Characterization of Palm Oil as Biodiesel

Neeraj Goreya*, Shankha Ghosh*, Priyank Srivastava*, Vivek Kumar*

* M.Tech. Scholar; Automobile Engineering; Amity University, Noida
** Assistant Professor; Mechanical and Automation Engineering Department; Amity University, Noida
*** Professor; Mechanical and Automation Engineering Department; Amity University, Noida

Abstract: The various sources of energy from which mechanical energy is obtained are non-renewable and are thus considered to be unsustainable. These sources include the various fossil fuels like the petroleum, coal and the natural gas. The burning of fossil fuels led to the production of the greenhouse gases increasing the levels of CO2 in the atmosphere. The adverse effects are the global warming and the ozone layer depletion.

In a nation like India, where consumable oils are still transported in, it is advantageous to investigate the likelihood of utilising such non-palatable oils as a part of CI motors which are not by and by used as cooking oil. Palm oil (otherwise called dendê oil, from Portuguese) is a consumable vegetable oil got from the monocarp (ruddy mash) of the product of the oil palms. The major objective is to provide a cheap and effective alternative to diesel. This paper is an exploration of the capability of the palm oil as a practical, modest and effective hotspot for the generation of biodiesel. The paper is based on the characterisation of palm oil compare to diesel.

Keywords: Palm Oil, Biodiesel, Transesterification.

I. INTRODUCTION

The nonrenewable fossil fuel has encouraged the search for petroleum substitutes. It helps to search an alternative fuel. The use of vegetable oils as alternative fuels has been around for one hundred years when the discoverer of the diesel engine Rudolph Diesel first tested peanut oil, in his CI engine. In the 1930s and 1940s vegetable oils were used as diesel fuels from time to time, but usually only in emergency situations. In 1940 first trials with vegetable oil methyl and ethyl esters were carried out in France and, at the same time, investors in Belgium were consuming palm oil ethyl ester as a fuel for buses. Not much was done until the late 1970s and early 1980s when concerns about high petroleum prices motivated extensive experimentation with fats and oils as alternative fuels.

Biodiesel is petroleum-based fuels derived from vegetable oils, animal fats, and waste cooking oil including triglycerides. Since the petroleum crises, the fast increasing prices and suspicions concerning petroleum availability there is a growing concern for the environment and the effect of greenhouse gases during the last spans. This has revived more and more benefits in the use of biodiesel as a substitute for fossil fuels.
Biodiesel is getting better attention as an alternate, non-toxic, biodegradable and renewable diesel fuel. It is resultant from oils and fats by transesterification with alcohols. In a country like India, where edible oils are still imported, it would be worthwhile to explore the likelihood of consuming such non-edible oils in CI engines which are not in the drill as cooking oil. Therefore, the study on Palm oil as fuel for CI engine was undertaken[1,2,3,4]. The previous research survey of the biodiesel from different feedstock’s with their conclusion is given below in a table I.

Table I: Literature survey

| Author                  | Used Feedstock               | Engine Tested                  | Operation Condition | Conclusion of different tests                                                                 |
|-------------------------|------------------------------|--------------------------------|---------------------|-------------------------------------------------------------------------------------------------|
| D. Dutta [5]            | Soyabean oil and Pangomia oil| Single cylinder four stroke water cooled CI engine | At constant speed of 1500 rpm | 1. BTE increases 4.46 – 6.75 %  
2. HC emission increases upto 21 ppm  
3. NOx ranges 42 – 67 ppm  
4. Smoke ranges 0.46 – 0.54 % |
| Obe M. Ali [6]          | Palm Oil                     | Four cylinder Mitsubishi 4068 CI engine with CR 22.4:1 | Speed in between 1500 – 2400 rpm | 1. 14% less heating value  
2. B30 decreases bp to 2.6%  
3. B30 increases bsfc upto 3% |
| A M Liaquat [7]         | Jatropha with wasted edible oil | Single cylinder four stroke CI engine | Speed in between 1500 – 2400 rpm | 1. Torque &hp decreases  
2. bsfc & NOx increases  
3. HC, CO & CO2 reduced |
| A Sanjid [8]            | Palm oil and Jatropha        | Single cylinder four stroke direct injector CI engine | Speed at 2400 rpm | 1. CO & HC reduced  
2. Nox increases |
| Swarop Kumar Nayak [9]  | Mahua oil with di methyl carbonate | Single cylinder four stroke CI engine with 16.5 : 1 CR | Speed at 1500 rpm | 1. bte & bsfc increased  
2. CO & HC reduced  
3. Smoke & NOx increased |
| S. Ram Kumar [10]       | Neem oil                     | Single cylinder four stroke CI engine | Speed at 1500 rpm | 1. Less bte  
2. High bsfc  
3. Low HC & Smoke |
| S. M AmeerUddin [11]    | Mustard oil                  | Single cylinder four stroke CI engine | Speed at 2000 rpm | 1. Loss bte  
2. Calorific values for mustard oil blend B10 & B20 were closed to diesel |
| Vaneetbharadwaj [12]    | Wasted mustard oil           | Kirloskar single cylinder four stroke CI engine | Speed at 1500 rpm | 1. Low hp  
2. High bsfc  
3. bte was same as diesel upto 30% of blend |
| EkremBuyukkaya [13]     | Rapeseed                     | Six cylinder four stroke turbocharged CI engine | Speed at 2100 rpm | 1. Lower blend produces better result as B20 gave best bte  
2. No change in bsfc for B20  
3. Increase in NOx for B20 |
| S.Oberweis [14]         | Rapeseed                     | Two cylinder four stroke CI engine | Speed at 1500 rpm | 1. small difference in bsfc  
2. NOx & CO2 emission increases |
II. PRODUCTION

Palm oil was transesterified with methyl alcohol to obtain methyl ester of Tung oil to reduce its kinematic viscosity in the range of diesel fuel. The process parameters such as molar ratio, KOH concentration and settling time were standardised to obtain higher recovery of esters. About 94 percent ester can be recovered if the palm oil methyl alcohol mixture of 5:1 molar ratio is preheated for 30 min at 60°C and then reacted with 1.5 percent KOH for 1 h at 60°C and then allowed to settle for 24 h in order to get methyl ester of 4.6 centistoke (cSt) kinematic viscosity. Different blends of biodiesel with diesel in the proportion of 10:90, 15:85 and 20:80 were prepared. The characteristic fuel properties such as kinematic viscosity, relative density, the gross heat of combustion, cloud and pour point, flash and fire point, carbon and ash content and total acidity of refined Tung oil, its methyl esters and their blends with diesel were compared. The results of different fuel properties of blends of the methyl ester of palm oil with diesel were almost similar to diesel. [16]

III. METHODOLOGY

The experimentation and calculation of the biodiesel required various processes for the production of biodiesel and test it on the engine along with it various blends.

- **Transesterification** - Firstly 25ml methanol was mixed with 3g of KOH and simultaneously preheating of Palm Oil was done for 30 minutes at 60-70-100 degrees. After all the both solutions were mixed and were put in the burette and left for the resting in the burette for the development of biodiesel. After few minutes there would be a separate layer of biodiesel and glycerol.
- **Dilution process** - 25% of n-Butanol is added to 75% of palm oil and shake well and similarly change in concentrations is done. [15]

Stage I : Flow chart of the method to develop biodiesel, Fig 1
Stage II : Flow chart of the engine testing in different blends, Fig 2

![Fig 1: Methodology Stage I](image1)
![Fig 2: Methodology Stage II](image2)
IV. PROPERTY

The properties of diesel, biodiesel and palm oil are given below in table 2.

| Property                | Diesel | Biodiesel from Transesterification | Palm oil without heating | Palm oil after heating | Dilution process |
|-------------------------|--------|-----------------------------------|--------------------------|------------------------|------------------|
| Calorific Value (kcal/kg) | 10000  | 11456                             | 8490                     | 1118.8                 | 10626.3          |
| Cetane Number           | 51 min | 55.9                              | 37.74                    | 54.3                   | 47.07            |
| Viscosity (cS)          | 3.9    | 5.59                              | 48                       | 35.66                  | 47.9             |
| Cloud Point             | -      | 1.4                               | 7.8                      | 1.8                    | 6.1              |
| Pour Point              | -      | - 2.6                             | 5.1                      | - 0.7                  | 4.9              |
| Free Fatty Acid         | -      | 0.2256                            | 1.8                      | 0.5922                 | 0.4754           |
| Acid Value              | -      | 0.4512                            | 3.6                      | 0.9588                 | 1.1844           |

V. ENGINE SETUP

A stationary four stroke, the single cylinder diesel engine was coupled with an eddy current dynamometer. The fig 3 shows the experimental engine setup. The specification of the experimental engine setup is given below:

Engine Model : Kirloskar AVI, four stroke, single cylinder, water cooled, direct injection, compression ignition engine;

- Bore : 80 mm;
- Stroke : 110 mm;
- Compression Ratio : 16.5;
- Maximum power : 5 kW;
- Speed : 1500 rpm;
- Injection Timing : 27° bTDC;
- HC Analyzer : Nucon Make, Model 490;
- NO Analyser : Nucon Make, Model 500;

Fig 3: Engine Setup

VI. ENGINE PERFORMANCE & EMISSION

After the engine testing, the calculated results of different engine parameters and emissions results are given below in table 3. From the table 3, we consider only diesel and biodiesel, PME100 in different loads for the graphs. Fig 4 shows that the graph of bp v/s load is nearly same for diesel and biodiesel. Fig 5 shows that fuel consumption of the engine was more in case of biodiesel. Fig 6 shows that brake specific fuel consumption was also higher in case of 100% biodiesel and it proportional blends. Fig 7 shows that brake thermal efficiency was more in case of diesel. Fig 8 shows that CO emission was more
in case of diesel. Fig 9 shows that HC emissions were also higher when diesel was used. Fig 10 shows that NO$_x$ emissions were higher in case of biodiesel.

Table 3: Results

| Load   | Fuel  | Speed, rpm | BP (kW) | FC (ltr/hr) | BSFC (Kg-kW/hr) | BTE (%) | CO (%) | HC (%) | NO$_x$ (ppm) |
|--------|-------|------------|---------|-------------|-----------------|---------|--------|--------|--------------|
| No load| Diesel| 1560       | 0       | 0.47        | -               | 0.03    | 0.03   | 24     |              |
|        | PME10 | 1546       | 0       | 0.51        | -               | 0.02    | 0.03   | 28     |              |
|        | PME50 | 1573       | 0       | 0.59        | -               | 0.01    | 0.01   | 41     |              |
|        | PME100| 1555       | 0       | 0.61        | -               | 0.01    | 0.01   | 57     |              |
| 20     | Diesel| 1574       | 0.79    | 0.53        | 0.57            | 13.05   | 0.03   | 4      |              |
|        | PME10 | 1530       | 0.76    | 0.62        | 0.69            | 10.87   | 0.02   | 72     |              |
|        | PME50 | 1555       | 0.79    | 0.74        | 0.81            | 9.74    | 0.01   | 78     |              |
|        | PME100| 1530       | 0.77    | 0.76        | 0.87            | 9.52    | 0.01   | 93     |              |
| 40     | Diesel| 1560       | 0       | 0.47        | -               | 0.03    | 0.03   | 4      |              |
|        | PME10 | 1522       | 1.52    | 0.71        | 0.39            | 18.91   | 0.03   | 3      | 146          |
|        | PME50 | 1533       | 1.55    | 0.84        | 0.47            | 16.78   | 0.02   | 221    |              |
|        | PME100| 1514       | 1.51    | 0.88        | 0.51            | 16.12   | 0.02   | 229    |              |
| 60     | Diesel| 1522       | 2.27    | 0.81        | 0.30            | 24.63   | 0.04   | 348    |              |
|        | PME10 | 1516       | 2.26    | 0.91        | 0.34            | 22.10   | 0.04   | 389    |              |
|        | PME50 | 1517       | 2.27    | 1.09        | 0.41            | 19.02   | 0.03   | 503    |              |
|        | PME100| 1515       | 2.27    | 1.11        | 0.43            | 19.26   | 0.02   | 516    |              |
| 80     | Diesel| 1515       | 3.03    | 0.99        | 0.27            | 26.87   | 0.05   | 652    |              |
|        | PME10 | 1508       | 3.01    | 1.10        | 0.31            | 24.18   | 0.05   | 768    |              |
|        | PME50 | 1511       | 3.01    | 1.24        | 0.34            | 22.98   | 0.04   | 835    |              |
|        | PME100| 1506       | 3.00    | 1.35        | 0.35            | 23.50   | 0.03   | 880    |              |
| 100    | Diesel| 1500       | 3.74    | 1.26        | 0.26            | 28.31   | 0.05   | 746    |              |
|        | PME10 | 1495       | 3.74    | 1.28        | 0.26            | 28.19   | 0.04   | 930    |              |
|        | PME50 | 1490       | 3.73    | 1.32        | 0.29            | 27.40   | 0.02   | 1049   |              |
|        | PME100| 1490       | 3.72    | 1.36        | 0.32            | 25.92   | 0.02   | 1065   |              |
VII. CONCLUSION

Present work is done to study the standardisation and Optimisation Of biodiesel production from Palm Oil using transesterification in order to design process parameter for production. The exhaust emission characteristics of Tung biodiesel blends B10, B50 and B100 were compared with diesel. Based on the results of the present work, following conclusion was drawn:

- The optimum conditions for maximum yield of biodiesel production were obtained at a molar ratio of 5:1, reaction time 60 minutes and 1.5% KOH concentration. A maximum yield of 94% was determined.
- The fuel properties of optimised biodiesel were found to be comparable to diesel and were conforming to the latest biodiesel standards.
- The calorific value of optimised Tung seed biodiesel was 9100 Kcal/Kg which is lower than diesel fuel.
- The flash and fire point of Palm seed biodiesel were determined to be 180°C and 194°C respectively which are higher than diesel fuel.
- The cloud and pour point were also observed to be lower for biodiesel fuel.
• Brake Power Developed by the Engine on selected Fuel Types during Fuel Consumption Test was comparable to normal diesel and results were almost same.
• Comparing different blends of palm biodiesel esters with normal diesel starting from no load condition to varying loads, we observed that
• Fuel consumption of the engine was more in case of biodiesel
• Brake specific fuel consumption was also higher in case of 100% biodiesel and it proportional blends
• Brake thermal efficiency was more in case of diesel
• Carbon monoxide emission was more in case of diesel
• Hydrocarbon emissions were also higher when diesel was used
• Nitric oxide emissions were higher in case of biodiesel
• Nitrogen Dioxide emissions were the double in case of biodiesel as compared to normal diesel.

ABBREVIATION
CI - Compression Ignition
CR - Compression ratio
KOH - Potassium hydroxide
PME - Palm methyl ether
bp  - Brake power
fc  - Fuel consumption
bte - Brake thermal efficiency
bsfc - Brake specific fuel consumption
HC - Hydrocarbon
NOx - Nitrogen oxide
ppm - Parts per million
cSt - Centi-stoke
CO - Carbon monoxide
CO2 - Carbon dioxide

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Fig 9 : Load v/s HC Emission
Fig 10 : Load v/s NOx Emission

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