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Performance analysis of a Four Stroke SI Engine using Pongamia Oil as Lubricant

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Abstract: **Due to scarcity of petroleum products such as mineral oils, bio-lubricants are gaining commercial importance. The mineral oil consumption is becoming rampant due to rapid industrialization and transportation. It is predicted that the available resources will be completely depleted in near future. The vegetable oil based Bio- lubricant is fast becoming a promising alternative option for mineral oil. People are analyzing the physical properties such as Specific gravity, Viscosity, Flash point, Pour point and Fire point for vegetable oil (Pongamia oil) , blends of vegetable oil. These properties are compared with that of mineral oil (SAE 15W 40). The investigation has also been made to study the characteristics of bio-lubricants in four stroke SI engine for neat vegetable oil and blends of vegetable oil and neat mineral oil. The bio lubricant is also tested for higher range of operating temperature. The mixture of 40% (BL40) blend of lubricant is the most preferred to solve this problem without adding any chemical agent.**

Keywords:Chemical Agent, Bio-Lubricant, Pongamia Oil, Four Stroke SI Engine, Mineral Oil
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1. INTRODUCTION

Engines are used as a power source for medium and heavy duty applications, because of the high efficiency and economy. Due to friction in the moving parts of an engine the excessive heat is generated by interaction between the surfaces. The friction and wear has to be controlled by lubrication and it also acts as a coolant facilitating heat dissipation from engine. Recent uncertainties concerning adequate, stable supplies of petroleum based lubricants have renewed interest in vegetable oil lubricants, especially for emergency use in spot shortage situations. Hence alternate lubricants have to be identified to have the lower friction and wear than the traditional lubricants and also meet out the demand of mineral oils. Bio-lubricants are products derived from renewable oils, such as the fatty acids from fats and oils, reacted with synthetic alcohols or polyols to produce esters. They are generally biodegradable and renewable. Also they possess good viscosity index, higher temperature withstand ability and considerable flash point, fire point, etc.

2. LUBRICANT

Lubrication is the process employed to reduce friction between, and wear of one or both, surfaces in close proximity and moving relative to each other, by interposing a substance called a lubricant between them. Lubrication plays a key role in the life expectancy of an engine. Without oil, an engine would succumb to overheating and seizing very quickly. Lubricants help mitigate this problem, and if properly monitored and maintained, can extend the life of an engine.

3. REASONS FOR SELECTING PONGAMIA OIL

Pongamia pinnata is one of the few nitrogen fixing trees to produce seeds containing 30-40% oil. Pongamia pinnata can be a definite source of raw material due to its easy availability in wild. Pongamia pinnata is drought resistant, semi-deciduous, nitrogen fixing leguminous tree. It grows about 15-20 meters in height with a large canopy which spreads equally wide. After trans- esterification process, crude oil shows excellent properties like calorific value, iodine number, cetane number and acid value etc. The leaves are soft, shiny burgundy in early summer and mature to a glossy, deep green as the season progresses. Flowering starts in general after 4-5 years. Cropping of pods and single almond sized seeds can occur by 4-6 years and yields 9-90 kg's of seed. The yield potential per hectare is 900 to 9000 Kg/Hectare. As per statics available Pongamia oil has got a potential of 135000 million tonnes per annum and only 6% is being utilized. The tree is well suited to intense heat and sunlight and its dense network of lateral roots and its thick long tap roots make it drought tolerant. The primary inducement for using Pongamia as bio-lubricant is high ignition temperature, high viscosity index, bio degradable, low oil evaporation loss.

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4. INTRODUCTION TO BIO LUBRICATION

It is estimated that about 50% of all the oil used ends up in the environment . Petroleum –based lubricants, which are the leading type of base oil used in this industry, is poorly non-degradable and represents an environmental hazard when released. This represents a strong incentive to provide lubricants that are biodegradable. In addition, the rapid increase in the price of petroleum products in recent years, the increased dependence on offshore sources, the declining rate of production from older domestic oil fields and the decrease in the rate of finding new reserves have prompted governments and individuals to press for renewable products as replacements for petroleum products in a practical manner. Bio-lubricants may be defined generally as materials that are based on biodegradable and renewable base stocks. Bio-lubricants do not have to be composed entirely of vegetable oil base stocks. They can be products derived from renewable oils, such as the fatty acids from fats and oils, reacted with synthetic alcohols or polyols to produce esters that can be considered as bio-lubricants. In addition, the natural vegetable oils can be treated to produce a modified product that is still biodegradable and renewable. Vegetable oil's properties (high viscosity index, low friction coefficient, high flash point, low volatile, higher shear stability, etc.) makes oil more suitable for lubrication over mineral oils. An interesting recent development is a growing realization that bio-lubricants present practical alternatives to petroleum-based lubricants. The rising of the prices of petroleum based products, ban by some countries in the use of non-biodegradable lubricants in applications where oils are lost into the soil and surface water, and depletion of oil reserves have necessitated the replacement of petroleum-based oils with less polluting and easily available renewable bio-lubricants for lubrication purpose.

5. PROPERTIES OF PONGAMIA OIL

In this paper, lubrication characteristics of Pongamia oil with various blends were carried out and results are compared with mineral oil based lubricants. Pongamia oil is extracted from the seeds of Pongamia pinnata tree.
Vegetable oil lubricants are biodegradable and non-toxic, unlike conventional mineral based oils. Low temperature study has also shown that most vegetable oils undergo cloudiness, precipitation, poor flow, and solidification at -10 ^{o}C upon long-term exposure to cold temperature in sharp contrast to mineral oil-based fluids.

Table 1: Comparison of Bio-lubricant and Mineral oil

Property	Pongamia oil	Mineral oil
Viscosity (cSt) (40°C)	39.73	87.89
Specific gravity (27°C)	0.9184	0.8628
Flash Point (°C)	268	226
Fire point (°C)	230	245
color	Yellowish red	Light amber
Odor	Odd	Mild petroleum oil

6. PONGAMIA OIL PREPARATION

The oil can be extracted by mechanical expeller method, soxhlet extraction method and cold percolation method. We chose mechanical expeller method for best result. It is an ordinary method used for the extraction of all types of oil. This process requires less time and recovers oil in higher amounts as compared to other methods.
The seeds of Pongamia pinnata seeds were grinded into fine particles and Pongamia oil-bio-lubricant is extracted from it. The following figures represent the seeds used for grinding and the extracted Pongamia oil.

Fig 1: Pongamia seed

Fig 2: Pongamia oil

7. EXPERIMENTAL WORK

The lubrication characteristics were performed using single cylinder four stroke SI engine using various blends of lubricants at different working environment like various temperature and speeds to determine the specific gravity, flash point, pour point and kinematic viscosity using specific gravity tester, open cup apparatus, pour point tester and red wood viscometer.

Fig 3: Single cylinder four stroke SI engine

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7.1 Parameter Selection for performing lubrication characteristics

Material Selection
- Bio-lubricant – Pongamia oil
- Conventional lubricant-mineral oil

Input Parameter
- Speed -1600 rpm
- Load condition- No load
- Temperature- 27°C

Output Parameter
- Specific gravity
- Flash point
- Pour point
- Kinematic viscosity

Types Of Testing Surface
- Wet condition (bio-lubricant)
- Wet condition (mineral oil)

8. LUBRICATION CHARACTERISTICS TEST

The lubrication characteristics test were performed using single cylinder four stroke SI engine under various lubricated condition.

Table 2: Details Of Single Cylinder Four Stroke SI Engine

Make	Greaves cotton Ltd
Model	MK 12/2 HSPP
Type	Four Stroke Petrol
Ignition type	Electronic Spark ignition
Power Rate	1.1 KW
Lubrication Oil	SAE 15 W 40
Speed	3000 RPM
SFC	700g / Kwh

9. RESULTS AND DISCUSSION

The lubrication characteristics like specific gravity, kinematic viscosity, flash point and fire point were measured for bio-lubrication (Pongamia oil), neat mineral oil and various blends of Pongamia oil with mineral oil and the results are compared with each other. In addition to this the crank case temperature are determined for the same above mentioned oil types using single cylinder four stroke SI engine and the results were compared.

9.1 Lubrication Characteristics Test

In this work, physical properties and crank case temperatures were determined to compare lubrication characteristics for mineral oil, Pongamia oil and blends of Pongamia oil. The blending symbols and the composition of various blends are mentioned in the table 3.

Table 3: Details Of The Composition Of Various Blends And Symbols

Symbols	Blend composition
M100	100% mineral oil
Bl10	10 % pongamia oil +90 % mineral oil
Bl20	20 % pongamia oil +80 % mineral oil
Bl30	30 % pongamia oil +70 % mineral oil
Bl40	40 % pongamia oil +60 % mineral oil
Bl50	50 % pongamia oil +50 % mineral oil
Bl60	60 % pongamia oil +40 % mineral oil
Bl70	70 % pongamia oil +30 % mineral oil
Bl80	80 % pongamia oil +20 % mineral oil
Bl90	90 % pongamia oil +10 % mineral oil
Bl100	100 % pongamia oil

9.2 Investigation of Specific Gravity For Various Blends

The specific gravity of various blends was taken at a particular room temperature of 27°C.

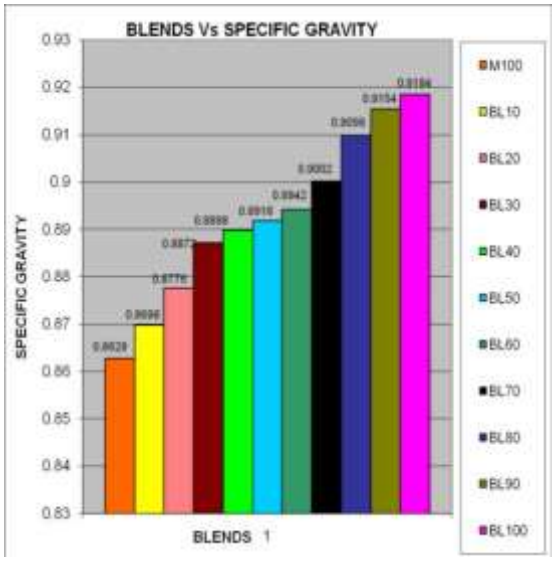

Fig 4: Blend vs Specific Gravity

The specific gravity of M100 was observed that 0.8628 and, specific gravity of BL100 was 0.9184. From our observation, the addition of Pongamia oil % is directly proportional to the specific gravity. I.e. if Pongamia oil % is increases the specific gravity also increases.

9.3 Investigation Of Kinematic Viscosity For Various Blends

The Kinematic Viscosity of various blends were taken at various room temperatures such as 40°C,50° C,60° C,70 °C,80° C,90° C and 100° C.

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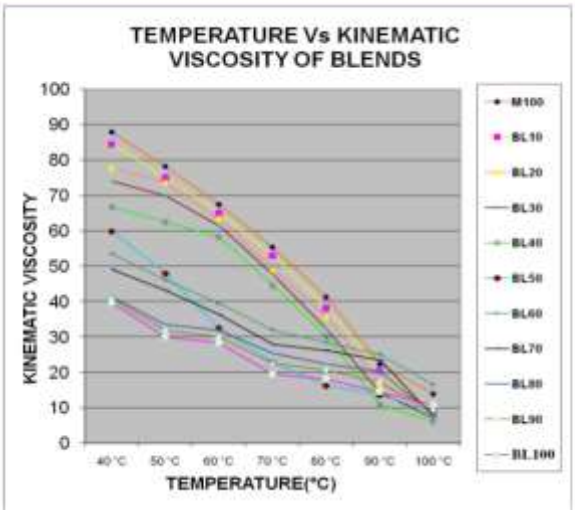

Fig 5: Temperature vs. Kinematic Viscosity

The Kinematic Viscosities of M100 and BL100 was observed that 87.896 CSt and 39.727Cst at 40°C respectively. From our observation, the addition of Pongamia oil % is inversely proportional to the Kinematic Viscosity.

9.4 Investigation Of Flash And Fire Point For Various Blends

The flash and fire point of various blends were measured

. **Table 4:** details of values for various blends

Sl. No	Blends	Flash point temperature (Open cup)	Fire point temperature (Open cup)
		°C	°C
1	M100	226	238
2	BL10	228	240
3	BL20	231	235
4	BL30	234	242
5	BL40	239	246
6	BL50	234	252
7	BL60	254	259
8	BL70	257	265
9	BL80	259	267
10	BL90	260	272
11	BL100	268	280

9.5 Investigation of Crank Case Temperature For Various Blends

The crank case temperatures for various blends were measured using the single cylinder four stroke SI engine. The oils were filled in the crank case completely and the engine is started and is made to run for complete 2 hours. The crank case temperatures were measured for the varying time. The temperatures that were determined and the results were compared for the various blends.

10. CONCLUSION

In this work, the lubrication characteristics like specific gravity, kinematic viscosity, flash point and fire point were measured for bio-lubrication (Pongamia oil), neat mineral oil and various blends of Pongamia oil with mineral oil and the results are compared with each other. In addition to this the crank case temperature are determined for the same above mentioned oil types using single cylinder four stroke SI engine and the results were compared.

The results observed were the flash and fire points of Pongamia oil are higher than that of Mineral oil. The specific gravity of Pongamia oil is greater than the specific gravity of Mineral oil. The Kinematic Viscosity of neat Pongamia oil is lesser than Kinematic Viscosity of the Mineral oil. The crank case temperatures were reduced while using Pongamia oil and blends of Pongamia oil than the neat Mineral oil. The temperatures of crank case while using Mineral oil were gradually increased without fluctuation, but in bio – lubricant oil the temperature increased for certain period of time (1 hour) then suddenly decrease in temperature and remains stable.

The cost of Pongamia oil is 3 times lesser than the Mineral oil. The property of Pongamia oil satisfies the properties of Mineral oil. Thus we conclude and recommend that Pongamia oil up to BL40 could be used as a alternate lubricant for Mineral oil.

Thus the Bio-lubricants can be employed as a good substitute for the conventional lubricants with the added advantage of eco-friendliness. The higher degree of temperature reduction will result in increased life of the lubrication system. Further, the use of bio-lubricants will reduce the consumption of petroleum based lubricants and will also ensure environment friendly disposal and reduced pollution.

11. LITERATURE REVIEW

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