24th ABCM International Congress of Mechanical Engineering
December 3-8, 2017, Curitiba, PR, Brazil

COBEM-2017-1315
STUDY OF GRAPE SEED OIL IN THE PROPOSAL OF BIOLUBRICANTS IN OPEN SYSTEMS

Adriano do Amor Divino Guilhon Serra
Thymisson Paixão
Ighor Ferreira
José Airton Neiva Alves da Silva Brasil
Paulo Roberto Ribeiro Filho
Universidade Estadual do Maranhão
adrianodoamor01@gmail.com
thaymisson.paixao@hotmail.com
ighor.caetano@hotmail.com
airton.bra@gmail.com
profpauloflexa@gmail.com

Abstract. *The study of the use of biolubricants is necessary to make possible the substitution of oils of mineral base, such substitution has its importance when it refers to the need to obtain a lubricant of renewable source, not harmful to the environment and thus tending to lower costs. The article presents grape seed oil as a possible lubricant that can replace LUBRAX HYDRA XP 46 and their counterparts. Its viability is proven by determining the physical properties and wear rate. The characterization of the properties is based on ASTM standards, as the tests showed that grape seed oil showed good results such as flash point and fire point superiority, and viscosity index of 83.09% higher than the value of Lubrax found in its MSDS. The wear rate is done by means of an experimental disk-type bench and test piece that allows the satisfactory results to be implemented in the Archard equation, in which it defines the value of the wear rate.*

Keywords: Biolubricants, Lubricant, Physical Property, Experimental Bench, Wear Rate

1. INTRODUCTION

Recently, Ferreira (2016a) treats wear as a concern for industrial maintenance, because it induces the malfunctions in the operation of a machine and replacement of components. Lubrication is the activity of minimizing the contact of surfaces that that have relative movement (as reported by Ribeiro, 2014a). The lubricant forms a protective film between the surfaces, reducing undesirable physical reactions such as degradation, temperature increase and shear. In general, Norton (2013) says that liquid lubrication differs due to the low shear strength that reduces the coefficient of friction, obtaining a wide application due to the property of cooling in the surface in contact.

The oil of grape seeds (Vitis sp.) is extracted through the cold pressing process and filtration, but little explored for tribological purposes, its plantations are found in several areas of Brazil, being the south, southeast and northeast regions the largest producers.

2. EXPERIMENTAL PROCEDURE

In the substitution analysis methodology, two parameters are taken for the comparison between the oils, since the first is given by the analysis of the physical properties of the oils, validating a basis of comparison between them by means of the proximity of their viscosities and reflecting other characteristics that reveal their potential, and the second parameter is obtained by performing an experimental simulation of an open system, in order to evidence the wear, a disc model wear bench was built against the test piece. This bench model is inspired according to ASTM G77-17 (2017).

The choice of grape seed oil was based on three relevant considerations, such as the great abundance of grape culture found in Brazil, by presenting a relatively low market value when compared to most vegetable oils and by the inexistence of studies and records of easy access reporting its use as a lubricant for open systems.

The characterization is done in a laboratory using ASTM D445 (2017), ASTM D2270 (2016), ASTM D4052 (2012), ASTM D92 (2016) and ASTM D97 (2017) standards that governed the tests necessary to obtain the values of the physical properties of the grape seed oil being the viscosity respectively at 40 ° and 100 °, viscosity index, density, flash point and fire point and pour point.

The experimental bench model shown in Fig. 1 consists of the application of an exerted force of the test piece to the disk that moves in the rotary direction, such action refer to the wear of the test piece, which is reduced by the lubrication dripped in the area contact information.

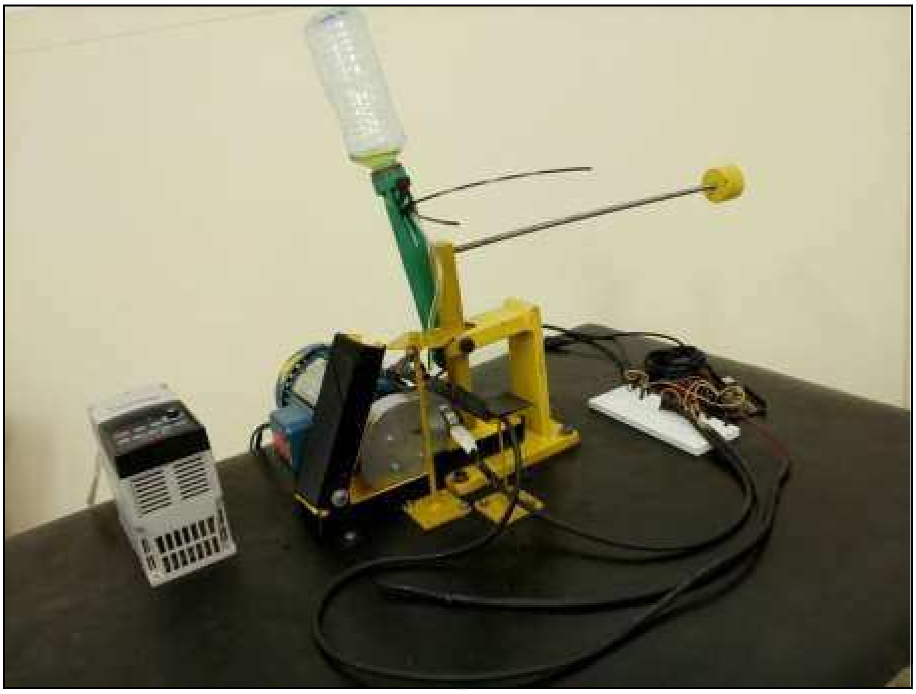

Figure 1. Experimental Bench

The bench is equipped with a temperature monitoring system where the results are collected and thus made the curve that describes the cooling of the oil on the contact surface. Table (1) below shows the main bench components.

Table 1. Principais componentes da bancada experimental

Material	**Quantidade**
Rubber sheet	1
Phototransistor	1
PowerFlex 4 Adjustable Frequency AC Drive	1
Jumpers	1
Infrared Led	1
Table	1
Vorges three phase 1/3 HP (1680 rpm)	1
Arduino board	1
Protoboard	1
Container	1
Supports	3
NTC Thermistors	2

For each test there were procedures to be followed where both the test piece and the disk were prepared, in which they established patterns between the tests and minimized the erros.

The standardization procedures were done through the roughness removed from the test piece and the disk, the objective is the similarity between the roughness averages of each other. As the mass differential is one of the parameters necessary to obtain the wear rate, before each test is carried out the weighing obtaining the initial mass and after the final mass test.

Based on FERREIRA (2016b), we can say that the wear rate (Q) depends on the volume lost (V) over the travelled distance (D). The equation of Archard is reduced to Eq. (1), since the SAE 4140 steel for the disk was SAE 1020 in the test piece with a hardness of 868.68 Newtons per square meter (N/m^2) of density of 7,85x10-3 (g/mm^3) and a force acting in the system of 12,5 Newton, force that allows the existence of the wear.

$$Q=V/D \tag{1}$$

3. RESULTS AND DISCUSSION

3.1 Physical Property Results

The comparison of mineral and vegetable oil was based on the proximity between the classes of kinematic viscosity at 40 ° C and 100 ° C, since the physical values of the vegetable oil obtained are close to the values presented by the manufacturers of mineral oil LUBRAX HYDRA XP 46 (FISPQ, 2011), an oil widely used in the industry for hydraulic systems operating at high temperature. Table 2 shows the values of the physical properties of the oils under study.

Table 2. Physical properties of the studied fluids

PHYSICAL PROPERTIES	**GRAPE SEED OIL**	**LUBRAX HYDRA XP 46 OIL**	**STANDARDS**
Kinematic viscosity at 40 ° C (mm^2 / s)	39,5	44,3	ASTM D445
Kinematic viscosity at 100 ° C (mm^2 / s)	8,5	6,83	ASTM D445
Viscosity index	201,4	110	ASTM D2270
Specific gravity (density at 20/4 ° C) (g / cm^3)	0,916	0,869	ASTM D4052
Flash point (° C)	> 300	244	ASTM D92
Fire point (° C)	> 300	> 258	ASTM D92
Pour point (° C)	-6	-18	ASTM D97

In relation to the flash point and the fire point, the oil of grape seed had higher values. This feature qualifies vegetable oil to work at higher temperatures than mineral oil. The value of the viscosity indexes of the possible biolubricant oil has a result superior to the mineral oil in 83.09%, that is to say, it has greater resistance to change of viscosity with the increase of the temperature of the working regime, presenting an oil more stable than the LUBRAX HIDRA XP 46. Figure 2 shows the appearance of the oils tested.

Figure 2. Grape seed oil on the left and LUBRAX HYDRA XP 46 on the right

3.2 Tests in the Experimental Bench

The experiment was arranged with a rotation of 1360 rpm, excited by the inverter frequency of 48.5 Hz. The running time was 7 minutes, where it ran about 3000 meters to a lubrication set with one drop every five seconds. Made to simulate an intermittent drive system with a view to a poorer lubrication where wear is evident.

The tests reveal the temperature dispersion curves of the oils are very close, such as the distance travelled, showing a very satisfactory behaviour as the cooling property of both, thus validating the substitution for the cooling requirement for a condition to 3000 meters in the open system. The graph with the results is shown in Fig. 3.

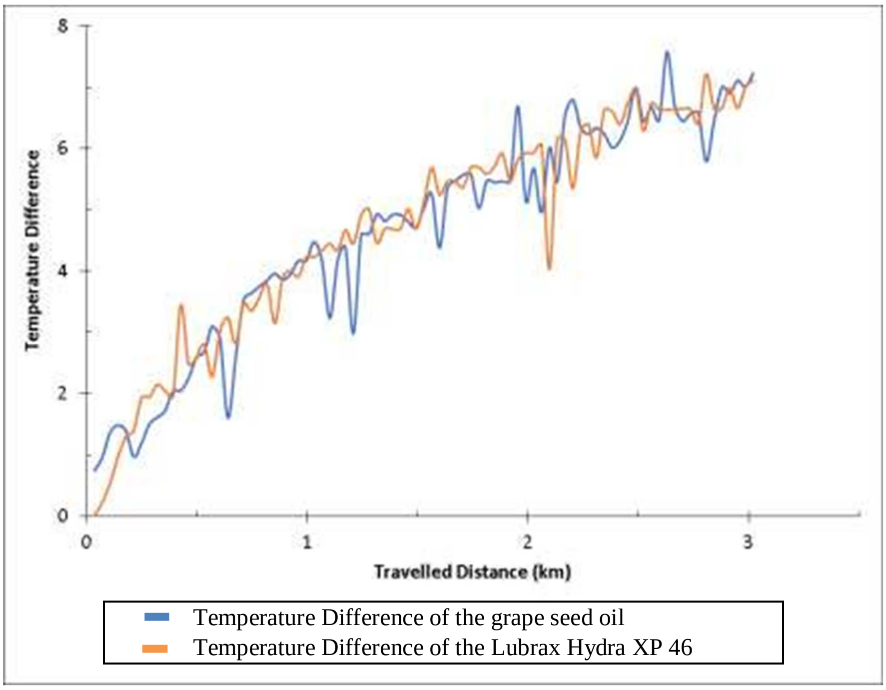

Figure 3. Comparative graph of the temperature variation.

The graph of Fig. 4 shows a trend line that is determined by a second-degree polynomial, both provides the coefficient of determination of approximately 95%.

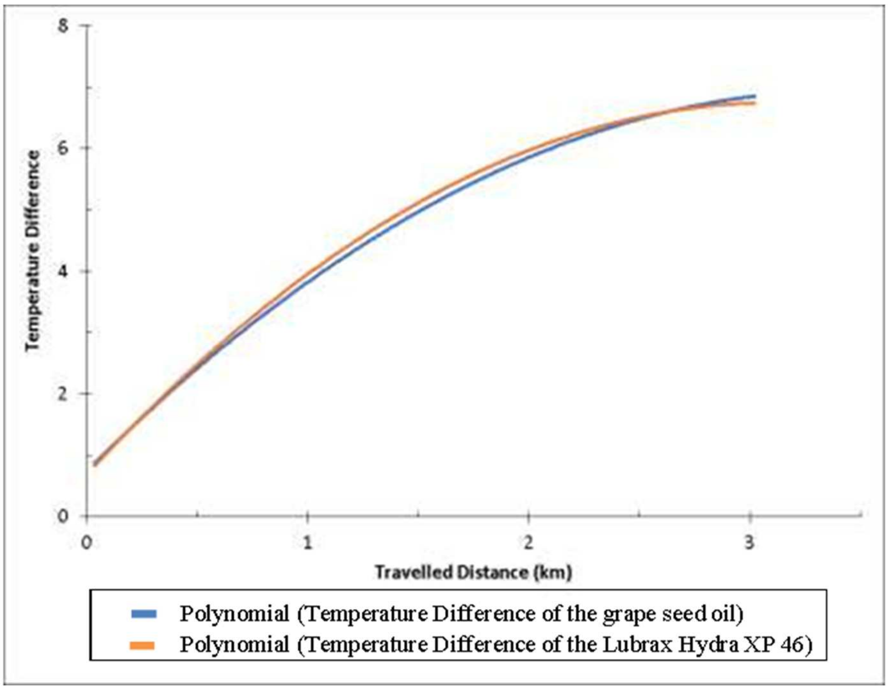

Figure 4. Comparative graph of the trend curve of the temperature variation.

Equations (2) and (3) respectively show the polynomial response of the trend line for vegetable and mineral oil by quadratic equations.

$$y = -0{,}5243x^2 + 3{,}606x + 0{,}7461 \quad (2)$$

$$y = -0{,}625x^2 + 3{,}8916x + 0{,}6921 \quad (3)$$

3.3 Wear Rate

For the calculation of wear it was necessary to obtain the mass by weighing and density (already tabulated for SAE 1020 steel) to find out the volume lost in the tests, such value obtained is divided by the distance thus discovering the wear rate. Table 3 shows the mass values before and after the tests.

Table 3. Mass (g) of the test piece

Description	Grape seed oil		Lubrax Hydra XP 46	
	Before	After	Before	After
1st measure	74,2747	74,2706	74,2158	74,2126
2st measure	74,2747	74,2706	74,2158	74,2125
3st measure	74,2748	74,2704	74,2156	74,2124
4st measure	74,2748	74,2705	74,2157	74,2127
Mean	74,2748	74,2705	74,2157	74,2126
Mass Difference	0,0042		0,0032	

The graph in the Fig. 5 shows the comparison of the wear rates between the oils.

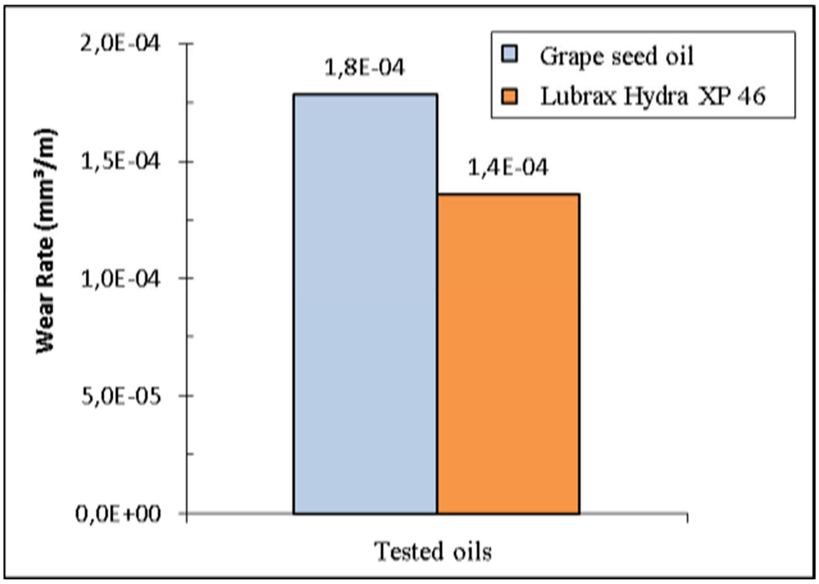

Figure 5. Wear rates comparative charts

The results presented demonstrate a good performance of the grape seed oil offering a percentage difference below 30%, this implies that even if it does not stand out, it can be replaced by the addition of a biodegradable anti-wearer, since a natural oil offered an excellent efficiency compared to a laboratory-manipulated oil.

4. CONCLUSION

From the comparative methodology, it is notable that according to an evaluation of the physical properties of the oils obtained in the laboratory, it can be concluded that those of vegetable origin presented better results than those of mineral and following origin: index of viscosity, density, flash point and fire point.

According to the results, it is possible to observe that the grape seed oil has the highest flash point and fire point, possibly it is indicated its use in mechanical systems with the environment that presents a more severe temperature, as it provides an effective dissipation of the heat.

The pour point of the vegetable-based oil even though it is lower than that of the mineral oil becomes relevant, because when compared to the other mineral oils it presents a satisfactory result.

The experimental bench had an excellent performance presenting sensible answers by what was expected in comparison with other works.

The tests showed how much the grape seed oil was likened to LUBRAX in the cooling system of the system, thus enabling its viability in such application. Therefore, for the wear rate, it presented a larger number, thus avoiding its possible indication and swap. This is explained by the fact that the mineral oil contains antiwear additives, so the application of this additive of biodegradable origin in the grape seed oil becomes a possible solution. It is important to report that grape seed oil can be improved as long as the question of the oxidation capacity in the metallic bodies, such an inherent anomaly of the oil can be remedied through antioxidant additives as used by the comparative but vegetablebased lubricant.

The feasibility of using vegetable oil as a substitute for oil of mineral origin has great environmental importance, reflecting sustainable development, but a larger number of trials are required to represent different applications. The detailed mapping of grape seed oil may reveal innovative proposals in the field of maintenance with the use of biolubricants.

5. ACKNOWLEDGMENT

I thank the Universidade Estadual do Maranhão along with Professor Paulo Flexa, Ighor Ferreira and Thymisson Paixão and the entire team of the Lubrication Laboratory responsible for technical and scientific support for the opportunity to be in development or study of lubrication of grape seed oil. Thanks also to FAPEMA for the support provided through the incentive and the expenses paid to present this study. In gratitude to Luzivam Rabelo for the review, José Airton for the translation responsibility and my family for encouragement and support for this work.

6. REFERÊNCIAS

ASTM D2270-10(2016), Standard Practice for Calculating Viscosity Index from Kinematic Viscosity at 40 °C and 100 °C, ASTM International, West Conshohocken, PA, 2016, www.astm.org

ASTM D4057-12, Standard Practice for Manual Sampling of Petroleum and Petroleum Products, ASTM International, West Conshohocken, PA, 2012, www.astm.org

ASTM D445-17a, Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity), ASTM International, West Conshohocken, PA, 2017, www.astm.org

ASTM D92-16b, Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester, ASTM International, West Conshohocken, PA, 2016, www.astm.org

ASTM D97-17a, Standard Test Method for Pour Point of Petroleum Products, ASTM International, West Conshohocken, PA, 2017, www.astm.org

ASTM G77-17. Standard Test Method for Ranking Resistance of Materials to Sliding Wear Using Block-on-Ring Wear Test, ASTM International, West Conshohocken, PA, 2017, www.astm.org

FERREIRA, Ighor Caetano Silva. Estudo da lubricidade dos óleos vegetais de mamona/linhaça através de ensaio de desgaste de contato lubrificado por gotejamento. 2016. 95 f. Monografia (Especialização) - Curso de Engenharia Mecânica, Universidade Estadual do Maranhão, São Luís, 2016.

QUAGLIATO, A. C. Óleo de Semente de Uva. Disponível em: <http://www.mundodosoleos.com/oleo-de-semente-deuva>. Acesso em: 26 jan. 2017.

NORTON R. L., 2013. Projeto de Máquinas, Bookman, 4ª edição, 2013, São Paulo, Brasil, 625 e 626 p.

RIBEIRO FILHO, P. R. C. F. Desenvolvimento de uma unidade experimental para estudo tribológico de desgaste de contato lubrificado por gotejamento de óleos vegetais. 2014. 111 f. Dissertação (Mestrado em Engenharia Mecânica) Universidade Santa Cecília, Santos, São Paulo. 2015.

PETROBRAS DISTRIBUIDORA S.A. “Ficha de Informações de Segurança de Produtos Químicos - LUBRAX HYDRA XP (5, 10, 15, 22, 32, 46, 68, 100, 150, 220)”, FISPQ, 2011.

7. RESPONSIBILITY NOTICE

The authors Adriano do Amor Divino Guilhon Serra, Thymisson Sousa da Paixão, Ighor Caetano Silva Ferreira, José Airton Neiva Alves da Silva Brasil and Paulo Roberto Campos Flexa Ribeiro Filho are solely responsible for the printed material included in this article.