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Effect of Al_2o_3 Nano Particles with Di-Ethyl Ether Mixed in Bio-Diesel (Rbme) on Performance and Emission Characteristics of Ci Engine

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Abstract:
At present scenario fossil fuels are most commonly used as energy resources. In these resources diesel is widely used for transportation and also in industrialization due to its reliability, high thermal efficiency and effectiveness, but it also releases high NO_x and particulate matter which has a great concern over the environment. To Minimize the usage of Diesel, Biodiesel is introduced, which is produced from edible and non-edible vegetable oils. Although it releases low NO_x emissions, it has low thermal efficiency high particulate matter and other gases in emissions. To overcome the situation some additives are added to increase combustion efficiency and lowering emissions. In this experimental work, biodiesel is prepared from Rice Bran Oil. Engine tests have been conducted to get the comparative measures of Specific Fuel Consumption (SFC), Brake Thermal Efficiency (η_{Th}) and Emission components like CO, HC, NO_X & O_2 are evaluated to study the behavior of B80, B60, B40 added with 20ppm Aluminum Oxide (Al_2O_3) nanoparticles and 5% Di-Ethyl Ether (DEE) at various loading conditions with standard diesel operation. It is observed that there is slight increase in the specific fuel consumption for the fuel B60 with 20 ppm Al_2O_3 and 5% Di-Ethyl Ether at full load operation. The brake thermal efficiency is matching than that of diesel operation at full load operation. A significant improvement in Emission components CO, CO2 & NO_X has been observed when the engine is fed with B60 and B80 with additives at both $3/4^{th}$ Full Load and Full Load conditions. However, HC emissions had increased. Keeping in view of performance and emission analysis the fuel blend B60 with 20 ppm Al_2O_3 Nano particles along with 5% DDE is the best combination.

Keywords: Rice Bran oil Methyl Ester (RBME), B40 (40% RBME and 60% of Diesel), B60 (60% RBME and 40% of Diesel), B80 (80% RBME and 20% of Diesel), DEE (Di-Ethyl Ether), Aluminum Oxide (Al_2O_3), Brake Thermal Efficiency(BTE), Brake Specific Fuel Consumption(BSFC).

I. INTRODUCTION

The utilization of fossil fuels has significant contribution to the global warming and urban air pollution. Therefore, alternate fuels which are sustainable in terms of supply and lesser environmental implications are required. Biodiesel has CI engine compatible fuel characteristics and being used as diesel substitute with minimum modifications to the engine. Usage of Bio-Diesel prepared from various vegetable oils has already taken place in many countries. Bio-Diesels gave performance and emission characteristics closer to Diesel fuel. So it's a good alternative for fossil fuels [1]. However, because of its high viscosity and low value of volatility most of the biodiesels produced from vegetable oil are limited to their direct usage in engines without any modifications. High viscosity linked with fuel jet penetration, atomization and produces thick smoke in the exhaust. Diesel engines with biodiesel produce the same power output with lower thermal efficiency and increased emissions. The addition of Al_2O_3 Nano particles and Di-Ethyl Ether will improve the performance and emissions characteristics. In this project "Performance and Emissions of a single cylinder four stroke DI diesel engine fueled with **RBME blends** (B40, B60, B80) with an addition of 20PPM of Al_2O_3 and 5% of DEE are compared with standard diesel operation Nano-Particles and Fuel-Additives are added to the fuel for effective combustion, good performance and low emission. The Metal Oxide (Al_2O_3) nanoparticles are used as fuel additives which reduce diesel emissions. The commonly used Nano metal oxides which are used as combustion catalysts for hydrocarbon fuels are Aluminum, Titanium, Manganese, Iron, Cerium, Copper, Barium and Platinum. These metal oxides additives are reduced diesel engine emissions and fuel consumption [10] [12]. These additives donates oxygen for the oxidation of unburned hydrocarbons and carbon monoxide thus can improve brake thermal efficiency and reduce specific fuel consumption and reduces emissions at full loads. [9] [10] [11]. Somewhere nanoparticles used as catalyst for Trans-esterification process by immersing it in NaOH solution [8]. Diethyl ether is an organic compound in the ether class with the formula $(C_2H_5)_2O$. It is highly volatile and flammable liquid. It is commonly used as a solvent in laboratories. DEE has a high cetane number of 85-96 and is used as a starting fluid, in combination with petroleum distillates for gasoline and Diesel engines because of its high volatility and low flash point. DEE is an Oxygenated additive. It reduces the NO_X emission when it is mixed with Bio-Diesel. And also increases the better performance and combustion characteristics. By increasing of DEE content, leads to the lowering of SFC and increasing the BTE [2] [3] [4] [5].

II. BIODIESEL PREPARATION

Transesterification

Biodiesel is used in substitution of diesel, which is produced from vegetable oil (edible & non-edible) reacts with methanol in the presence of catalyst, which is known as transesterification. Here we used Rice Bran oil as raw material to produce biodiesel. Triglycerides reacts with methanol to form Di-glycerides, followed by mono glyceride and finally results to form fatty acid methyl ester. Base catalyst NaOH was used with Methanol. Fig. I to IV shows the various stages of transesterification process. The properties of the Biodiesel blends with additives (5% DEE, 20 ppm Al_2O_3) is shown in Table I

Figure.1. heating raw oil 65°c

Figure.2. stirring after addition of sodium meth oxide


Figure.3. separation of biodiesel from glycerol


Figure.4. final pure bio-diesel

Nanoparticles Dispersion

Nano-particles [20ppm (0.2gms) of Al_2O_3] were added per liter of Biodiesel. Nanoparticles are dispersed into Bio-Diesel in the recommended composition using an Ultrasonicator at frequency of 40kHz for 30 minutes by maintaining temperature of 60°C. It is best technique to disperse nanoparticles without formation of precipitate as because it may lead to block the fuel injector nozzle. Nanoparticles are also dispersed into Biodiesel by continuous stirring for 1hr with low speed, without producing turbulence. The Fig. V and Fig.VI depicts the dispersion of Nano-particles using ultrasonicator. The specifications of the nanoparticles used is shows in Table II

Table.1. Properties of Fuel Blends

S.No	Characteristics	Fuel Samples			
		Diesel	B40 + Al2O3 + DEE	B60 + Al2O3 + DEE	B80 + Al2O3 + DEE
1	Density (Room Temp) Kg/M^3	850	855	860	875
2	Kinematic Viscosity (at 40°C) C.St	3.72	4.10	4.10	4.37
3	Calorific value (kj/Kg)	44800	43100	42300	41500
4	Flash point	62	94	98	108
5	Fire point	65	105	112	125

Figure.5.al₂o₃ nano particles


Figure.6. nanoparticles dis persion in ultrasonicator

Table.2. Specifications of Al_2o_3 Nano Powder

Chemical Name	Gamma Aluminum Oxide, Nano powder, gamma phase, 99.9%
Average particle size	< 50 NM
Appearance	White Powder
Molecular weight	101.96g/mol
Melting point	2040 ºC
Boiling point	2980 ºC
Surface area	>40 m^2/g
Density	4.0 g/cm^3

Addition of Di-Ethyl Ether

Di-Ethyl Ether is an oxygenated additive which increase the Combustion rate and reduce the emissions. Here 5% of is added to this mixture of Biodiesel blends and Al_2O_3 Nano-particles. The final mixture is stirred thoroughly using a magnetic stirrer. The specifications of DEE are shown in Table III as specified by the manufacturer.

Figure.7. Di-Ethyl Ether

Table.3. Specifications of Dee

Chemical Name	Diethyl ether EMPLURA
Chemical formula	$(C_2H_5)_2O$
Molar mass	74.12 g/mol
Ignition temperature	180 °C
Solubility	69 g/l (20 °C)
Melting point	-116.3 °C
Boiling point	34.6 °C (1013 hPa)
Flash point	-40 °C
Explosion limit	1.7 - 36 %(V)
Vapor pressure	587 hPa (20 °C)
Density	0.71 g/cm^3

III. EXPERIMENTAL SETUP

The experimental Setup Consists of a Four-Stroke single cylinder, water cooled high speed direct injection CI engine which is coupled with Rope-Brake Drum Dynamometer as shown in the Fig VIII and load is varied by adding weights on Rope as shown in Fig. IX. The specifications of the engine are tabulated in Table IV. Exhaust Gas analyzer probe is inserted into the engine exhaust manifold to analyze the emissions, and exhaust gas temperature was measured with thermocouples connected to digital Indicator.

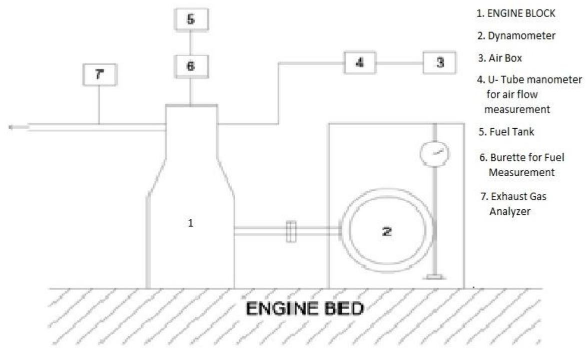

Figure.8. Layout of The Experimental Setup

Engine Specification

Table.4. Engine Specifications

S.No	COMPONENT	DESCRIPTION
1	Engine	Single Cylinder KIRLOSKAR AV1 engine
2	No.Of Strokes	4-Stroke Engine
3	Type of Cooling	Water Cooled
4	Max Power	5HP
5	Bore (in mm)	80 mm
6	Stroke Length	110 mm
7	Compression Ratio	17:1
8	Cubic capacity	0.553 Ltr
9	Engine Speed	1500 rpm
10	Dynamometer Type	Brake Drum Loading
11	Air Box	M S Fabricated with Orifice meter
13	Type of injection	Direct Injection
14	Temperature sensors	Thermocouple at engine exhaust manifold
15	Exhaust Gas Sensors	INDUS PAE-250.N gas analyzer

Figure.9. Experimental Setup

Exhaust Gas Analyzer

INDUS PAE-250N Exhaust Gas Analyzer is used to measure the emission components like CO, CO2 HC, O2, & NOX.

Figure .10. analyzer displaying emissions

Figure.11. analyzer rear view

The gas analyzer works on Non- Dispersive Infra-Red (NDIR) principle for measuring CO, C02 & HC emissions and *Electro chemiluminescence* (ECL) for measuring O2 & NOx. Fig. X & XI shows the front and rear views of the analyzer used in this experimentation. Table 3.2 shows the specifications of the five-gas analyzer.

Table.5. Gas Analyzer Specification

Description	**Specification**
Gases Measured	Carbon Monoxide, Carbon Dioxide, Oxygen, Oxides of Nitrogen, Hydrocarbon
Principle	NDIR & Electrochemical
Range	HC: 0-30000ppm, CO: 0-15%, CO_2: 0-20%, O_2: 0-25%, NO_X: 0-5000ppm
Accuracy	CO: ±0.06, CO_2: ±0.5, O_2: ±0.1, HC: ±12
Gas flow rate	1Litre/Min
Sample Handling System	S.S. probe, PU tubing with easily detachable connectors, water separator cum filter, disposable particulate fine filter.
Sample Extraction	With a built-in-pump- Auto ON/OFF
Data communication	RS232 interface for computer connectivity
Other Features	1. Automatic fresh air intake during Auto Zero 2. Line leak check facility 3. Lambda for Petrol & CNG Engines

IV. RESULTS AND DISCUSSIONS

Brake Specific Fuel Consumption

The brake specific fuel consumption as shown in Fig. XII was increased with the increase in the dilution of diesel with biodiesel (RBME). At full load operation the BSFC for fuel blend B60 with Nano and DDE additives is 0.39 Kg/Kw hr compared to 0.36 Kg/Kw hr for diesel operation. For the B80 with Nano and DDE additives an increase in 19.44% is measured. Hence B60 with additives is proved to be the best blend in this context.

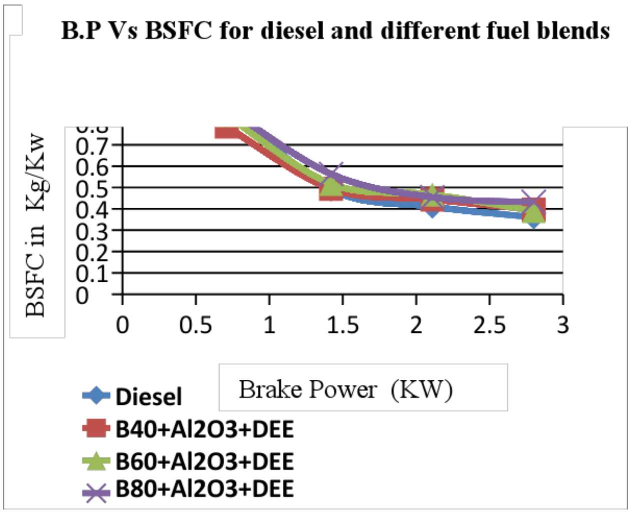

Figure.12. variation of bsfc at various loads for different fuel blends with nano additives and diesel

Brake Thermal Efficiency

The brake thermal efficiency at 3/4th full load operation is slightly improved and almost same as that of diesel engine operation at full load. There is tradeoff between the BTE and Emission components. Fig XIII shows the variation of BTE for different blends with additives.

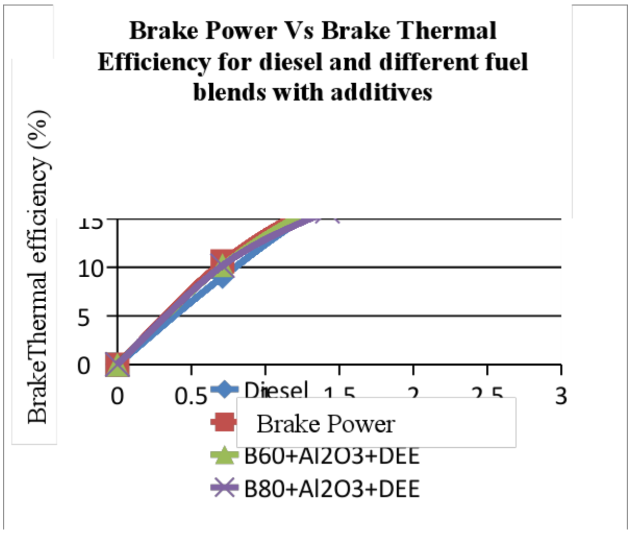

Figure.13. variation of bte at various loads for different fuel blends with nano additives and diesel

Emission Analysis

Oxides of Nitrogen (NO_X)

At 3/4th full load the oxides of Nitrogen (NO_X) emissions is decreased by 12.8%, 22.7% & 37.8% when the engine is fueled with B40, B60, B80 with Al_2O_3 Nano particle and 5% DEE respectively. At full load a reduction of 19.8%, 23.4% & 35.5% of NOX is observed at the above fuel blends when compared to diesel engine operation as shown in Fig. XIV. The reduction of NO_x is attributed to the decrease in the exhaust gas temperature with higher percentages of biodiesel in the mixture. Considering the other emission components, B60 with the Nano and DEE additive is the better blend.

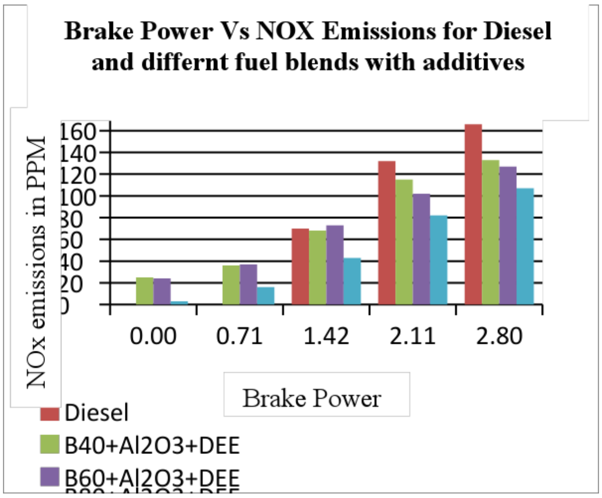

Figure. 14. variation of no_x for different fuel blends

Carbon monoxide (CO)

The carbon monoxide emissions had improved by 25.7% at 3/4th full load for B80 with additives when compared to diesel operation due to biodiesel and DEE concentration, the oxygen present in them will support a better combustion. However, an increase of 11.4% for the same blend is observed at full load as shown in Fig. XV is observed.

Hydro carbons (HC)

The hydrocarbon emissions are not so encouraging. Fig. XVI shows the steep rise in the HC Emissions for B80 with additives at full load. However, a marginal increase is observed at half and 3/4th full load operation.

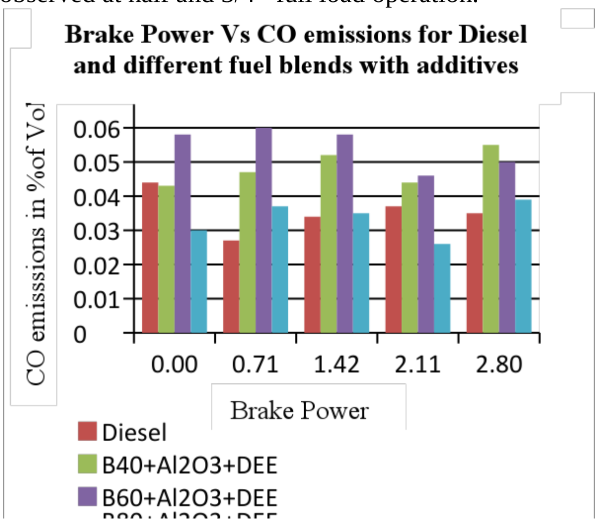

Figure.15. Variation Of Co Emissions With Different Fuel Blends

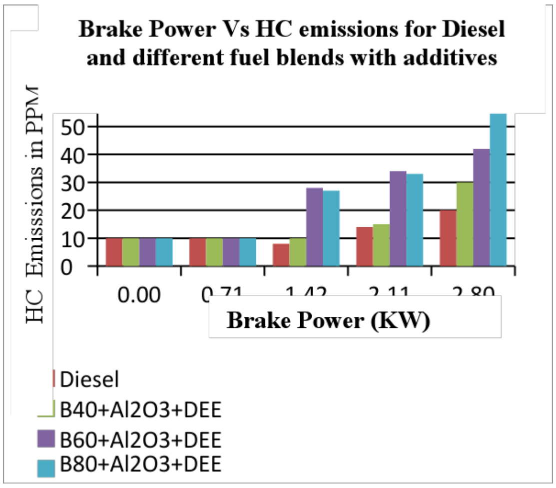

Figure.16. variation of hc emissions for different fuel blends

Carbon -dioxide (CO2) and O_2 Emissions

A significant reduction in carbon dioxide is achieved for the fuel blend B80 with 20 ppm Nano particles and 5% DEE at both 3/4th full load and full load conditions as shown in Fig.XVII. For the blend B60 with additives a slight reduction in CO_2 is observed. There is no much changes in the O_2 emissions are noted as depicted in the Fig. XVIII

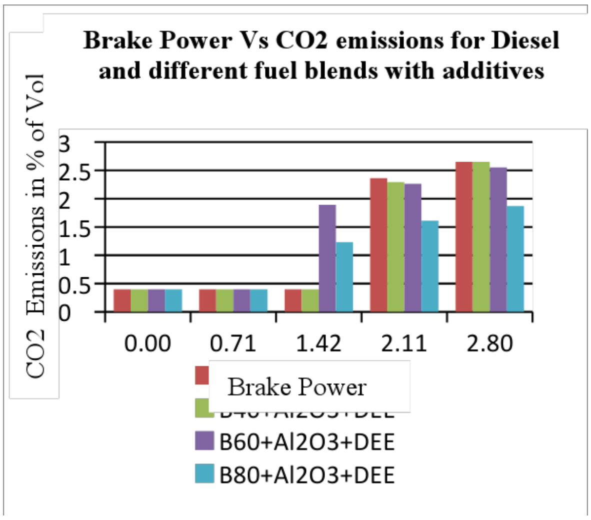

Figure.17. variation of co_2 emissions for different fuel blends

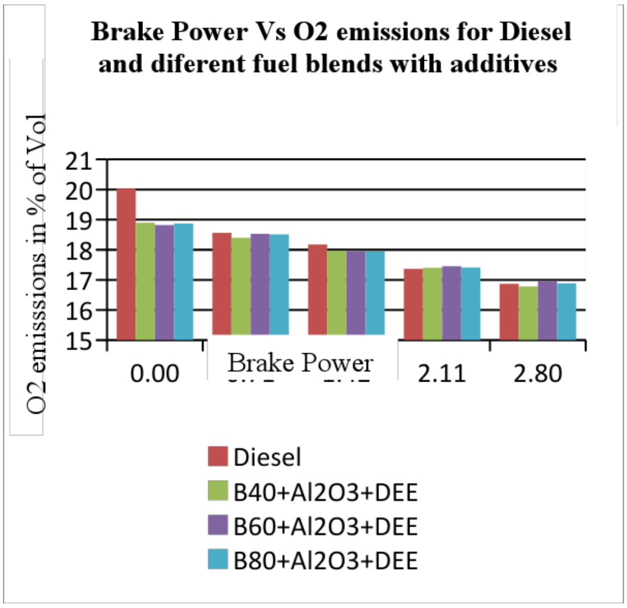

Figure.18. variation of o_2 emissions for different fuel blends

V. CONCLUDING REMARKS

- The brake specific fuel consumption and Brake thermal efficiency is nearly equal when the engine is fed with a mixture of B60, 20 ppm Nano particles & 5% Di-Ethyl Ether at full load operation. Even though there is an increase in BSFC the emission parameters like NO_X, CO_2 had reduced considerably. Therefore, B60 with 20 ppm Nano particles & 5% Di-Ethyl Ether is proved to be the best combination.
- The Oxides of Nitrogen had considerably reduced by 23.4% & 35.5% for B60, B80 with the mentioned additives at full load conditions respectively as Di-Ethyl Ether is an Oxygenated additive which reduces the NOx emission when it is mixed with Bio-Diesel. Even though the reduction in NO_X is higher when fuel blend B80 with additives is used, we conclude that B60 with 20 ppm Nano particles & 5% Di-Ethyl Ether is the better fuel blend as compared with the other emission and performance parameters.
- The CO and CO_2 emissions are improved when the engine is run with B60 & B80 with additives. In this context, the **blend B60 with 20 ppm Nano particles & 5% Di-Ethyl Ether is preferred as the best blend** as there is always a trade-off between the parameters.

VI. FUTURE SCOPE

The effect of engine wear and degradation of lubricating oil can be evaluated with the use of biodiesel along with Al_2O_3 Nano particle and 5% Di-Ethyl Ether. The particulate matter and smoke levels can also be tested for further investigations. The compression ratios can also be varied to know the optimum compression ratio with these blends and additives.

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