

# Experimental Investigation of Palm Biodiesel with Nanomaterial as a Fuel Additive on Performance and Emission of Diesel Engine

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**ABSTRACT:** As the petroleum reserves are depleting at a faster rate due to the growth of population and subsequent energy utilization, an urgent need for search of renewable alternative fuel arise. Also the treat of global warming and stringent government regulation made the engine manufacturer and consumers to follow the emission norms to save the environment from pollution. This paper reveals the results of experimental investigations on a four stroke, single cylinder, D.I. diesel engine with various blends of Biodiesel at atmospheric temperature. The findings of performance and emission investigations are compared with different blends of palm biodiesel with and without nanomaterial additive. The results indicate that with fuel additive, at different blends (B20, B40, B60, B80 and B100) brake thermal efficiency is less and brake specific fuel consumption is more, while emission parameters such as smoke density, HC and NO<sub>x</sub> are appreciably less.

**KEYWORDS:** BTE, BSFC, smoke density, HC, NO<sub>x</sub>, cerium oxide nanomaterial etc.

## I. INTRODUCTION

Although diesel engines are usually more efficient than petrol engines, emissions from the diesel engine are typically at higher end. This has resulted to some extent negative impact on its wide acceptance and use, especially in application of auto-motives. In recent times, stringent emission legislation has been imposed worldwide on the oxides of nitrogen (NO<sub>x</sub>), particulate matter and smoke emitted from automotive diesel engine and this has posed serious challenges to the researchers and engine manufacturers. These aspects have drawn the attention to conserve and stretch the oil reserves by conducting research on alternative fuels [14] [15]. In view of this, researchers found that vegetable oil is a potential substitute because it has several advantages such as it is renewable, environment-friendly also high yield crops exist in rural areas. Therefore, in recent years, systemic efforts have been made by several researchers to consider and use vegetable oils as fuel in engines. Vegetable oil esters are receiving increasing attention as a non-toxic, renewable and biodegradable alternative diesel fuel. These esters have become known as biodiesel [2][1][15][9].

Biodiesel use requires virtually no changes in the fuel injection system and is technically viable with petroleum-derived diesel fuel. Many studies have shown that the properties of biodiesel are near about similar to diesel fuel. Therefore, biodiesel can be used in diesel engines with minor or without any modifications. Biodiesel has high viscosity, density, iodine value and poor non-volatility, which leads in poor combustion, atomization problem and pumping problem inside the combustion chamber of a diesel engine. In case of longer use of vegetable oils in CI engines, problems such as gumming, injector fouling, piston ring sticking and lubricating oil contamination are bound to occur [4][5]. The solution to the issues has been advances in several ways, such as preheating the oils, blending them with diesel, transesterification and thermal cracking. Transesterification, or alcoholysis, is the reaction of a fat or oil with an alcohol to form esters and glycerol [13][12][10]. According to research, the use of cerium oxide nanomaterial as an additive with biodiesel showed very significant results in terms of emission. The cerium oxide acts as an oxygen donating

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catalyst and provides oxygen for the CO oxidation or the reduction of Nox by absorbs oxygen. The activation energy of cerium oxide acts to burn off carbon deposits in the engine cylinder at the temperature of wall and prevents the deposition of non-polar compounds on the cylinder wall results reduction in HC emissions [15]. The tests revealed that cerium oxide nanoparticles can be used as additive in diesel-biodiesel blend to improve complete combustion of the fuel and reduce the exhaust emissions significantly [14][7][6][11][3]. The objective of this work is to test palm biodiesel and its blends at atmospheric temperature with and without nanomaterial additive (cerium oxide) at constant load condition.

The properties of Palm biodiesel are given in Table no. 1 [13][8].

**Table 1.** Properties of palm biodiesel

|  |                    |
|--|--------------------|
| Calorific Value, kJ/kg                             | 37254              |
| Density @ 15 <sup>0</sup> C, kg/m <sup>3</sup>     | 875.1              |
| Calorific Value, kJ/kg                             | 37254              |
| Specific gravity @15 <sup>0</sup> C                | 0.8722             |
| Pour Point   | -12 <sup>0</sup> C |
| Cloud Point  | Not Applicable     |
| Flash Point  | 175 <sup>0</sup> C |
| Ash content  | 0.001%             |
| Viscosity at 40 <sup>0</sup> C, mm <sup>2</sup> /s | 4.1                |
| Cetane number                                      | 52                 |
| Visual appearance                                  | Dark Brown liquid  |

## II. EXPERIMENTATION AND EXPERIMENTAL SETUP

The experimentation was conducted out to study the performance and emission characteristics of palm oil biodiesel. Biodiesel (B100) and its blends B20, B40, B60, B80 with and without additive (cerium oxide) were used to test the engine of the specifications indicated in Table.2. The experiments were carried out on a single cylinder, 4 stroke D.I. diesel engine. No engine modifications were done. 3gm of cerium oxide in 1 litre of each biodiesel blend was used and stirred it manually for near about 15-20 min unless and until all the nano-particle of additives gets completely dissolved into biodiesel and biodiesel blends. The engine was loaded using the eddy current dynamometer. The engine speed in rpm was sensed using a sensor pre-installed in the eddy current dynamometer and was noted from the display on the control panel of the dynamometer.

**Table 2.** Specifications of engine

|                   |  |
|-------------------|--|
| Type              | Single-cylinder, four-stroke, compression ignition diesel engine |
| Bore              | 80 mm  |
| Stroke            | 110 mm   |
| Compression ratio | 16.5:1   |
| Rated speed       | 1500 rpm   |
| Rated output      | 3.7 kW   |
| Dynamometer       | Eddy current, water-cooled with loading unit                     |

The constant engine load corresponding to various blends of biodiesel was maintained. At each blend, the engine was made steady for 20 minutes and then performance and emission parameters were measured. The various graphs were plotted between Brake thermal efficiency and Biodiesel blend, BSFC and Biodiesel blend, Smoke density and Biodiesel blend, HC and Biodiesel blend and also between NOx and Biodiesel blend.

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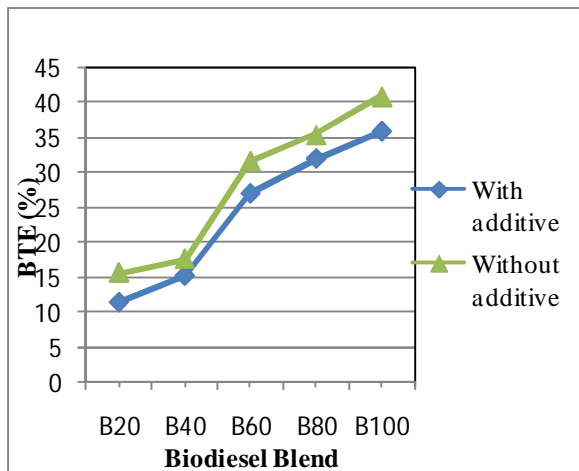


Figure 1. BTE vs Biodiesel blend

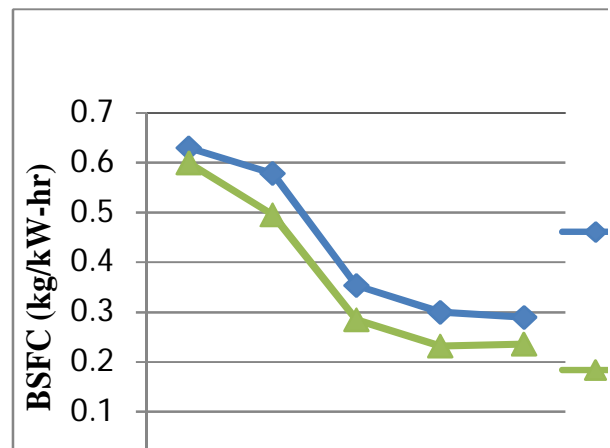


Figure 2. BSFC vs Biodiesel blend

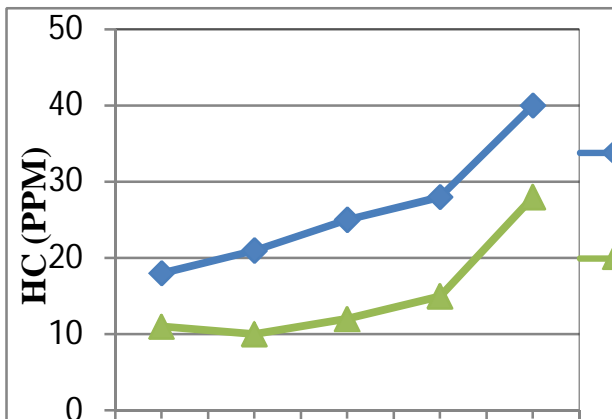


Figure 3. HC vs Biodiesel blend

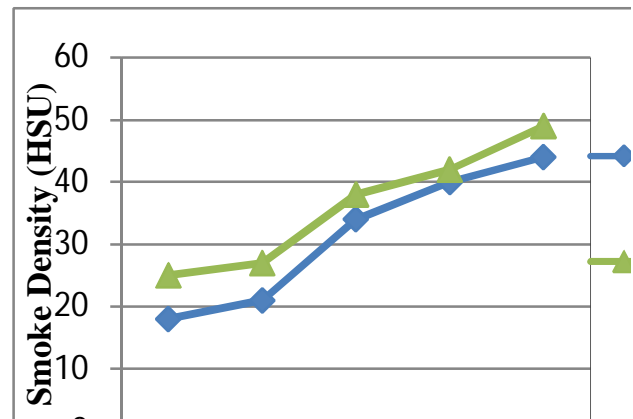


Figure 4. Smoke Density vs Biodiesel blend

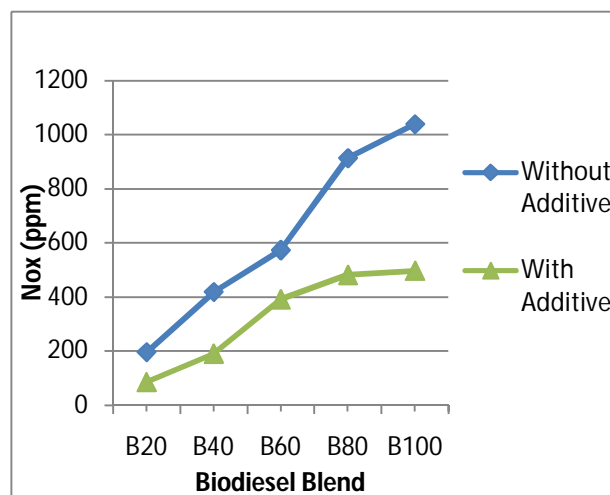


Figure 5. NOx vs Biodiesel blend

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## III. RESULTS AND DISCUSSIONS

### A. BRAKE THERMAL EFFICIENCY:

The variation of brake thermal efficiency with various biodiesel blend is shown in figure 1. In all cases it increases with increase in biodiesel blend. This is due to a reduction in heat loss and increase in power. The trend is approximately same for all blends but is slightly less as compared to biodiesel with additive.

### B. BRAKE SPECIFIC FUEL CONSUMPTION:

The variation of brake specific fuel consumption is shown in figure 2. For all blends tested, brake-specific fuel consumption decreases with increase in proportion of biodiesel blend. The overall characteristics of palm oil biodiesel with and without cerium oxide are similar. This is due to the mutual effect of low heating value and high density of palm oil biodiesel. Cerium oxide oxidizes the carbon deposits in the engine leading to effective operation and reduced fuel consumption. Corresponding to the efficiency characteristics, the specific fuel consumption will decrease with an increase in the dosing level of nanoparticles.

### C. HC:

Figure 3. Indicates the variation of HC with respect to different biodiesel blends, where HC emission is found to be significantly reduced on the addition of the Cerium oxide. It acts as an oxidation catalyst also lowers the carbon combustion commencement temperature and thus improves hydrocarbon oxidation, promoting complete combustion.

### D. SMOKE DENSITY:

The variation of smoke density is shown in figure 4. For all blends tested, smoke density increases with increase in biodiesel blend proportion. The smoke density increases with increase in blends is due to incomplete combustion of fuel, but smoke density is less while using additive as compared to without additive. This is because the use of oxygenated fuel improves better combustion which reduces smoke significantly.

### E. NO<sub>x</sub>:

Observation has been made on the level of the NO<sub>x</sub> emissions from biodiesel, in the pure form and in the modified form is shown in figure 5. Due to high thermal stability of cerium oxide, it maintains less combustion temperature as nanomaterial particles absorb the heat produced. Hence it is found reduced NO<sub>x</sub> emission level using cerium oxide as an additive.

## IV. CONCLUSION

Based on experimentation and analysis of Palm biodiesel with and without cerium oxide as a fuel additive, it revealed that cerium oxide nanoparticles can be used as an additive in diesel-biodiesel blend to improve complete combustion of the fuel and reduce the exhaust emissions significantly. Also there is future scope in experimental investigation in the direction of improvement of performance and more reduce emission characteristics. Hence in general, large quantity of conventional fuel will be saved with the use of optimized Biodiesel blend with nanomaterial additives.

### ABBREVIATION (for figures)

B20 - Palm Biodiesel 20% +Diesel 80%  
B40 - Palm Biodiesel 40% +Diesel 60%  
B60 - Palm Biodiesel 60% +Diesel 40%  
B80 - Palm Biodiesel 80%+Diesel 20%

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B100- Palm Biodiesel 100%  
BSFC - Brake Specific Fuel Consumption (kg/kW h)  
BTE – Brake Thermal Efficiency (%)  
HC – Hydro carbon (ppm)  
Nox – Nitrogen oxide (ppm)

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