 doi:10.20944/preprints202209.0471.v1

Article

Manufacturing of Bio–Grease Vegetable Oil from Sugarcane Filter Mud for Lubrication System with Environment Friendly for Friction Reduction

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Abstract: Environment approachable products such as fuels and lubricants are among the best choices in several countries that contain renewable products as alternatives. To protect human life, alternative methods of saving the environment and production balance is needed to reduce the effects of the crisis and the contamination of the Environment. This research concentrated on the Manufacturing and testing of bio- grease from sugar cane filter mud vegetable oil as a lubricant for friction reduction and determining the properties of both bio grease and Mineral oil grease with environmental problems. SC filter mud oil as an alternative use for bio-grease preparation in addition to mineral oil grease. The Testing was accepted to determine the quality of the eco-friendly grease produced. For the preparation of this bio- grease, the SC Filter cake sample is taken from different sugar factory which found in Ethiopia. The sample has a moisture content of 78%. Using this sample first oil is extracted by Soxhlet apparatus, n-hexane solvent and temperature for extraction from 42 -68°C. The maximum temperature and time for extraction of oil were 68 and 7hrs respectively. The extracted oil's physical properties include color, acid value, specific graphite, saponification value, iodine value, density, and viscosity. Finally, the friction behavior in function of time for both grease at identical load, the friction coefficient vs time for SC filter Cake Grease_ Na_ MoS2 and industrial mineral one (I_ Greasily _ MoS2), grease was determined.

Keywords: biodegradable lubricating grease; friction; energy; penetration; sugar cane filter cake mud oil; temperature and wear

1. Introduction

The growing global population together with mechanization and transformation has led to an increase in energy consumption. There are money mechanisms for improving the Energy efficiency, Friction reduction using bio Grease one way for energy consumption Reduction. In Mechanical operation machine processes, heat is developed between machine element, huge amount Energy is wasted due to frictional damages [1]. we do not understand that significant quantity of energy is being wasted because of friction. Renewable raw material -based bio grease stay showing great impending and are a highly smart candidate to replace the predictable mineral grease for the use in lubricant production because they are structurally similar to the long chained hydrocarbons in mineral oils with the characteristics of being renewable, non-toxic, financial and environmental friendly [2].

Plant bio grease, non-conventional resource, are finding their way into lubricants for industrial and transportation applications. Unwanted disposal is also of less concern for plant oil-based products because of their environment-friendly and nontoxic nature.

Biofuels have by this time been accepted around the world for their advantages over conventional petroleum fuels, including the opportunity for energy independency [2, 3]. By shifting mineral oil based or synthetic lubricants by bio grease lubricants, the power wastage can be saved up to fifteen to seventeen percent or more, in addition to cultivating the other routine. Many countries including Austria, Canada, Hungary, Japan, Poland, Scandinavia, Switzerland, the USA, and the EU are either in the process of formulating or have already passed legislation to regulate the use of mineral oil-based lubricants in environmentally sensitive areas [3, 4]. Additionally, bio-degradable and non-toxic Bio-based based lubricants are environment during use. They can be disposed of through composting so that, the entire energy can be changed through cyclic of the nature. Thus all vegetable seed oil boil-based such as hydraulic fluid, spindle oil, chain oil, and greases of various types will provide energy saving in sroportions [1, 2, 5] . The consequence of friction generated on industrial apparatus (machine elements) and on automobiles is a major problem confronting man. As a result, greases or lubricants prepared from petroleum goods were initially developed to limit these dangerous situations [3].

The option to develop as much as possible bio-based materials as industrial and automotive bio- lubricants has increased in recent years. This tendency is primarily due to the non-toxic and ecofriendly or biodegradable characteristics of plant oils that can replace mineral oils as base fluids in lubricant making [3, 6]. Grease or Lubricants, which include organic and inorganic substances capable increase the performance of machine element efficiency, minimizing friction, depressing the wear of friction surfaces, and avoiding damage by scoring, are employed to upgrade the durability and dependability, serviceability and service efficiency of mechanisms, machines, and equipment. Another to reduce friction and wear in the machine element being lubricated under various operating conditions, protect against rust and corrosion, and prevent dirty water and additional contaminants from entering the part being lubricated [6, 7].

Bio Grease is a readily biodegradable, non-toxic is designed to provide high film strength, withstand high operating temperatures, maintain excellent stability, and extend lubricant life [8]. Toxicity has really been an important problem for a while, and the certainties toward the user will continue winning attention [9]. Bio Grease features high load carrying and anti-wear characteristics along with low water washout properties [10]. It is designed for heavy-duty use in a variety of industrial and marine applications.

Eco-friendly greases which are made from renewable resources via vegetable oils provide a suitable alternative to the petroleum base greases that are environmentally toxic and non- Eco-friendly. Vegetable oils-based lubricants are semi-solid colloidal dispersions of thickening agents (a metal soap) in a liquid lubricant matrix (Plant oil) [11]. Now a day the world of tribology today is the search of conventional, eco-friendly high viscous oils that will satisfy the requirements of lubrication [12]. Now a day in the world 60% and 40% of grease are used by industrial sectorial and automotive areas respectively [13].

2. Materials and Methods

A sample of sugarcane filter mud was collected from a different sugar factory found in Ethiopia located. The sample is collected from Wonji which is located latitude and longitude of 8°27′N 39°17′E with an elevation of 1588m above sea level. The sugar cane mud sample had some impurities such as sand and other dirt. This impurity was removed by hand-picking. Then the arranged sample was dried in the oven at 110 °C to 6hrs to reduce its humidity content. The dried sample was taken to the laboratory of the Chemical engineering department in Jimma University, for extraction of oil.

Determine the moisture content of sugar cane mud

Sample 50g, 80g, and 160g of the cleaned sample was weighed and dried in an oven at 110°C and the weight was measured every 2:30hrs. The process was repetitive to a constant weight was obtained.

The amount of humidity in the sugar filter mud is considered using the following equation (1)

Humidity or Moisture % =

(W_1-W_2)/ W_1×100%...(1)

Where: W_1 = original sample of weight earlier drying.
W_2= sample of Weight after drying
Size Reduction and balancing the sample for oil extraction

The humidity was detached by placing the sample in a sun for 6 days from 25°C to 30°C. The dried filter mud was crushed by hand with a sieve size of 1 mm- 2.5 mm. The sample was sieved with a set of sieves sizes arranged in 1 - 1.5 millimeter, 1.5 - 2 millimeter, 2 -2.5 millimetre's to get sizes to investigate the effect of elements size on yield and amount of oil.

Figure 1. Sugar cane filter mud sample in an oven.

3. Results and Discussion

The Raw filter mud was collected from the Ethiopia sugar factory and the humidity content of the sample was checked which is shown in Figure 1.

Table 1. Humidity or Moisture content of filter mud oil.

	Mockup mass (g)		
Time(Hr.)	Mockup 1	Mockup 2	Mockup 3
Initial mass(g)	50.00	80.00	160.00
Mass after 2h	35.5	62.00	110.63
Mass after 4h	21.3	41.82	75.52
Mass after 6h	13.40	35.5	55.54
Mass after 8h	12.52	30.35	43.34
Mass after 10h	12.12	25.13	36.42
Mass after 12h	12.10	24.923	35.31
Moisture content (%)	75.8	75.077	76.46

From Table.1, the humidity content of the three- Mockups dried in an oven containing a mass of 50,80 and 160 grams were 75.8%, 75.077% and 76.46% separately. Thus, the ordinary humidity content of the four Mockup was 75.78%. The end result approves to the humidity content of the dehydrated sugar filter mud, which was between 75 - 77%.

The special effects of functional parameters such as drying conditions of the sample and extraction time on the number and value of important oils extracted by means of Sox let extraction were studied using Sugarcane filter mud material. To investigate the influence of operating parameters on the yield and quality of oil extracts, the focus area in the analysis of the results was directed towards the following points: The results of oil characterization showed that the oil extracted from the sugarcane filter mud oil is suitable to produce bio grease for lubricants. However, in terms of the mass of oil yield, the oil content was found to be lower by more than two folds than the oil content of most of the

 doi:10.20944/preprints202209.0471.v1

other plants [14]. Figure 2. Shows the size Reduction and balancing of the sample and Extracted oil from filter mud by using Sox let extraction method.

Figure 2. Size Reduction and balancing of the sample and Extracted oil from filter mud by using the Soxy let extraction method.

3.1. Analysis of factors affecting oil yield

Percentage yield of oil extracted by using Soxhlet = (W1-w2)/W1 = (40 – 39.7)/40 ×100% = 0.75% @particle 1.8-2mm size, temperature of 40°C and time of extraction two hours.

For 60gm, (W1-w2)/W1 = (60 – 59.5)/60 = 0.833%. In a similar way, the other is done.

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Table 2. Total percentage of oil produced for Soxhlet extractor for different particle size, time, and weight by means of n-hexane as a solvent and temperature 45°C.

Mockup Size (mm)	Mockup weight (g) and percentage obtained		Time for Extraction (hours)		
			Two	four	Six
1.8 - 2	Weight	40	39.7	39.5	39.48
	%Yield	-	0.75	1.25	1.3
	Weight	50	49.5	49.3	49.15
	Yield	-	0.8	1.4	1.6
	Weight	60	59.5	59.1	59.0
	yield	-	0.833	1.5	1.667
1.4 - 1.8	Weight	40	39.57	39.46	39.376
	% yield	-	1.075	1.35	1.56
	Weight	50	49.5	49.25	49.15
	% yield	-	1	1.5	1.7
	Weight	60	59.33	59.01	58.90
	% yield	-	1.125	1.65	1.85
1 - 1.4	Weight	40	39.55	39.44	39.37
	% Yield	-	1.125	1.4	1.57
	Weight	50	49.4	49.185	49.1
	%Yield	-	1.2	1.63	1.82
	Weight	60	57.25	58.97	58.84
	%Yield	-	1.25	1.71	1.93

Table 3. Total amount percentage oil for Soxhlet extractor for altered element size, time, and weight using n-hexane as a solvent and temperature 55°C.

Sample size (mm)	Mockup weight (g) and percentage obtained		Time for Extraction (hours)		
			Two	four	Six
	Weight	40	39.64	39.49	38.44
	%Yield	-	0.9	1.27	1.4
1.8 - 2	Weight	50	49.53	49.27	49.175
	Yield	-	0.94	1.46	1.65
	Weight	60	59.49	59.05	58.95
	yield	-	0.85	1.58	1.75
1.4 - 1.8	Weight	40	39.52	39.424	39.368
	% yield	-	1.2	1.44	1.58
	Weight	50	49.4	49.22	49.13
	% yield	-	1.23	1.56	1.74
	Weight	60	59.2	58.86	58.8
	% yield	-	1.35	1.9	2
1.0 - 1.4	Weight	40	39.48	39.4	39.368
	% Yield	-	1.3	1.5	1.58
	Weight	50	49.3	49.14	49.05
	%Yield	-	1.4	1.72	1.9
	Weight	60	59.04	58.836	58.674
	%Yield	-	1.6	1.94	2.15

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Table 4. Total % oil obtained for Sox let extractor for different element magnitude, time, and weight using n-hexane as a solvent and temperature 65℃.

Sample size (mm)	Mockup weight (g) and percentage obtained		Time for Extraction (hours) Two	four	Six
1.8-2.00	Weight	40	39.5	39.46	39.46
	%Yield	-	1.25	1.35	1.5
	Weight	50	49.325	49.175	49.1
	Yield	-	1.35	1.65	1.8
	Weight	60	59.16	58.89	58.65
	yield	-	1.4	1.85	2.25
1.4-1.8	Weight	40	39.46	39.372	39.356
	% yield	-	1.35	1.57	1.61
	Weight	50	49.215	49.075	48.975
	% yield	-	1.57	1.85	2.05
	Weight	60	58.902	58.632	58.596
	% yield	-	1.83	2.28	2.34
1.0-1.4	Weight	40	39.396	39.368	39.346
	% Yield	-	1.51	1.58	1.634
	Weight	50	49.175	49.02	48.875
	%Yield	-	1.65	1.96	2.25
	Weight	60	58.644	58.578	58.506
	%Yield	-	2.26	2.37	2.49

3.2. Influence of extraction time on percentage of oil obtained

The percentage obtained of sugar filter mud oil can be influenced by abstraction time, temperature, solvent type, particle size, and other components in the sample. Withdrawal time plays a great role in the percentage obtained of sugar filter cake mud fat using n-hexane as a flush. Figure 3, indicates that as the contact time increases the oil percentage also increases. In another expression, when an extreme amount of extractable oil is obtained, the oil percentage level remains constant even by outspreading the reaction time. So, in the Soxhlet removal, the extreme oil yield could be found at an extraction time of 6 hours. The removal rate is fast at the beginning of the removal but gets slow gradually. The reason is that when the sugar filter mud powder is uncovered to the fresh solvent, the free oil on the surface the of sample is solubilized and oil is removed rapidly inducing a fast rise in the removal rate. As time passes by, the concentration of oil increases in the solvent resulting in a decrease in the diffusion rate.

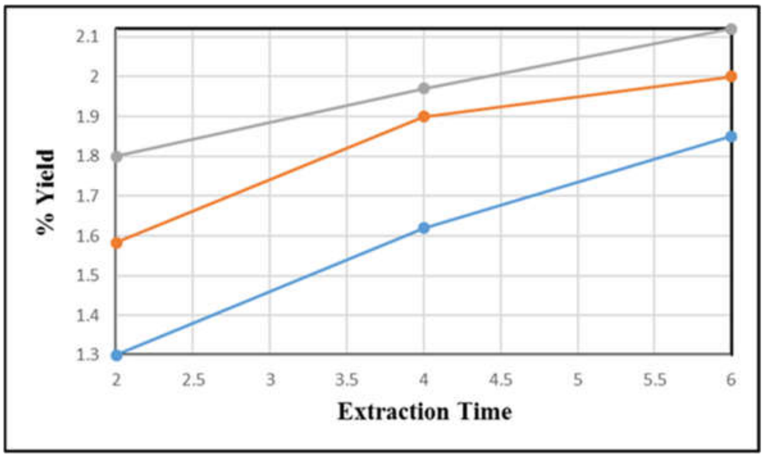

Figure 3. Average influence of time on sugar caned Filter mud oil yield at particle size 1.82mm-2mm, 1-1.4mm, and 1.4-1.8mm for gm.

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3.3. Influence of temperature on oil percentage

The capacity of oil can be affected by temperature, as temperature rises from 45℃ *to* 65℃% of oil, yield is increased. Since increasing the heat, both the diffusion coefficient and the solubility of the oil into both solvents are enhanced, thus heat treatment improves the removal of sugar filter cake mud oil. The higher the removal temperatures the easier to break the molecule inside the caked mud; thus, the percentage of oil also gets high.

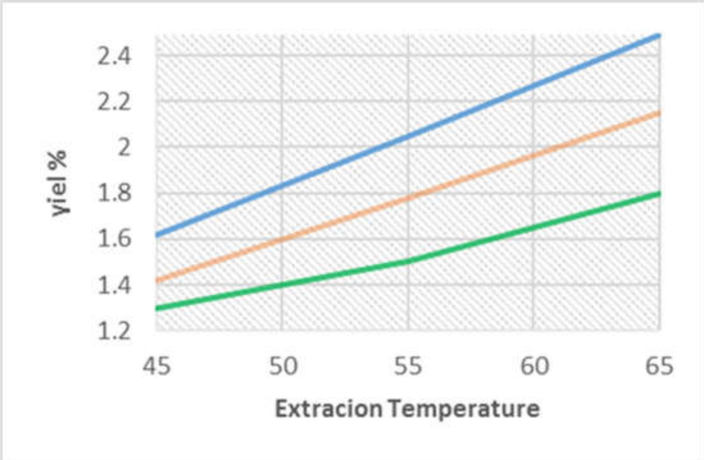

Figure 4. The effect of temperature on % yield at particle size (a) 1.8-2mm, (b) 1.4-1.8mm and (c) 1-1.4mm using n-Hexane as a solvent.

3.4. Prepared Bio Grease

Six sets of Bio Grease prepared were carried out with measurements from the extracted fixed filter mud oil and different proportion of sodium hydroxide (thickener) and small additives (Molybdenum disulphide). 50gm of filter mud oil with a fixed was heated at 90 °C. Sodium hydroxides were added according to the different ratios. The mixture was stirred and heated up to a temperature of 130°C- 160 °C for 15 minutes and then cooled to 90°C. Molybdenum disulphide additives added up to weight of 0.25-0.5gm. The stirring and heating were continued at temperature of 90°C for next 30 minutes, cooled at room temperature of 25°C, and stored for future analysis. The basis for the preparation was on two parameters, which were percentage weight and temperature.

Table 5. Prepared Bio Grease .

Grease formulation	Sample					
	1	2	33	4	5	6
Mass of base oil (g	50	50	50	50	50	50
Mass of thickener (g)	.5	1	1.1	1.2	1.35	2.5
Mass of additive (g)	0.25	0.25	0.25	0.25	0.25	0.25
Mixing temperature	90	90	90	90	90	90
Max.Rxn. temperature	130-160	130-160	130-160	130-160	130-160	130-160
Temp. for additive	90	90	90	90	90	90
Cooling period(min)	60	60	60	60	60	60
Cooling temp.	25	25	25	25	25	25
Percentage ratio	50:0.5:0.25	50:1:0.25	50:1.1:0.25	50:1.2 :0.25	50:1.35:0.25	50:2.5:0.25

3.5. Physicochemical properties of prepared Bio-Grease

During the grease production/preparation it has been observed that at the mixture of base oil from SC filter mud, thickener (sodium hydroxide) and additive (Molybdenum disulfide) and continuous stirring, the product changed as the reaction progresses from melt to syrup to the formation of plastic like particles which later changed to hard lumpy

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larger particles and finally into particles having fine beach sand-like consistency because of pounding.

3.5.1. Appearance

The physical appearance of the grease shown below has a black gold colour, with a smooth and homogeneous texture.

Table 6. below shows a bio grease product prepared with a black gold colour, as seen under the camera and its texture is soft and sticky.

Samples	Description	Appearance
1	Fluid	Black gold liquid
2	Semi fluid	Black gold semi fluid
3	Semi fluid(soft)	Black gold very soft
4	Semi hard	Black gold Hard
5	Semisolid	Black semi solid
6	Solid	Black color very hard

Figure 6. Bio Grease prepared physical appearance.

The ratio of base oil to sodium hydroxide (thickener) matters a lot because the higher the quantities of the thickener, the more difficult will be the formation of grease. The additives (Molybdenum disulfide) used functioned in many ways such as enhancing the existing desirable properties (heat resistance), suppressing the existing undesirable properties (evaporation loss), and imparting new properties (high load resistance), high oxidation and wear resistance.

3.5.2. Temperature

The comparison between sugar cane filter cake and an industrial lithium grease showed that in relation with the temperature increase between ring and block tribometer show that the sugar cane filter cake grease have better behavior than industrial one, in the first case, the temperature will stabilize around 48, while for the second case the temperature stabilized at 70 for the industrial grease base lithium. In both case the starting to stabilize the temperature occur after 25 minutes approximately, this result demonstrated that the sugar cane filter cake grease with additive MoS2 has more contribution to energy conservation and lubrication protection to wear of surface in contact.

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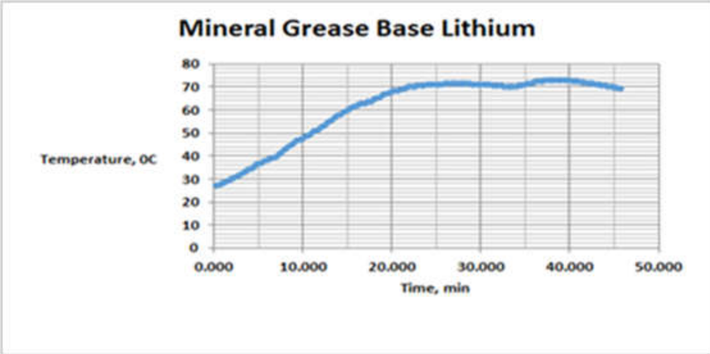

Figure 7. I_ Grease_ Li _ MoS2 Temperature vs time for Load= 123N .

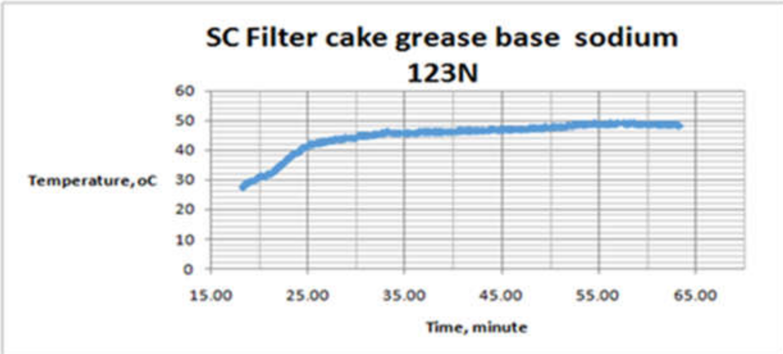

Figure 8. SC_ Filter Cake Grease_ Na_ MoS2 Temperature vs time for Load=123N.

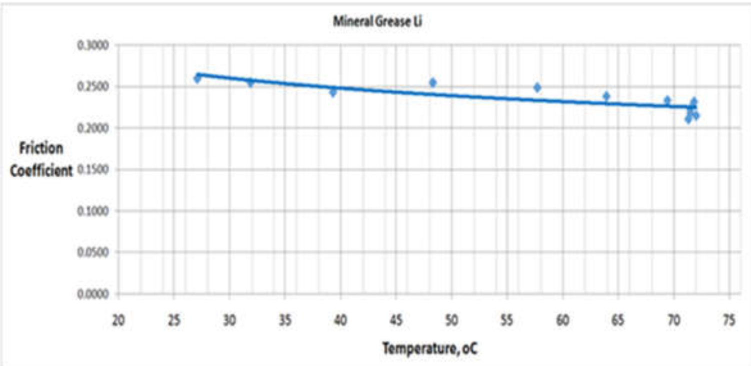

Figure 9. Mineral _ Grease_ Li _ MoS2 Friction coefficient vs temperature for Load = 123N.

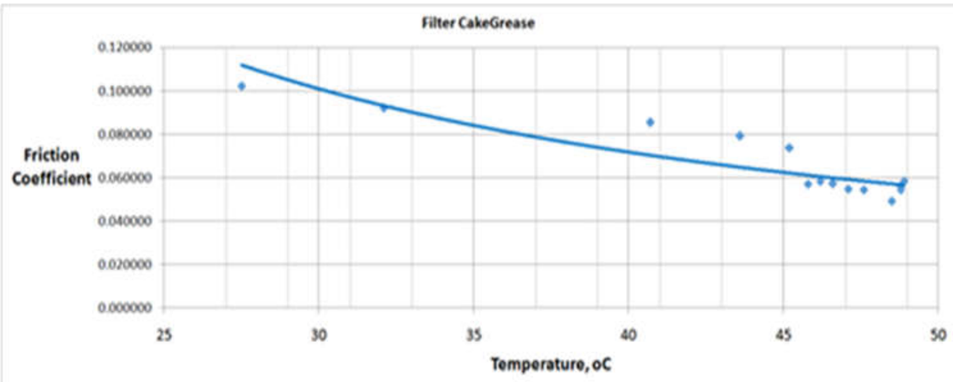

Figure 10. SC_ Filter Cake Grease_ Na_ MoS2 Friction coefficient vs temperature for Load=123N.

At the same time, the friction coefficient shown in figures 4:11 and 4:12, the friction coefficient decreases in both cases with the temperature, as in the temperature variation with the time after around 65℃ for the mineral grease and around 48℃ for sugar cane filter cake grease is observed certainly tendency to keeping constant, it can see that there is certainly concentration of values for both case. Sugar cane filter cake grease showed has less friction coefficient than that mineral one. These have correspondence with temperature behaviour with the time, the more heat generated in the friction system with mineral grease where temperature stabilized around 70℃ the friction was higher than in the system with sugar cane filter cake grease where temperature was stabilized at 48℃ after 48 minutes approximately; that confirm the sugar cane filter cake grease show better lubricant properties that mineral grease.

3.5.3. Energy

The result referred to the friction in relation with energy consumption in the tribometer (P, kW) shown that there are less friction coefficient and consumption of energy when is used the Sugar Cane Filter Cake Grease with sodium soap and additive of molybdenum disulphide (SC Filter Cake Grease_ Na_ MoS2) than the Industrial Grease base Lithium soap with additive of molybdenum disulphide (I_ Grease_ Li _ MoS2) for both testing load at 123N.

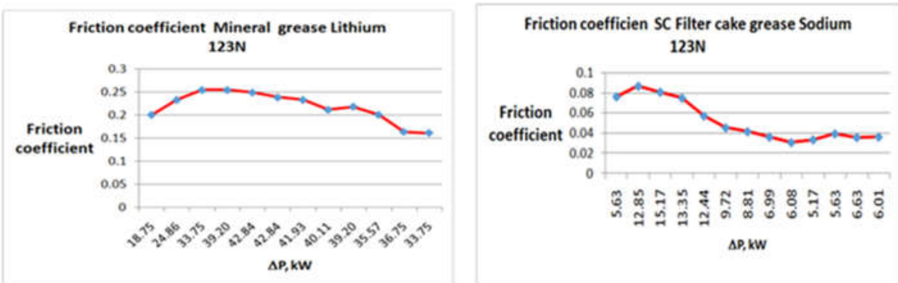

Figure 10. Friction coefficient vs energy consumption for Load=123N.

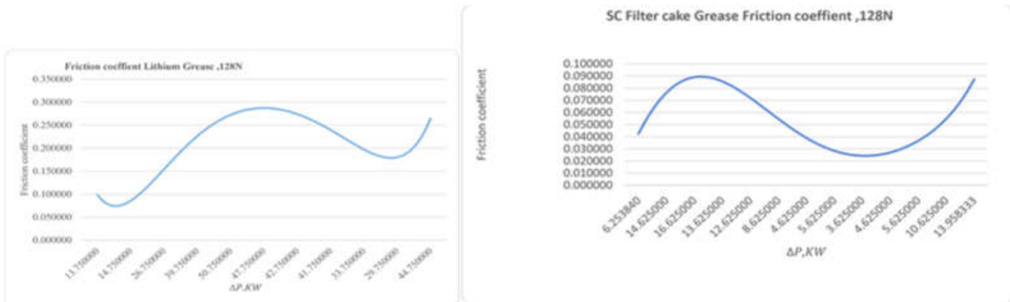

Figure 11. Friction coefficient vs energy consumption for Load=218N.

For both case as showed in the figure above the friction coefficient are smaller for the SC Filter Cake Grease_ Na_ MoS2 has demonstrated that this has better tribology behavior than the industrial one testing in this research, can be use as grease lubricant according to this result.

3.5.4. Wear

Wear is the reformist loss of material that results from two materials sliding against each other at the contact area under load. It occurs certainly in a wide variety of industries where machines and engines are in operation, including automotive, aerospace, oil & gas and many others. The wear mark on the block using the grease SC_ Filter cake grease Na -MoS2 has an average diameter of 0.58 mm, like the average diameter for mineral grease (I- Grease-Li -MoS2) with a magnitude equal to 0.60 mm.

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3.5.5. Friction Coefficient

Behavior of the friction coefficient obtained from block- ring tribometer for both greases is shown that, the value of friction coefficient for the mineral grease (I_ Grease_ Li _ MoS2) are between 0.22 and 0.29 for the first time of the test, and for the SC Filter Cake Grease_ Na_ MoS2 are between 0.03 and 0.098; after twenty minutes approximately for both grease the friction coefficient decrease. The friction coefficient for both cases decreases progressively with respect to the time, obtaining some stability around the twenty-five minutes. At the end of test after forty minutes, the grease (SC Filter Cake Grease_ Na_ MoS2) has a coefficient of friction equal to f = 0.05, the coefficient of friction obtained with the mineral grease (I_ Grease_ Li _ MoS2) was equal to f = 0.22, there being significant difference between the two quantities since grease properties mostly depend on the amount of thickener used, oil viscosity and additive substance which influence tribological properties of Bio-grease prepared when compared to that of commercial mineral industrial grease. As a general for both grease the applied force (normal force) is the same, friction force got for SC filter mud oil grease is less than that of I – Li- based grease ,since coefficient of friction force is directly proportional to friction force and inversely proportional to that of functional(normal) force.

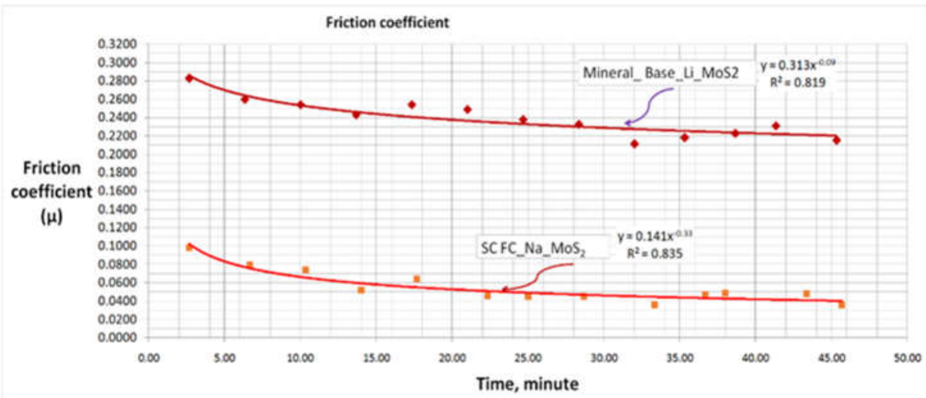

Figure 13. Behaviour of friction coefficient vs time .

4. Conclusions

4.1. Introduction

Under these chapters different discussions were made in relation to the results in arriving at both extractions of oil and preparation of Bio-Grease from SC, filter mud oil.

4.2. Conclusion on extracted oil

There are different methods used for extraction of oil from SC filter mud and other vegetable plants, among them Soxhlet extraction is the best method for extraction oil. The soxhlet extraction method is used for SC filter mud sample which is maximum per cent oil yield is obtained, n-hexane solvent is used because hexane has high extraction ability when compared to another solvent in addition to a less toxic substance. The maximum oil yield obtained is 2.5% for 60g, 1.63% for 40g and 2.15% for 50g at temperature of 65, 6 hours and particle size between 11.4mm. To get maximum quantity of the product suitable particle size, temperature and optimum time for extraction is important.

The results of physio chemical characteristics obtained from SC filter mud is suitable for preparation of Bio-Grease, however the yield oil of SC filter cake mud (around 4-4.5%from 100g) is so much less when compared to other vegetable plants. The moisture content of the sample is around 75%, which is in acceptable standard level. The percentage oil yield is affected by the extraction temperature, time, sample size and solvent type used. The physicochemical properties such as specific gravity, kinematic viscosity, density, saponification value, iodine value and acid value are nearly similar to the other vegetable oil, but the acid value of the SC filter mud is very high that is around 2.3 value because the sample has nearly waste product which not fresh vegetable sample, therefore when filter mud used directly for compost it decreases the soil quality.

4.3. conclusion for Bio-Grease

The research work that the aim of producing a biodegradable grease and some characteristics was met and it can be concluded that the SF mud (black gold oil) used is a good renewable source for biodegradable grease production. Testing were carried out to determine the quality of the biodegradable grease produced.

Lubricating Bio- grease was formulated using the vegetable oil extracted from the sugar cane filter mud; as saponification reaction with sodium and small additive (Molybdenum disulphide).The amount of base oil from SC filter mud, thickener (NaOH) and additive (Molybdenum disulphide) to produce normal Bio- Grease for this research is obtained at ration of (base oil: Na: MoS2) 50:1.2:0.25.The grease produced at this ration has black gold color and appearance of smooth and homogeneous texture, dropping point of 150 , applied load of 123N, Block on Ring Wear, of 0.58mm, alkali content of 2.25,shear stability of 14.4%.

At the preliminary study of friction coefficient carried out in this research, show tendency to increment in the first time with the temperature, and in certain interval of the temperature decrease slightly with the increase of the temperature; also as it is possible to be observed from a certain value of temperature the friction coefficient tends to stabilize, for the mineral grease around 70°C and for the sugar cane filter cake grease around 48°C. This decrease must be influenced by the contents in both cases of high pressure additive (MoS2). It was also observed that sugar cane grease shows lower friction coefficients for the same test conditions than mineral grease.

The inclusion of molybdenum disulphide (MoS2) as a solid lubricant and extreme pressure in the lubricating grease of sugar cane filter cake, leads to the obtaining of properties, similar and greater than to mineral grease which possesses molybdenum disulfide as an extreme pressure additive.

In the established tribological experimental conditions, a limiting lubrication regime is obtained, in which the combination of the fatty acids present in Sugar cane filter cake vegetable oil and the presence of MoS2, avoid metal-metal contact and increase the load distribution along the contact area, thereby reducing the friction and hence the shear stress between the opposing surfaces.

SC Filter Cake Grease_ Na_ MoS2 grease has physicochemical and tribological properties suitable for use in the lubrication of mechanical elements subjected to high contact loads.

The comparison between sugar cane filter cake and an industrial lithium grease showed that in relation with the temperature increase between ring and block tribometer show that the sugar cane filter cake grease has better behavior than industrial grease.

At the same time the behavior of friction in function of time of both grease at identical load, the friction coefficient vs time, for SC Filter Cake Grease_ Na_ MoS2, the friction coefficient showed has less values than the mineral one (I_ Grease_ Li _ MoS2).

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