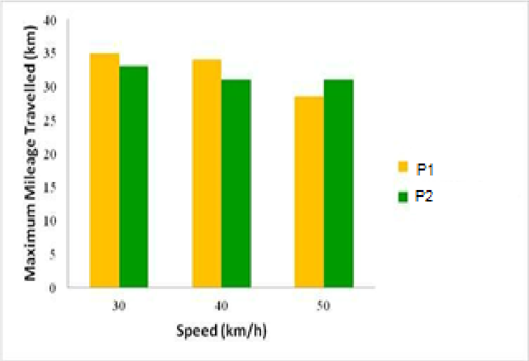

Figure 5. Maximum mileage travelled for P1 and P2 at three different speeds

Overall, the fuel consumption was higher for P2 engine oil due to the higher viscosity value that caused increased friction and heat between the rotating parts. This contributed to the power loss and increment of the fuel consumption, hence the maximum mileage travelled decreased [9,10].

This has also been proven by Alias in his work, where using low viscosity engine oil improved the automotive fuel economy, not only because it could lower the frictional loss of the engine oil seal, but also because leak free performance is essential to efficient engine function [10].

4. CONCLUSIONS

The findings of this experiment show that:

1. Engine oil P1 produces greater frictional torque compared to P2 over the speed range of 1200 to 2000 rpm.
2. The coefficient of friction value of the engine oil P1 increases with temperature from 90 ˚C and 100 ˚C, but for engine oil P2, the value of coefficient of friction increases only at 100 ˚C.
3. Engine oil P1 creates smaller wear scar diameter than engine oil P2 at high speed and low temperature.
4. Although engine oil P1 and P2 have the same grade, the fuel consumption test shows that engine oil P1 contributes to better fuel consumption based on its higher maximum mileage travelled. This can be due to a better tribological engine oil characteristic of P1 than P2.

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