GASOLINE ENGINE LUBE OIL WEAR STABILITY

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ABSTRACT

Lubricant has an important function in protecting the parts of an engine where to minimise the wear formation on the surface between two moving parts. The mixing of lube oil SAE10W-30 Petronas oil and Shell oil may have caused an effect to the wear stability of the lubricant. The aim of this study is to determine the behaviour of the oil's viscosity, COF and WSD of the ball using the FBM. The experiment was done under different speed and the mixture was rested. Based on the analysis, the viscosity is thinning as the temperature gets high. The thinnest oil is 20% Shell mixture and 5% Shell is the thickest but viscosity was not affected by the rested time. COF has decreased as the speed increased. However, longer resting period did not give any effect as the speed higher but has increased COF. The WSD was increased by the higher concentration of Shell as well as the speed. Overall, different concentration of Shell oil and rested time has an effect on the lubricity performance.

KEYWORDS

Viscosity, Coefficient of Friction (COF), Wear Scar Diameter (WSD), Four Ball Machine (FBM), Mixing Oil

1.0 INTRODUCTION

In a manufacturing industry, lubricant has been widely used to assist their equipment last longer thus can make the cheaper cost for maintenance. On the other hand, in an automotive industry, the function of lubricant has been the same which is to maintain the good health of the engine especially and been introduced to the most of the crucial part of the designs. Once the equipment is broken because of a wear, the best thing to do is to replace the torn part or replace the whole equipment if the damage is too severe. There are many brands with a different company that produced multigrade mineral base engine oil in the market. Even though the viscosity grade is the same, however, it did not give the same lubricity for the engines. In a multigrade mineral base lubricant, an additive was added to enhance the quality and performance of the oil. Though, the compability between the additives was unknown as it might become less effective or not functioning when they were mixed. A problem may arise if the user wants to change the usual engine oil to a different brand.

In this project, the focus is on the determining the effects of mixing between two lube oil with different concentration and rest time based on its wear stability. The viscosity, friction and the wear scar will be evaluated based on the result.

2.0 LITERATURE REVIEW

There are a few types of base oil that exist in the industry. Some of them are mineral, synthetic, natural and exotic oil. Mineral oil is derived from the crude oil and will have to go through a refining process and producing a wide range of qualities. Meanwhile, synthetic base oil is actually a man made that going through a process of synthesizing. Next, natural base oil is a vegetable oil from a plant oil. The purpose of having this type of base oil is for the renewable and environmental interest. At some point, base oil itself cannot provide the desirable needs, hence why additive was being introduced. Additive in base oil will help to enhance the characteristic of oil or even lubricating grease. Lubricant is consisting of base oil and additives while grease consist of base oil, additive and thickener. A few additives that are commonly used are antioxidant and anti-wear where can avoid oxidation of an oil and protect base oil from oxidation and metals from corrode, according to Ahmad Hussain et al, 2018 [3].

According to R.S Bajwa, 2019 [1], stribeck curve was used to define the lubrication regimes representing the boundary lubrication, mixed lubrication and hydrodynamic lubrication. It also shows the relationship of the coefficient of friction and sliding velocity. The authors state, it happens when the sliding surfaces are separated by a very thin molecular film of lubricant, A. Mann et. al, 2016 [2]. Thus, there is a metal to metal contact between the sliding surface by Qianfan Xin, 2013 [6]. This will cause highest friction happening at this stage. Mixed lubrication is a transition region between full hydrodynamic lubrication and boundary lubrication which have low coefficient of friction as described by Ioan D. Marinescu et. al, 2004 [4]. The principle of hydrodynamic is the block must be tilted forward as it moves to drags the liquid into the gap, if not, the liquid will flow at the side of the gap as it cannot support the load by Jaywant H and Sreenivas K, 1996 [5]. It allows large loads to be supported by thin film as the oil wedge will provide a hydrodynamics lift. The moving surfaces are held apart by the pressure generated within the fluid film.

According to Edith, 2018 [7], the fluid film thickness is depending on the viscosity of the oils, speed and load. In the paper, the speed and load are constant which automatically makes viscosity is the only reason in the changes in fluid film thickness. The changes that are possible to happen are sedimentation, colour or clarity intensity, or acidity. Dave Wooton, 2017 [8] said that if the intensity of the mixture is absolutely bright, the mixture is highly possible of compatible while if the colour is darker or cloudy, the mixture is not compatible. There are a few types of war that can happen in an engine due to poor lubrication. The example of the wear are abrasive wear, adhesive wear, corrosive wear and fatigue wear. With poor lubrication, a strong adhesive force can exert to the piston rings and cylinder leading to high friction forces thus formation of severe wear scars on the surfaces by S. Hisham et al, 2017 [9].

3.0 METHODOLOGY

The research design of this experiment was illustrated in a work chart in the Figure 1 below. The first step was, two oils of a different brand that is commonly used by users were chosen, which were Petronas and Shell. Petronas oil was used as the main oil for the mixed oil that will be prepared. A standard, high quality 12.7 mm ball bearing from SKF were chosen to run the wear test using the Four Ball Machine. Three different mixture of 5% Shell oil, 10% Shell oil and 20% Shell oil were weighted by volume using the digital scale machine and mixed using the mixer machine to determine the kinematic viscosity after. For mixed oil, the mixtures were rested for a day and two weeks before undergoes any tests. The next test which was the wear test using the Four Ball Machine for an hour long. A constant load of 392 N and a constant temperature of 75℃ was maintained throughout the experiment. The sliding speed varying from 1200 rpm, 1400 rpm and 1700 rpm for all oil samples. The coefficient of friction value was automatically calculated by the built-in software using the friction torque value generated from the four ball. The diameter of the scar later then analysed by using the electronic microscope using the iSolution Lite software and 10x/0.3 (WD 6.8) magnification has been used.

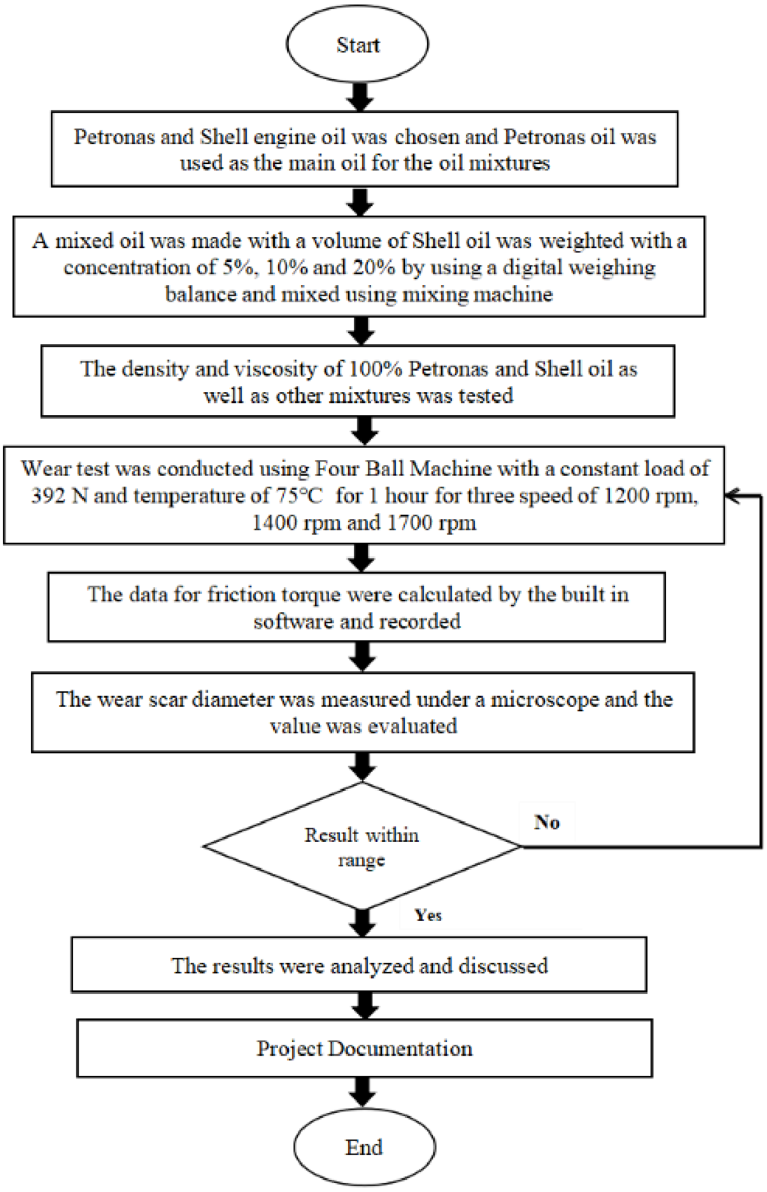

Figure 1 The work flow chart for the experiment

4.0 DATA ANALYSIS

After completing the experiment for all different types of lubricant mixtures, all of the raw data has been taken and recorded to be analysed. The tests that has been conducted in order to obtain the data were kinematic viscosity test which to get the measure of viscosity of the lubricant with an increasing temperature of every 10°C, four ball test which the coefficient of friction data can be extracted and lastly the scarred surface of the steel ball which the diameter of the scar will be evaluated. All the data has been analysed in Microsoft Excel and represented in a graph form to be able to see the trends effectively.

4.1 Kinematic Viscosity Test

The kinematic viscosity was tested for each and every oil mixture, including the 100% oil without mix. From the test, the result was shown in the Figure 2 below. During start up at the temperature 20°C, the viscosity of both oils was having almost similar value of 147.0 cSt. Then the value decreasing sharply until it reaches 40°C and gradually decreasing after that until temperature 100°C. Petronas oil loses 61% of its viscosity while Shell oil loses only 51% at 40℃ due to slow decrease after temperature 20℃. Shell oil maintains as the thickest oil until the end of the test compared to Petronas oil by 3.0 cSt thicker. The oil also managed to follow standard by the Society of Automatic Engineer (SAE). In comparison to the properties taken from the website, the viscosity of Petronas oil at 100℃ was 10.2 cSt and 11.9 cSt for Shell oil where in the experiment, the value comes out as 11.2 cSt and 14.3 cSt respectively. This indicate the value from this test are almost accurate. From the trend, Shell oil has slightly higher viscosity throughout the test compared to Petronas and this shows that Shell oil are thicker than Petronas.

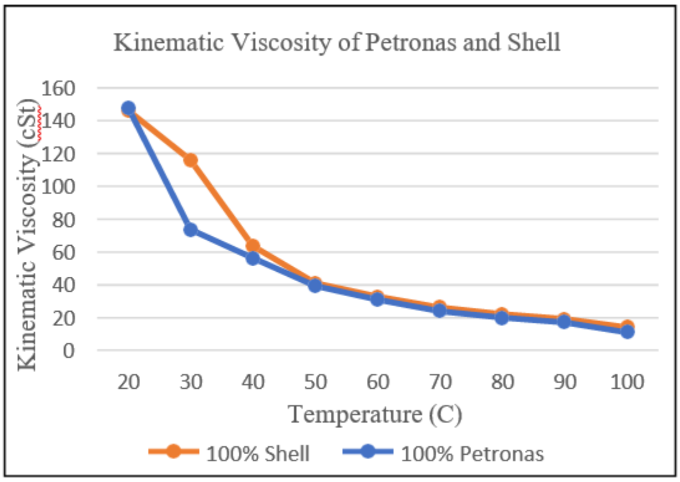

Figure 2 Kinematic Viscosity against Temperature for 100% Petronas and Shell

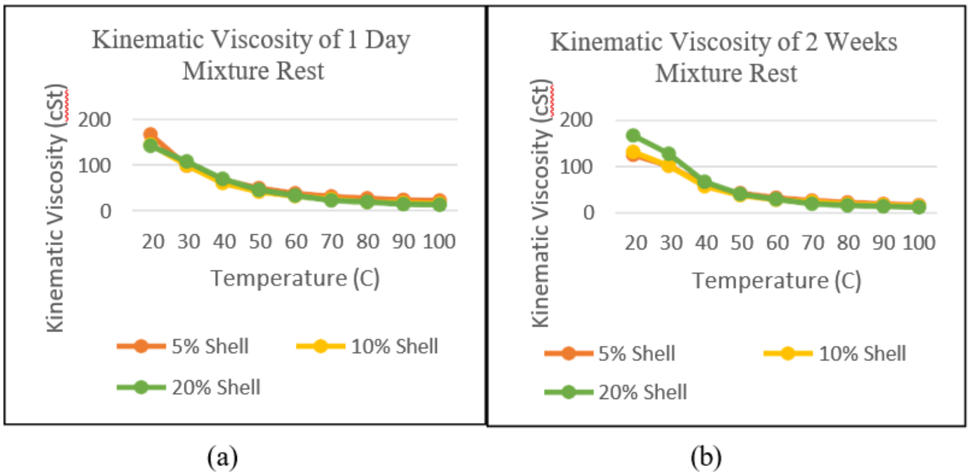

Figure 3 Graph of Kinematic Viscosity against Temperature for (a) 1 day and (b) 2 Weeks

Based on Figure 3(a), all the different percentage volume of Shell mixture gives the same trend which are decreasing gradually with an increasing temperature. At temperature of 40℃, 5%, 10% and 20% Shell oil has the viscosity decreased by 61%, 58%, and 51% on average respectively. From this, it shows that the mixture with the highest volume of thicker oil of 20% Shell when mixed together with a thinner oil, it does not help in increase the viscosity thickness of the thin oil. The total viscosity reduction in Figure 3(a) was for 5% Shell was 86% while 10% Shell was 89% and 20% Shell was 92%. By temperature 100℃, all of the viscosity value falls under 20 cSt with the lowest of 12.3 cSt.

4.2 Coefficient of Friction

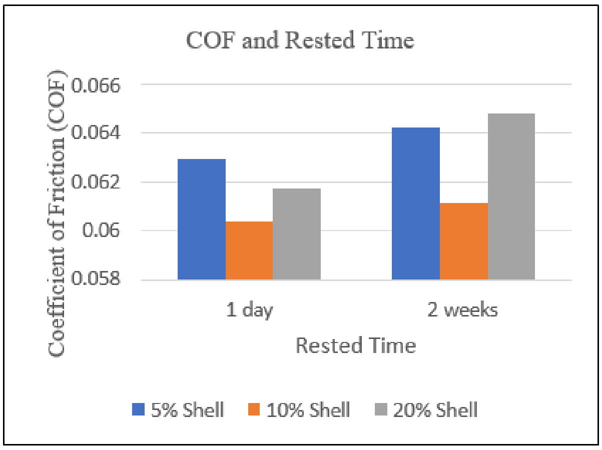

Figure 4 Relationship between COF and rested time

The relationship between COF and the time for the mixture rested are shown as Figure 4. The bar graph showing that the value of COF was increased on 2 weeks period mixture rested for all percentage volume of Shell oil. For one day period, 10% Shell oil showed a smallest value of COF recorded of 0.0604 while the largest was 5% Shell oil of 0.0629. During the 2 weeks period, the smallest COF value remained on 10% Shell of 0.061. However, the largest COF value was for 20% Shell oil of 0.0648. The total of 0.0031 increased within the period, thus, rested mixture gives a significant increase of COF for 20% Shell oil mixture. Meanwhile, for 10% Shell oil, there is only slight increase on a second week period of 0.00073. It shows that with this percentage volume of Shell oil, it does not give a drastic change in COF even if the mixture was rested for 2 weeks

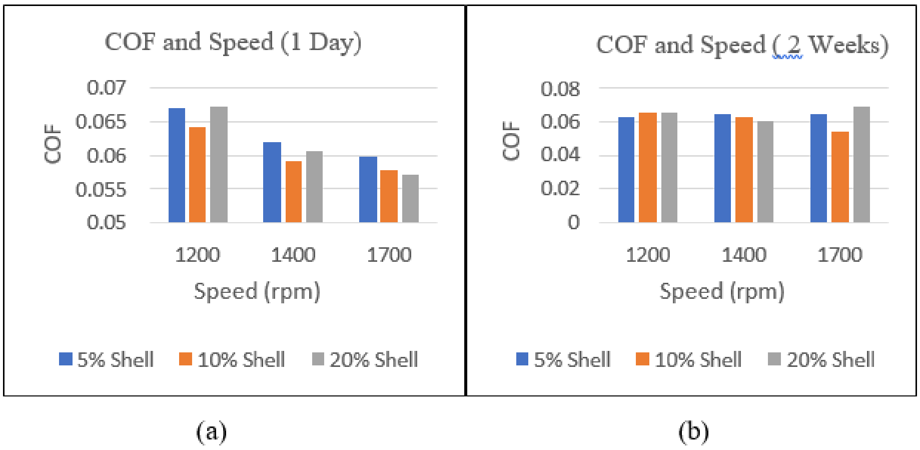

Figure 5 The relationship between COF and speed for (a) 1 day and (b) 2 weeks

Based on a Figure 5(a), the COF is decreasing as the speed reach 1700 rpm. 10% Shell oil has maintained a low COF value than other Shell oil concentration while 20% Shell oil recorded a significant decrease of 15% from the beginning. An average value of decreasing COF is more than 9%, Thus, the speed has given a significant impact to COF for mixture rested for 1 day. Higher speed has thicker oil that cause an additive to be effective resulting in lower friction value. Meanwhile in Figure 5(b), the COF are maintained at the same rate from speed of 1200 rpm to 1700 rpm. In comparison between both of the figures, the trend indicates that the longer the mixture being rested, the higher COF value may be recorded. The higher the concentration of Shell and the longer the mixture rested, it can give a significant increase in friction. at this period, the additive is no longer effective that may due to the oxidation of an oil that were exposed in the air for too long.

4.3 Wear Scar Diameter

The trend for WSD with three different sliding speed for mixtures rested for 1 day are illustrated in a Figure 6 below. Based on the graph, the WSD are at the highest during low speed, 1200 rpm and the value decreasing at 1400 rpm and slightly increase until 1700 rpm. However, for 10% Shell oil concentration, the WSD are slightly increased by 1.9% while 5% Shell and 20% Shell WSD value was significantly reduced by 7.5% and 7.8% respectively. As the speed increases, WSD value of the 5%, 10% and 20% Shell oil also increased by 6.2%, 1% and 0.5% respectively. The change in WSD of the 10% and 20% Shell mixture can be neglected due to only small amount of diameter that were increase, which are below 1%. When the Shell oil that has a bigger WSD, mixed with Petronas oil that has smaller WSD, it results in smaller WSD value. So, with the correct amount of volume of Petronas oil, the WSD value can be reduced.

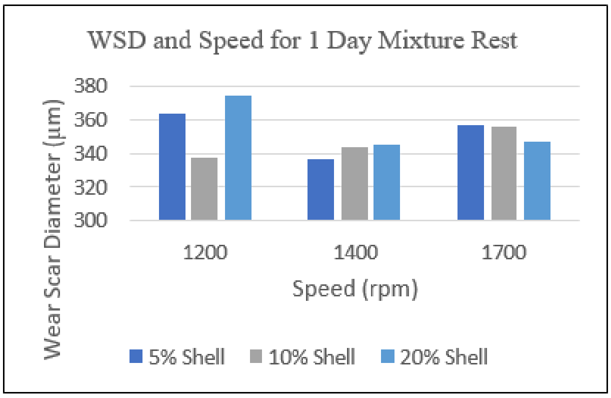

Figure 6 Relationship between WSD and Speed for 1 day

The WSD result for mixtures rested for 2 weeks long are illustrated in Figure 7. The highest WSD was at 1200 rpm and the smallest WSD was at 1400 rpm with 10% Shell oil mixture maintained as the lowest scar diameter. At a speed of 1400 rpm, the WSD drops not more than 3% for each concentration. Meanwhile, there were a significant increase of the WSD at a speed of 1700 rpm. It was increased by 5.2% and 8.6% for 10% and 20% Shell mixture respectively. However, for 5% Shell mixture, the WSD was slightly decreased by only 1.6%. Since the change are too small, the WSD can be assumed the same as during 1400 rpm value.

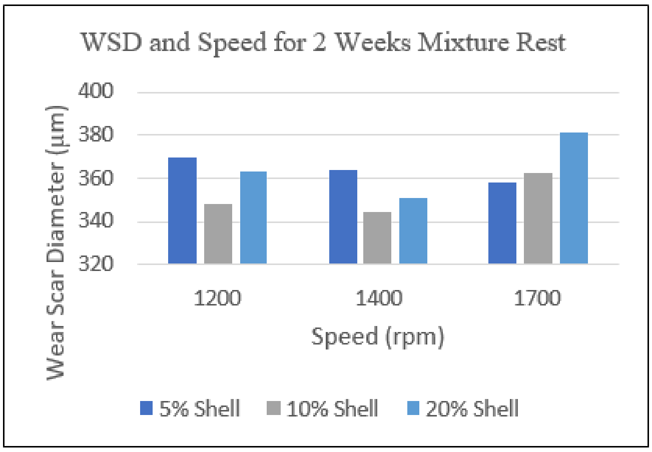

Figure 7 Relationship between WSD and speed for 2 weeks

The WSD for 2 weeks mixtures showing the same trend as Figure 8. This indicate that even the mixture was rested for 2 weeks, it does not change the WSD value against the sliding speed. An increasing value of WSD from 1400 rpm to 1700 rpm are noticeable, unlike during the mixture rest for a day. Similar to the mixture rested for a day, the best percentage mixture of Shell oil was at 10%.

4.4 Physical Observation of an oil

In this experiment, all of the oil mixtures did not change in colour and no sedimentation observed at the bottom of the beaker even after rested for a day and 2 weeks. Thus, there is low possibility of the oil to be chemically reacted.

5.0 CONCLUSION

Overall, it may be said that the objective of this study was achieved successfully and the following conclusions can be drawn based on the findings of the study:

1. The kinematic viscosity of all oil's concentration mixtures is decreased as the temperature increased. Shell oil was tested to have a higher viscosity at high temperature than Petronas oil. Mixing of two different oil brand can affect the kinematic viscosity. This may due to a loss and shear down of the viscosity index improver of the mixed oil that may have a different type of additives reacted.

2. The coefficient of friction has affected by the period of rested mixture. The longer the mixture rested, the higher the friction value for all Shell oil concentration. Adding the two different brand of an oil that has different viscosity thickness can reduce the value of the coefficient of friction.

3. Speed and rest time of the mixture has an effect in worsen the wear on the surface of the ball. The diameter of the wear has increased as the rest time longer. This may due to the oxidation of an oil that causes by mixing of the two oils. The antioxidant additive that helps to slow down the rate of oxidation which may have in one of the oils has reacted with others additive to make it less effective.

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