Experimental Investigation of Performance and Emission Characteristics of CI Engine Fuelled With Mahua Oil – Pine Oil Blend

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Abstract. Huge competition of the developing countries opens the challenge to create to new technique which make them as super powers. Most of the developing countries economics are mainly depends on the energy sectors which make them to seek alternate. Biofuel is best element which brings them to Independence on other countries. This study investigate the performance and emission characteristics of four stroke diesel engine fuel with mahua oil and Pine oil blend. The fuel was prepared in the volume ratio M30P70, M50P50 and M70P30 and compared with diesel fuel. The experiment was carried out by varying the loading conditions. The experimental results shows M30P70 has higher brake thermal efficiency, lower BSFC because of the lower viscosity of the Pine oil. The emission results show that adding of pine oil in the blend leads to higher Nox emissions because of its lower cetane number of the Pine oil. Co and HC emissions shows reduction pattern because of the lower viscosity of pine oil.

1. Introduction
Escalating fuel crisis and degradation of environment because of pollution from automobilespress a global need to find a replacement for fossils fuels or conventional fuels which also helps a country’s economy by reducing the burden of the cost in importing oil. Huge money flow to the countries which are having its own finite resource of petroleum from developing countries taught to provide the better alternate. So it is need to find the better alternate fuel which is most economics, highly efficient, less polluting element. Many researches were done in the alternate fuels. Most of the biofuel such as palm oil, sunflower oil, coconut oil, soybean oil, neem oil, karanja oil, mahua oil andpolanga oil, are highly viscous in nature which make them to not suitable to utilization in IC engines which contributes poor injection which affects the whole combustion process of the engine.

The parameter which used widely interms of measuring the fuel ignition quality is Cetane number which influence the ignition delay and efficiency of combustions. The constituents of fuels and structure of the molecules decides the cetane number of the biofuel. The shorter hydrocarbon chain fuel such methanol, Ethanol, butanol haslower cetane number which can be used effectively with help of the ignition qualities improvers [1]. Quite a lot of oxygenated fuels off the record as alcohol, carbonate ether and ester. Mentioned above are the finest example of alternates for diesel fuel. Variety
of vegetable oils also be a fuel for CI engine. Countries like USA uses soybean oil, Canada uses rapeseed oil, Malaysia uses palm oil, Philippines uses coconut oil etc [2]. West African countries are initiates the production biofuels through cultivating more amount oil crops. Jatropha curcas – perennial oil crop are planted in more numbers in order to produce the more amount of straight vegetable oil [3]. India has good interest in few oil species such as neem, karanja, mahua and jatropha which is suitable for CI engines [4]. P.kDevan et al.[5] conducted experiment with paradise methyl ester blend with Eucalyptus oil. Heating value of the Eucalyptus oil and paradise oil methyl ester was closer value with Diesel fuel. Lower viscosity of blended fuel supports for proper vaporization and the reason for faster burning of the fuel. Higher cetane number of the paradise oil methyl ester (POME) supports the better combustion even though other fuel Eucalyptus oil has lower cetane number. Blending of the Biofuel supports for compensating the properties such as heating value, cetane number volatility and viscosity.

K. Purushothaman et al [6] examined the behaviour of orange oil -DEE blended diesel fuel in CI engine. The chemical formula for orange oil was C10H16. The orange oil has cetane number of 47, heating value of 34650 kJ/kg and viscosity of 3.52 cST.Paramvir Singh et al. [7] conducted the experiment of the dual fuel engine fuelled with Aamala seed oil biodiesel and Eucalyptus oil. Blended fuel which contains the 70% Aamala seed oil biodiesel and with 30% of eucalyptus oil was found to be better. Blending of these biofuel reduces the effect of lower heating value and higher viscosity. Higher peak release rate blended fuel causes the higher NOx. SrinivasKommana, et al [8] found that higher pressure and higher compression ratio supports the better reduction in emissions when employing the lower cetane biofuel Eucalyptus oil blend with higher cetane number palm oil biodiesel. M. Habibullah et al [9] involved the palm oil and Coconut oil biodiesel as fuel for CI engine. He found that the combination of the both biofuel helps in reduction of the CO and HC but it produce the higher NOx. India has more number of tress of mahua which kernel contains almost 40% of oil content. India produces mahua oil almost 60 MT per annum. Mahua oil has higher filter plugging point, cloud point and higher viscosity so it need to be converted into biodiesel [10]. 30 % blending of the mahua oil biodiesel with diesel supports good oxidation stability. The oxidation stability of mahua oil biodiesel was found well than jatropha oil biodiesel [11]. The yellowish turpentine contains volatile combustible hydrocarbon isomers mixtures α- pinene , Ψ pinene, β-pinene and some terpenes isometric [12].

2. Methodology
The mahua oil and pine oil was purchased from the local vendor. Various physical and chemical properties of fuel was shown in the table 1. The fuel was prepared by blending in the volume basis such that M70P30 (70% of mahua oil and 30% of Pine oil ), M50P50 (50% of mahua oil and 50% of Pine oil )and M30P70 (30% of mahua oil and 70% of Pine oil ).

| Description            | Diesel | Mahua Oil | Pine oil |
|------------------------|--------|-----------|----------|
| Density (kg/m³)        | 830    | 924       | 875      |
| Calorific value (MJ/kg)| 42.5   | 37.6      | 42.8     |
| Flash point (°C)       | 50     | 212       | 52       |
| Kinematic Viscosity (cST at 40°C) | 4.59 | 24.60 | 1.3 |
| Cetane Number          | 48     | 43        | 11       |

Table 1. Properties of Biofuels.
The experimental setup was shown in the figure 1. The Specifications of the engine was given in the table 2. The four stoke diesel engine was coupled to eddy current dynamometer which is used to apply load in the engine. Air flow rate was measured using air box having orifice meter and u tube manometer. The fuel was supplied to engine through the two way value coupled to burette which used to measure the volume flow rate of the fuel. The engine was allowed to run for half an hour with diesel fuel to achieve the steady state of the engine. Load was applied for 0% to 100% of the loading conditions. Mass flow rate of the fuel ($M_f$) and mass flow rate of the air ($M_a$) was recorded in order to determine the various performance parameter. The engine tail pipe was attached to the Avl gas analyzer and bosh Smoke meter from that various emotions was noted.

3. **Result and Discussions**

3.1 **Brake thermal efficiency**

Fuel density, load acting on the engine and heating value of the fuel is main element which used to determine the brake thermal efficiency (BTE). The figure 1 shows the variation of the brake thermal efficiency against the brake power. The diesel has the higher BTE because of the lower density of the diesel fuel because of that mass consumption for diesel was lower and reason for higher thermal efficiency. Increasing the pine oil helps in better combustion of the blended fuel leads higher thermal efficiency. Increasing the pine oil in the blended fuel leads to reduction in the viscosity and increases the rate of combustion and provided the Higher BTE. Lowest BTE was found for M70P30 and Higher BTE was found For M30P70 among the Blended fuel.

3.2 **Brake Specific Fuel Consumption**

BSFC was influenced by the engine efficiency, density and calorific value of the fuel. Diesel fuel has the lowest BSFC when compared to M70P30, M50P50 and M30P70. Highest BSFC was found for M70P30 because of the lower value of the heating value of the fuel and followed by M50P50 and M30P70. Increasing the mahua oil leads to slower combustion because of the higher viscosity of the M70P30 which leads to greater BSFC for M70P30.

### Table 2. Specifications of the engine.

| Specification            | Detail                                                                 |
|--------------------------|-----------------------------------------------------------------------|
| Engine power             | 5.2 kW @ 1500 RPM                                                    |
| Cylinder bore, Stroke length | 87.5 mm X 110 mm                                                   |
| Temperature sensor       | Range : 0-1200 °C, Type k                                           |
| Load sensor              | Range : 0-50 kg, Type S beam                                        |
| Cylinder pressure        | Range 5000 psi Model HSM111A22, Make PCB Piezotronics,             |
Figure 1. Engine setup.

Figure 2. Variations of BTE against Brake power.

Figure 3. Variations of brake Specific fuel consumption (BSFC) with respect to Brake power (BP).

The figure shows that variation of the BSFC with respect to brake power. BSFC was the parameter which depends on the mass flow rate of the fuel and calorific value of the fuel. Increasing the Mahua
oil leads to increase in BSFC which can be evidently seen through value for M30P70 and highest for M70P30. The lower calorific value and higher density of the mahua oil in the blended fuel was the reason higher BSFC for M70P30. The increase in the pine oil the blended fuel reduces the Fuel consumption of the lower density and higher calorific value.

3.3 Emissions

3.3.1 Carbon mono oxide

![Figure 4](image)

**Figure 4.** Variations of CO emissions vs Brake power.

Figure 4 shows the variation of the CO emissions with respect to brake power. Diesel fuel has the higher CO emission at full load conditions because of the lower air fuel ratio at the operating conditions. CO emissions increase with increase in mass of the fuel injected in the engine. Due to lowering the air fuel ratio and 0% of oxygen content in diesel fuels suffers higher CO emissions. Higher viscosity of mahua oil provide the higher CO emissions which can be seen in the M70P30 and M50P50. Increasing the pine oil reduces the CO emissions. M30P70 has the lower CO emissions

3.3.2 Unburnt Hydrocarbon. The figure 5 demonstrate the variations of the HC emission with respect to BP. Increasing the mahua oil in blended fuel increase the unburnt HC. Because of poorer viscosity of M70P30 has the advanced in HC when compare to M30P70 and M50P50. More amount of Oxygen present in the M30P70 along with its lower viscosity support for better combustion and leads lower HC emissions in M30P70. Higher unburnt HC emissions was found greater for Diesel fuel due to the lower air fuel ratio supplied to operating at that conditions and 0% Oxygen content of Diesel fuel.
3.3.3. Oxides of Nitrogen. The figure 6 demonstrate the oxides of nitrogen contrary to brake Power. Increasing the Pine oil in blended fuel increase the Nox emissions. Since of the Poorer cetane number of Pine oil leads to higher rate of heat release and produce high temperature hot gas which act as main reason for Nox emissions. Higher viscosity and lower calorific value of the mahua oil blended fuel reduces the Nox emissions because of the slow rate of the fuel burning. That’s why M70P30 has lower Nox substances.

3.3.4. Smoke. The figure 7 shows the variations Smoke emissions counter to Brake power. The Smoke emission is higher for M70P30 because of sophisticated viscosity of mahua oil which suffers from poor atomization. Lower Smoke was found for M30P70 because of oxygen content of Pine oil and Mahua oil. Increase pine oil in the blended fuel reduces the requirements of air because of increasing in the oxygen level in the blended fuel. Pine oil provide proper atomization and also supports its blended fuel to burn properly. M30P70 smoke emissions was lower than Diesel because of lower air fuel ratio requirements and percentage of oxygen present in the blended Fuel.
4. Conclusion
Brake thermal efficiency was found greater for M30P70 because of the poorer viscosity of M30P70. BSFC was found lower for M30P70 because of high energy density of the Pine oil. Increasing the pine oil in blended fuel decrease the Smoke, Carbon mono oxide ,unburnt hydrocarbon and increase the oxides of nitrogen. But increasing the mahua oil blended fuel leads to increase in CO, HC , Smoke and reduces the NOx emissions.

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