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ANALYSIS OF THE THERMAL PROPERTIES OF CARNAUBA OIL FOR USE AS BIOLUBRICANT

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Abstract. *The search for alternative sources of production of lubricants is necessary to meet future demands and reduce the potential environmental damage that oil products can generate. Vegetable oil is a viable alternative because it is a renewable resource, biodegradable and its use implies advantages in environmental, social and economic, and for the most part, has satisfactory results in their properties when compared to mineral oils. This pioneer study analyzes the thermal properties of a vegetable oil extracted from the carnauba seeds, an endemic palm of the Brazilian semi arid northeast. The thermal properties of the analyzed carnauba oil were resistivity and thermal conductivity, temperature gradient and thermography, the latter two being tested in a simulated mechanical system. The values obtained were compared with those of commercial oil SAE 10W30 API SM, in previous studies the carnauba oil showed similar properties and this oil. Given the results, it was noticed that the carnauba oil is more capable to dissipate heat in a mechanical system that commercial oil SAE 10W30 API SM, demonstrating the possibility to use as biolubricant.*

Keywords: *carnauba oil, biolubricant, thermal properties.*

1. INTRODUCTION

Lubricating oils are generally of mineral origin extracted from petroleum, but the fact that oil is a nonrenewable resource, the search for new alternative sources of production of lubricants is necessary to meet future demands and also decrease the potential environmental damage that petroleum products derived could generate.

Vegetable oil as a base for lubricants is a viable alternative as it is a renewable resource, biodegradable and its use implies advantages in environmental, social and economic, and for the most part, has satisfactory results in their properties when compared to the mineral oils. So arise biolubricant of plant origin and readily biodegradable, non-toxic to the environment (TRAJANO, 2013).

Lubricants based on renewable raw materials and their derivatives are drawing increased attraction in various applications. Here, the environmental awareness is the key factor of success (WAGNER et al., 2001).

The biolubricants in addition to having excellent properties in the environmental aspect also present great lubricating properties. According to Fox et al. (2007), the molecular structure of vegetable oils form lubricating films of high strength, which interact strongly with metal surfaces, reducing both friction and the wear. In fact, vegetable oils have the most desirable lubricating properties such as good contact lubrication, high viscosity index, high flash point and low volatility (TRAJANO, 2013).

In this context, this study pioneer analyzes the thermal properties of a vegetable oil extracted from the seeds carnauba, an endemic palm of the Brazilian semi-arid northeast. Carnauba is botanically classified as belonging to the *Palmae* family, *Copernicia* genus and *Copernicia prunifera* species (QUEIROGA et al., 2013).

The importance of analyzing the thermal properties of carnauba oil arises from the need to determine the efficiency of the vegetable oil to dissipate heat in a mechanical system. The most important properties of a lubricant are reduce the wear between contacting parts and dissipate heat a mechanical system for keeping the system in balance.

2. METHODOLOGY

The thermal properties were analyzed temperature gradient, thermography, thermal conductivity and thermal resistivity.

According to Cavalcanti (2014), in previous studies it was realized that the carnauba oil showed similar properties to commercial oil SAE 10W30 API SM. For this study it was decided to comparatively analyze the thermal properties of both oils, so that the SAE 10W30 oil was a standard sample because it is a commercial oil quality standard certificate.

2.1 Temperature gradient and thermography

For these tests we used a mechanical system simulated from a benchtop equipment. The main function of this equipment is to simulate the contact of a lubricated sleeve bearing or not.

Each trial lasted 2 hours uninterrupted with the rotating shaft 1500 RPM, it was applied a load of 1.2 Newton, which generated the contact enters the sample and the stem, and the oil that lubricated the system dripped at a constant rate 1 drop / min. The variables were the same in each assay, changing only the oil, Fig. 01.

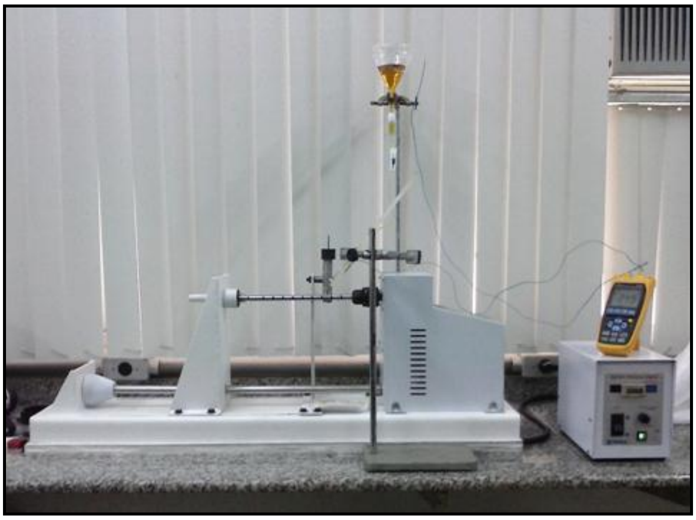

Figure 01. Equipment simulation of a mechanical system.

For analyze the SAE 10W30 oil was used together with the stem H1, the samples A1, A2, A3, A4 and A5.

For analyze the carnauba oil was used together with the stem H2, the samples A6, A7, A8, A9 and A10.

In this test, Fig. 02, it was possible to analyze the heat dissipation through the system temperature gradient that was recorded by thermocouples, a thermocouple was attached near the contact between the sample and stem, and the other thermocouple, recorded the temperature in environment.

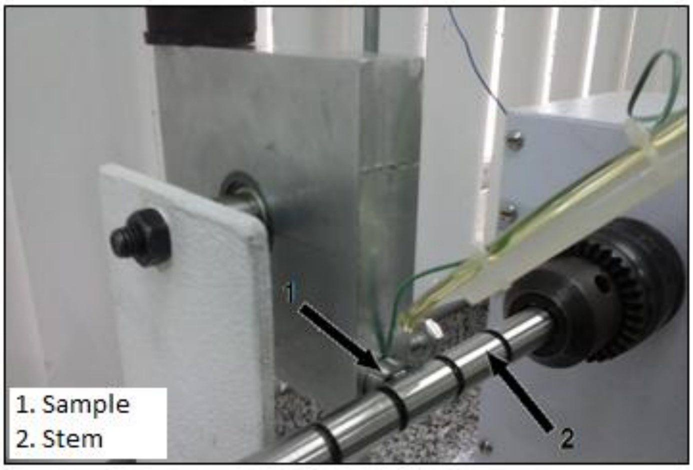

Figure 02. Contact between the sample and the stem during the test.

The system temperature was also analyzed by infrared thermography through equipment E-Series InfraRed Camera E-60, the FLIR manufacturer with accuracy to plus or minus 2 ° C, Fig. 03.

Figure 03. Infrared Camera FLIR E-60.

Infrared thermography is a technique that detects the infrared radiation that each body emits and which is related to the temperature thereof, this thermography it is a picture whose camera sensor captures the infrared radiation, marking different temperature zones of different colors. The thermography was generated every 10 minutes during the test period for each sample pair and stem.

2.2 Thermal conductivity and resistivity thermal

For thermal conductivity measurements, and resistivity of the oils was used an analyzer thermal properties of the brand Decagon Devices Inc., KD2-Pro model. The sensor KS-1 was used for liquid samples, which provides the conductivity values in a range from 0.02 to 2.00 (W / m. K) and a resistivity range 50-5000 (ºC. cm/W) with a precision of plus or minus 5%.

Initially the equipment and the sensor have been calibrated to a standard solution of glycerin provided by the equipment manufacturer. After the readings have been initiated, it was used a graduated glass cylinder of 10 ml capacity which was placed in the oil and inserted into the sensor, Fig. 04.

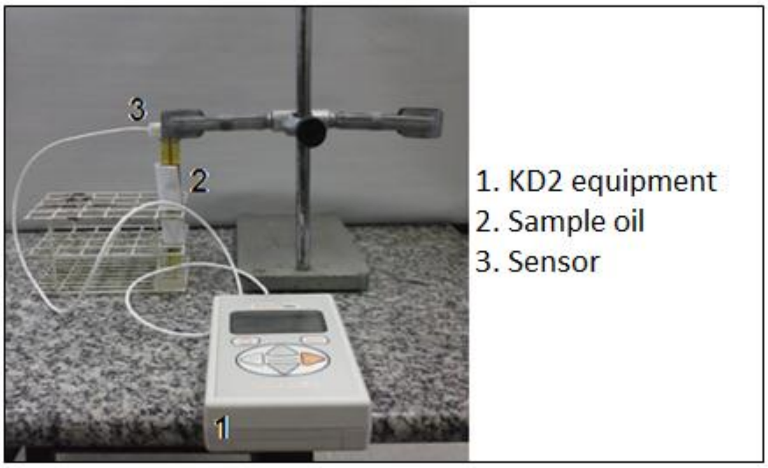

Figure 04. Test conductivity and thermal resistivity with KD2 equipment.

For each oil five readings were made at room temperature in the interval from 15 to 15 minutes, as recommended by the equipment manual.

3. RESULTS AND DISCUSSION

Observing the oil temperature gradient, since the heat dissipation is one of the most important functions of a lubricant, Fig. 05, the temperature variation between each sample and the environment shows that this parameter the carnauba oil was more efficient that SAE 10W30 commercial oil.

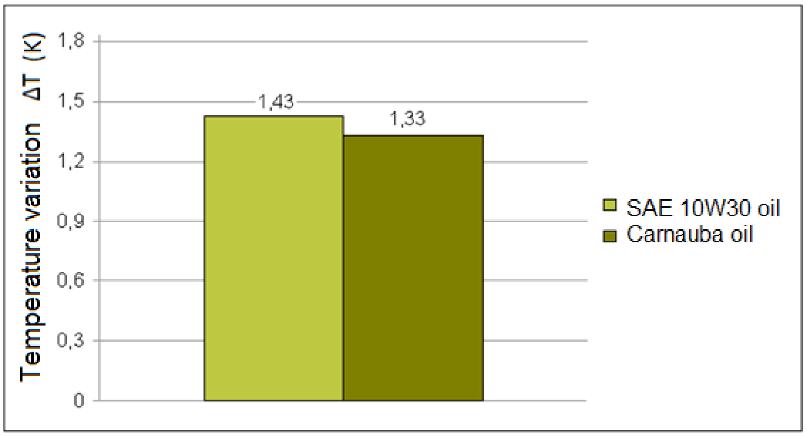

Figure 05. Temperature gradient oils.

Results also observed in thermography, Fig.06.

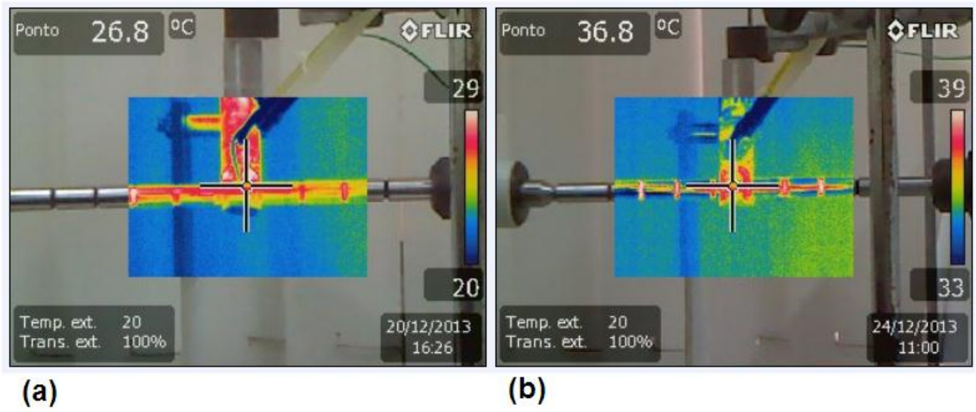

Figure 06. (a) Thermography test with SAE 10W30 oil; (b) and carnauba oil.

On the right side of each thermography, Fig. 06, there is a temperature range which reveals the minimum and maximum temperature of each system, from these values, it is clear that the carnauba oil has a temperature variation lower. Oil that has the lowest system temperature range means that it has a better cooling capacity of the mechanical system.

For greater reliability on the results of the temperature gradient analysis were developed conductivity analysis and thermal resistivity of carnauba oil and SAE 10W30 oil.

The results of thermal conductivity and thermal resistivity are shown in Tab. 01.

Table 01. Values of conductivity and thermal resistivity of the oils.

Type of oil	Temperature (°C)	Thermal conductivity K (W/m°C)	Thermal resistivity rho (°C cm/W)	error
Carnauba oil	28.8	0.160	624.9	0.0036
SAE 10W30 oil	28.8	0.135	741.6	0.0044

From Tab. 01 it can be seen that the thermal conductivity of carnauba oil is greater than the SAE 10W30 oil, demonstrating that the carnauba oil has greater capacity to dissipate heat, making the lubrication system with carnauba oil cooler than the system lubricated with SAE 10W30 oil.

4. CONCLUSIONS

The carnauba oil when compared to the SAE 10W30 API SM oil has greater efficiency to lubricate a mechanical system, with higher capacity to dissipate heat due to its good thermal properties.

Given the analysis, carnauba oil showed satisfactory results, showing a good correlation to its application as biolubricant. However, additional tests are needed, considering that this study is a pioneer in engineering.

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6. RESPONSIBILITY NOTICE

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