Experimental Investigation of The Effect of Nano Additives With Biodiesel in CI Engine

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Abstract: An experimental investigation was carried out to understand the effect of performance and emission characteristics of a single cylinder four stroke direct injection kirloskar Diesel engine with the addition of cerium oxide nanoparticles in Diesel-camphor Bio-Diesel blends. The experiments were performed on C.I. Engine for Bio-Diesel blends of B-10, B-15 and B-20 and find out the best resulted blend (BR) in which it gives better performance characteristics and minimum emission characteristics. With the best resulted blend, add various concentrations of 30, 60 and 90 ppm of nanoparticles mixed with ultrasonicator and perform experiments. Calculate the performance and emission characteristics for different concentrations of nanoparticles and compared the results among the fuel blends.

Keywords: Camphor Biodiesel, Cerium Oxide nanoparticles, diesel engine, Performance and Emission characteristics, Ultrasonicator.

I. INTRODUCTION

Vehicles are increasing day by day, there by the usage of fossil fuels is also increasing exponentially. Till now we are depending on hydrocarbon fossil fuels which are non-renewable and also they are producing huge amount of harmful emissions. As the hydrocarbon fuel reserves are depleting in a faster way due to the population explosion and improved technology which uses higher fuel energy consumption, it is much required an alternative renewable fuel. The governments and organizations like pollution control board etc., are imposing extra taxes or fines on the vehicle manufacturers as well as on the customers those who violate the emission norms for their vehicles. In recent, BS –III vehicles are banned in metro cities like Delhi, Bangalore etc. To avoid all these problems, we need alternative fuels which decrease harmful emissions, and the fuels which are renewable in nature. Biodiesel from vegetable oils is one of the renewable alternative fuels that are used in a diesel engine with or without doing some modifications like decreasing viscosity or removing fatty acids etc., by using esterification and transesterification processes. The use of biodiesel increases the oxygen content in the combustion, which improves the combustion efficiency. The properties of biodiesels like density, viscosity, calorific value etc., are also similar to that of diesel.

A. CAMPHOR OIL

Camphor essential oil is derived from the camphor trees native to parts of Asia, particularly Japan, China, and Taiwan. These days, the trees are also cultivated in India, Egypt, South Africa and Sri Lanka. In the production of camphor tree products and white camphor oil, Taiwan is the largest producer in the world. The scientific name of camphor tree is Cinnamon Camphora, other names include Laurus camphora, Hon-Sho, and True camphor. The camphor essential oil is generally extracting from the old trees with a minimum age of 50 years. These trees are long growing trees which are about 35 meters tall. The oil is extracted with the steam distillation of different parts of the trees which includes the branches, root stumps, flowers and chipped wood. The filtered products are undergone for successive processes like pressing, distillation and rectified under vacuum. This camphor essential oil has good durable and aromatic properties. The molecular formula of camphor oil is $C_{10}H_{16}O$. Molecular weight is 152.23 g/mol.

B. CERIUM OXIDE NANOPARTICLES

There are some interesting properties of nanoparticles such as higher surface area, catalytic activity, thermal conductivity and chemical properties are significantly different from their bulk or normally available form. Nanoparticles are used to improve the brake thermal efficiency and to reduce the amount of harmful emissions, smoke, specific fuel consumption and ignition delay. In the experimental investigation Cerium Oxide (CeO_2) nanoparticles were used as additive to biodiesel blend with a size of 10 to 30 nanometers which are available commercially. The purity of the nanoparticles is 99% and they are cubic phase in its structure. For three different

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samples, the concentration of CeO_2 used is of 30 ppm, 60ppm and 90 ppm on weight basis.

The properties of the diesel, camphor oil and the combination of diesel and cerium oxide nanoparticles:

Properties	Units	Diesel	Camphor Oil	Diesel + Cerium Oxide
Kinematic Viscosity at 40^0C	cSt	3.4	1.9	3.65
Density at 15^0C	Kg/m^3	840	894.2	837.5
Flash Point	^{0}C	50	51	11
Fire Point	^{0}C	72	68	14
Cetane Number	-	46	50	44.6
Calorific value	kJ/Kg	42700	38200	39000

Table 1.1 Properties of Fuel

II. METHODOLOGY

The experiments were conducted on Single Cylinder four stroke Direct Injection Combustion Ignition Engine for biodiesel blends of B-10, B-15 and B-20 and find out the best resulted blend (BR - which is any of B-10, B-15 or B-20) which gives better performance characteristics and produce lower emissions. With the best resulted blend, add different concentrations of 30 ppm, 60 ppm and 90ppm of nanoparticles mixed with ultrasonicator and perform experiments. Calculate the performance and emission characteristics and analyze the results. Analyze and compare the results with four different fuel series: Biodiesel-Diesel (BR-D85), Biodiesel-Diesel-Nano additive (BR-D85-N30), Biodiesel-Diesel-Nano additive (BR-D85-N60) and Biodiesel-Diesel-Nano additive (BR-D85-N90). The required weight of the nanoparticle dosage for each sample measured with the help of precision electronic balance and mixing process was done with an ultrasonic shaker, by applying a constant agitation for at least 30 minutes to produce a uniform dispersion of nanoparticles in the liquid fuel. The nano particle dispersion fuel was utilized immediately after the preparation, in order to avoid sedimentation or any settling down to occur.

AVL Di-gas analyzer is an exhaust gas measuring instrument which measures the exhaust emissions concentrations such as hydrocarbons (HC), carbon monoxide, carbon dioxide and oxides of Nitrogen (NO_X) from the exhaust of combustion ignition engine. This gas analyzer has two cables. One is fitted at the exhaust of the engine pipe and the other cable is inserted into the inlet of the gas analyzer.

The gases from the exhaust of the engine are passed through two elements which are moisture separator and filter element are used to trap the emission particulates and vapor. The concentrations of different emissions are measured in different units. The Carbon Monoxide (CO) is measured in volume percentage (%) of the exhaust air, the concentrations of the hydrocarbons (HC) and oxides of Nitrogen (NO_X) are measured in ppm (parts per million). Selective absorption principle is used to measure the emissions. For the four fuel series, which are mentioned in the methodology, the performance and emission experiments were conducted and the effect of Nano particles was analyzed.

Fig: Diesel Engine

III. EXPERIMENTAL SET UP

Engine Parameter	Specifications
Engine	Kirloskar, Single cylinder, Four stroke, Direct injection C.I. Engine
Engine type	Water cooled
Bore × Stroke	87.5 mm × 110 mm
Compression Ratio	17.5:1
Rated speed	1500 rpm
Rated power	5 HP

Table 3: Engine Specifications

The Kirloskar is a single cylinder, four stroke, vertical, water cooled, direct injection diesel fuelled engine. The engine is to produce rated power of 5 HP at rated speed of 1500 rpm. Diesel fuel, camphor oil blends and nanoparticle-biodiesel blends were tested in kirloskar engine without any variation in the ignition pressure, operating speed, and ignition timing. AVL Di-gas analyzer is an exhaust gas measuring instrument which measures the exhaust emission concentrations such as hydrocarbons, oxides of carbon and oxides of Nitrogen. The concentration of Carbon Monoxide (CO) is measured in terms of volume percentage whereas the concentrations of the hydrocarbons (HC) and oxides of Nitrogen (NO_X) are measured in terms of ppm (parts per million).

A. Experimental Procedure:

At first the engines is running at no load condition with diesel fuel for the duration of about 10 to 15 minutes, note

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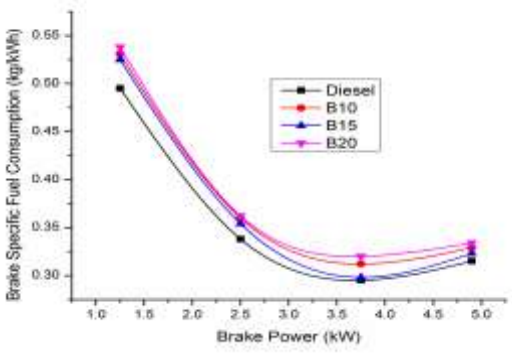
down the time taken for fuel consumption and take the readings of Exhaust Gas Analyzer for emissions measurement. Repeat the same procedure for biodiesel blends of B-10, B-15 and B-20 and find out the best resulted blend. B-15 gave the best results in terms of both performance and emissions. With the best resulted blend (B-15), add various concentrations of 30, 60 and 90ppm of nanoparticles mixed with ultrasonicator for nanoparticle dispersion and perform experiments. The procedure for all the biodiesel blends and Nanoparticle-biodiesel blends are same and note down all the readings. With the noted readings calculate the performance characteristics such as brake thermal efficiency and brake specific fuel consumption and understand the emission readings and finally compare the results among the different fuel blends.

IV. RESULTS

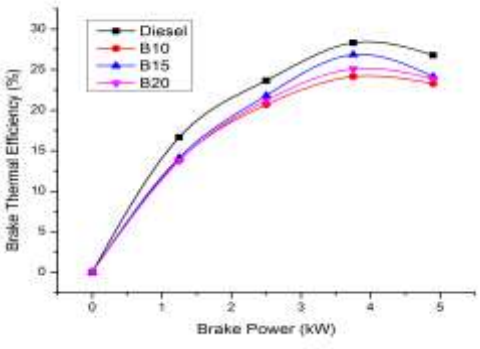
A. PERFORMANCE ANALYSIS (Blends)

In the performance analysis the fuel blend is having better performance characteristics means it is having highest brake thermal efficiency and lowest brake specific fuel consumption compared to other fuel blends.

Performance characteristics such as Brake Thermal Efficiency and Brake Specific Fuel Consumption were measured. Performance characteristic graphs were plotted. One is for Brake Power Vs Brake Thermal Efficiency and the second is for Brake Power Vs Brake Specific Fuel Consumption and we can analyze and compare the results among different blends of fuels.



(A) Brake Power Vs Brake Thermal Efficiency,



(B) Brake Power Vs Brake Specific Fuel Consumption

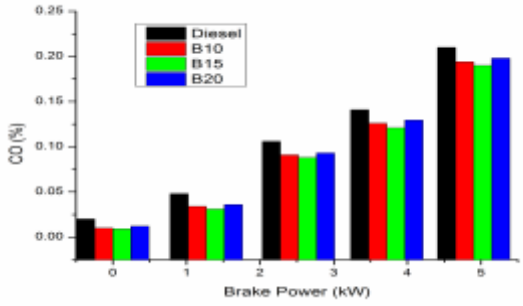
The graph was drawn between Brake power and Brake Thermal Efficiency for Diesel and blends of B-10, B-15 and B-20. The graph (A) shows that, the Brake Thermal Efficiency for Diesel is more (Maximum at 75% of the load i.e., BTE-28.32%) and B15 (BTE-26.84%) is approximately near to diesel compared with other blends.

The graph (B) for Brake Specific Fuel Consumption (BSFC) was drawn for Diesel and for the blends of B-10, B-15 and B-20; Diesel shows the minimum value (BSFC-0.295 Kg/kWh at 75% load) and B-20 shows the highest BSFC at all loads.

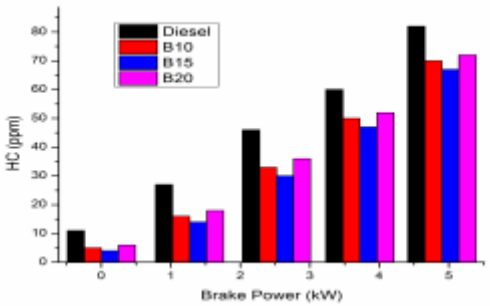
B. EMISSIONS ANALYSIS (Blends)

In emissions analysis, the fuel blend is having better emission characteristics means the fuel blend is producing the lowest oxides of carbon, unburnt hydrocarbons and oxides of NO_X compared with other fuel blends.

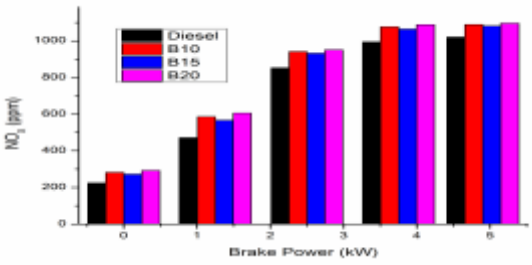
The main constituents of the emissions are Carbon Monoxide (CO), Hydrocarbons (HC) and Oxides of Nitrogen (NO_X). The three types of emissions were measured and graphs were plotted against Brake Power to analyze and compare the results with different blends and also with nanoparticles at various concentrations.



(A) Brake Power Vs HC emissions



(B) Brake Power Vs CO emissions



(C) Brake Power Vs NO_X emissions

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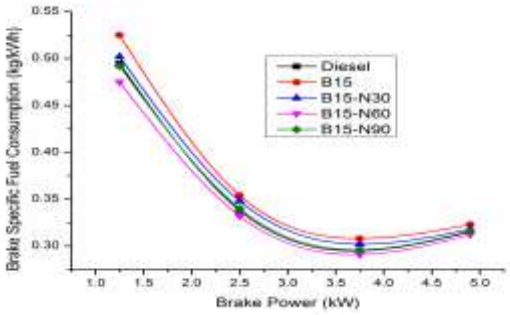
Addition of Camphor biodiesel reduces the HC emissions compared with diesel and the above graph (A) shows that among all, B-15 blend gives the lowest (reduction of 21.67% compared with diesel) HC emissions.

Carbon Monoxide emissions are due to incomplete combustion of fuel. With the use of biodiesel, the amounts of CO emissions were decreased. From the graph (B), B15 produces less CO emissions (about 14.1% reduction) compared with diesel.

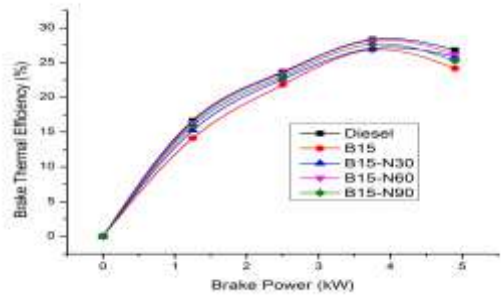
The addition of biodiesel results in higher NO_X emission compared with diesel. The graph (C) shows that Diesel produces less NO_X compared to biodiesel blends, and B-15 produces the second lowest (7.04% more than Diesel) emissions .

CONCLUSION1: The performance and emission results of various blends are analyzed. The results are best for B15 blend compared with other blends in terms of Brake Thermal Efficiency, Brake Specific Fuel Consumption, HC, CO and NO_X emissions.

With the best resulted blend (B-15), add various concentrations of Cerium Oxide Nanoparticles of 30, 60 and 90 ppm on weight basis and compare the results with Diesel.



(A) Brake Power Vs Brake Thermal Efficiency

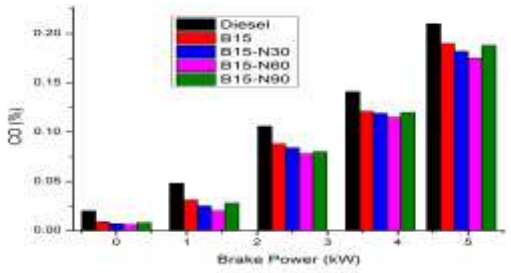


(B) Brake Power Vs Brake Specific Fuel Consumption C.

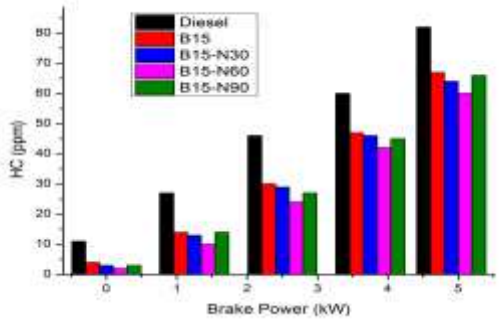
PERFORMANCE ANALYSIS (With CeO_2)

B15 blend is mixed with different concentrations of Cerium Oxide nanoparticles of 30, 60 and 90 ppm, the graph (B) was plotted among diesel, B-15 and other nano additives, which shows that Brake Thermal Efficiency for B-15-N60 gives (BTE-28.17%) approximately equal to the pure diesel which is more than other concentrations.

From the graph (B), Cerium Oxide nanoparticles added with B15 blend, 60 ppm of CeO_2 (BSFC- 0.291 Kg/kWh) gives the lowest BSFC compared with 30 and 90 ppm and also compared with diesel.

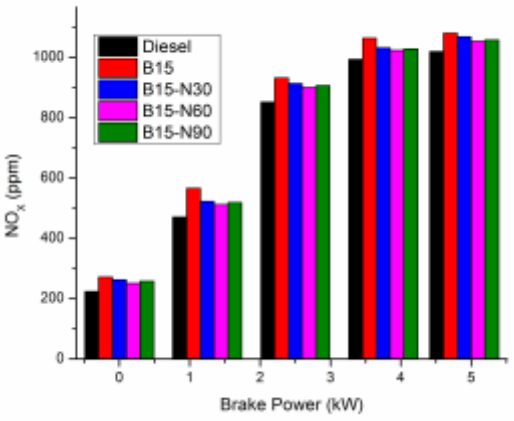


(A) Brake Power Vs HC emissions



(B) Brake Power Vs CO emissions

D. EMISSIONS ANALYSIS (With CeO_2)



(C) Brake Power Vs NO_X emissions

Cerium Oxide nanoparticle acts as an anti-oxidant and improve the combustion efficiency that reduces the HC emissions. The graph (A) shows that, out of 30 and 90ppm of CeO_2, 60 ppm gives the lowest HC emissions which is 30% lower than Diesel emissions.

With the addition of nanoparticles, the amounts of CO emissions are reduced due complete combustion. The graph (B) shows that B15-N60 gives the lowest CO emissions (18.43% reduction compared with Diesel emissions) out of other concentrations.

From the graph (C), we can observe that by adding the Cerium Oxide nanoparticles the amount of NO_X emissions

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are decreased at 60 ppm of CeO_2 compared with 30 and 90 ppm but it is 3.01% more than the Diesel emissions.

V. CONCLUSION

The addition of camphor biodiesel as a blend with concentrations of 10, 15 and 20% with diesel and conducted the experiments and analyze the results of performance and emission characteristics.

- B-15 gives the better performance and emission characteristics but NO_X emissions are more.
- To avail the benefit of Cerium Oxide nanoparticle's anti-oxidant and catalytic properties to improve complete combustion and reduce NO_X, 30, 60 and 90 ppm concentrations of CeO_2 is added.
- Out of all these concentrations 60 ppm with B-15 blend gives the better performance and emission characteristics, especially in terms of reduction of specific fuel consumption and NO_X emissions.

VI. FUTURE SCOPE

As the hydrocarbon fuels are non-renewable energy sources and the consumption is increasing rapidly, there is an urgent need of alternative fuels to sustain in future. There can be tested with various non-edible oils which are renewable in nature. In order to improve the performance characteristics and reduce specific fuel consumptions and to decrease the significant amount of emissions, along with the alternative fuels, avail the benefit of nanoparticles which have the specular properties compared with their own properties when it is bulk in form. Test with various types of nanoparticles at various concentrations.

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