

# Performance Evaluation of Diesel Engine with Preheated Bio Diesel with Additives

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**Abstract:** This paper mainly reviews about the usage of preheated bio diesel added with 0.5% Etchant as an alternative fuel and evaluates its performance for various blends with different loads. Bio diesel is added with Etchant for rapid combustion as for the bio diesel, the cetane number is high that results in shorter delay of ignition and the mixture is preheated to raise its temperature to improve the combustion process. Analysis of the parameters required to define the combustion characteristics such as IP, BP,  $\eta_{bth}$ ,  $\eta_m$ , ISFC, BSFC, IMEP, MFC, Exhaust Gas Temperature, Heat Release and heat balance is necessary as these values are significant to assess the performance of engine and its emissions of preheated bio diesel.

**Keywords:** Bio Diesel, Alternative Fuel, Palm Sterin, Ethanol, Loads, Preheated, Performance, Mechanical Efficiency Brake Thermal Efficiency, Combustion Process, Heat unaccounted, etc.

## 1 INTRODUCTION

As the consumption of the resources to fulfill the necessary energy requirements is increasing from day to day, demand for the fuels is also increasing rapidly as major sources are the fossil fuels. This may lead to depletion of the resources and considering the impact of the emissions from the engines using the petroleum fuels, Researchers are forced to find the substitute for the petroleum products as a new source of energy which is always recommended to replace with foreign exchange through the import of petroleum products. To improve the environment, decrease foreign imports and enhance the use of renewable fuels, biodiesel is considered an alternative fuels for IC Engines because of abundant availability and bio degradable <sup>[1]</sup>. Bio diesel is infeasible compared to conventional fuels as there is a large disproportion between edible oils and fuels. Therefore non edible oils come into play for the commercial production of bio diesel and research has been increased to improve the performance characteristics considering available oils <sup>[2][3][4]</sup>. For the conventional IC Engines, biodiesel can be considered as an alternative fuel without any modifications of the engines.

Calorific value of diesel is more when compared to bio diesels but mixing with suitable blends combinations it sufficiently reaches an acceptable level for better performance of the engine <sup>[5]</sup>. Animal and Vegetable oils added with small quantities of ethanol or methanol, yielding ethyl or methyl ester are the sources for the production of bio diesel and the by product in the process is glycerin. Blending rules are to be followed for determining the viscosity, cloud point, cetane number and density for a biodiesel basing on ester profile <sup>[6]</sup>. Implications on the environment during the production of the bio diesel auspicious were to be considered.

Effects on the environment caused by the product life cycle such as depletion of ozone layer, toxic gases, change in climatic conditions and others are to be assessed. Compilation of the consumption and emission of the product's life cycle at every phase is mandatory and preliminary analysis is to be performed to identify other possible issues.



Palm Oil is the world's second largest cultivating oil about 18% of world production and about 10% is used for biofuels. Palm Oil mills are briskly becoming as a major source of renewable energy because of their biogas and biomass. Palm Oil is a lucrative crop adapted to humid tropics and the area confined to the cultivation of palm oil is likely to have a significant improvement in the future because of its environmentally favorable qualities over its full life cycle. Different methods are developed by the researchers for the production of biodiesel [7].

Pedro Benjumea, John Agudelo and Andres Agudelo had evaluated the mixing rules to determine the viscosity and density basing on the effect of the temperature with distillation curves, cloud point and heating value for palm sterin bio diesel and its blends [8].

Preheating is one of the simplest method to reduce the viscosity level thereby minimize the troubles due to poor fuel droplet formation and atomization that results in lots of carbon deposit formation on the valves and injector choking [9]. Researchers have indicated the required preheating temperature to resolve trouble of clogging and the fuel inlet temperature of the biodiesel for the appropriate viscosity value [10][11].

Ethanol because of its high octane value, has been used as an alternative fuel or fuel additive for complete combustion of the fuel [12] and works are being done to improve the combustion characteristics of the ethanol as an additive and as an alternative fuel [13] [14] [15] [16]. It is considered for replacement of the fossil fuels for the transportation and is used in dual fuel injection systems and also in turbo charged engines [17] to enhance the engine performance while operating under high load and speed conditions.

## 2. EXPERIMENTAL INVESTIGATION

### 2.1. Description of the Test Rig

The experiment source is a four stroke single cylinder water cooled, naturally aspired stationary diesel engine equipped with a preheater setup with thermostat arrangement as the thermostat automatically maintains the inlet temperature of the biodiesel. The diesel engine by means of flexible rubber coupling is coupled to Eddy Current Dynamometer mounted on as MS channels base frame which is balanced parameters equipped with fuel tank, air box, fuel measuring digital indicators, transmitter, manometer and various sensors connected with the transmitter for transmitting necessary signals. All these signals received with the help of signal conditioner and signal converter are interfaced to computer for computerization for better efficiencies and accurate correctness of combustion in the process.



**Figure 1.** Experimental Setup Four Stroke Diesel Engine

## *2.2. Specifications of Test Rig*

Engine: 4-stroke single cylinder diesel engine

Engine Make: Kirloskar

Coolant: Water

Rated Power: 3.7 kW (5HP)

Connecting rod length: 234 mm

Stroke Length: 110 mm

Bore Diameter: 80 mm

Swept Volume: 562cc

Rated Speed: 1500 rpm

Compression ratio: 16.5:1

### *2.2.1 Dynamometer*

Load Measurement Method: Eddy Current

Make: POWER MAG

Coolant: Air

Arm Length: 150 mm

Rated Torque: 2.4 kg-m

### *Test rig constants*

Orifice Diameter: 20 mm

Density of water: 1000 kg/m<sup>3</sup>

Density of Diesel: 0.82 gram/cc

Value of  $C_d$ : 0.62

Caloric Value of Diesel: 44500 kJ/kg

Value of  $C_p$  for water: 4.18 kJ/kgK

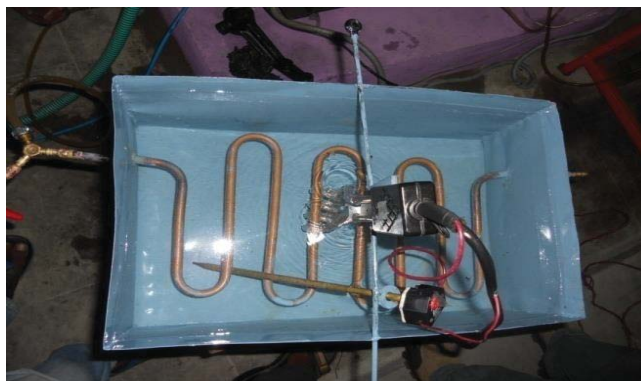
## *2.3. Preprocess Setup*

Due to higher value of cetane number, shorter ignition delay and more combustion duration can be seen in bio diesel when compared to diesel. So etchant is added for an increase in considerable amounts for complete and rapid combustion so that to minimize the unburned mass of fuel.

## *2.4. Preheating*

Preheater Technique is used to increase the inlet temperature of the bio diesel entering the engine so that the combustion process takes place quickly by reaching the self-ignition state.

The preheating equipment consists a long copper tube aligned parallel for better heat exchange process is placed in a water bath maintained at a constant temperature of 65°C using a thermostat to regulate the temperature. Blend that flows through the copper tube enters the combustion at 80°C. These conditions are followed for all the blends for all the load conditions.



**Figure 2.** Preheating Biodiesel Experimental Setup

### 2.5 Dissolved Oxygen

Electrometric meter method is used to determine the amount of dissolved oxygen in the Bio Diesel

In the process, Electric current is passed through the two solid electrodes contained in oxygen sensitive membrane probes which are immersed in the electrolyte. The oxygen molecules are allowed through the semi permeable membrane layered on the electrode pair. Reaction between the oxygen molecules with internal filling solution develops small electric impulses. The change in electric current is reflected by the meter readings.

Change in the current is more if more amount of DO is present in the sample which in turn can observe raise in meter readings directly.

#### 2.5.1 Working Procedure

0.1% conc. KOH is used as the electrolytic solution.

Fill a glass jar of 250ml with Biodiesel +0.5% Ethanol.

Probe is dipped in glass jar and the particles are allowed to settle down and the readings are noted.

Variation of the Oxygen levels dissolved in Biodiesel + % Ethanol with respect to time as shown below.

**Table 1.** Dissolved Oxygen levels of Biodiesel + 0.5% Ethanol, Pre Heated Bio Diesel condition with PPM

S.No	Time (sec)	PPM (At stable conditions)
1	60	5.2
2	120	3.9
3	180	3.6
4	240	3.4
5	300	3.1
6	36	2.8
7	420	2.7
8	480	2.7

Palm Sterin Properties
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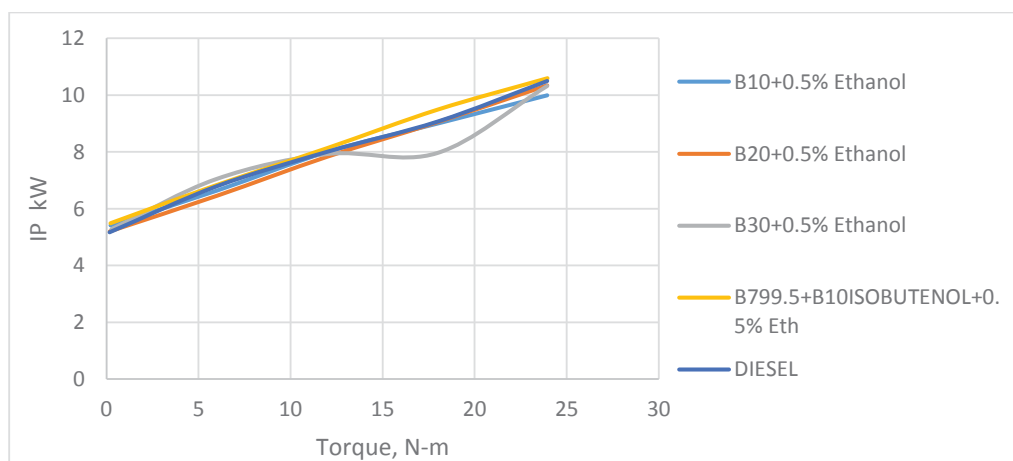
**Table 2.** Properties of Palmsterin Bio Diesel with Additives

		Units	Test Result
1	Fire Point	Deg C	174
2	Flash Point	Deg C	168
3	Kinematic Viscosity at 40°C	Cst	4.8
4	Density at Room Temperature	Gm/ml	0.873
5	Acid Value	mg KOH/gm	0.42
6	Ester Content	%m/m	98.9
7	% of Carbon Content	%m/m	0.035
8	Smoke Emission		28% greater than Diesel
9	Iodine Value	% level	18
10	Cetane Number		42
11	Glycerin Content	%m/m	0.13

### 3. RESULTS AND DISCUSSION

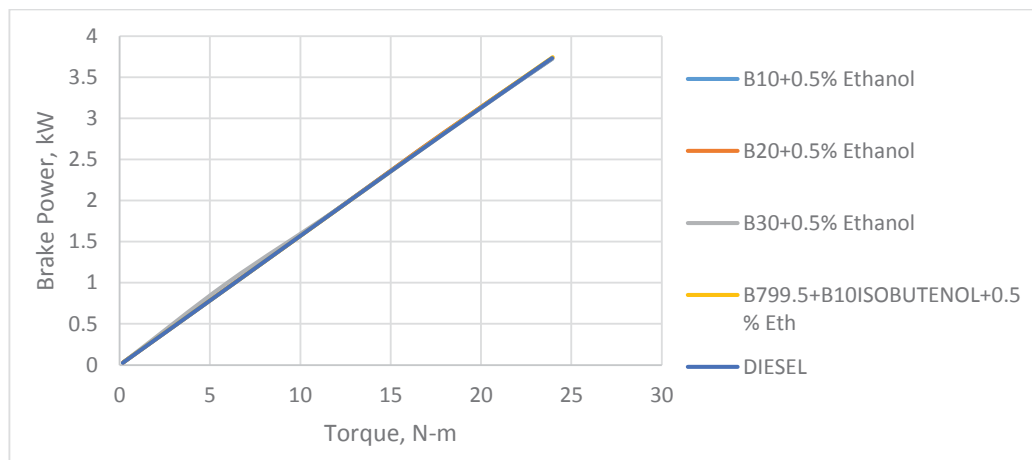
Palm Sterin oil blends added with ethanol under pre heated condition was injected into four stroke single cylinder diesel engine as the working medium. This test is on the engine at  $\frac{1}{4}$ ,  $\frac{1}{2}$ ,  $\frac{3}{4}$  and full load conditions and the test results will be compared with standard diesel values and graphs had been plotted for various characteristics of the engine.

#### 3.1 Comparison of Torque and Indicated Power (IP):

**Graph 1.** Comparison of IP with respect to Torque

Indicated Power developed in the combustion process, shows the accurate values represented in the graph with constant torque. From the **graph 1**, IP of the blends is approximately equal to diesel IP.

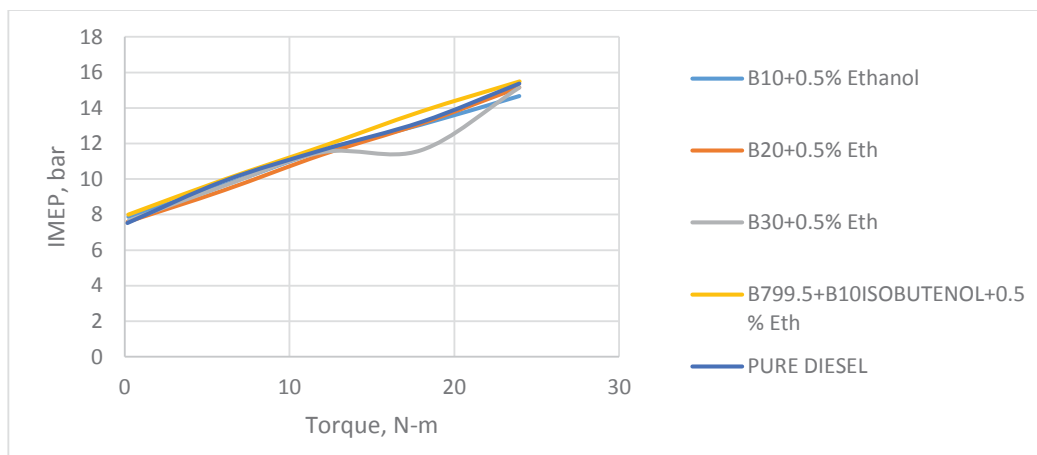
### 3.2 Comparison of Torque and Brake Power (BP):



**Graph 2.** Comparison of Brake Power with respect to Torque

Brake power is the power available at the engine shaft for transmitting the power. Brake Power of all fuels is noticeably same on increasing the load. Brake power is the energy used as a mechanical term.

### 3.3 Comparisons of Torque and Indicated Mean Effective Pressure (IMEP):



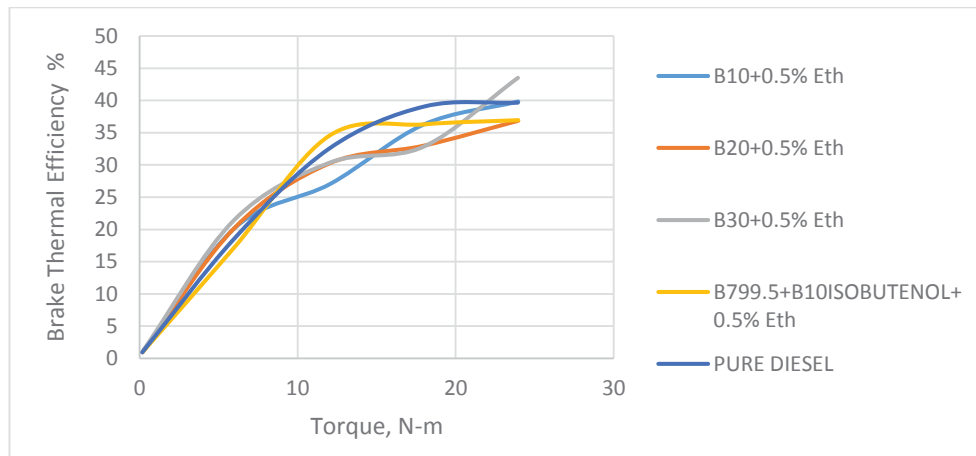
**Graph 3.** Comparison of IMEP with respect to Load

From the **graph 3**, as the torque on the engine was increased, the IMEP of all the fuels are increased. The IMEP is considerably more for bio diesels because of complete combustion of the fuel in the chamber and adding of the etchant. It can be noted that IMEP increases on of preheating of the fuel which results in higher combustion rate and having more IMEP values.

### 3.4 Comparisons of Torque and Brake Thermal Efficiency:

Brake thermal efficiency describes the amount of power produced with respect to the energy supplied. Brake thermal efficiency of the bio diesels is less when compared to that of pure diesel. As the torque being applied increasing, brake thermal efficiency of the all fuels is same only upto a torque of 8 N-m and efficiency diesel is superior to all other after noticeable proportion change of blend. Brake thermal

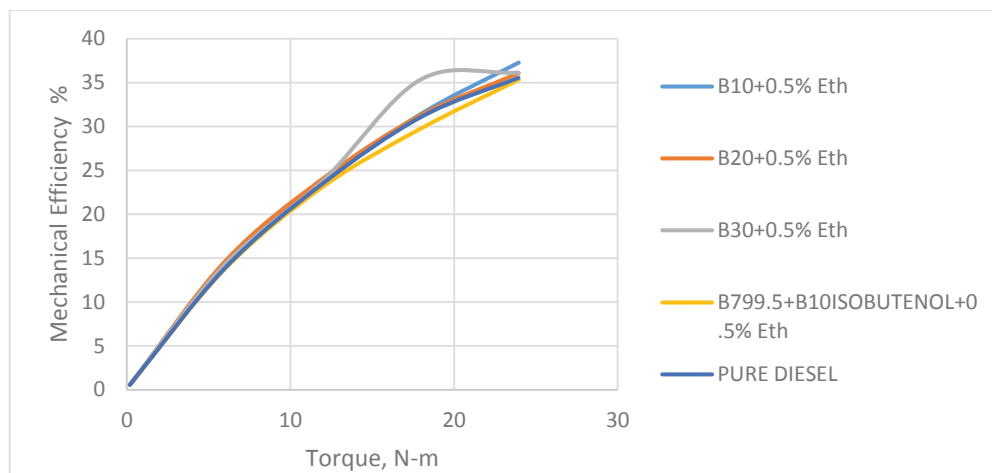
efficiency of the fuel was increased relatively on application of pre heating and adding of ethanol and Iso butenol for the combustion process.



**Graph 4.** Comparison of  $\eta_{bth}$  and Load

Because of their oxygenated fuel characteristics which results in effective combustion, BP and MSFC of the fuels are relatively less compared to diesels. Brake thermal Efficiency is less in CI Engines but this phenomenon can be reversed using bio diesel blends.

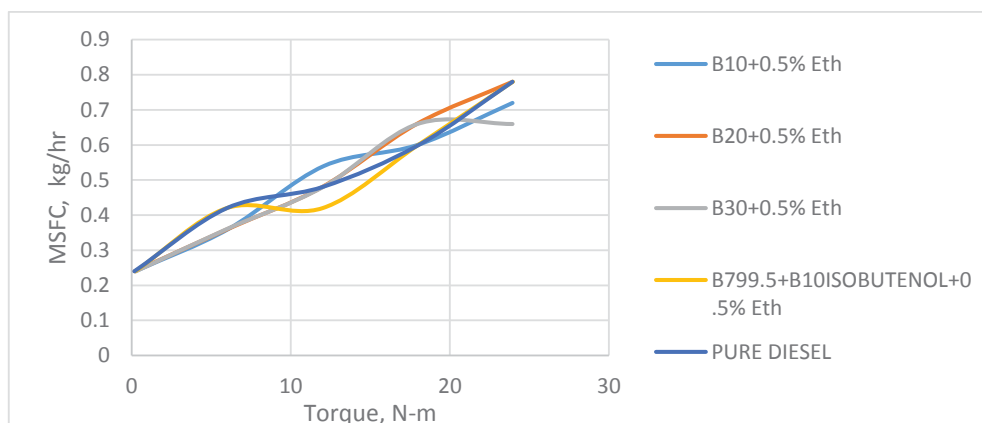
### 3.5 Comparisons of Torque and Mechanical Efficiency:



**Graph 5.** Comparison of  $\eta_m$  and Load

Greater the torque greater is the mechanical efficiency. It is evident that change in Mechanical Efficiency was proportional to the variation of the torque as shown in **graph 5**. Amount of utilized power with respect to the total power developed is increasing on increasing the torque. Mechanical efficiency of all blends is same as the diesel due to the effective combustion of the fuels. This results in better performance of the engine. Therefore blends of Palmsterin oil added with etchant when subjected to preheating condition results rise in efficiency same as for diesel.

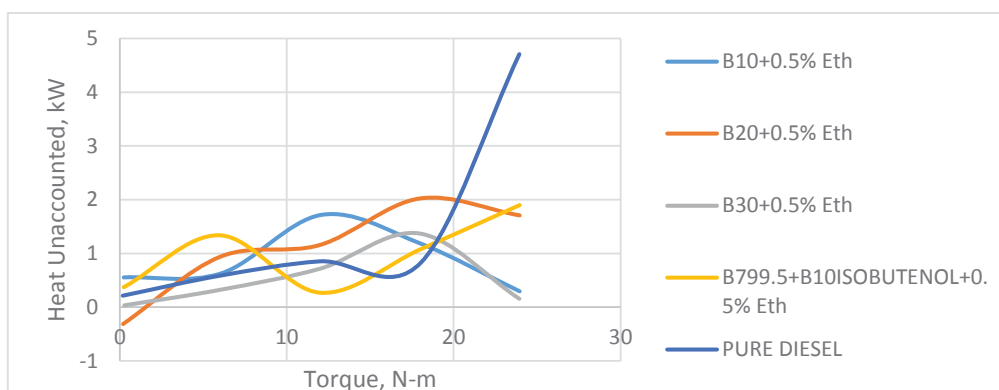
### 3.6 Comparisons of Torque and Mass Specific Fuel Consumption (MSFC):



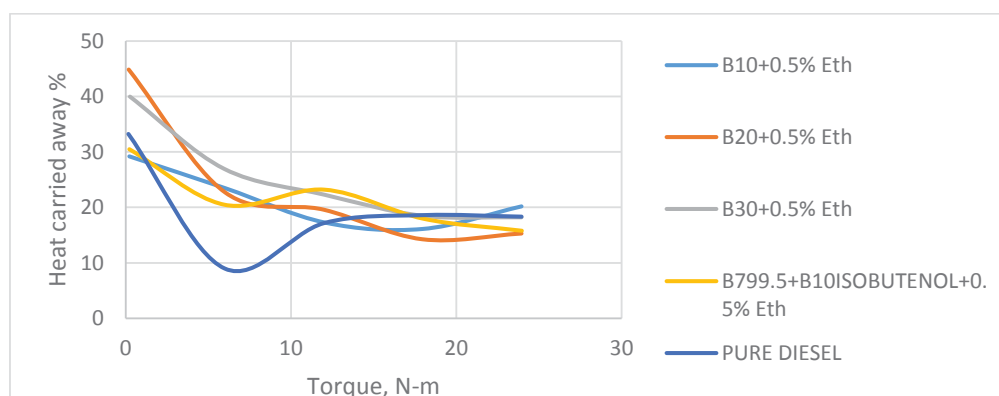
**Graph 6.** Comparison of MSFC and Load

MSFC is the amount of fuel required to produce power. On increasing the torque applied the amount of fuel required to sustain the load is also increased. Rate of consumption of fuel is directly proportional to the viscosity of the fuels there by MSFC is more for the bio diesel although they are mixed in same compositions.

### 3.7 Comparisons of Torque and Heat Unaccounted:



**Graph 7.** Comparison of Heat Unaccounted and Torque



**Graph 8.** Comparison of Heat carried away and Torque

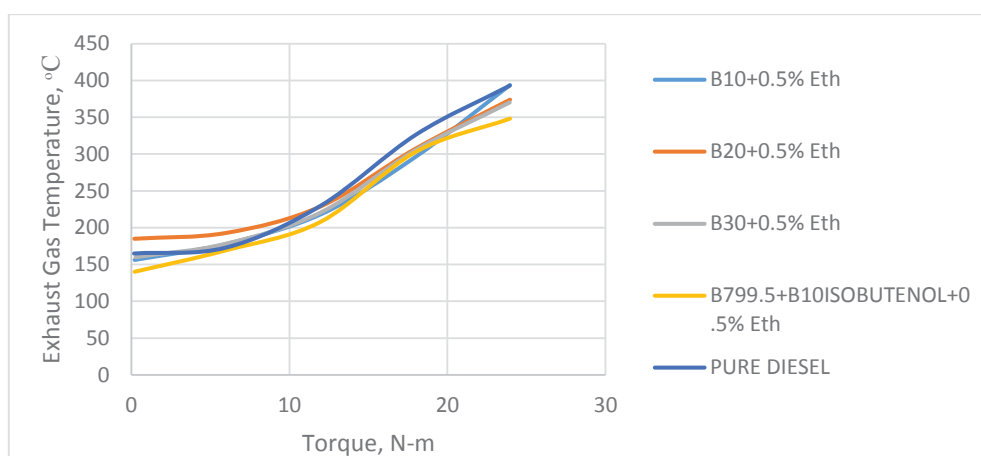


Unaccounted amount of heat for bio diesels is slightly varying when compared to diesel. As only some part of the power developed is utilized to run the vehicle, the rest of the energy is lost as for blow down losses, exhaust loss and due to frictional losses.

Though some part of heat lost was being utilized for raising the temperature of the coolant and the lubrication oil and pumping losses, these losses were fallen into unaccountable losses and it is inappropriate to include them in accountable heat.

As shown in the **graph 5**, unaccounted heat is gradually increased on increasing the torque condition and rapid increase in heat unaccounted can be noticed for the diesel for the maximum condition and heat carried away is decreasing on adding of the torque as the mechanical efficiency is increased for all the fuels.

### 3.8 Comparisons of Load and Exhaust Temperature:



**Graph 9.** Comparison of Exhaust Temperature and Torque

Generally rise in exhaust temperature is due to increase of the horse power. Combustion of the engine increases the exhaust temperature as 35% of generated energy is lost due to exhaust emissions. From the **graph 6**, Exhaust temperature of the fuels increased on increasing the torque. As more amount of energy is required on increasing the load on the engine, working temperature will be increased there by exhaust temperature is also raised.

## CONCLUSION

Considering the above results, current experiment proves Palmsterin oil can also be valuably used as a significant fuel substitute in transportation. This study can be extended by determining the as IP, BP,  $\eta_{bth}$ ,  $\eta_m$ , ISFC, BSFC, IMEP, MFC, Exhaust Gas Temperature, Heat Release and heat balance and the environment impacts and energy analysis to improve the production of Vegetable and Animal Oils. Palm Sterin blends added with etchants give better efficiency and other results when comparing with the results of Palmsterin blends with etchant. IMEP is increased between torques 15 and 20 N-m while Mechanical Efficiency of B30 is increased between same torques compared to other fuels which are noticeably same. As the exhaust gas temperature is comparatively same for diesel and blends which represents the combustion rate.

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