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# TRIBOLOGICAL STUDIES REGARDING THE CRUDE RAPESEED OIL PRESS

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## ABSTRACT

*The aim of this paper is to present a tribology test conducted on crude rapeseed oil press. The experiments were carried out with four-ball machine. The oil was tested at speed of 1000 rot/min and loads of 140 N and 200 N. Times of the test were 1200, 2400 and 3600 seconds. During the action of the 140 N load, the friction force has an almost linear increase, unlike the friction force recorded at the load of 200 N, when it was noticed a sharp increase in the range of 0 to 800 seconds, followed then by a stabilization of the friction force.*

KEYWORDS: lubricant, rapeseed oil, friction force, four-ball machine

## 1. Introduction

In the recent years, tribological and rheological behavior studies of vegetable oils have been the subject of research both from our country and other countries. The gradual replacement of conventional lubricants with fast biodegradable lubricants aroused the interest of many researchers [1-8].

The tribological behavior of the vegetable oils was tested on various tribology testers [9-12], but in particular on the four-ball machine [13-21].

The four-ball machine can be used to perform studies of the resistance to wear and resistance to galling. In the work [22] the authors studied the tribological behavior of sunflower oils, obtained from the six stages of processing in comparison with the hydraulic oil H32.

Jayadas [23] compared the wear resistance of coconut oil with the SAE 20W50 mineral oil. Chiong Ing *et al.* [14], using the four-ball machine, conducted a tribology study for an oil palm refined in comparison with a paraffinic mineral oil.

Farooq *et al.*, in the work [24], using the entire machine with four balls, have examined the tribological behavior for the sesame oil and castor oil. Masjuki *et al.* [25] have studied resistance to wear for both mineral oils SAE10 and the ESA30 additives (varying percentages) with methyl ester of oil palm on the four-ball machine. Husnawan *et al.* [26], using the four-ball machine have studied the influence of the oil palm and the additive amino phosphates in a mineral oil (SN 500). It was noted that the palm oil caused a sign of wear less than mineral oil while the mixture of mineral oil with oil palm 30% and additive by 3% amino phosphates causes the smaller wear diameter.

## 2. Experimental procedure

Tribology tests have been carried out on the four-ball machine (Fig. 1).

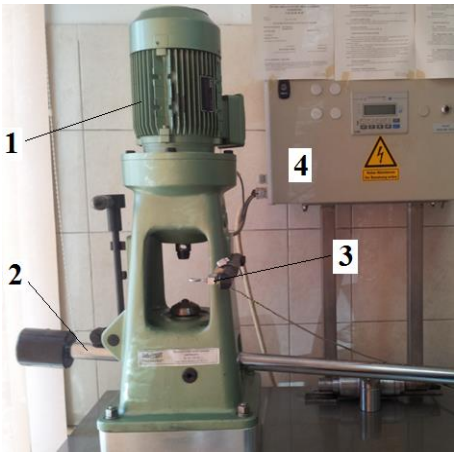


***Fig. 1.*** *Four-ball machine*

This machine is located within the laboratory "Lubritest" of Department of Mechanical Engineering of the Engineering Faculty from "Dunarea de Jos" University of Galati.

In Figure 1 is presented an overall picture of the four-ball machine, together with the acquisition

system data, in accordance with standard SR EN ISO 20623:2004.

The four-ball machine components (fig. 1) are: the electric motor drive (1), the charging system (2), the force transducer (3), the electronic panel for programming the parameters of the work (4).

Using the four-ball machine was tested a lubricant that is introduced between the four balls (Fig. 2), a ball, (2) what rests on three other balls, (1) carrying a rotating movement; at the same time a system of loading (Fig. 1, pos. 2) ensures a contact pressure between the four balls [27].


***Fig. 2.*** *All the four balls*


***Fig. 3.*** *The acquisition system and processing of experimental data*

The friction force was measured using a tens sensor (3) (Fig.1), fixed between the support frame and the cup mounting arm of the three-ball system. The signal sent by the tens sensor is captured by a Scout type 55 system (2) (Fig. 3) and sent to a computer (1) (Fig. 3). The CATMAN® Express 4.5 system was used for data acquisition and processing.

**Table 1.** The chemical composition EN31 (%) [26]

| Material | C | Cr | Mn | Si | S | P | VHN |
|---|---|---|---|---|---|---|---|
| EN31 | 1.0 | 1.3 | 0.5 | 0.35 | 0.05 | 0.05 | 805 |

The four balls have a diameter of 12.7 mm made of steel with the composition and the hardness presented in Table 1. The balls are especially treated and have a very small tolerance of the diameter (± 0.0005 mm), hardness and the quality of the surface: Ra = 0.02 ... 0.03 mm.

## 3. Experimental results

In this paper was performed a tribological tests on crude rapeseed oil press. The experiments have been performed on the four-ball machine. It was measured the friction force obtained as a result of the contact between the ball located in the rotational motion and on the three fixed balls.

The oil has been tested at speed of 1000 rot/min and loads of 140 N and 200 N. The period of the tests has been 1200, 2400 and 3600 seconds.

Figure 4 represented the variation of friction force for 1200 seconds, on 140 N. It can be noticed a linear increase of the friction force through the analyzed time interval.

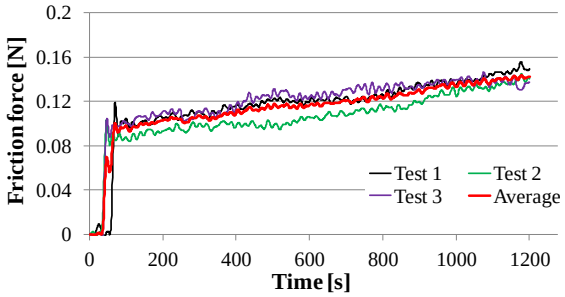


***Fig. 4.*** *Friction force variation with time at 140 N, 1200 seconds*

In Figure 5 were represented the variations of friction force in time for 1200 seconds, for the load with 200 N. Increasing the load from 140 N to 200 N it is notable an increase of the friction force. In the first part of the tests (0-800 s) was recorded a sharp increase of the friction force. In the range 800-1200 seconds it is observed a slight stabilization of the friction force.

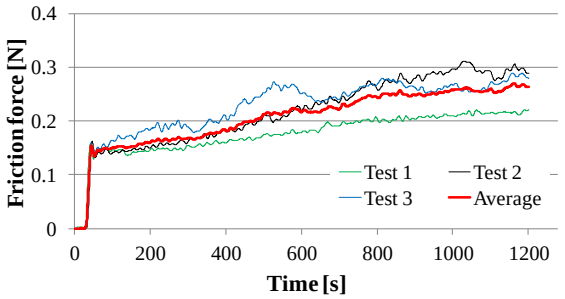


***Fig. 5.*** *Friction force variation with time at 200 N, 1200 de seconds*

In Figure 6 were represented the variations in time of friction for 2400 seconds, for the load of 140

N. Increasing the time of the test is to be noted that the growth of the linear trend of the friction force remains the same.

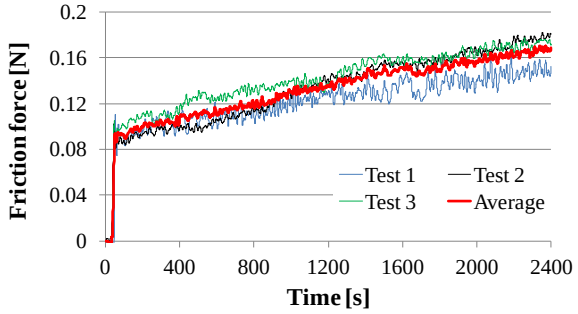


***Fig. 6.*** *Friction force variation with time at 140 N, 2400 de seconds*

In Figure 7 were represented the variations in the time of friction force for 2400 s, for the load of 200 N. It is observed a stabilization trend of the friction force after 1200 seconds.

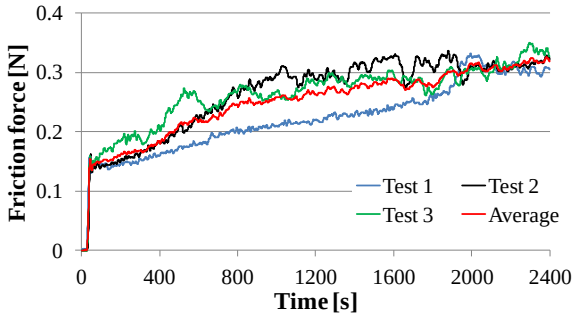


***Fig. 7.*** *Friction force variation with time at 200 N, 2400 seconds*

In Figure 8 were represented the variations of friction force for 3600 seconds, for the two loads for which were carried out the tests.

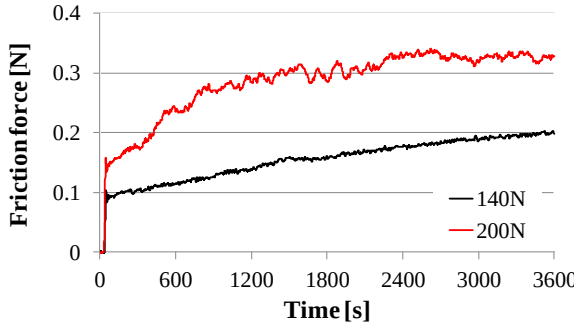


***Fig. 8.*** *Friction force variation with time, at 140 N and 200 N loads*

The tests conducted with load of 140 N indicate an almost linear increase of the friction force, on the whole period analyzed. In the case of the tests carried out at the load of 200 N, there appears a sharp increase in the range 0-800 seconds followed by a slight increase until the final of the tests.

In Figure 9 were represented the variations of the friction force with time for 140 N and 200 N loads. So, were calculated average values of the result of friction force for the last 300 seconds of each test.

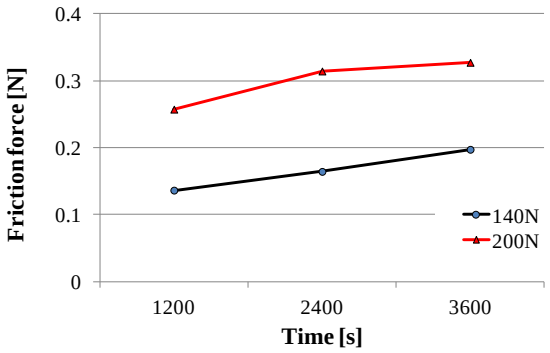


***Fig. 9.*** *Friction force variation with time, both loads of testing, average values*

The friction force increases with the load increases, for all periods of the test. Also, the friction force increases with time trial, for both loads.

An increase of the load with 43%, from 140 N to 200 N, causes, for the test of 1200 seconds, an increase of the friction force with 87.8%. For the test of 2400 seconds, the increase is 91.3% and for the test of 3600 seconds, the increase is 65.5%.

For the tested oil on 140 N, in the period 1200 - 2400 s, the friction force increases with 19.96%, while in the last period of time the increase is 20.41%, comparable to that of the first period of time.

For the tested oil on 200 N, in the period of 1200 – 2400 s, the friction force increases with 22.18% while in the last period of time the growth is much smaller, representing 4.2%. After this last period of time, the friction force registers a tendency of stabilization.

## 4. Conclusions

The friction force varies with the increase of load at which the oil has been tested. During the action of the 140 N load, the friction force has an almost linear increase, unlike the friction force recorded at the load of 200 N, when it was noticed a sharp increase in the range of 0 to 800 seconds, followed then by a stabilization of the friction force. In order to determine the time after which takes place the stabilization of the friction force, for rapeseed oil

tested to load on 140 N, it is necessary to make tests for further periods of 3600 minutes.

## References

**[1]. Bogatu L., Ciupariu D., Tănăsescu C.**, *Improving the oxidation stability and biodegradability of environmentally friendly lubricants*, Revista de Chimie, 61, no. 10, 2010.
**[2]. Bogatu L., Dragomir E. R.**, *Influence of additives on antiwear and extreme pressure behavior of vegetable oils*, Revista de Chimie, 67, no. 4, 2016.
**[3]. Bhaumik S., Pathak S. D.**, *A comparative experimental analysis of tribological properties between commercial mineral oil and neat castor oil using Taguchi method in boundary lubrication regime*, Tribology in Industry, vol. 38, issue 1, p. 33-44, 2016.
**[4]. Hassan M., Ani F. N., Syahrullail S.**, *Tribological features of refined, deodorized and bleached palm oil with mineral oil blend*, Tribology Transactions, 2015.
**[5]. Calixto Rodríguez-Martínez, Francisco Lafargue-Pérez, José Ángel Sotolongo-Pérez, Annarella Rodríguez-Poveda, Juliano Chitue de Assuncao Nascimento**, *Determinación de las propiedades físicas y carga crítica del aceite vegetal Jatropha curcas L.*, Ingeniería Mecánica, vol. 15, no. 3, p. 170-175, Havana, ISSN 1815-5944, 2012.
**[6]. Calixto Rodríguez-Martínez, Francisco Lafargue-Pérez**, *Comparación experimental de un aceite vegetal y un aceite mineral básico como lubricantes en el par tribológico acero-babbit*, Tecnologia Quimica, Havana, vol. 33, no. 1, p. 74-80, 2013.
**[7]. Stanciu I.,** *A study of rheological behavior for refined rapeseed oil*, Ovidius University Annals of Chemistry, vol. 24, no. 1, p. 51-54, 2013.
**[8]. Stanciu I.,** *New relationship to describe the rheology of sunflower oil*, Ovidius University Annals of Chemistry, vol. 25, issue 1, p. 28-31, 2014.
**[9]. Arnsek A., Vizintin J.**, *Lubricating properties of rapeseed-based oils*, Journal Synth Lubr, 16 (4), p. 281-296, 1999.
**[10]. Kalin M., Vizintin J.**, *The tribological performance of DLC-coated gears lubricated with biodegradable oil in various pinion/gear material combinations*, Wear, 259, p. 1270-1280, 2005.
**[11]. Maru M. M., Trommer R. M., Almeida F. A., Silva R., Achete C. A.**, *Assessment of the lubricant behavior of biodiesel fuels using stribeck curves*, Fuel Processing Technology, 116, p. 130-134, 2013.
**[12]. Salih N., Salimon J., Yousif E.**, *The physicochemical and tribological properties of oleic acid based triester biolubricants*, Industrial Crops and Product, 34, p. 1089-1096, 2011.
**[13]. Spânu C., Rîpă M., Ciortan S.**, *Study of wear evolution for a hydraulic oil using a four-ball tester*, The Annals of University "Dunărea de Jos" of Galati, Fascicle VIII, Tribology, p. 186, 2008.
**[14]. Chiong Ing T., Rafiq A. K. M., Ayli Z., Syahrullail S.**, *Tribological behavior of refined bleached and deodorized palm olein in different loads using a four-ball tribotester*, Scientia Iranica B, 19 (6), p. 1487-1492, 2012.
**[15]. Haseeb A. S. M. A., Sia S. Y., Fazal M. A., Masjuki H. H.**, *Effect of temperature on tribological properties of palm biodiesel*, Energy, 35, p. 1460-1464, 2010.
**[16]. Ing T. C., Rafiq A. K. M., Azli Y., Syahrullail S.**, *The effect of temperature on the tribological behavior of RBD palm stearin*, Tribology Transactions, 55, p. 539-548, 2012.
**[17]. Rounds F.**, *Effects of hydroperoxides on wear as measured in four-ball wear tests*, Tribology Transactions, 36 (2), p. 297-303, 1993.
**[18]. Shahabuddin M., Masjuki H. H., Kalam M. A., Bhuiya M. M. K., Mehat H.**, *Comparative tribological investigation of bio-lubricant formulated from a non-edible oil source (Jatropha oil)*, Industrial Crops and Products, 47, p. 323-330, 2013.
**[19]. Zulkifli N. W. M., Kalam M. A., Masjuki H. H., Shahabuddin M., Yunus R.**, *Wear prevention characteristics of a palm oil-based TMP (trimethylolpropane) ester as an engine lubricant*, Energy, 54, p. 167-173, 2013.
**[20]. Zeng X., Wu H., Yi H.**, *Tribological behavior of three novel triazine derivates as additives in rapeseed oil*, Wear, 262, p. 718-726, 2007.
**[21]. Zhu F., Fan W., Wang A., Zhu Y.**, *Tribological study of novel S-N style 1,3,4-thiadiazole-2-thione derivatives in rapeseed oil*, Wear, 266, p. 233-238, 2009.
**[22]. Calomir C., Ştefănescu I., Şolea L. C., Chiriţă G.**, *Vegetal oils as lubricating materials*, The Annals of „Dunarea de Jos" University of Galati, Fascicle VIII, Tribology, p. 154-160, (XV), ISSN 1221-4590, Galati University Press, 2008.
**[23]. Jayadas N. H., Prabhakaran N., Ajithkumar G.**, *Tribological evaluation of coconut oil as an environment-friendly lubricant*, Tribology International, 40, p. 350-354, 2007.
**[24]. Farooq M., Ramil A., Gul S., Muhammad N.**, *The study of wear behavior of 12-hydroxystearic acid in vegetable oil*, Journal of Applied Sciences, 11 (8), p. 1381-1385, 2011.
**[25]. Masjuki H. H., Maleque M. A.**, *Investigation of the anti-wear characteristics of palm oil methyl ester using a four-ball tribotester test*, Wear, 206, p. 179-186, 1997.
**[26]. Husnawan M., Saifullah M. G., Masjuki H. H.**, *Development of friction force model for mineral oil basestock containing palm olein and antiwear additive*, Tribology International, 40, p. 74-81, 2007.
**[27]. *****, *Micro Photonics Inc., Friction & Wear Testing, Four Ball Wear*, online at http://www.microphotonics.com/tribomt.html (12.08.2008).