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Review on bio based (Vegetable Oil) Lubricants as an alternatives of mineral oils for gearing applications

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Abstract -*The unfavorable effects of mineral based oil on the environment, there is a steady increase in the demand of bio based vegetable oil, eco-friendly lubricants. However, development of a biodegradable base lubricant that could replace a substitute of conventional mineral oil is a big challenge. Vegetable oils are recognized as rapidly biodegradable and for this reason they are categorized as promising candidates for base fluids in environment-friendly (no soil and water pollution) lubricants. Vegetable oil based lubricants have excellent lubrication properties, lesser oxidative stability and poor-temperature stability. Bio based lubricants has low thermal stability, poor viscosities at higher temperature, lower oxidation stability and short range of viscosities, limit their potential application as an industrial lubricants. This review paper represents the prospects of vegetable oil lubricants used in automobile applications for power transmission. Automobiles are used in various applications in industries and loading purposes, etc. so the oil used in this is basically mineral based oils if it leakage then mixing with soil and from it rain water goes to the rivers mixes with drinking water creates sever diseases. That's why commercial oil is necessarily to replace by bio based lubricants.*

***Key words*: vegetable oil lubricants, gear box, edible and nonedible oils**

1. INTRODUCTION

Lubricants acts as safeguards for any tribological system for various utilities and applications. In general lubricants are the multifaceted agents required for smoother operations for rubbing components. Depending upon the properties required, availability, technology, compatibility; they have oscillated from the nature based to conventional mineral based through the ages. Worldwide population growth has forced the excessive extraction of limited crude reserves in variety of industrial applications. Conventional lubricants made from the mineral oils (crude petroleum) and additives package are potentially toxic in water and soil due to their heavier composition of pollutants and lower biodegradation capability. Oil prices hikes day by day, improper disposal techniques of waste used oils, and absence of lubrication norms worldwide threatening environment has unconditionally drew its attention towards the natural counter parts. Vegetable oils be the better alternatives to the conventional counterparts of mineral based oils. Bio based oils are chemically triglycerides having long chains of unsaturated free fatty acids attached at hydroxy groups via ester linkage. Variations in physical and chemical properties and the behavior depends on these basic block. They are preferred over toxic counterparts mainly due to their comparable technical properties like higher oiliness, viscosities and indices, higher flash points, less evaporative losses and lower accounting cost including the operation cost and nature replenishment cost. Although they do have certain inferior problems like reduced oxidation and thermal stabilities, poor cold flow properties, lower shelf life; but by regular improvement in techniques and systematic research work they can be improved. Oils can be edible or nonedible. Lot of varieties are present worldwide, but only few of them have been used depending upon their potential. Researchers have done much more work worldwide on the edible oils. Harnessing edible oils for nonfood applications (fuel/lubricant) disturbs household balance. India is the largest edible oil importer in the world and consistent increasing bills for ever increasing population affects our economy. So the alternatives in the form of nonedible oil varieties do not pose any such threat and in fact improve to the rural economy.

1.1 Lubrication

It is the process employed to reduce friction between the two mating surfaces, and wear between them, by interposing a substance called a lubricant (lubrication film) between them. The lubricant film can be a solid called dry lubrication (e.g. Molybdenum disulfide MoS_2), a solid/liquid dispersion, or a liquid such as oil or water called fluid film lubrication, a liquid-liquid dispersion (e.g. grease) or a gas. Lubrication allows smooth running of parts without interruptions and noiseless operations, reduces the wear rate by reducing friction between the matting parts, and prevents from excessive stresses or seizures of bearings due to excessive heat generation. When lubrication film breaks down, components of mating parts rubs each other, causing excessive heat generation due to excessive friction, local welding takes place, destructive damage and failure occurs. Vegetable oils or bio lubricants produced by plants by pressing them into the crusher and applying squeezing pressure by crushers. Vegetable oils can be classified in various ways depending upon the source, applications etc. Oils can be edible or nonedible in nature. Globally innumerable amount of such varieties are present.

Edible vegetable oils: A liquid fat that is capable of being eaten as a food or food access, like Coconut, Olive, Soya-bean, Sunflower, Palm, Peanut, Rapeseed, and Corn etc. Various countries import edible for their food requirements. India is the biggest importer of edible oils in the world. Approximately, 16.6 million tons of edible oils consumed

each year in India. Therefore, edible oil seeds usage for lubricant needs may not be able to meet domestic requirements for ever increasing population.

Non edible vegetable oils*:* As an alternative of commercial oil nonedible vegetable oil and tree borne seeds are very effective for lubrication purpose. These products from nonedible vegetable oils like Neem, castor, Mahua, rice bran, Karanja, Jatropha, and linseed oils which offer better or at least same performance as petroleum oil based products besides being less expensive. Non edible vegetable oils are technically and environmentally provides good results in mechanical lubrication and easily available resource for bio based lubricants. Being a tropical country, India is rich in forest resources having a wide range of trees, which yield a significant quantity of oilseeds. India is importing crude petroleum & petroleum products from Gulf countries. Indian scientists searched for an alternate to petroleum based lubricant to preserve global environment and to withstand economic crisis.

1.2 Regimes of Lubrication

In fluid film lubrication, the load is fully separated by formation of lubrication film within the gap between the parts which is in relative motion against each other and solid to solid contact is avoided by creating a lubrication film between them. Hydrostatic lubrication is when an external pressure pump is used to generate the lubrication film in the bearing by suppling lubricant oil continuously. And where the motion of the matting parts surfaces, and the right design of bearing is used for lubrication around the bearing is Hydrodynamic lubrication. Boundary lubrication is the regime of lubrication in which the load is carried by the surface asperities (roughness) rather than by the lubricant film, and in mixed lubrication regime the fluid film and boundary lubrication regimes both exist. In mixed lubrication regimes the generated lubricant film is not enough to separate the matting parts completely, but hydrodynamic effects are considerable. Lubricant also used to cool the workpieces and also prevent from wearing and tearing. Lubrication is required for smoother operation of mechanical machines like pistons, pump, cams, bearings, turbines, cutting tools etc. where without lubrication the components each other and generates heat and caused seizer of the same.

2. Research Approaches on Vegetable Oil with Base Oil

Amit Suhane et. al, 2016 [1] Bio Lubricants are having polar attraction to metal, Mineral based have no polarity and therefore no affinity to metal, thus elimination to metal to metal contact .Vegetable oils and mainly the Non edible oils have a huge potential in formulation of lubricants boosting the agriculture practices and strengthening the rural economy. Vegetable oils are perceived to be alternatives to mineral oil for lubricant formulations because of certain inherent technical properties and their ability towards biodegradability**.**

Amit Kumar Jain et. al ,2012 [2] Various non edible vegetable oils can be utilized for making bio lubricant apart from regular applications like medicine, soap etc., as edible oil is in heavy demand for cooking purpose. The main advantage of bio lubricant production from nonedible vegetable oils lies in the fact that it has potential to replace the conventional forms of lubricants. It is also a high source of oil which can be converted into bio lubricant and provide a major source of renewable lubricants both locally and internationally. Non edible vegetable oils are promising source of bio lubricants owing to the similar tribological properties which are comparable to petroleum based lubricants. Much more has to be done to improve the oxidative stability, cold flow properties and irregular ignition characteristics of nonedible vegetable oils

S. Syahrullail et. Al,[3] studied the performance of vegetable oils as a lubricant tested by using a four ball tribo tester machines under extreme pressure conditions, which having standards of ASTM D2783. The testing lubricants are commercial stamping oil, commercial hydraulic oil, jatropha oil, RBD palm olein and palm fatty acid distillate. The normal load used for test is126 kg. Result from this shows that vegetable oils have a high coefficient of friction when operating in extreme pressure conditions at a normal load of 126 kg. Palm fatty acid distillate (PFAD) showed the highest coefficient of friction. This is because it is semi-solid at room temperature. In a semi-solid state, PFAD cannot flow very well. Lubricant film for PFAD breaks down easily under high normal load. Jatropha and RBD palm olein remain in a liquid condition at room temperature, and they were able to maintain the lubricant film. For the mineral oil representatives (commercial stamping oil) the coefficient of friction was low. This is due to the anti-wear additive that is included in the mixture. Commercial stamping oil (STP) has the lowest wear scar diameter the ball bearing lubricated with jatropha oil showed the smallest wear scar diameter, followed by palm olein, and palm fatty acid distillate In this experiment, PFAD oil can be considered a failure because it caused ball bearing wear of about 5.25 mm diameter commercial stamping oil performs very well and produces a wear scar diameter of 0.62mm.

A. Imran, et. Al, [4] studied the effect of Jatropha oil blended with lube oil on friction and wear characteristics has been investigated. Experiment carried out by Cygnus Wear Testing Machine under the load of 30N, and high rotational speed of 2000 rpm and 1 hour of running. Lubricant SAE 40 oil has been used as a base lubricant in this test. The test has been conducted on aluminium pins and cast iron disc lubricated with Jatropha oil blended bio-lubricant (JBL). To prepare the bio-lubricant, five blends are prepared from 0 to 50% by volume of Jatropha oil mixed with lubricant SAE 40. In order to understand the characteristics of lubricant,

viscometer and multi oil analyzer tests have been conducted. Result shows that linear pin wear under 2000 rpm and 30 N loads for each pin vary from 0.02 to 0.05 mm. It was observed that the higher or maximum wear occurred in the beginning of the experiment for some of the test specimen. Maximum wear occurred for JBL40 while JBL10gives minimum. Observations shows that except JBL40, for each JBL, pin wear decreases gradually and constant wear rate obtained. It can be seen that JBL30, JBL 40 and JBL50 have high value of wear while pure lubricant SAE 40, JBL10 and JBL20 have low value of pin wear and their value are nearly with each other. The JBL10 and JBL30 shows the same C.O.F which is almost 0.15 and JBL50 shows almost same C.O.F throughout the whole operation time which is 0.235. The value of friction coefficient (μ) for boundary lubricant is in the range of 0.001 to 0.2 except for JBL50. . The range of temperature is about 20ЊC to 100ЊC. it can be noticed that the 30% and 40% of Jatropha oil based bio-lubricant are produce more heat than other while the 10% of Jatropha oil based bio-lubricant is generated lower heat. At 40ЊC operation temperature 10%, 20% and 30% of Jatropha oil based bio-lubricants meet ISO VG100 requirement but 40% and 50% of Jatropha oil based bio-lubricants do not meet the requirements.

S.Syahrullail, et. al, [5] studied in this paper, palm fatty acid distillate (PFAD) was mixed in mineral oil and it properties were tested. The mixing percentage (PFAD to mineral oil) varies from 5% to 25% of the total mass. Testing was conducted using a four-ball tester with the American Society for Testing and Materials (ASTM) standard 4172. The results show that by mixing a 20 % total mass of palm oil in the mineral oil, the coefficient of friction reached its lowest value. Five mixing test lubricant which had PFAD mass percentages of 5%, 10%, 15%, 20% and 25% were prepared. At the same time, pure PFAD and commercial metal forming oil were tested to compare the performances. The lowest value of the coefficient of friction was for the test lubricant S5 (CMFO 80% + PFAD 20%), which was 0.054. The coefficient of friction of pure PFAD is lower when compared to pure CMFO (which represents mineral oil, the coefficient of friction has been decreased from 0.08 to 0.054 (20% PFAD).

Amit Suhane, et. al [6] studied wear performance of castor oil based lubricant tested for lower speed applications. The experiment were carried out by Taguchi's L16 orthogonal array considering the effects of various operating factors load, speed and mixing ratio. Using Taguchi optimization method, optimum combination of these three factors have been reported. Wear performance of castor oil based lubricant in varying blending ratio viz; tribological properties like coefficient of friction and wear scar have been analyzed in four ball testing machine through. Test oils are karanja and caster oils and steel balls of 12.7 mm of diameter is used in four ball tester machine using ASTM D 2783/ D 4172. There are four blend are prepared by mixing ratios of 10 to 25 percent of refined karanja oil and castor oil used as base oil. The time for test is approximately 1 hour and 40^c temperature. In present investigation, wear performance of castor oil based lubricant has been examined for low speed applications. It is clearly visible that from the SN ratios and ANOVA minimum coefficient of friction can be obtained from combination of load-200N, speed-600 rpm and 20 % blend ratio and minimum wear scar diameter can be obtained from combination of load-300N, speed-500 rpm and 20 % blend ratio.

H.M. Mubarak et. al, [7], studied the source, properties, as well as advantages and disadvantages of the bio based lubricant. The second part describes the potential of vegetable oil-based bio lubricants as alternative lubricants for automobile applications. The last part describes the world bio lubricant market and its future prospects. Bio lubricants are potential alternative lubricants because of their low toxicity, good lubricating properties, high viscosity index, high ignition temperature, increased equipment service life, high load-carrying abilities, good anti-wear characteristic, excellent coefficient of friction, natural multigrid properties, low evaporation rates, and low emissions into the atmosphere Bio degradability of some oil fuels are mineral oil 20-40%, Vegetable oils 90–98%, Esters 75–100%, Polyols 70–100%, Trimelliates 0–70%.The world has approximately 1700 small and large lubricant manufacturers. An estimated 300 of these manufacturers are Engine Oils 48%, Process Oils 15%, Hydraulic Oils 10%, and Others Oils 28%, in the world market segmentation by application area. Asia/Pacific 37%, North America 28% ,Western Europe 13%, Rest of World 23% in the World market, the segmentation by geographical area.

Amit Suhane, et. al, [8] studied in this paper about availability if bio based oils in Indian perspective**.** Lubricant makes the machinery and units work smoothly and efficiently. Conventional mineral oil based lubricants has been in use for long due to its superior lubricating properties but at the same time it's excessive usage and improper disposal practices pose threat to the climate and therefore raise serious concern over risk and health hazards. Statistics shows that lubricating oils which accounts for 90% of lubricant consumption consists of base oils and remaining chemical additives formulated in different prepositions. Today, India accounts for 5.3% of global demand. The Indian automobile Industry sixth in the world, manufactures over 11 million vehicles and exports about 15% each year. Statically, motorcycle (two wheelers) oil is the largest product category in the consumer automotive lubricants segment, accounting for about 60% of the consumer automotive lubricants consumed. Overall, consumer automotive lubricants account for 13% of the total market , India's $ 2.8 billion lubricant market stands third in the world with the annual consumption of 1.86MMT (million metric tonnes), of which automotive use is around 60 %. In India it is expected to consume more than 100 million tons

per annum of mineral oil products before the dawn of the 21st century and this suggests consumptions of around 2.0 million tons per annum of lubricants.

Vegetable crops and derived oils can prove to be strong contender in reducing the risk associated with the usage of toxic mineral oil based lubricants, they being renewable and biodegradable. India due to its rich vegetation possess immense potential to explore and harness the vegetable oil crops for lubrication purpose. The need for such alternative becomes more prominent in Indian perspective owing to absence of legal policy for the usage of such toxic lubricants and guidelines for the restrictions of malpractices, which is otherwise implemented in large number of environment friendly countries. The need of hour is to explore the full potential of Indian breeds of different vegetable crops as per application, usage and availability.

Amit Suhane, et al, [9] this paper represents the suitability of various vegetable oils for as an alternative lubricants in automotive gearing applications.

Following conclusions can be drawn from the above:

1. Alternative forms has to be explored at local and global level to cater the increasing demands of lubricants in industry and compliment the depleting mineral oils.

2. Using varieties of nonedible oil for lubricating purpose does not add up to the import bills of country.

3. Vegetable oil based lubricants cannot be used in every applications on account of insufficient amount of production and exploration. Moreover, they should be used at places where the properties and performances are best matched.

4. Chemical structure of oils and fatty acids have profound effect on the physical properties and tribological performances.

5. Nonedible oil varieties like castor, mahua, karanja etc. has potential in pure and blended form for lubricating purpose of automotive gears due to their good lubrication properties.

6. Mineral based lubricants perform better in terms of overall performance and compatibility with machinery components on account of strong base stocks and special additive package.

7. Overall performance of vegetable oil based lubricants can be sufficiently increased to commercial levels by application of proper modification and blending technique for desired application.

8. Full accounting costs plays an important role in deciding the feasibility of natural oils for specific applications.

9. Excessive usage of conventional oil lubricants leads to faster depletion of their sources so that need of their alternatives can be fulfil by nonedible bio based lubricants.

10. Extensive exploration of alternatives and promoting their bulk production with implementation of legal policies may determine promising future for them.

Amit Suhane, et al, [10] studied in this paper represents the tribological investigation of mahua based oil lubricants for mechanical tribological properties. Mahua oil is blended with conventional gear oil (90T) in different ratios. Tribo pair used is plain carbon steel cylindrical pin and mild steel disc. 90T Oil is blended with mahua oil in prepositions varying from 5%-25% by volume. Total five blends have been prepared. The plain carbon steel pin used is cylindrical in shape and is tested against the circular mild steel disc. Pin dimension used is 30mm x 6 mm, whereas disc dimension is 160mm x 8mm.Pin and disc material has carbon % (0.20-0.35) and (0.40-0.55%) respectively. POD machines is used for measuring wear characteristics at varying speeds of 60 to 600 RPM. The test load is 10 N and the disc is rotated at 100 RPM for duration of 30 Minutes further tests are carried out at higher load and speeds. Five blends are prepared in the ratio varies from 5 to 25.,the result shows that specific wear for given loadings and speed for all the oil samples more or less are increasing and reportedly in the range of 0.000064 mm3/Nm to 0.001792 mm3/Nm. Coefficient of friction values reported during experimentation in the range of 0.014 to 0.03 clearly suggests the regime at contact zone to be boundary lubrication. Worn out surface of pins suggests pronounced abrasive and adhesive wear pattern under prevailed boundary film lubricated conditions. The observations from the experimentations suggests that addition of 5-10% mahua oil in the 90T oil has good wear reducing traits for maintenance purpose at different operating conditions.

3. CONCLUSIONS

Following conclusion can be drawn:

1) The main purpose is to reduce the environmental hazards due to mixing of mineral based oil into the soil, here we can observe that various bio based vegetables oils are available to fulfilling all the requirements of lubricants used in heavy gearing applications.

2) The caster oil is to be seen as same as mineral oils for all mechanical properties which used to fulfil the requirement of lubrication.

3) Mahua oil seems very good at low load and speeds but at higher speed its viscosity decreases gradually.

4) The purpose of all the articles are to replace the commercial oil lubricant to the bio based lubricants, so that lesser influence to the environment.

5) The bio based lubricants are fulfilling all the mechanical asperities at low load and speed conditions, but at higher speeds as the temperature increases due to higher frictions, the viscosity decreases and lubrication properties degrades at higher speeds.

6) India is an agriculture based economy so the plants and seeds and crops that will used for production of bio lubricants are available at economically cheap and easy.

7) Lot of alternatives of commercial mineral oils are available in the nonedible forms of bio lubricants like karanja oil, caster oil, mahua oil, jatropha oil, linseed oil, and many more.

REFERENCES

1. Kavindra Singh, Amit Suhane Effect of additive addition in base oil of a lubricant – A Review (2016)

2. Amit Kumar Jain, Amit Suhane Capability of Biolubricants as Alternative Lubricant in Industrial and Maintenance Applications (March 2013)

3. S. Syahrullail , S. Kamitani , A.Shakirin ,Performance of Vegetable Oil as Lubricant in Extreme Pressure Condition (2013) 172 – 177.

4. A.Imran, H.H. Masjuki, M.A. Kalam, M. Varman, M. Hasmelidin, K.A.H. Al Mahmud, S.A. Shahir, M. Habibullah, Study of Friction and Wear Characteristic of Jatropha Oil Blended Lube Oil (2013) 178-185.

5. S. Syahrullail, M.A.M. Hariz, M.K. Abdul Hamid, A.R. Abu Bakar, Friction Characteristic of Mineral Oil Containing Palm Fatty Acid Distillate Using Four Ball Tribo-tester, 2013, Pages 166-171.

6. Amit suhane, R.M. Sarviya, A. Rehman, H.K. Khaira, Experimental study of caster oil based lubricant for automotive applications,(2014),104-107.

7. H.M. Mobarak n , E. Niza Mohamad, H.H. Masjuki, M.A. Kalam, K.A.H. Al Mahmud, M. Habibullah, A.M. Ashraful The prospects of bio lubricants as alternatives in automotive applications(2014) 34–43.

8. Amit Suhane, R .M .Sarviya, A.Rehman, H.K.Khaira,Prospects of Vegetable Oils for Lubricant Formulations in Indian Perspectives(2014).

9. Amit Suhane, R. M. Sarviya, A. Rehman, H. K. Khaira, Suitability of Alternative Lubricants for Automotive Gear Applications,(2014) 64-67.

10. Amit Suhane, A. Rehman, H.K. Khaira, Tribological investigation of mahua oil based lubricants for maintenance applications (2013) 2367-2371

11. Amit Suhane, A.Rehman, H.K.Khaira, Potential of Non Edible Vegetable Oils as an Alternative Lubricants in Automotive Applications, (2012) 1320-1335.

12. Kraipat Cheenkachorn, Study of Wear Properties of Different Soybean Oils, (2013) 633 – 639

13. Alejandrina Campanella , Eduardo Rustoy , Alicia Baldessari , Miguel A. Baltanás, Lubricants from chemically modified vegetable oils(2010) 245-254.

14. Ebtisam K. Heikal, M.S. Elmelawy, Salah A. Khalil, N.M. Elbasuny, Manufacturing of environment friendly Bio lubricant from vegetable oil(2017), 53-59.

15. N.J. Fox, G.W. Stachowiak, Vegetable oil-based lubricants—A review of oxidation (2007), 1035-1046.