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Performance and Emission Characteristics of Cotton Seed and Hexanol Oil Biodiesel with CeO2 Additives on Single Cylinder Diesel Engine

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ABSTRACT

Energy utilization from renewable sources plays a vital role to meet the demands of theclean environment. Commercialization of biodiesel is comparatively less than the otheralternative sources due to its suitability and yield. In this paper, it is focused on performance and emission characteristics of cotton seed and hexanol oil biodiesel and in blended withcerium oxide as an additive. The blending proportion was made as B10, B15, B20, and100% Diesel. The testing was performed in Single cylinder four stroke diesel engine. The Performance characteristics were obtained in between the brake power withspecific fuel consumption and emission characteristics such as HC CO and $NO_x$and other gases. It was observed that the combination of B15 proportion with CeO2 blendproduces effect results with other blends in specific fuel consumption and reduced emissionbehavior.

Keywords : Biodiesel, Blend, Cerium oxide, Performance, Emission.

I. INTRODUCTION

Biodiesel is a prominent fuel replacement for the fossil fuel to meet energy demands andglobal warming issues. Among various other alternative sources of energy, biodiesel helps inobtaining immediate generation and harmless to the environment **Abbas Alli et al**were undergone experiment on various biodiesel blends with CeO2 as the additive. Theyobservedthat the CeO2 helps in burning the Carbon particles deposited over the walls of the cylinders **Chen He et al** were tested using cotton seed oil with the diesel as a blend. It was observed theincrease in cetane number due to the addition of the cotton seed oil. Also, it helps in improving theefficiency of the engine **Duple Sinha et al** was conducted an experiment on waste seed oil as a blend with the diesel. They suggested that B10 and B20 blends show the increase inthermal efficiency and low specific fuel consumption CeO2 act as Oxygen donating catalyst andhelps in improving the combustion and increase in thermal efficiency of the engine . The CeO2blends will helps in obtaining lower hydrocarbons and carbon monoxide emissions. Hexanol oiland cotton seed oil posses 30 to 40% of oil content and can be used as a strong alternate for other biofuels .**Md. Nurun Nabi et al** were conducted an experiment on cottonseed oilbiodiesel, they observed almost 77% of biodiesel were extracted from the cotton seeds and remainingportion of methanol and other allied substances.Sandeep **Singh et al** wereconducted experiment of cottonseed biodiesel, they suggested that B10, B20 and B30 blends ofbiodiesels were a strong substitute of the mineral oil diesel and helps in obtaining the samecharacteristics of the diesel . **V. Sajith et al** (2015) were conducted experiment on biodieselblends with CeO2 as an additive in range of (20-80ppm). This addition of CeO2 helps inreducing NOx and other Emissions . Addition of CeO2 also having greater impact of enginecombustion, emission and performance characteristics []. Among the other additives withbiodiesel blends CeO2 has acted as a prominent catalyst and allows proper mixture with thebiodiesel to enhance the combustion properties

II. METHODS AND MATERIAL

1. Cotton seed oil and hexanol biofuels :-

The Cotton seed oil and hexonal biofuels was taken for the testing purpose. Theproperties of this biodiesel are shown in Table 1. The hexonal oil exhibit greater density of880 Kg/m3, when compared to cotton seed oil of 610 Kg/m3. Also, hexonal oil has thecetane number of 51 than 48 for the cotton seed, which proves lower Nox emission thanthe cotton seed oil.

Properties	Density (Kg/m3)	Viscosity(cSt)	Flashpoint (0C)	Cetane No	Calorific Value(KJ/Kg)
Cotton seed	610	5.96	175	48	49600
Hexonal	880	3.5	178	51	37000

Table 1. Properties of Neem and Cotton seed oil

2. Cerium oxide additive:-

The cerium oxide particles of fine grain size have been added as an additive ofsuitable proportion with the biodiesel blends. This addition helps in enhancement ofvarious performance characteristics of the samples and the properties of the cerium oxide were listed in Table 2.

Parameters	Values
Molecular formula	CeO2
Molar mass	172.115 g/mol
Appearance	white or pale yellow solid
Density	7.215 g/cm3
Melting point	2,400 °C (4,350 °F; 2,670 K)
Boiling point	3,500 °C (6,330 °F; 3,770 K)
Solubility in water	Insoluble
Crystal structure	cubic (fluorite)

Table 2. Properties of Cerium Oxide Additive

3. Blending :-

The blending of Hexonal oil and Cotton seed oil was taken in the ratio of B10, B20, B30
andin addition to the regular Diesel. The blending composition of the Samples was listed inTable 3.

Sl No	Blend	Composition
1	Blend10	HX-5% + CO-5% + 90% Diesel
2	Blend 15	HX-7.5% + CO-7.5% + 85% Diesel
3	Blend 20	HX-10% + CO-10% + 80% Diesel
4	Diesel	100% Diesel
5	Blend 15+ **$Ce0_2$**	HX-7.5% + CO-7.5% + 85% Diesel

		+20 (ppm)
5	Blend 15+ **Ce0**2	HX-7.5% + CO-7.5% + 85% Diesel +40 (ppm)
5	Blend 15+ **Ce0**2	HX-7.5% + CO-7.5% + 85% Diesel +60 (ppm)

Table 3. Biodiesel blending composite

4. Engine Setup And Procedure

For experimental testing, Kirloskar single cylinder water cooled variable diesel compression engine integrated with EGR is used. For loads on the engine, the Eddy current dynamometer is used. To apply loads to the engine, the Eddy current dynamometer is connected to the flywheel. To inject the fuel, an injection pressure of 200 bar is maintained. The pressure of the cylinder is evaluated by the piezo-sensor installed on the head of the engine cylinder and the angle of the crank encoded on the fly wheel. The normal engine is supplied with 0 to25oBTDC injection point variation. The HC, CO, CO2, UBHC and NOX emissions are evaluated using the fire gas analyzer AVL-DIGAS 444. AVL smoke meter measures the opacity of the smoke.

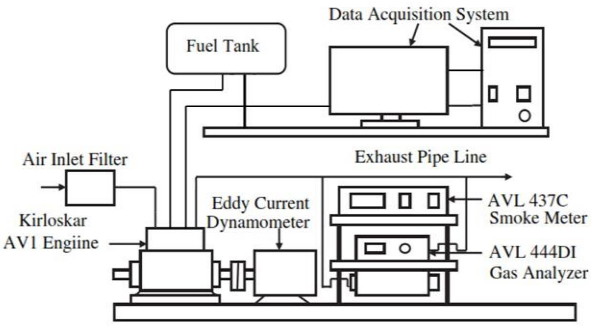

Fig.1. Schematic diagram of experimental set up

Fig.2. Complete Experimental engine setup

Engine make	VCR Engine test setup 1 cylinder, 4 stroke, Diesel with EGR (Computerized)
Type	Kirloskar, Type 1 cylinder, 4stroke Diesel, water cooled.
EGR	Water cooled, ss 304, Range 0-20%

Displacement	661 cc
Bore & Stroke	875 mm & 110 mm
Compression ratio	12 to 18
Fuel	Diesel &Petrol
Rated brake Power	3.5 KW
Rated Speed	1500rpm
Dynamometer	Eddy current, water cooled with loading unit
Ignition system	Compression Ignition
Injection point variation	0-25 deg BTDC
Connecting rod length	234mm
Software	"IC Engine Soft" Engine performance analysis software

Table 4: Test Engine specifications

Test procedure

Experiment has been conducted on with diesel and cottonseed oil, hexanol biodiesel with cerium oxide as an additive. The test was carried out with in two stages. In the first stage the experimental examination was done by using standard diesel. In second stage of examination the cottonseed oil and hexanol biodiesel with cerium oxide as an additive blends are used i.e blend10 blend15 and blend 20 The cooling of the engine is accomplished by circulating water through the jacket soft hecylinderhead and the engine block.

III. RESULTS AND DISCUSSION

The biodiesel blends was successfully tested on the engine setup and the results was drawn 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

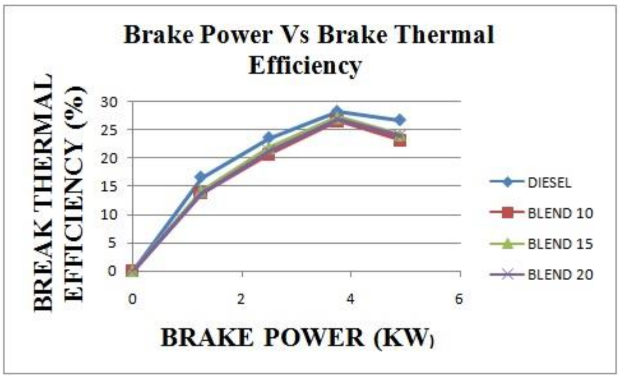

Fig 3. Brake Power Vs Brake Thermal Efficiency

In Fig 3, the graph between brake vs thermal efficiency for various biodiesel blends .At 9kg load, it was observed that the Brake Thermal Efficiencies for Diesel, Blend 10, Blend 15 and Blend 20 are 28.32%, 26.62%, 27.25% and 26.93% respectively.

The graph was drawn between Brake power and Brake Thermal Efficiency for Diesel and blends of Blend 10, Blend 15 and B lend20. The Fig 3, shows that, the Brake Thermal Efficiency for Diesel is more (Maximum at 9kg load i.e., BTE-28.32%) and Blend 15 (BTE-27.25%) is approximately near to diesel compared with other blends.

B.Brake Power Vs Brake Specific Fuel Consumption

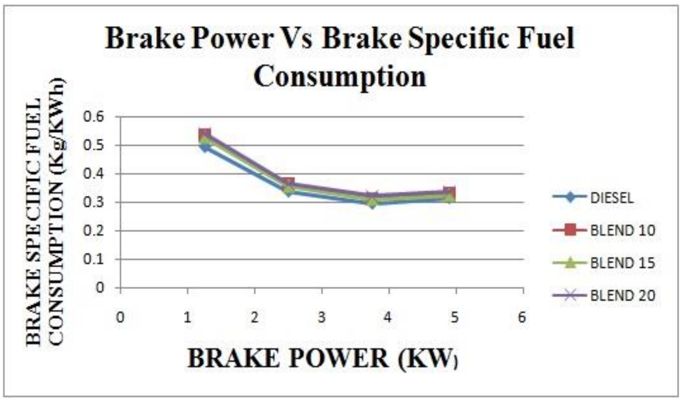

Fig 4: Brake Power Vs Brake Specific Fuel Consumption

In fig 4,shows the graphs between brake poweVs brake specific fuel consumptionit was observed that At 9 kg load, Brake Specific Fuel Consumption for Diesel, Blend 10, Blend 15 and Blend 20 are 0.295, 0.313, 0.309 and 0.321 Kg/kWh respectively.

The above graph for Brake Specific Fuel Consumption (BSFC) was drawn for Diesel and for the blends of Blend 10, Blend 15 and Blend 20; Diesel shows the minimum brake specific fuel consumption 0.295 Kg/kWh at load 9kgand Blend20 shows the highest brake specific fuel consumption among all loads.

EMISSIONS ANALYSIS

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 various concentrations.

C.Brake Power Vs HC emissions

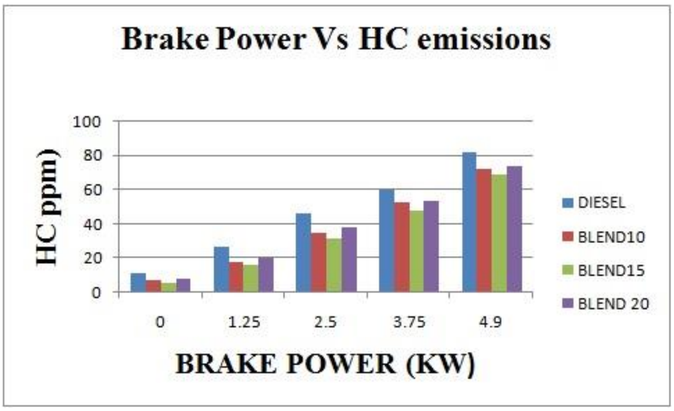

Fig 5. Brake Power Vs HC emissions

Fig 4 shows the emissions graphs of hydrocarbons for various blends .Inthis graph we absorbed that the At 9 kg load, Unburnt Hydrocarbon (HC) emissions for Diesel, Blend 10, Blend 15 and Blend 20 are 60, 53, 48and 54 ppm respectively.

Addition of hexanol biodiesel reduces the HC emissions compared with diesel and the above graph shows that among all, Blend 15 blend gives the lowest reduction of compared with diesel HC emissions.

D.Brake Power Vs CO emissions

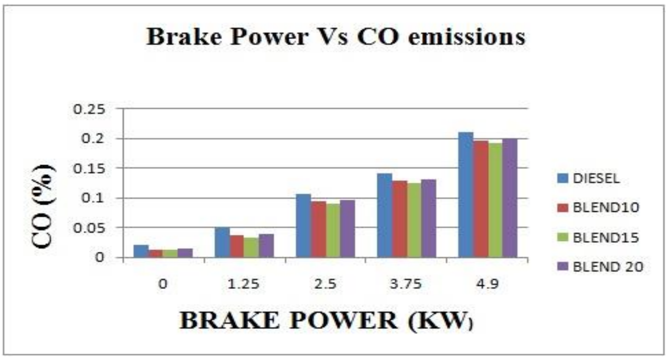

Fig 6. Brake Power Vs CO emissions

Fig 6 shows the emission graph of carbon monoxide and brake power At 9kg load, Carbon Monoxide emissions for Diesel, Blend 10, Blend 15 and Blend 20 are 0.141%, 0.128%, 0.123% and 0.131% respectively. 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 Blend15 produces less CO emissions compared with diesel.

E. Brake Power Vs NO_X emissions

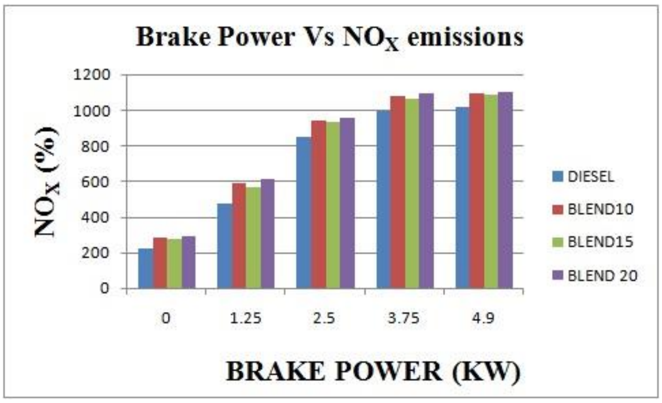

Fig 7. Brake Power Vs NO_X emissions

Fig 7, shows the graph between brake power and oxides of nitrogen. It was observed that the At 9 kg load, Oxides of Nitrogen (NO_X) for Diesel, Blend 10, Blend 15 and Blend 20 are 994, 1078, 1066 and 1090 ppm respectively.9640526761

The addition of biodiesel results in higher NO_X emission compared with diesel. The graph above shows that Diesel produces less NO_X compared to biodiesel blends, and Blend 15 produces the second lowestemissions .

CONCLUSION

The performance and emission results of various blends are analyzed. The results are best for Blend 15 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 (Blend 15), add various concentrations of Cerium Oxide Nanoparticles of 20, 40 and 60 ppm on weight basis and compare the results with Diesel.

ANALYSIS OF BLENDS WITH CeO_2

PERFORMANCE ANALYSIS

F. Brake Power Vs Brake Thermal Efficiency

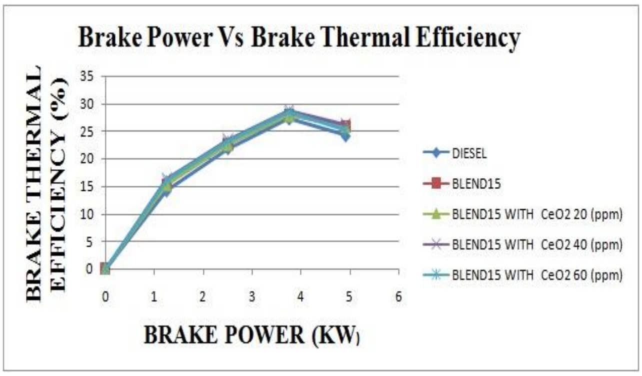

Fig 8. Brake Power Vs Brake Thermal Efficiency

The graph between brake power and brake thermal efficiency.Blend 15 is added with different concentrations of Cerium Oxide nanoparticles of 20, 40 and 60 ppm. Atload 9 kg, Brake Thermal Efficiencies for Diesel, Blend 15, Blend15+$CeO_2$20ppm, Blend 15+$CeO_2$40ppm and B15+$CeO_2$60ppm are 28.32%, 27.25%, 27.95%, 28.73% and 28.42% respectively.

The above graph was plotted among diesel, Blend 15 and other nano additives, which shows that Brake Thermal Efficiency for Blend15+$CeO_2$40ppm gives (BTE-28.73%) approximately equal to the pure diesel which is more than other concentrations.

G.Brake Power Vs Brake Specific Fuel Consumption

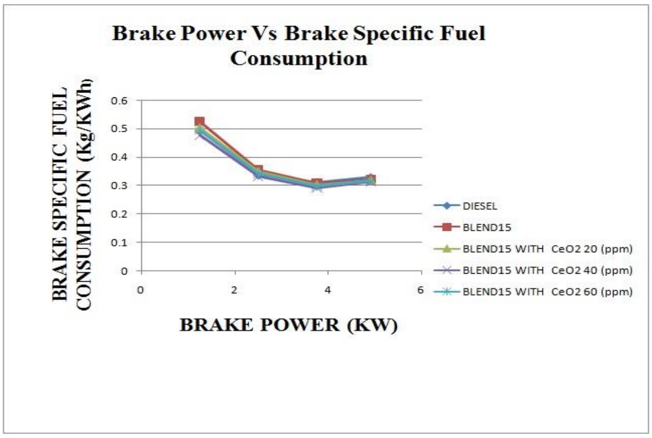

Fig 9. Brake Power Vs Brake Specific Fuel Consumption

The graph between brake power and brake specific fuel consumption At load 9kgs, Brake Specific Fuel Consumption for Diesel, B15, Blend15+ CeO_2,20ppm Blend 15+ $CeO_2$40ppm and B15+$CeO_2$60ppm are 0.311, 0.309, 0.303, 0.292 and 0.297respectively.

From the graph Cerium Oxide nanoparticles added with Blend 15 with 40 ppm of CeO_2 (BSFC- 0.292 Kg/kWh) gives the lowest BSFC compared with 20 and 60 ppm and also compared with diesel.

EMISSIONS ANALYSIS

H. Brake Power Vs HC emissions

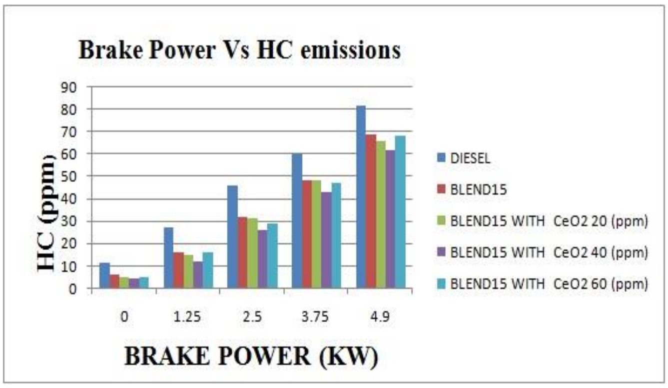

Fig 10. Brake Power Vs HC emissions

In Fig 10, the graph between Brake Power Vs HC emissions At load 9kgs, Unburnt hydrocarbons (HC) emissions for Diesel, Blend15, Blend15+$CeO_2$20ppm, Blend15+$CeO_2$40ppm and Blend15+$CeO_2$60ppm are 60, 48, 48, 43 and 47 respectively.

Cerium Oxide nanoparticle CeO_2 acts as an anti-oxidant and improve the combustion efficiency that reduces the HC emissions. The graph above shows that, out of 20ppm and 60ppm of CeO_2, 60ppm gives the lowest HC emissions which is lower than Diesel emissions.

I.Brake Power Vs CO emissions

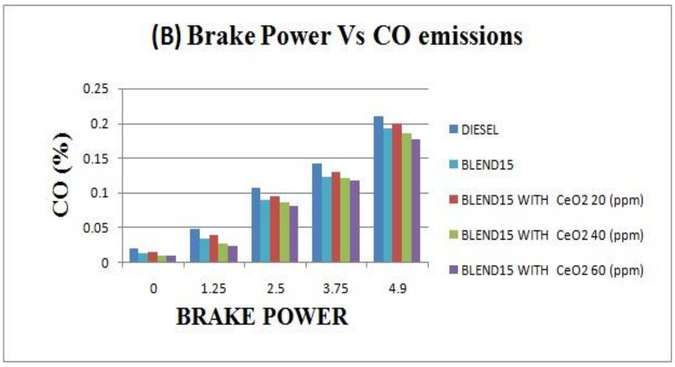

Fig 11: Brake Power Vs CO emissions

Fig 11 shows the graph between brake power and co emissions At load 9kg, Carbon Monoxide emissions for Diesel, Blend 15, Blend15+$CeO_2$20ppm, B15+$CeO_2$40ppm and B15+$CeO_2$60ppm are 0.141%, 0.123%, 0.132%, 0.121% and 0.117% respectively.

With the addition of nanoparticles, the amounts of CO emissions are reduced due complete combustion. Thegraph shows thatBlend15+$CeO_2$60ppmgives the lowest CO emissionsDiesel emissionsout of other concentrations.

J.Brake Power Vs NO_X emissions

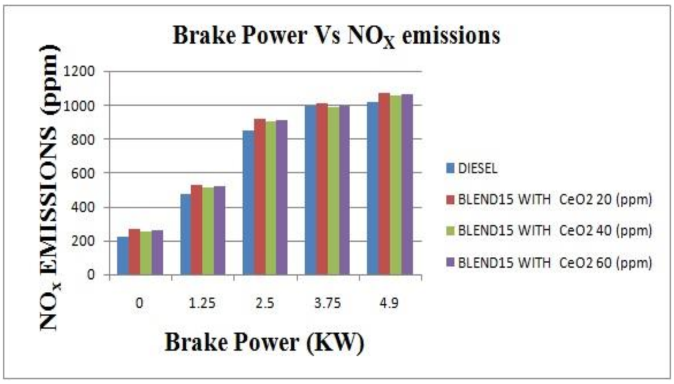

Fig 12. Brake Power Vs NO_X emissions

Fig 12 shows the emission graph between brake powerand oxides of nitrogen At 9kgs load, Oxides of Nitrogen (NO_X) for Diesel, Blend15, Blend 15+ $CeO_2$20ppm, B15+ $CeO_2$40ppm and B15+ $CeO_2$60ppm are 994, 1066, 1012, 988 and 994 respectively.

From the graph we can observe that by adding the Cerium Oxide nanoparticles the amount of NO_X emissions are decreased at 60 ppm of CeO_2 compared with 30 and 90 ppm but it is 0.81% less than Diesel emissions.

IV. CONCLUSION

The performance and emissions behaviour of various biodiesel blends were performed on single cylinder diesel engine The addition of cotton seed oil and hexanol on biodiesel as a blend with concentrations of 10, 15 and 20ppm with diesel and conducted the experiments and analyze the results of performance and emission characteristics. Blend 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, 20, 40 and 60 ppm concentrations of CeO_2 is added. Out of all these concentrations 40 ppm with Blend 15 blend gives the better performance and emission characteristics. And the following results was obtained.Maximum Brake Thermal Efficiency for Diesel is 28.32%.Maximum Brake Thermal Efficiency for Blend15 is 27.25%.Maximum Brake Thermal Efficiency for B15+ $CeO_2$40ppm is 28.73%.So efficiency of Blend 15+ $CeO_2$60 is approximately equal to diesel efficiency.Compared with Diesel emissions,For CO emissions of B15+ $CeO_2$40,ppm it is reduced by 18.42%. For HC emissions of B15+ $CeO_2$40,ppm it is reduced by 31%. For NO_X emissions of B15+ $CeO_2$40,ppm it is reduced by 0.82%.One can reduce the significant amount of CO and HC emissions considerably and especially NO_X emissions are also reduced with the help of CeO_2nano additive.

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