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Analysis of Lubricant Oil Characteristics Using the Ball Falling Relative Motion Method on Temperature Variations

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ABSTRACT: The purpose of this research is to analyze the viscosity/viscosity of lubricating oil using the relative motion method of falling balls at various temperatures. This research is using experimental method. Where the test is carried out using temperature variations of 320C, 500C, 600C and 800C, steel balls with varying diameters, including 9.50 mm, 8.00 mm, 6.00 mm and 4.80 mm as well as variations in the viscosity of lubricating oil, including SAE. 10, SAE 40, SAE 90 and SAE 140. Data analysis used the method of calculating the fluid resistance equation of Stokes' law and the equation of motion from Newton's second law. The Stokes law equation by taking the example of a lubricant with a viscosity of SAE 10 is obtained for a steel ball diameter of 9.50 mm to obtain a fluid resistance of 7.159.200 m/s^2, a steel ball with a diameter of 8.00 mm to obtain a fluid resistance of 6.028.800 m/s^2, for a steel ball with a diameter of 6.00 mm obtained a fluid resistance of 4.521.600 m/s^2, for a steel ball with a diameter of 4.80 mm, a fluid resistance of 3.617.280.000 m/s^2 was obtained. It can be seen that at a certain viscosity value the weight of the steel ball will affect the fluid resistance, the greater the weight of the steel ball, the greater the fluid resistance value and vice versa. The equation of Newton's second law of motion shows that the lubricating oil with SAE 10 with 3.5 gram steel ball at a temperature of 32 is 17.92 $gr.mm/s^2$, a temperature of 50^0C is 2471.8 $gr.mm/s^2$, a temperature of 60^0C is 25396 ,82 $gr.mm/s^2$, temperature 80^0C is 28000 $gr.mm/s^2$. For the weight of the steel ball 2.1 grams at a temperature of 32^0C is 7609.98 $gr.mm/s^2$, a temperature of 60^0C is 5555.5 $gr.mm/s^2$, a temperature of 80^0C is 13884.15 $gr.mm/s^2$. The results of the above calculations indicate that the viscosity value will decrease or decrease with increasing temperature applied to the lubricant, thus the flowability of the lubricating oil will increase faster.

KEYWORDS: Viscosity, Oil, Stokes, Temperature

INTRODUCTION

Viscosity is the value of the viscosity of the oil. This value is symbolized by a number. The higher the number, the thicker the oil. Single-grade oil has a fixed viscosity value, at low oil temperature and high temperature, for example SAE 20, SAE 30, SAE 40. While multi-grade oil has different viscosity value at low oil temperature and high temperature, for example SAE 5W /20, SAE 10W/ 30, SAE 20W/50, SAE 20W/50. Single-grade type oils are often found in transmission oils and two-stroke (2-stroke) engine oils. While multi-grade oil is generally found in engine oil.

The thicker the oil, the thicker the layer. The smooth coating of the viscous oil gives it the extra ability to sweep or clean lubricated metal surfaces. On the other hand, oil that is too thick will provide excessive resistance to flow oil at low temperatures, thus interfering with the lubrication of the required components. For this reason, the oil must have a more precise viscosity at the highest or lowest temperature when the engine is operated.

Determining the value of the viscosity of a liquid is by measuring the amount of time it takes for a given amount of liquid to flow through a tube under very specific conditions. Due to the repeated conditions, it can be seen from the amount of time it takes to flow through the tube. It is applied to a certain temperature to measure it, because the liquid will turn more and more dilute as the temperature rises. To measure the level of viscosity/viscosity of lubricating oil by the method of falling ball relative motion. This study aims to analyze the viscosity/viscosity of lubricating oil with the relative motion method of falling balls at various temperatures.

LITERATURE REVIEW

By using the Saybolt viscometer. The oil used is type 2 wheeled vehicle oil. From this research, the results obtained are three types of oil, namely oil A at a temperature of 55^0C the viscosity value becomes 90,895 cSt, at a temperature of 100^0C the viscosity value becomes 20,875 cSt, oil B at a temperature of 55^0C the viscosity value becomes 86,825 cSt, at a temperature of 100^0C the viscosity value becomes 23,580 cSt, oil C at a temperature of 55^0C the viscosity value becomes 87,519 cSt, at a temperature of 100^0C the viscosity value becomes 21,397 cSt. These results indicate that the higher the temperature, the lower the viscosity value and the thinner the oil will be. Of the three types of oil, oil B does not experience significant changes when heated [1].

Then tested with a mileage of 30, 60, and 90 km with a constant speed of 70 km/hour then oil samples were taken. The results of the test are calculated using the viscosity formula with Stokes' law = $(\mathbf{2gr2}(\boldsymbol{\rho}-\boldsymbol{\rho})\ )t$. At a distance of 90 km oil C still shows the highest viscosity with a value of 2.55 Ns⁄m^2 while oil A still shows the lowest viscosity with a value of 1.70 Ns⁄m^2 [2].

Viscosity values using the Stormer method (observing the fluid flow time in the burette and using the Poiseuille equation). Color analysis by utilizing the grayscale histogram value in Delphi image processing. Analysis of the amount of impurities using centrifugation.

For the parameter analysis of the amount of impurity, no results were obtained, because the lubricant with the impurity material is homogeneous enough that it cannot be seen with the naked eye [3].

The higher the viscosity value, the more time (t) it will take to drain 60 ml of fluid. At SAE 20 with an average kinematic viscosity of 66, SAE 40 with a kinematic viscosity of 190, while SAE 90 with a kinematic viscosity of 240 [4].

In the cylinder block, the temperature increased until the last hour while the temperature of the lubricating oil was relatively stable even though at the 4th hour the temperature increased by 5°C but at the end of recording the temperature returned to the beginning to 55°C. For the type of CS lubricant, the temperature in the cylinder head is relatively stable even though the temperature increases at the 5th hour but at the end of recording the temperature returns to the beginning. In the cylinder block the temperature decreases which does not occur in the two types of lubricants [5].

Theoretical Basis

Lubricating oil is a substance or chemical that is generally in the form of a liquid that is given between two moving objects or serves as a protective layer that separates two interconnected surfaces to reduce wear and tear so that the service life can be longer [6].

Lubricating oil is classified into two namely [7]:

1. Classification Based on Thickness
2. Classification Based on Quality

The factors that affect the viscosity of a material are [8]:

1. Temperature
2. Viscosity and temperature have an inverse ratio, where the higher the temperature, the lower the viscosity of the material.
3. Pressure
4. Viscosity in food is not too affected by pressure.

.

5. Steel ball weight

An object moving in a fluid will experience friction, this is caused by the viscosity of the fluid. The coefficient of viscosity of a fluid can be obtained by using the experiment of a ball falling in the fluid. The frictional force acting on an object moving relative to a fluid will be proportional to the object's relative velocity with the fluid. It can be determined by the following equation [9]:

F = -B. V

Where :

F = Friction experienced by the object

B = friction constant

V= object speed

Stokes law as follows:

F= -6 .ρ .h .r . 2

Where :

h = viscosity of the fluid

R = radius of the ball

V = ball speed (seconds)

$$W = \frac{4}{3}(\pi\,.r^3.\rho)g \quad (dyne)$$

$$B = \frac{4}{3}\left(\pi\,.r^3.\rho_{t-t_o}\right)g \quad (dyne)$$

$$K = \frac{w-B}{h}\left(th + \frac{m}{h}\left(e^{\left(\frac{K}{m}.tn\right)} - 1\right)\right)$$

The falling ball method is a method that is often used because of its simplicity.

RESEARCH METHODOLOGY

This study took samples of Single Grande lubricating oil, namely SAE 10, SAE 20, SAE 30, SAE 40. The viscosity test of the lubricating oil used the falling ball method and was carried out at the Mechanical Engineering Laboratory, Musamus University, Merauke.

The procedure for measuring the viscosity of lubricating oil using the falling ball method is as follows:

1. Prepare the tools and materials needed to measure the viscosity of the lubricating oil.
2. Measure the weight of the steel ball.
3. Measure the diameter of the steel ball.
4. Put 500 ml of lubricating oil into the measuring cup at normal temperature.
5. Heating 500 ml of lubricating oil in a measuring cup to a certain temperature.
6. Measuring viscosity by dropping a steel ball on a measuring cup containing lubricating oil that has been heated to a certain temperature and measuring how long it takes the steel ball when it is dropped from the oil surface to the bottom of the measuring cup

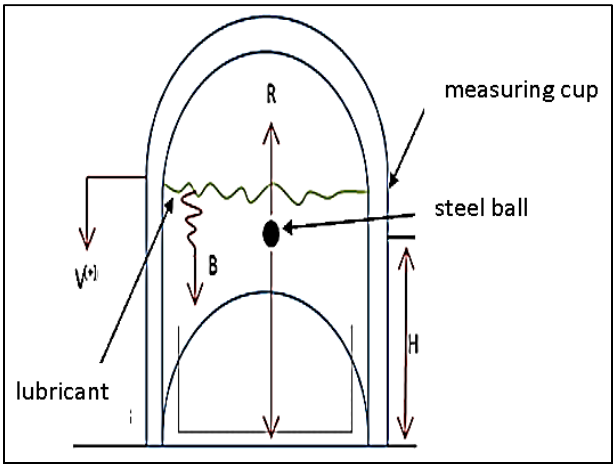


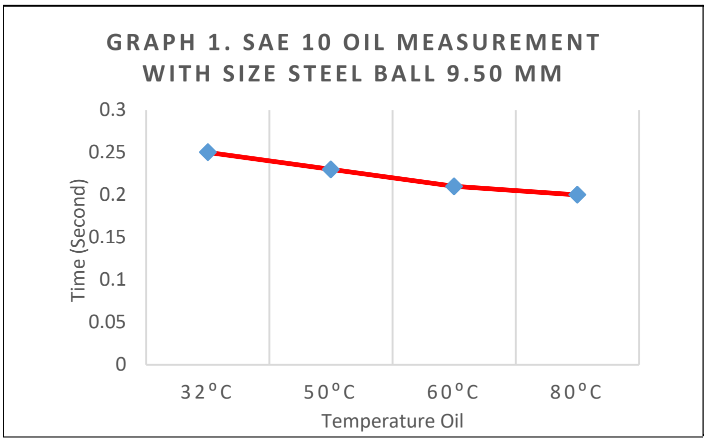
Figure 1. Testing the Falling Ball Method

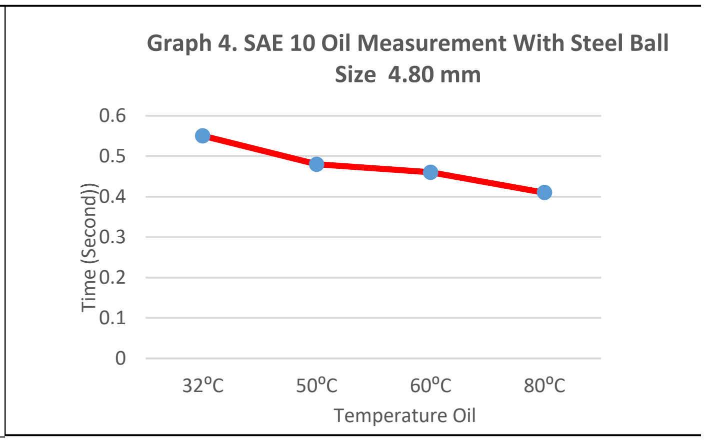
RESULTS AND DISCUSSION

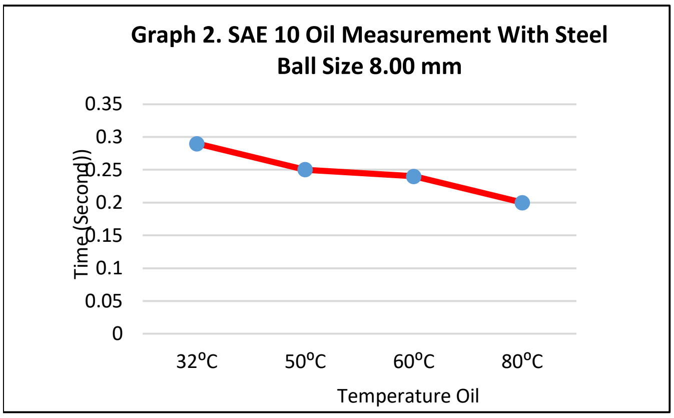
Results

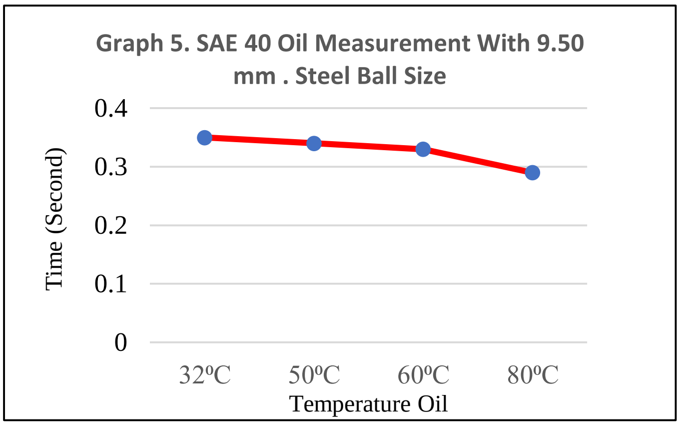
The following are the results of the viscosity test using the falling ball method which was carried out on several experiments, using 4 balls of different sizes and temperatures.

1. Viscosity test by steel ball drop method on SAE 10 . oil

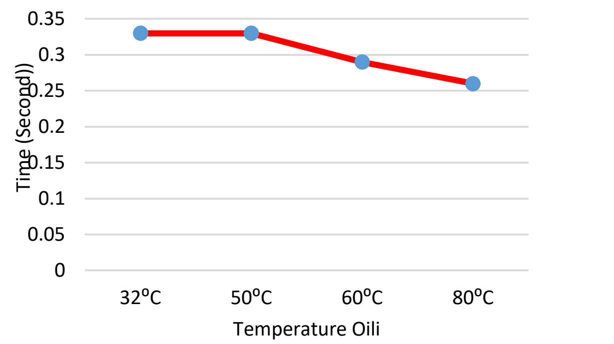




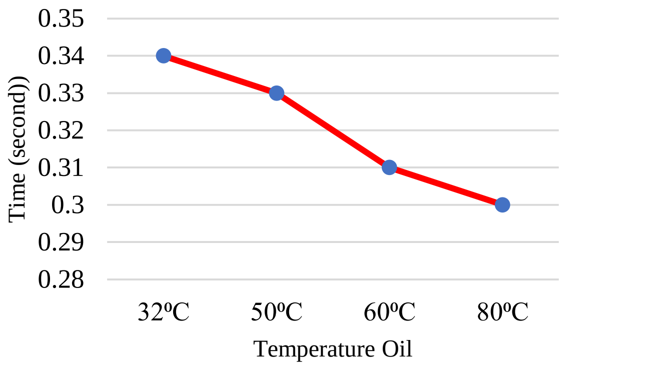




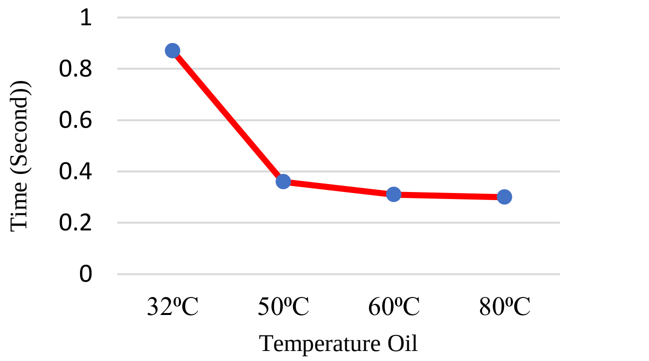
Graph 3. SAE 10 Oil Measurement With Steel Ball Size 6.00 mm



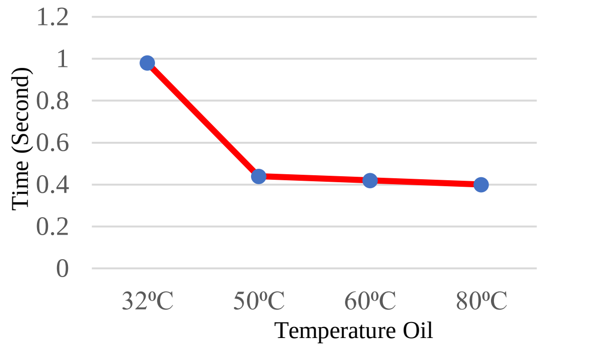
Graph 6. SAE 40 Oil Measurement With Steel Ball Size 8.00 mm



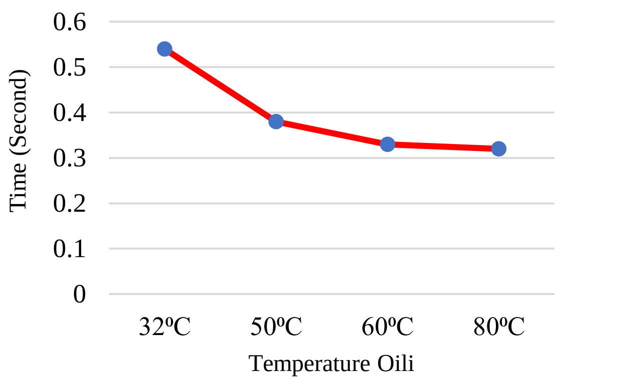
Graph 7. SAE 40 Oil Measurement With Steel Ball Size 6.00 mm



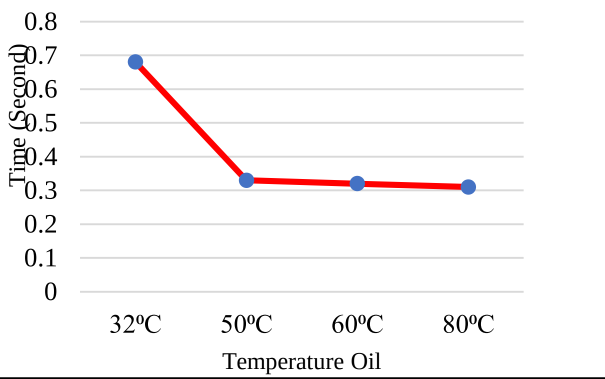
Graph 8. SAE 40 Oil Measurement With Steel Ball Size 4.80 mm



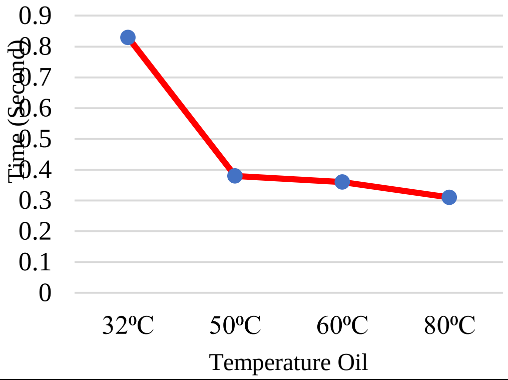
Graph 9. SAE 90 Oil Measurement With 9.50 mm . Steel Ball Size



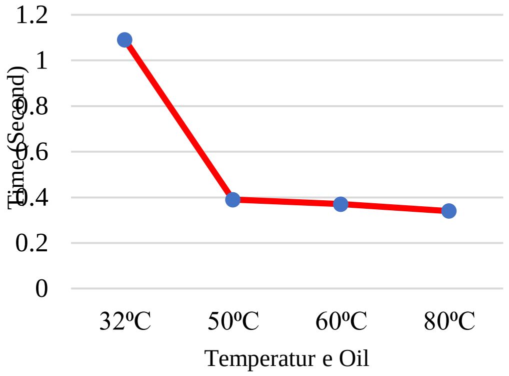
Graph 10. SAE 90 Oil Measurement With Size Steel Ball 8.00 mm



Graph 11. SAE 90 Oil Measurement With Steel Ball Size 6.00 mm



Graph 12. SAE 90 Oil Measurement With Size Steel Ball 4.80 mm



DISCUSSION

Overall, it can be seen from the research data that the higher the temperature, the faster the falling motion of the steel ball in the measuring cup will be. Besides that, the viscosity of the lubricating oil is also directly proportional to the speed and time of the ball falling. It is also seen that the lower the viscosity number of the lubricating oil, the longer the heating time and the relatively long falling speed of the steel ball.

From the Stokes law equation by taking the example of a lubricant with a viscosity of SAE 10, it is obtained for a steel ball diameter of 9.50 mm to obtain a fluid resistance of 7.159.200 m/s^2, a steel ball with a diameter of 8.00 mm to obtain a fluid resistance of 6.028.800 m/s^2, for a steel ball with a diameter of 6.00 mm, the fluid resistance is 4.521,600 m/s^2, for a steel ball with a diameter of 4.80 mm, the fluid resistance is 3.617.280,000 m/s^2. It can be seen that at a certain viscosity value the weight of the steel ball will affect the fluid resistance, the greater the weight of the steel ball, the greater the fluid resistance value and vice versa.

From Newton's second law of motion, it can be seen that the lubricating oil with SAE 10 with a steel ball of 3.5 grams at a temperature of 32 is 17.92 gr.mm/s^2, a temperature of 50^{0}C is 2471.8 gr.mm/s^2, a temperature of 60^{0}C is 25396.82 gr.mm/s^2, temperature 80^{0}C is 28000 gr.mm/s^2. For the weight of the steel ball 2.1 grams at a temperature of 32^{0}C is 7609.98 gr.mm/s^2, a temperature of 600C is 5555.5 gr.mm/s2, a temperature of 80^{0}C is 13884.15 gr.mm/s^2. The weight of the steel ball 1.1 grams at a temperature of 32^{0}C is 3232.31 gr.mm/s^2, a temperature of 50^{0}C is 3232.31 gr.mm/s^2, a temperature of 60^{0}C is 4185.48 gr.mm/s^2, a temperature of 80^{0}C is 5207,092 gr.mm/s^2.

For SAE 40 with 3.5 gram steel ball at a temperature of 32 is 9142.875 gr.mm/s^2, temperature 50^{0}C is 9688.56 gr.mm/s^2, temperature 60^{0}C is 10284,645 gr.mm/s^2, temperature is 80^{0}C is 13317.465 gr.mm/s^2. For the weight of the steel ball 2.1 grams at a temperature of 320C is 5813.136 gr.mm/s^2, a temperature of 50^{0}C is 2938.47 gr.mm/s^2, a temperature of 60^{0}C is 3329.86 gr.mm/s^2, a temperature of 80^{0}C is 7466, 665 gr.mm/s^2. The weight of the steel ball 1.1 grams at a temperature of 32^{0}C is 465,047 gr.mm/s^2, a temperature of 50^{0}C is 2716,043 gr.mm/s^2, a temperature of 60^{0}C is 3662,846 gr.mm/s^2, a temperature of 80^{0}C is 3911,105 gr. mm/s^2.

Likewise, for the next calculation data, it will be seen that the movement of the steel ball will move faster or the travel time of the steel ball in the measuring cup will be faster as the oil heating temperature increases. The results of the above calculations indicate that the viscosity value will decrease or decrease with increasing temperature applied to the lubricant, thus the flowability of the lubricating oil will increase faster.

CONCLUSION

From the results of calculations and discussions, it can be concluded that the viscosity of lubricating oil can be analyzed using a simple method, namely the relative motion of the ball. If the lubricant is heated at a certain temperature, namely 32^{0}C, 50^{0}C, 60^{0}C, and 80^{0}C according to the research, it can be seen that the movement of the steel ball will move faster or the travel time of the steel ball in the measuring cup will be faster as the oil heating temperature increases. The results of the above calculations indicate that the viscosity value will decrease or decrease with increasing temperature applied to the lubricant, thus the flowability of the lubricating oil will increase faster.

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