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Vegetable oil as an alternating lubricant: A review

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Abstract
From past different vegetable oils have been used in food but now a day decreasing resources of mineral oil, the increasing environmental awareness and the growing prices of crude oil have created the interest in new environmental lubricant and additive candidates. In order to minimize friction and wear in machine elements lubricating oil plays an important role. Vegetable oils are renewable lubricants having properties like non-toxicity, viscosity-temperature characteristics, biodegradability, excellent lubricity and low volatility. Hence vegetable oils can be deserving candidates as base fluid for eco-friendly lubricants. Also Indian has a great potential of producing vegetable oil based lubricants. Most of the researchers showed that vegetable oils can be used as lubricant either by chemical modification or by blending additive for a particular application. So the present paper study shows potential of cotton seed oil as an alternating lubricant.

Keywords: vegetable oils, lubricant, renewable, biodegradable, cottonseed oil

1. Introduction
Lubricant performs various functions in mating parts of engines and machines, such as protection of metal surfaces against corrosion, shocks absorbs ion, acts as a heat transfer agent and flushing out contaminants. Hence it is required for effective and efficient working of an automobile at operating conditions. Since long time, mineral oils have been used as a lubricant in engines. But, Mineral oil is a product of crude oil, so that availability of mineral oil depends upon crude oil. Every year near about 5 to 10 million tons of petroleum products dispose in the environment leads to problems regarding environmental pollution and human health. Today depletion of reserves of crude oil, the growing prices of crude oil and concern about protecting the environment against pollution have stimulated the search for environment-friendly lubricants as an alternative for mineral oils in engines. As compared to mineral and synthetic oils, vegetable oil based lubricants have properties of low toxicity, low emission into the environment high viscosity index, high lubricity, high load carrying capacity, good anti-wear capability excellent coefficient of friction and high flash point. Also, Vegetable oils are being used as lubricants for industrial as well as transportation applications. India has a great potential of producing edible and non edible vegetable oils, which can be used as potential source for vegetable oil based lubricants [3]. Many of the researchers have been used vegetable oil as a biodiesel, but only few researchers have pointed vegetable oil-based lubricants for automotive applications. Hence the paper work is touching possibility of vegetable oil as an alternating bio-based lubricant.

2. Classification of lubricants
Table 1 shows the classification of Lubricants based on various criteria.

Table 1: Classification of Lubricants

Sr. No	Category	Sub Category	Description
1	Physical appearance	Solid Lubricant	The film of a solid material is composed of inorganic or organic compounds. Eg. Graphite, molybdenum disulphide and cadmium disulphide.
		Semi solid Lubricant	Liquid is suspended in a solid matrix of thickener and additives Eg. grease
		Liquid Lubricant	Eg. Petroleum, vegetable, animal, and synthetic oils.
2	Base oil resource	Natural oils	Oils derived from animal fats and vegetable oils.
		Refined oils	Oils derived from crude or petroleum reserves Eg. Paraffinic, naphthenic, and aromatic oils.
		Synthetic oils	Oils synthesized as end products of reactions that are tailored per requirement. Eg. Synthetic esters, silicones, and polyalphaolefines.
3	Applications	Automotive oils	Used in the automobile and transportation industry. Eg. Engine oils, transmission fluids, gearbox oils, as well as brake and hydraulic fluids.
		Industrial oils	Oils used for industrial purposes Eg. Machine oils, compressor oils, metal-working fluid, and hydraulic oils.
		Special oils	Oils used for special purposes according to specific operations Eg. Process oils, white oils, and instrumental oils.

3. Properties of Lubricants

Tribology is the science of interacting surfaces in relative motion and brings together all major disciplines involving friction, wear and lubrication. Hence proper lubrication is required to counteract the effect of friction and wear. Lubrication is the process of reducing friction and wear between moving/sliding surfaces, by the introduction of lubricants in between them [2]. Any substance introduced between two moving/sliding surfaces in order to reduce the friction is known as lubricants. Lubricants are available in liquid, solid, and gaseous forms. The main properties of lubricants are taking into account as follows [1, 3].

3.1 Viscosity

Viscosity is the most important property of lubricant. The viscosity of lubricant is defined as a measure of its resistance to flow. It is an important factor for determining the application of particular Lubricant. Viscosity is directly related to temperature, pressure and film formation. For example, low viscosity oils can be used for automotive transmission oils, while higher viscosity oils are used in diesel engine oils.

3.2 Flash point

Flash point is defined as the minimum temperature at which a liquid produces a sufficient concentration of vapor above it to form an ignitable mixture with air. Flash point of the lubricant should be high enough for reducing the risks of fire and to allow safe operation.

3.3 Fire point

Fire point is the temperature at which the combustion of a lubricant continues. Fire point is an important factor for storage and transportation point of view.

3.4 Pour point

Pour point is the lowest temperature at which oil flows or pours. In general language pour point (PP) is defined as the lowest temperature at which movement of the specimen is observed. Good lubricant has lower pour point so that it provides excellent lubrication for cold starts.

3.5 Cloud point

Cloud point is the temperature at which solids dissolve in oil. To prevent clogging of filters, temperature must be maintained above the cloud point.

3.6 Viscosity Index

Viscosity Index indicates changes in viscosity with changes in temperature. A high viscosity index indicates small changes in temperature; while a low viscosity index indicates high changes in temperature.

3.7 Oxidative Stability

Oxidation is the most important reaction of oils resulting in increased acidity, corrosion and volatility when vegetable-based oils are used as engine oils. Oxidation stability is the ability to exhibit resistance toward oxide-forming tendency, which increases when temperature rises.

3.8 Rust and corrosion prevention

Rust is chemical reaction between water and ferrous metal while corrosion is a chemical reaction between chemicals and metals.

4. Advantages disadvantages and properties of Vegetable oil

Vegetable oils have several advantages and disadvantages due to good inherent qualities. Table 2 summarizes the some of the advantages and disadvantages of vegetable oils compared to mineral oils [1, 2, and 3].

Table 2: Advantages and disadvantages of vegetable oils

Advantages	Disadvantages
Rapid biodegradation	Low thermo-oxidative stability
Generally less toxic	Operating temp. limitations
Renewable	Unpleasant smell
Good viscosity and high VI	High pour point
Ideal cleanliness	
Low volatility	
Higher lubricity	
Higher flash points	
Good boundary lubrication	
Reduced engine emissions	
Disposal at minimal expense	

Table 3 shows the physio-chemical properties or specifications of vegetable oils [4]. From table it is clear that vegetable oils can be efficient and inexpensive substitutes to petroleum based oils. Vegetable oils have valuable and useful physio-chemical properties and offer several technical advantages

Table 3: Properties of vegetable oils

Properties→ oil↓	Kinematic Viscosity (at 40˚c) cSt	Flash point (˚c)	Pour point (˚c)	Cloud point (˚c)	Density (kg/l)
Corn oil	34.9	277	-40.0	-1.1	0.9095
Linseed oil	22.2	241	-15.0	1.7	0.9236
Peanut oil	39.6	271	-6.7	12.8	0.9026
Rapeseed oil	37.0	246	-31.7	-3.9	0.9115
Soya bean oil	32.6	254	-12.2	-3.9	0.9138
Sunflower oil	33.9	274	-15.0	7.2	0.9161
Palm oil	39.6	267	-	31.0	0.9180
Cottonseed oil	33.5	234	-15.0	1.7	0.9148

5. Potential of Vegetable oils as alternative lubricants

A vinash Kumar Agarwal presented the necessity of petroleum-based fuels due to increasing industrialization and motorization of the world. Because of finite reserves of petroleum-based fuels it is necessary to search an alternative fuels which can be produced from resources available locally within the country such as alcohol, biodiesel, vegetable oils etc. This paper reviews the properties, characterization, production and current statuses of biodiesel and vegetable oil. He also dictated the experimental research work carried out in various countries [4]. Ertugrul Durak and Filiz Karaosmanoglu investigated the effect of Cottonseed oil (CSO) with Turkish origin as an additive in base oil. Experimentation was performed by using base oil that is SAE 20W50 oil and lubricating oil at concentration ratios 2.5, 5 and 10 volume % additives as CSO. Tests were conducted for five different speeds and three different loads. Measurement of friction coefficient was aimed in the journal bearing under static loading at ambient room temperature (25◦C). The experimental study found that the CSO could be used as an additive of friction modifier [5].

Sachin M. Agrawal *et al* determined the influence of lubricant on wear and frictional force using pin on disc machine with M2 HSS tool. Authors used the cottonseed oil for their research because of increasing crude oil prices emphasis on the development of renewable and environmentally friendly fluids [6]. K Balamurugan *et al* studied the performance of soya bean oil as a lubricant for diesel engines. For experimentation purpose authors have been used diesel (single and twin-cylinder) engines and four ball wear test machine and. Diesel engines were lubed with various soya bean oil formulations as crude SBO, Soya bean Methyl Ester (SBME), SAE 40+SBME, SBME+ POME+ Castor oil. Test results showed that bio-degradable additives such as POME, Castor oil improve the wear resistance and oxidation stability of soya bean oil methyl ester [7].

N.H. Jayadas *et al* and Chacko Preno Koshy *et al* evaluated the tribological and thermo-physical properties of coconut oil. Authors used different testing machines such as a modified pin-on-disc tribometer, four-ball tester and a test rig to test the wear on two stroke engines. Also, the influence of an anti-wear/extreme pressure (AW/EP) additive i.e. Zinc-Dialkyl-Dithio-Phosphate (ZDDP) and molybdenum disulfide (MoS_2) nano-particles (unmodified and surfactant-modified) on the tribological performance of coconut oil was evaluated by doing experiment. For comparison, the tests were repeated on a different mineral lubricant oils. The results of the experiments show that anti-wear and extreme pressure properties of coconut oil were improved due to addition of suitable concentration of AW/EP additive [8, 9].

G Senthil Kumar *et al* studied the tribological and exhaust emission characteristics of sunflower based lubricant. For the testing Sunflower Methyl Ester (SFME) was mixed with manufacturer's recommended oil (MAK 2T oil) in definite proportions. Nano copper particle was used as an additive in SFME. Emission analysis for smoke was performed using an exhaust gas analyzer. Thus study made conclusion that vegetable oil can be used as a blend of lubricating oil with added additives [10]. S.M. Alves *et al* studied the tribological behavior of soyabean oil, sunflower oil, and mineral oil, synthetic oil lubricants with nano-particles of oxides (ZnO and CuO). These oxide nano-particles used as additive for extreme pressure. High Frequency Reciprocating Rig equipment and SEM/EDS was used to study the anti-wear behavior of CuO and Zn O. The friction coefficient was measured using piezo-electric force transducer. The results showed that with the addition of nano-particles to conventional lubricant, the tribological properties can be significantly improved. Also, lubricants developed from modified vegetable oil can replace mineral oil by improving the tribological properties and environmental characteristics [11].

6. Conclusion

The present work highlighted the potential of vegetable oil as an alternative lubricant. Vegetable oils are having excellent inherent qualities like renewability and biodegradability which suits them as a bio-lubricant in case of automobile applications. Due to specific structure and inherent qualities, vegetable oils are excellent raw materials for the formulation of bio-lubricants. Also the study encourages and supports the research on renewable natural sources as alternatives.

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