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Experimental Investigation on Usage of Oilseed Cakes and Liquid Oil in Standard Lubricant to Improve the Performance of CI Engines

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ABSTRACT

As we all appreciate that, globally CI engines run on petroleum products in general. The exhaust emitted due to burning of such fossil fuels greatly damage our environment. Therefore it is high time to think over and to act towards sustainable use of our natural resources such as petroleum products. Lubricants in practice now-a-days used as additive to the base fuel are all of petroleum origins. It is important to explore the satisfactory uses of such lubricants which are derived from renewable resources. Therefore the exploration towards use of alternative additives such as vegetable oil and oil cakes become very important towards saving our environment for our future generation. Vegetable oils and oil cakes are easily degradable since they are of organic nature. They are also non-conventional as they can be replenished by nature. Mechanical performances of C. I. engines resulting from the use of biolubricants is explored in the present investigation. For this purpose suitable admixture obtained from oilseeds were used. The experiments have been conducted with a mixture of palm oil, oil cakes into the base mineral oil, at different compositions. The selection of admixtures were made by performing kinetic rate study to know the equilibrium contact time which was found to be 1.5 hours in the present study. Blends of oilseed cake with palm oil in different compositions were added to base SAE 20W40 mineral oil to obtain different lubricant blends. The parameters evaluated include brake thermal efficiency, brake specific fuel consumption, volumetric efficiency, mechanical efficiency etc. The engine performance studies were carried out on a C.I. single cylinder, water cooled, 4-stroke engine. Compared to the use of mineral oil alone as lubricant, the Oilseed cake and palm oil-based, laboratory prepared lubricant revealed superior properties and offered appreciable expedience on engine. The several illustrative graphs plotted during the investigation supports our above findings.

KEYWORDS: *SAE 20W40: the engine oil used (ravenol motorbike4-t, mineral oil), CI: Compression Ignition Engine, Biolubricant: Lubricants derived from vegetable/animal fat origin.*

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I. INTRODUCTION

The consumption of fossil fuels in the transportation sector is mostly responsible for global air pollution though the industrial sectors are equal culprit. Both function on engines and fuel system. To control the consumptions as well as emission parameters engine manufacturers need to deign eco-friendly fueled engines which provide sufficient power and efficiency while emitting flue gases within tolerance limits [1]. The present investigation is aimed at searching for such a lubricant from natural biodegradable and renewable origin. Base mineral oil (SAE 20W40) with palm oil and oilseed cake blended together is used in C.I. engine. For finding the suitable mixing proportion of the ingredient the rate kinetic study and the relevant literature as mentioned in references were used.

Edible oils are in use in developed nations such as USA and European nations for lubrication but in developing countries the production of edible oils are not sufficient. In a country like India, there are many plant species whose seeds remain unutilized and underutilized have been tried as bio-lubricants such as used in this research paper. Apart from this the use of biomaterials will result in tri-biological benefits. It will certainly be a bonus. Non-edible oil seeds are the potential feedstock for production of bio lubricant in India. Large scale non-edible seeds plantations can provide energy security to the country, foreign exchange can be saved and hence it will provide employment to the rural masses. Further it will create infrastructure facilities for oil extraction, bio-mass utilization and commercialization from existing trees. Plantation of such trees will help in maintaining ecological balance and increasing green cover. Above activities will reduce countries dependency on imported fuels and chemicals.

Emission of exhaust gases from automobiles in our transportation system are much responsible for air-pollution. Particularly during the broad day light the exhaust gases interact with sunlight by way of photosynthesis reactions to form secondary pollutants. A major share of pollutant gases responsible for global air contamination are originated from the transportation sources. The share works out to be 22% for India. As we know all the transport vehicles run on engine. The engines need fossil fuels for burning and simultaneously require lubricants for higher efficiency as well as lower wear and tear etc [2]. Due to the greater environmental concerns towards saving our environment from air pollution, the automobile industries are making their best to use such fuels and lubricants which help in combating pollution. The industries have started developing vegetable oils and their derivatives to be used as lubricants such as sunflower oil, rapeseed, soyabean, palm oil, mahua oil etc in order to replace petroleum based lubricant [3]. The high price of crude oil, its high evaporability as well as disposal problem of exhausted lubricants give rise to use of biodegradable biolubricants as such lubricants are environment friendly and are obtained from renewable sources [5, 8]. Therefore, researches for suitable biolubricants from vegetable or animal fats origin become pertinent. The present research is an outcome of such thought and need. We know that main function of lubricants in two or four strike engines is to decrease the frictional force, by way of forming a thin viscous layer between the moving parts in engines such as piston and cylinder. An ideal lubricant must reduce the wear of moving parts and power loss [2]. Such engine oil also cools the engine by absorbing heat and reduces corrosion. The hydrodynamic action of lubricants in journal bearing, crankshaft bearing in moving pistons are of utmost importance. It can be highlighted that frictional forces consume about 15-20% of fuel in an I. C. engine. Thus to reduce this fuel loss, search for lower coefficient of friction lubricant with other advantages have been the aim of present research. Aiming at above said tasks, blends of oilseed cakes and palm oil in different compositions and proportions were added to base SAE20W40 mineral oil to obtain different lubricant blends [4]. The parameters evaluated include brake thermal efficiency, brake specific fuel consumption, mechanical efficiency. The engine performance and emission tests were carried out on a C. I. engine of single cylinder, water cooled, 4-stroke. Compared to a mineral oil used alone, the oil seed cake mixed with palm oil-based lubricant revealed superior properties and offered appreciable advantages on engines and emission performance. It was observed that such blended lubricant have superior lubricity, which reduces wear and tear on the diesel engine and thus makes the engine components last longer.

II. EXPERIMENTAL STUDY

The engine used for the investigation is single cylinder, 4-stroke, water cooled, high speed diesel engine. The engine is mounted on the ground. The test engine was directly coupled to an Eddy current dynamometer with control facility for loading the engine. The experimental setup is shown in the Fig A below:

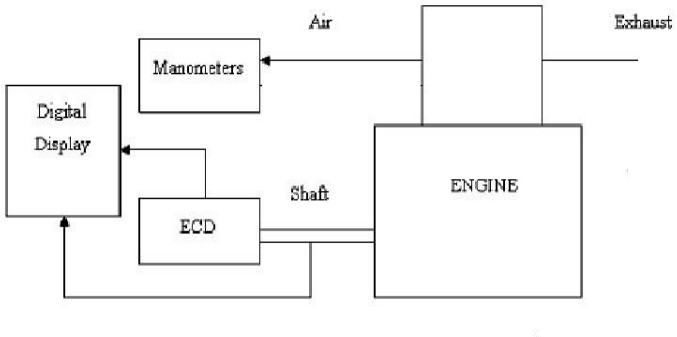


Fig A: Block diagram of Engine test bench and the experimental apparatus.

Engine Specifications	
Model	AV1
Cycle	4 strokes
Rated power	3.75 kW (5HP)
Speed	1500rpm
Bore diameter	80mm
Stroke length	110mm
Cooling system	Water cooled
Cubic capacity	0.661 litres
Ignition system	Compression Ignition
Compression ratio	17.5 : 1
Lubricating oil specification	SAE 20W40
Lubricating oil capacity	3.7 litres

III. EXPERIMENTAL METHODOLOGY

The aim of this experimental study was to investigate an appropriate composition of oilseed cake with palm oil and mineral oil mixture that may be used as a biodegradable lubricant for 4-stroke CI engines giving desired result.

Preparation of the mixture:

The standard mixture was prepared in the laboratory by mixing three ingredients in different proportions such as shown in Table A

Table A

Ingredient	**Composition (Vol %)**		
	Mineral oil %	**Palm oil %**	**Oilseed cake (powdered-form)**
Mixture 1	100	0	0
Mixture 2	80	17	3
Mixture 3	75	18	7

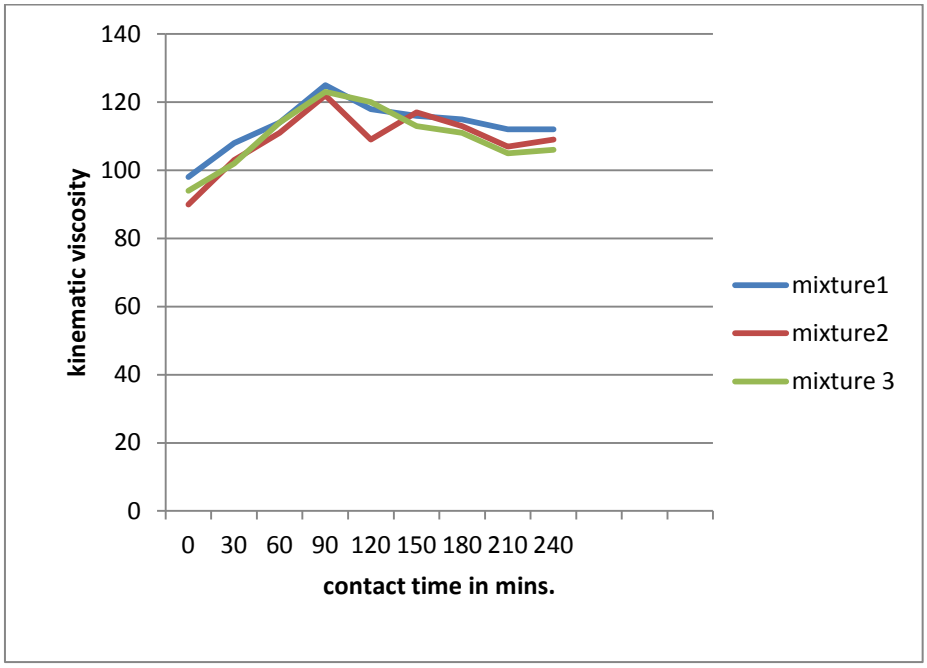
The above composition was tried based on preliminary studies [7, '14] on these ingredients. The palm oil was procured from palm seeds grinded locally to avoid adulterations etc. Oilseed cake was procured from local oil grinders. The same was pulverized and dried at 40° C and sieved to pass through 75 Micron I.S. sieve. Powdered oilseed cake, the palm oil and the standard mineral oil were mixed in the proportions mentioned in table-A. The mixture was kept in plastic container and vigorously shaked on vibratory shaker in the laboratory for 4 hours. A kinetic rate study was carried out. At every half hour interval the mixture sample was withdrawn and analysed for the equilibrium contact time between the admixtures. The same was found to be 1.5 hours [Refer to Graph A] In each case the tests have been carried out at 0%, 20%, 40%, 60%, 80% and full load i.e. 100% loading conditions.

Table B: Physical characteristics of SAE 20W40, oilseed cake &Palm oil Mixtures 1, 2 & 3

Typical properties	**Mixture 1**	**Mixture 2**	**Mixture 3**
Specific gravity @ 20°C	0.855	0.865	0.872
Kinematic viscosity @ 40ºC	120	40.24	43.10
Flash point, ºC	220	280	265

IV. RESULTS AND DISCUSSION

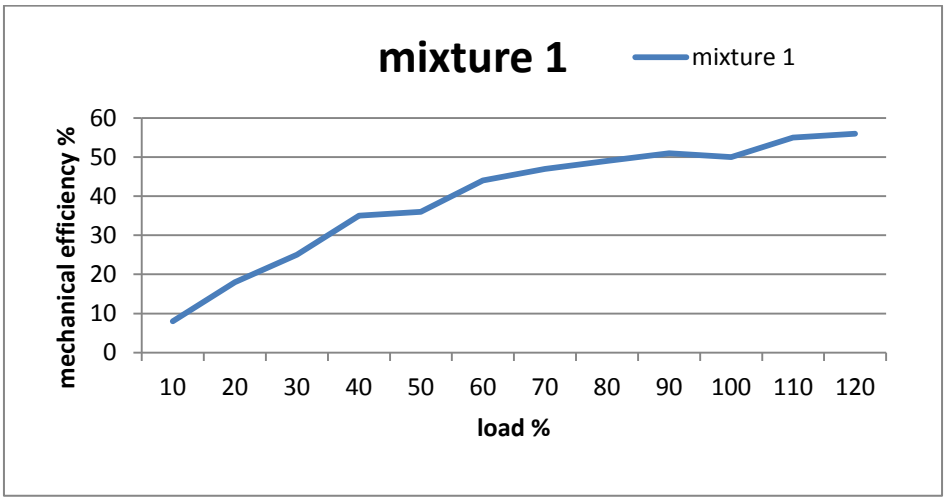
The experiments were conducted with various combinations of oilseed cake with palm oil blends and straight mineral base SAE 20W40 oil. The parameters, such as mechanical efficiency, brake thermal efficiency (BTE), brake specific fuel consumption (BSFC) were evaluated. Mixtures 1,2 &3 of oilseed cake with palm oil in SAE 20W40 oil is taken and tested for various parameters. As evident from the graph A the equilibrium contact time works out to be 90 minutes. The results are as shown below:



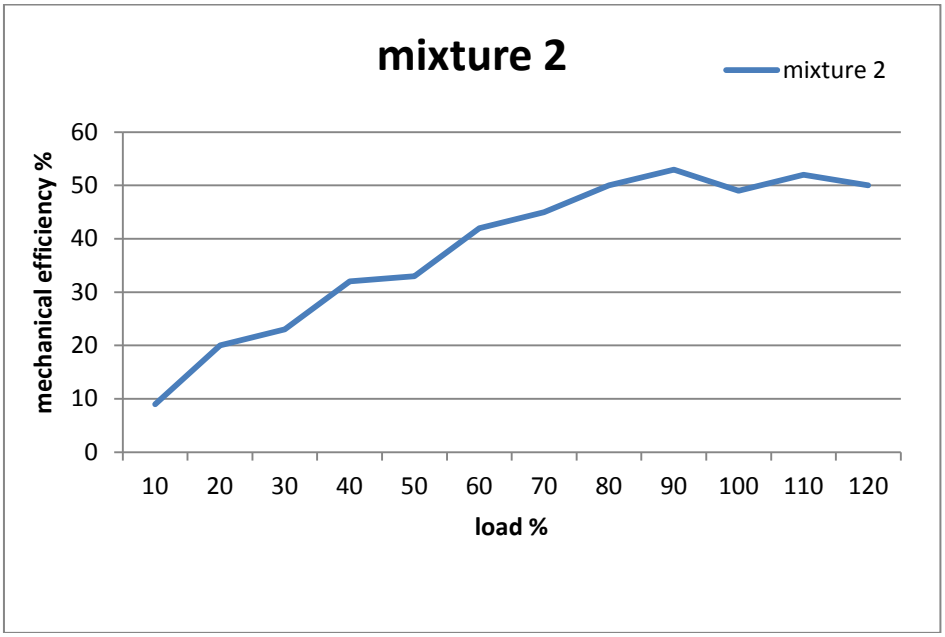
Graph A: Rate kinetics

Mechanical Efficiency

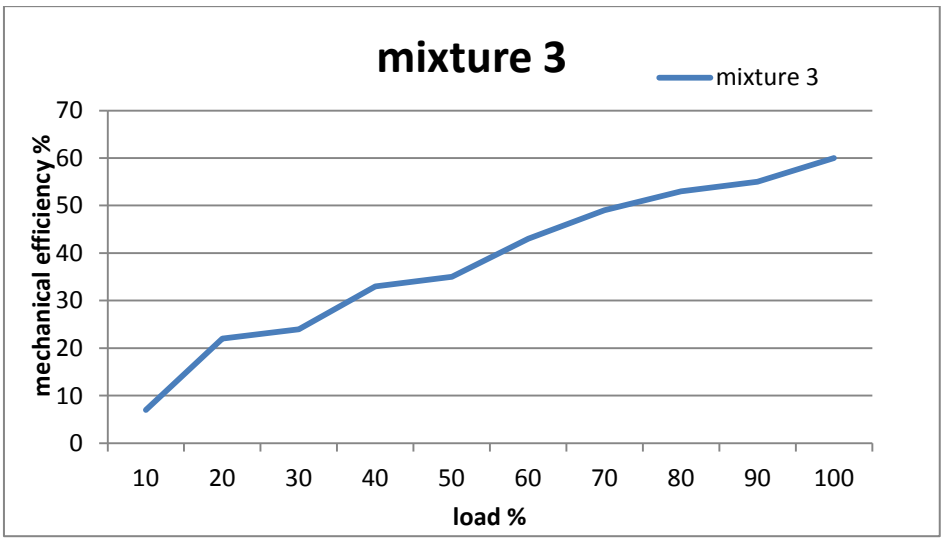
Graph below shows variation of mechanical efficiency with respect to percentage loads for SAE 20W40 and different mixtures of oilseed cake with palm oil blends. Maximum mechanical efficiency is 60 % in case of mixture 3.



Graph-B1



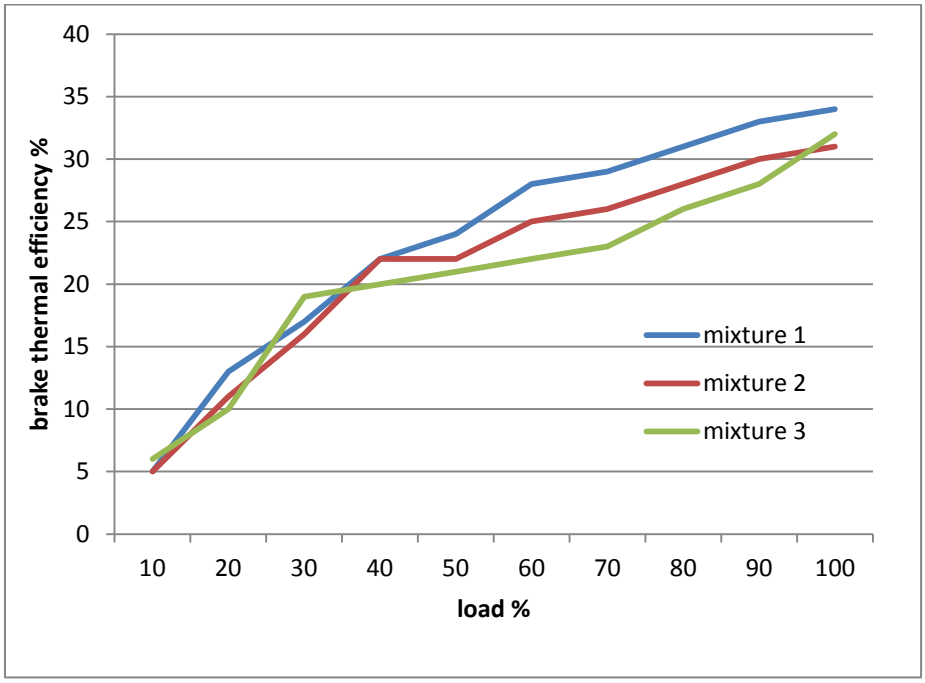
Graph-B2



Graph-B3

Brake Thermal Efficiency

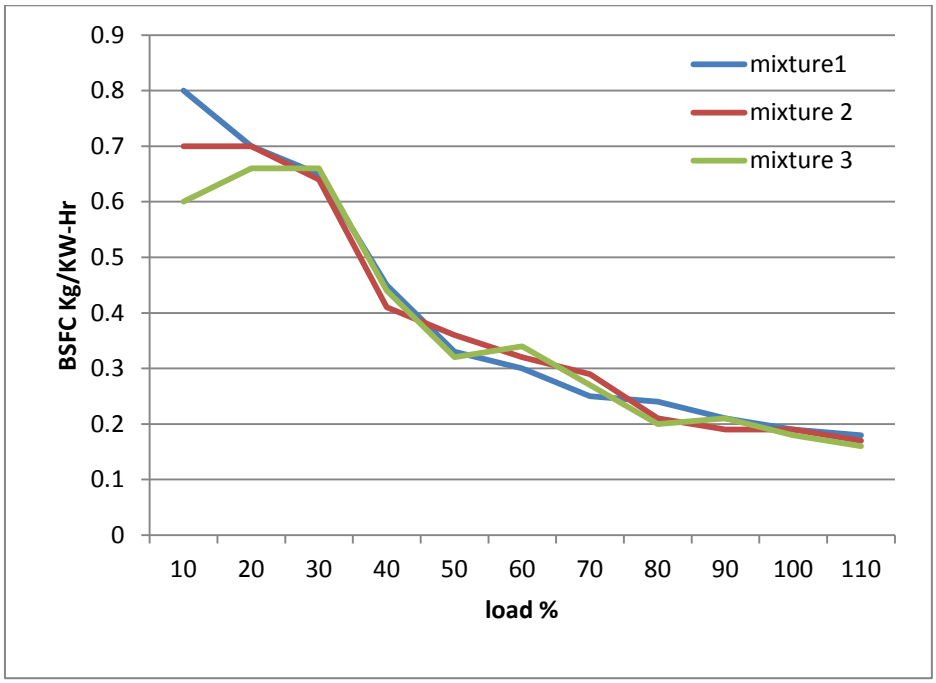
Graph C below shows variation in brake thermal efficiency with loading conditions for SAE 20W40 and different compositions of oilseed cakes with palm oil. Brake thermal efficiency of SAE 20W40 is very close to various oilseed cakes with palm oil blends for entire range of operation. Maximum brake thermal efficiency of SAE 20W40 (i.e. mixture 1) is 34.92 % and for mixture 2 is 32% and for mixture 3 is 33.8 %.Therefore, all the three mixtures were found to be almost equally efficient in brake applications.



Graph C

Brake Specific Fuel Consumption

Graph D below shows variation of brake specific fuel consumption with loading conditions for SAE 20W40 and different compositions of oilseed cakes with palm oil. The graph reveals that there is no convincing change in the fuel consumption compared to oilseed cakes with palm oil blends.



Graph D

V. CONCLUSION

Conventional mineral oil based lubricants are extremely harmful for the biosphere when they get into the environment. Due to poor degradability mineral oils remain in the ecosystem for a long time. Eco friendly hydraulic oil, refrigerator oil, gear oil, motor oil, two stroke engine oils & lubricants and eco-friendly greases for both general purpose and multipurpose should be widely used. Eco-friendly bio-degradable lubricants have to be immediately introduced in the market to replace the mineral oil and other non-biodegradable products currently in use. In the present research, the blend of oilseed cake with palm oil when used along with base mineral oil shows higher efficiency of CI engines whereas other parameters were found to be comparable in case only base mineral oil (i.e. mixture 1) was used.

Due to the use of upto 10 % Bio lubricants & admixtures such as oilseed cakes, there may be considerable saving in initial cost. It is also expected that if suitable study is carried out to evaluate the frictional resistance & wear and tear of engine, the proposed mixture 3 (i.e. of base mineral oil with oilseed cake in palm oil) will earn favorable results. This may be because of Dispersion of solid particles of oilseed cakes coating the moving shaft & ball bearings thus reducing the friction [6]. The adsorbed molecules of oilseed cakes occupy valuable space gaps in the oil mixture to make it more uniform and consistent. The dispersed molecules in case of mixture 3 may also absorb heat thus reducing the engine temperature.

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