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Research Article

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Effect of Oil Oxidation Temperature (Mineral Base ISO VG 46) in Hydraulic System

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Abstract Lubrication systems in hydraulic systems are widely used in the manufacturing world, especially in the steel industry. Lubricating oil is one of the most vital engine operational support substances. In fact many hydraulic systems have premature failure due to poor lubricating conditions. The purpose of this study was to study the effect of temperature and time of detention on hydraulic oil by using temperature and time variation at 40 °C, 60°, 80 °C and heating treatment 48 hours, 96 hours, 144 hours and 288 hours, was performed by Total Acid Number (TAN) method using Automatic Potentiometric Titrator AT-510, and viscosity using Constant Temperature Bath CT-500. The results of the analysis show that the TAN and viscosity values are influenced by temperature rise and holding time. The highest TAN value test was at 80 °C with 288 hr detention time of 2,6060 mg KOH / g and the highest viscosity was 52.31 cSt.

Keywords Lubrication, Mineral Oil, Hydraulics, Total Acid Number (TAN), Viscosity

1. Introduction

Technological advances in manufacturing are growing very rapidly encouraging people to always learn science and technology. In the world of manufacturing, especially in hydraulic known various kinds of powerpack working on the system, which are interconnected with each other. If there is one of machine system is damaged, it will affect the damage to hydraulic machine. The lubrication system is one of the main systems in the machine with a series of tools ranging from oil storage, oil pumps, oil pipelines, and oil pressure. Hydraulic systems operate at a temperature range of 40 °C to 50 °C, at high temperatures will reduce the life of the system components and can damage the system. It is important that the operator monitor the oil temperature at the time the system operates. If the oil temperature rises above the normal operating temperature, finding the cause at the right time can reduce the possibility of system damage [1]. The purpose of this research is to evaluate the effect of temperature and time of detention on the increase of oxidation and viscosity on hydraulic oil through TAN value analysis. From this research result it is expected that the equipment used in hydraulic system can last long.

2. Literature Review

Hydraulic fluid in the form of oil is a very important part of a hydraulic system, the liquid can be liquid and gas. The term fluid in hydraulics comes from a general term that is liquid and is used as a medium for power and power transfer. Hydraulic fluid in its application has four purposes, namely: as a transfer (successor) style, lubricant on the part of the rubbing, the gap between the two planes of friction and as a coolant or heat absorber arising from friction [2]. Mineral oil is the most widely used hydraulic fluid. Relatively inexpensive, widely available, and can be offered appropriately rated viscosity. They have good lubrication, are not corrosive, and are compatible. Mineral oil is chemically stable for a reasonable operating temperature, at high temperatures, however, chemical damage.

Premium grade mineral oil contains an additive package to overcome the effects of wear, oxidation, and foam formation, and to improve the viscosity and lubrication index. Mineral oil is essentially hydrocarbons, but they all contain thousands of different types of structures, molecular weight and volatility.

The basic principle of hydraulic system work is a system in which force and energy are transferred through liquid, usually using oil. The hydraulic system consists of three important components: Hydraulic power pump, flow rate fluid and piston (actuator), can be piston or motor.

One of the properties of liquids is to continue the pressure in all directions. It can also mean that liquids can increase force and pressure, is a precipitation process for separating impurities such as water, soil, rock and other solid impurities. The distillation process aims to separate the molecular molecules of hydrocarbons into base oil into components such as gasoline, aviation and oil. Passing through the filtering system again, as well as adding additives to enhance its ability and function [3].

Synthetic Oils

Synthetic Oils usually consist of Polyalphaolifine coming from the cleanest part of the sorting of mineral oil, gas. Synthetic oils can be mixed with mineral oil and vice versa, the most stable base is polyol-esters, which at least react when mixed with other ingredients. Synthetic oils tend not to contain reactive carbon materials, compounds that are not very good for oil because they tend to join with oxygen to produce acid. The hydraulic oil oxidation referred to here is the most dominant lubricating reaction in the service. It is responsible for many lubricating problems including increased viscosity, varnish, silt and sediment formation, additive depletion, damage to oil, filter blockage, loss of foam control, acid rise, corrosion formation. Therefore, understanding and controlling oxidation is a priority of lubricant chemists [2]. Acidity and alkalinity indicate the level of oxidation of the lubricant and the ability to neutralize the outer acid from sources such as gas combustion. The acidity of the lubricant is measured with the amount of potassium hydroxide required for neutralization of the KOH (mg / g). Tests are often developed to study the oxidation of fluid produced by temperature rise or catalyst addition. For convenience, these modifications are used to perform the tests in a shorter period of time. Implementation of this method is often useful, but the resulting data should always be studied carefully as it may not suit the fluid behavior in the application in the field [1]. To learn the oxidation potential of hydraulic fluid the test differs in reaction temperature or oxygen concentration. Lubricants are often measured by the effects of lubricating temperature. Since the lubricant operates in several temperature zones, testing at different temperatures provides a better assessment of lubricant quality. Hot temperatures are often used to speed up the oxidation process because temperature has two effects on any reaction. The first effect involves activation energy. If the system does not contain enough energy to push a reaction above the threshold, nothing will happen. The second effect is related to the speed of the reaction. The oxidation reaction is approximately twice the rate for every 10 °C temperature rise, which means that the oil resistance will be reduced by half for every 10 °C temperature rise.

Viscosity is a statement of "resistance to flow" of a system that obtains a pressure. The thicker the viscosity of a low fluid if the fluid flows easily, the high viscosity value when flowing hard, is called the viscous fluid, the larger the force it takes to make it flow at a certain speed. The fluid viscosity is denoted by η ("eta") as the shear drag ratio. To measure the amount of viscosity required unit of measure [2]. In the international standard system the viscosity unit is designated as a kinematic viscosity with units of measure: mm^2/s atau cm^2/s. 1 cm^2/s = 100 mm^2/s, 1 cm^2/s = 1 St (Stokes). This so-called fluid property is a measure of the resistance of a fluid to deformation or deformation. The viscosity of a gas increases with increasing temperature, when the temperature increases the molecular activity is greater. While in the liquid, the molecular distance is much smaller than the gas, so that molecular cohesion is very strong. The increase in temperature reduces the molecular cohesion and this is manifested in the reduced viscosity of the fluid [3].

3. Research Methodology

The analysis method with Total Acid Number (TAN) using Authentic Potentiometric Tirator AT 510 (APT) based on [4].

The sample to be tested amounts to 2 types of lubricant (Oil A and Oil B). Oil A is mineral oil having base oil in Group II classification, base oil has sulfur content level less than 0.03%, more complex purification process, also called hydrocracking. Oli B is mineral oil having base oil in the Group I classification, the base oil has a sulfur content level of more than 0.03%, the process of purifying base oil in Group I is the most simple (solvent-refined).

In both samples will be tested Total Acid Number and viscosity. In the process of heating the oil sample will use the C-DO DRYING-OVER tool with temperature variation (40 °C; 60 °C; 80 °C) and holding time (48; 96; 144; 288 hours) to obtain oil color comparability.

4. Results and Discussion

In the heating process of oil samples A and B using C-DO DRYING-OVER appliance with temperature variation (40 °C, 60 °C, 80 °C) and holding time (48, 96, 144, 288 hours) obtained color comparative.

The oil A, at a temperature of 40 °C with a holding time of 48-288 hours, does not change color, at 60 °C with a holding time of 288 hours begins to slightly change color to dark, while at 80 °C the oil color change A occurs at holding time 48-288 hours. The oil B, at a temperature of 40 °C with a holding time of 48 - 288 hours, oil B does not change color, at a temperature of 60 °C with holding time of 144-288 hours begins to experience slight discoloration to darkness, while at a temperature of 80 °C the darker oil color changes occur from the time of detention 48-288 hours.

From the test results can be seen that the high temperature of the oil experience the process of oxidation or carbon chain disconnection that affects the color becomes darker and a rise sludge. The color change is caused by oxide compounds arising from the reaction of oxygen with hydrocarbons in base oil resulting in a very small (<1 micron) sludge and dark color. Oil A is more capable of suppressing the oxidation process than oil B, so that at a temperature of 80 °C with a holding time of 288 hours the color change in oil A is not too dark as oil B. Result of TAN test analysis at temperature 40 °C, 60 °C and 80 °C with variable holding time 48 hours, 96 hours, 144 hours and 288 hours. In this TAN test, the temperature is set at 40 °C, 60 °C, 80 °C. The variables used in this test are the holding time of 48, 96, 144, 288 hours, as shown in figure 1.

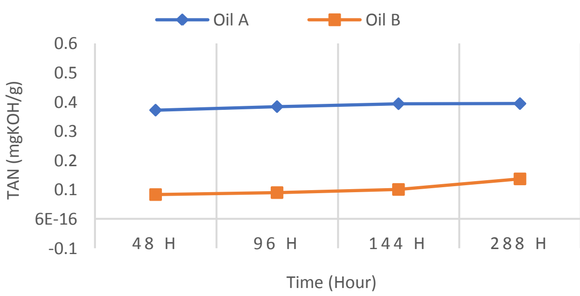


Figure 1: TAN testing at 40 °C

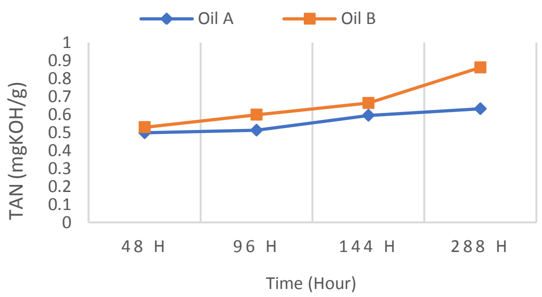


Figure 2: TAN Temperature Test 60 °C

In the TAN test results at a temperature of 40 °C, it can be seen that the increased oxidation value in oil A and oil B did not increase significantly.

Based on the results of the test, it can be concluded that the oxidation value is increased in both samples. However, in this case, oil sample B has a higher increase when compared with oil sample A. The highest difference of TAN value was at 288 hours of detention at 0.2298 mgKOH / g. In oil B, the increase of oxidation occurs because at 60 °C, has received many oxidation processes resulting in hydrocarbon chain breakdown causing increased acidity of the oil. While on oil A, the increase of TAN value tends to be more stable and not significant. At a temperature of 60 °C at any time of detention, oil A can maintain a hydrocarbon bond well so that oxidation is slow.

In this case the function of antioxidant additives in oil A also has an effect on slowing down the oxidation process. The antioxidant additive reacts when the hydrocarbon compound in the base oil undergoes oxidation to react to form a non-acid compound which does not alter the acidity of the oil and suppress the formation of sludge. The quality of base oil also influences the increase of TAN value, it can be seen on sample oil B TAN value tends to be higher than sample oil A which has better base oil quality, as seen in (figure 2).

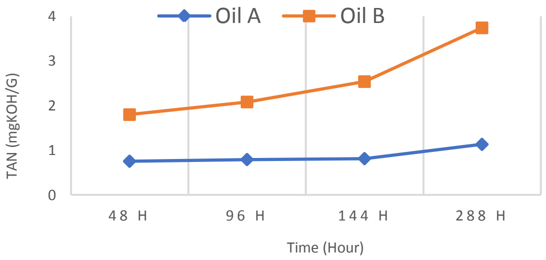
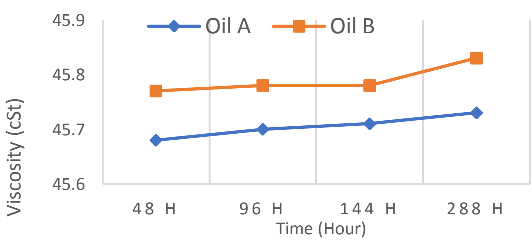


Figure 3: TAN Temperature Test 80 °C

Based on the results of the TAN test at the 80 °C retention temperature, the two oils have an increase in oxidation value when compared to the holding temperature of 40 °C and 60 °C, because at 80 °C the temperature of the oil contains a base oil having hydrocarbon and additive compounds, this condition of many catalysts or oxidation accelerators that cause oxidation in the oil runs very quickly and base oil and additives compete attractively to obtain broken hydrocarbon chains. In the initial conditions of hydrocarbon molecules reacting with various types of catalysts to form free radicals (electrons need a pair to balance the spine value, so the radical molecules become unstable and readily react with other molecules, forming a new radical). However, in this case the increase in TAN value in oil B has increased significantly. This does not happen in oil A, because oil A can maintain the TAN value and oxidation process is slow because base oil on oil A through hydrocracking treatment is purification by hydrocarbon chain cracking process with reaction of hydrogen assisted with catalyst to convert heavy molecule into ring molecule and simultaneously with the occurrence of hydrotreating reaction is to reduce the sulfur and oxygen compounds. The very fast oxidation in oil B is caused by the many chemical reactions in the oil that make up the acid compound so that the TAN value increases and can affect the lubrication performance. At 288 hours of detention, the antioxidant additive in the oil was not working properly due to the large amount of oxidation occurring in the oil. Oxidation occurs when the oxygen reacts with the base oil where the base oil is generally hydrocarbon based oil. When the oil is oxidized some hydrocarbon molecules will change shape to acid and sludge that impact on the performance of the oil properties. Therefore, in this case the quality of base oil is instrumental in maintaining the value of TAN because it has a high sulfur value. High sulfur values in base oil will easily oxidize and form acidic compounds, so the TAN value increases faster when compared with oil A which has a lower sulfur value, as seen in (figure 3).

In testing of this viscosity, the temperature is set at 40 °C, 60 °C, 80 °C. Variables used in this test were detention time of 48, 96, 144, 288 hours.

Based on the test results, the viscosity or viscosity value of both lubricants tends to be stable and there is no significant change during any detention. The viscosity stability of both samples occurs because at a temperature of 40 °C, the oxidation in the oil is so slow that the chemical reaction that forms the sludge or soot that triggers a rise in viscosity value is not formed (figure 4)



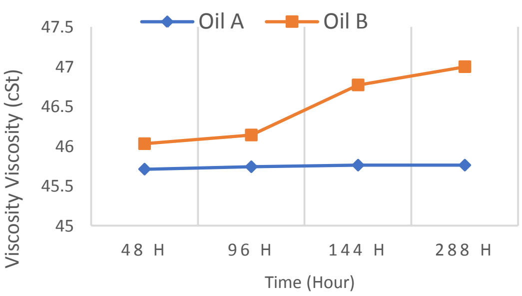


Figure 4: Temperature viscosity test 40 °C *Figure 5: Testing of viscosity Temperature 60 °C*

Based on the above test results, the viscosity or lubricant viscosity value is relatively stable and there is no significant change at 60 °C detention temperature, either at detention time of 48 hours to 288 hours. In the oil A sample having better base oil, the viscosity increase occurred as much as 0.05 cSt while in the B oil having lower base oil quality the viscosity increase was 0.97 cSt. Oil A and oil sample B does not decrease its viscosity value at 60 °C because oil has additive which is viscosity index or change of viscosity value due to high temperature change so as to maintain its viscosity, but it should be paid attention to this test oil sample A and oil B with a temperature of 60 °C and all holding times of the viscosity value increased as TAN values also increased (figure 5).

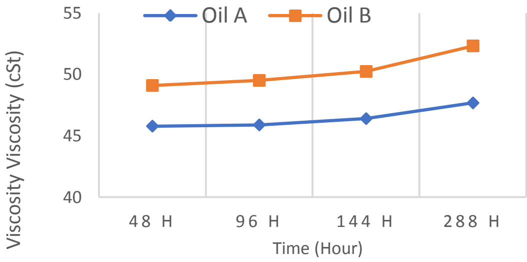


Figure 6: Temperature viscosity test 80 °C

Based on the test results, viscosity or viscosity value in samples A and B has increased significantly i.e. at temperature 80 °C holding time 288 hours (figure 6). The increase of viscosity value occurs because in this condition both oil samples experience high oxidation especially on oil B (exceeds the standard). High oxidation in the oil will form hydrocarbon molecules in base oil to acid and sludge. The acid and sludge compounds have an effect on the oil viscosity value. A very small sludge size (<1 micron) and many sludge makes it difficult to filter using a filter installed on the machine and over time sludge will become a blob. In the 80 °C heating process with 48 hours, 96 hours, 144 hours and 288 hours of detention time, additives such as viscosity index will not work properly because the oil has been oxidized and has produced soot and sludge, which makes the value of viscosity increased significantly. When compared to the TAN value in both samples, the viscosity will increase significantly if the TAN value exceeds the standard set in each firm (maker). The relationship between the viscosity level of TAN shows that the viscosity increases significantly when excess oxidation occurs in the lubricant. it shows that the lubricant has a usage limit that can be represented by the TAN value or the life of the oil can be seen from the high TAN value. As seen in (figure 7).

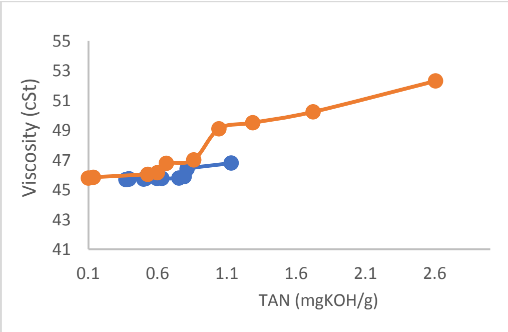


Figure 7: Graph of Viskosity Relation to TAN Improvement

5. Conclusion

The value of TAN in the hydraulic oil (mineral) increases with increasing temperature and holding time. The highest TAN value occurred in oil A with a temperature of 80 °C and a holding time of 288 hours, which was 1.1315 mg KOH / g. While the highest TAN value occurs in oil B with a temperature of 80 °C and a holding time of 288 hours, which is 2.6060 mgKOH / g. Increased viscosity value occurred significantly on oil B (52.31 cSt) given a temperature of 80 °C with a holding time of 288 hours. TAN value had an effect on the increase of viscosity value, especially on oil B sample having TAN value of 2,6060 mgKOH / g and its viscosities value was 52.31 cSt. The viscosity value did not increase significantly in the oil sample having a TAN value below 1.0 mg KOH / g in both A and B oil samples. In the elevated TAN values of oil B with temperature 80 °C and holding time 288 hours, with a percentage increase of 260% that is 2.6060 mg KOH / g of the standard allowable TAN value (1.0 mg KOH / g), sludge is formed where the acid compound very harmful to the hydraulic system that can cause corrosion and damage to metal parts that are in direct contact with oil.

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