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# The Effects of Cerium Oxide Nano-particle as Fuel Additives in Diesel and Biodiesel Blends: A Review

**Abstract**— *The main objective of paper is the need to reduce emission which is major impulse to the development of alternative fuel; biodiesel has been developed as an alternative fuel for C.I. engine but it show slightly lower performance and reduction in  $SO_x$ ,  $CO$ ,  $HC$ ,  $CO_2$  emissions as compare with diesel. But due to higher oxygen contain in biodiesel the formation of  $NO_x$  was observed higher. Nano-fuels have shown better improvement in combustion, performance and emission characteristics of CI engine. The blending of biodiesel increases the thermal efficiency near to that of diesel and also significantly large reduction in  $NO_x$  is observed.*

**Index Terms**— *Nano-particle, alternative fuel, biodiesel, performance, emission,  $NO_x$*

## I. INTRODUCTION

The diesel engines are generally more efficient than spark ignition engines but the engine emissions from the burning of fuel in the diesel engine are higher. This has the negative impact on its wide acceptance and uses, especially in automotive applications. Recently govt. of India start following the new engine emission norms Bharat Stage-IV all over in country in order to regulate the pollutants comes out after burning of fuel in internal combustion engine & spark ignition engine, mostly  $NO_x$ , particulate matter, hydrocarbons. Biodiesel contains 10-15% more oxygen and absence of sulfur so, it leads to improve complete combustion and reduce the engine emissions as compare with diesel but the calorific value of biodiesel-diesel blends can reduce the % of fuel demand all over in the world. Nift et. Al [1] has studied on the causes of emission of particulate matters and provides several techniques to those emissions by optimizing the composition of fuel, modification in engine and by catalytic reduction of  $NO_x$ . The engine emissions are affected by properties of fuel such volatility, density, flash point, fire point, viscosity etc. those properties of fuel alter by adding fuel additives. The ASTM distillation curve represent by the volatility of the diesel, viscosity of fuel affects lubrication and optimization of charge while the flashpoint, fire point represents the lowest temperature below which the fuel handle safely. So it is appropriate method to change the physiochemical properties to optimize the combustion process. Generally biodiesels are produce from trans-esterification process on fatty acids so contains nearly 16% more oxygen as compare with diesel which causes the emission of  $NO_x$ . The stability of nanoparticles can improved by adding appropriate surfactant in blend and ultasonication process of dispersion of nanoparticles in blends mixing well in proportion and following by agitator stabilizes the nanoparticles in fuel.

## II. EFFECT OF FUEL ADDITIVE ON THE PERFORMANCE AND EMISSION CHARACTERISTICS OF THE ENGINE

### A. Engine Performance

Many of the researchers & scientist were conduct the experiments on various diesel-biodiesel fuel blends by adding cerium oxide nanoparticles. A brief review of the effect of the cerium oxide nanoparticles fuel additives is

presented here. Most of the researchers/scientists have reported that the the addition cerium oxide varies from 10-80 ppm in blend of biodiesel and diesel improves the performance. Ajin C. Sanjeevan et al. [2] had conducted an experiment to find out the effect of cerium oxide nanoparticles on four stroke di diesel engine running at 1500 rpm. The performance of the diesel and diesel having nanoparticles in various concentration 5, 15, 25 and 35 ppm. The nanoparticle based fuel prepared by precipitation method and dodecyl succinic surfactant were added for stable suspension then it was seen that with the addition of nanoparticles the viscosity, flash point, fire point increases. By varying the dosage in ppm of nanoparticles the load test were carried out which results in 2% increase in break thermal efficiency for 35 ppm. Ranaware A. A. et al. [6] had worked on the performance test on compression engine with cerium oxide nanoparticles additive in diesel fuel. More oxygen for oxidation of  $CO$  is provided by cerium oxide nanoparticles and removes the oxygen for reducing the emission of  $NO_x$ . The diesel fuel containing 25 ppm concentration of cerium oxide shows the higher brake thermal efficiency for diesel is nearly 25.67% and 23.63% for the diesel fuel containing 25 ppm concentration of cerium oxide. 3-4% increase in the brake thermal efficiency of the fluid containing 0.4% Ferro fluid with diesel. V. Arul Mozhi Selvan et al. [10] carries the performance test on single cylinder water cooled variable compression ratio diesel engine for diesel and ethanol-diesel-biodiesel blend with cerium oxide nanoparticle as fuel additive in 25 ppm concentration. By adding the biodiesel the phase separation of diesel and biodiesel were prevented. The stable suspension was obtained by the turbidity produce in fuel. The BSFC was observed to be lower for cerium oxide mixed diesel fuel and higher for diesel. The cerium oxide mix diesel fuel shows peak mean effective pressure of 10.2 Mpa..V. Sajith et al. [3] had investigated on single cylinder water cooled DI diesel engine with jatropha biodiesel having the varying concentration of cerium oxide nanoparticles from 20-80 ppm. The diesel engine operates at 1500 rpm. The performance results were plotted as load vs. efficiency the result was shows in fig 1Which indicates the increase in thermal efficiency by varying load and dosing level of cerium oxide nanoparticles.

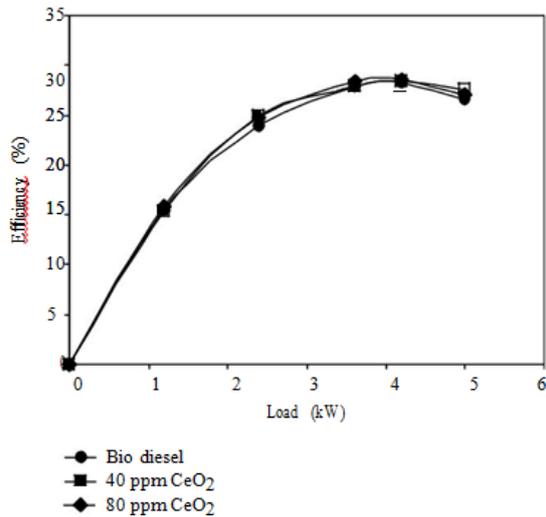


Figure 1: Variation of the brake thermal efficiency with load for biodiesel and modified biodiesel with different dosing levels of the additive [3]

### B. Engine emissions

The experiments were carried out by various scientist and researchers on single cylinder DI diesel engine by using biodiesel, diesel and diesel-biodiesel blends by adding the cerium oxide nanoparticles as fuel additive found that cerium oxide provide more oxygen for improved combustion and reduce the emissions. Rao, K. S et al. [9] had worked on four stroke compression ignition diesel engine for the effect of biodiesel on Nox formation and the results obtain by burning the various blends of biodiesel then compare with the diesel which shows that the emission of HC, PM, CO are less but the Nox emission was found to be higher. The factors like injection timing, heat loss by radiation, flame temperature, and exhaust gas temperature. The higher oxygen contains in biodiesel as compared with diesel is also a major factor for an increase in Nox. Two techniques were implemented to decrease the Nox emissions. Nox Absorber Catalyst (NAC) and Selective Catalytic Reduction (SCR). Carried the Exergy analysis On vertical single cylinder DI diesel engine running at a constant speed of 1500 rpm S. Karthikeyan et al. [4]. The cerium oxide nanoparticles are added in grape seed oil methyl ester biodiesel with concentration varied from 50 ppm to 100 ppm shows that the HC, CO, Nox emissions were found to be less as the concentration increases due to increase in surface area to volume ratio. Ajin C. Sanjeevan et al. [2] investigated on variable compression ignition engine running at 1500 rpm in which the concentration of cerium oxide varies from 5 ppm to 30 ppm shows the reduction in hydrocarbon emission about 40-50% as the load varies mostly at higher load. the cerium oxide nanoparticles also reduces the Nox emission by 30% at higher load and 5% addition of surfactant like CTAB further reduce the Nox emissions. V. Sajith et al. [3] were conducted the experiment on water cooled single cylinder DI diesel engine running at a constant speed of 1500 rpm. Blends of jatropha biodiesel with 20-80 ppm concentration of cerium oxide varied the emission analysis results in 30 % reduction in NOX and no significant change in carbon monoxide was found. Gurinder Singh et al. [8] reviewed the various research papers to study the effect of nanoparticles on emission. He concludes that

addition of nanoparticles improves the calorific value of diesel, diesel-biodiesel blends and improve the combustion which leads to reducing the harmful engine emissions in which mostly nonmetal oxide had effective results. Ranaware A. A. et al. [6] carried out the experiments on cerium oxide nanoparticles and water-based Ferro fluid as additive in neat diesel for diesel engine. the results shows that the Nox emissions are lower at all load of engine and further reduction was found by adding 0.4% to 0.8% of Ferro fluid, it conclude that mixture of cerium oxide nanoparticles with Ferro fluid is the better way to reduce the Nox emission. The reduction in hydrocarbon emission were found due to addition of cerium oxide in biodiesel because it has ability to transform from CeO<sub>2</sub> (+4) to Ce<sub>2</sub>O<sub>3</sub> (+3) state by low-energy reaction. After oxidation of cerium oxide it converts to carious oxide (Ce<sub>2</sub>O<sub>3</sub>). The carbon combustion oxidation temperature is lower by cerium oxide catalyst.

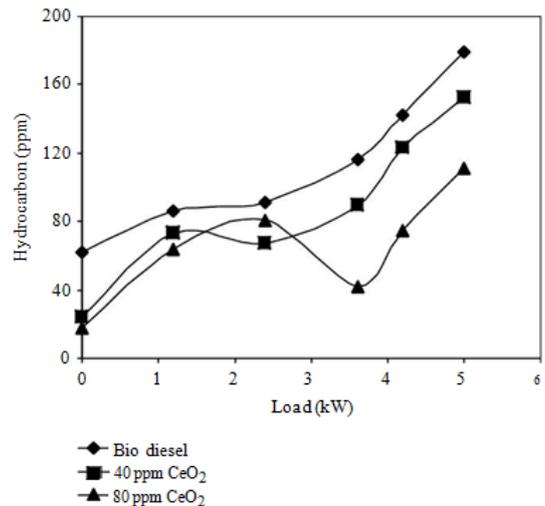


Figure 2: Variation of hydrocarbon emission with load for different dosing levels of fuel additive in bio diesel [3]

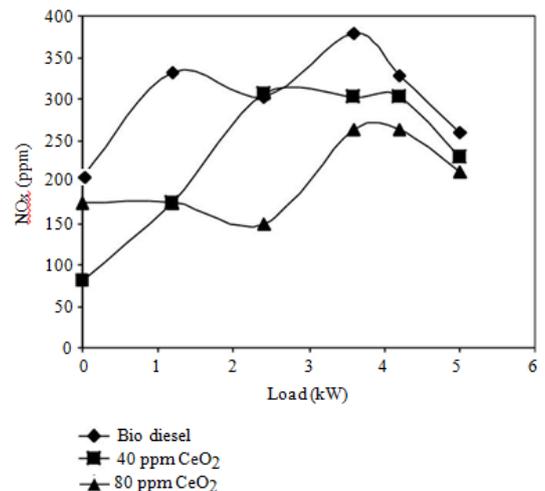


Figure 3: Variation of NOx emissions with load for different Additive dosing levels in bio diesel [3]

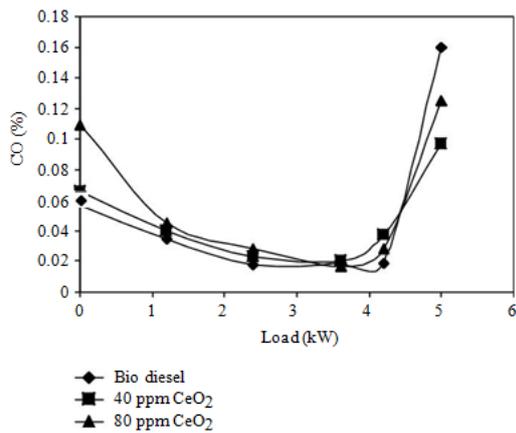


Figure 4: Variation of CO emissions with load for different additive dosing levels in bio diesel [3]

### C. Fuel Properties

Mostly addition of metal oxide additives improves the properties of fuel like viscosity, flash point, fire point and change in properties depends on additives rate. Flashpoint of fuel represents the volatility as the flashpoint increases volatility decreases the variation in volatility according to change in dosage is represented on the graph which is nearly linear. It is desirable to have high flashpoint to handle the fuel safely so the cerium oxide-based biodiesel is safer than the base fuels. The kinematic viscosity of diesel, biodiesel, diesel-biodiesel blends changes with temperature and dosing level of additives. The viscosity of blends decreases with increase in temperature for all dosing of additives. Apparently addition of nanoparticles increases the resistance of fluid layer and viscosity increases. Viscosity change effects on hydrocarbons emissions and lower viscosity provides insufficient lubrication of fuel injection pumps which reduces the combustion performance of the fuel. Hani Choiz et al. [7] the emission characteristics for VCR engine for various biodiesel blends which concludes that the metal oxide nanoparticles shows effective reduction in smoke emission due to altering physicochemical properties like volatility, viscosity, flash point, fire point etc. Viscosity also effects on fuel atomization, large fuel droplets burns poorly which results in increased smoke and emission. The cloud point and pour point properties remain the same by adding the additives. V. Sajith et al. [3] conclude that by mixing of cerium oxide nanoparticles in blends of biodiesel by the ultrasonication process and mixing it by adding agitator to disperse the nanoparticle in blends the stability of fuel increases and the properties of fuel altered.

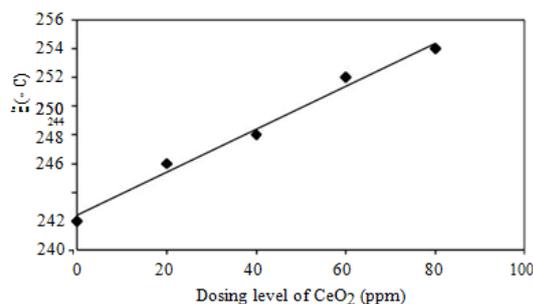


Figure 5: Variation of flash point with nanoparticle dosing level for biodiesel [3]

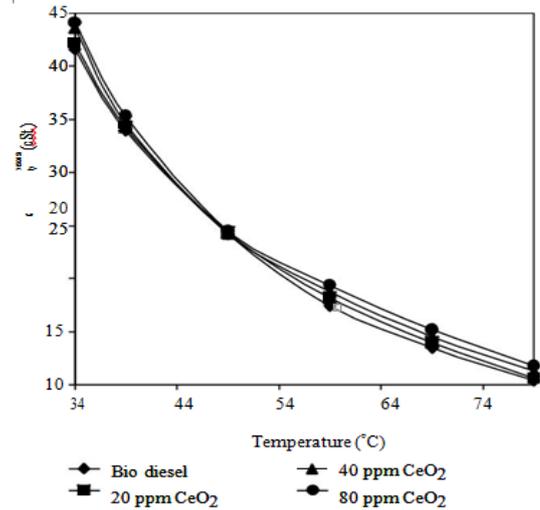


Figure 6: Variation of the kinematic viscosity of biodiesels with temperature at different dosing levels of the additive [3]

### III. CONCLUSIONS

From the study of the literature of various research papers, it is found that the cerium oxide additive Perform well in diesel, diesel-biodiesel blends and improves the performance characteristics of CI Engines with improved brake thermal efficiency, brake specific fuel consumption and reduce the engine emissions without any physical modification in an engine. Just by changing the physicochemical properties, the effect found to be useful. The addition of cerium oxide shows the significant effect on engine emissions the pollutant coming out from burning of fuel in diesel engine were found to be reduce as compare with base line as diesel. From the review, it clears that the further research on cerium oxide nanoparticles in various biodiesel-diesel blends by varying the parameters like compression ratio, level injection pressure levels of dosing improves the performance and emission characteristics of CI engine which will definitely reduce the consumption of diesel.

### APPENDIX VCR DIESEL ENGINE SETUP

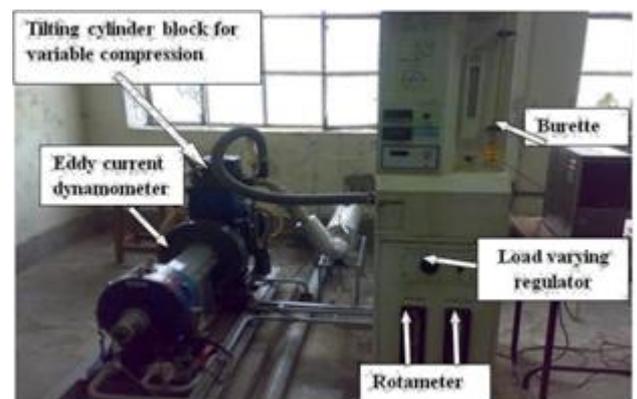


Figure.7: single cylinder four strokes, variable compression ignition engine. Ajin C. Sanjeevan et al. [2]

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