International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

Performance and Emission Characteristics of a C.I Engine with Cerium Oxide Nanoparticles as Additive to Diesel

Nithin Samuel[1], Muhammed Shefeek K[2]

[1]Department of Mechanical Engineering, Baselious Mathews second College of Engineering, Kollam, Kerala, India

[2]Department of Mechanical Engineering, IES College of engineering, Chittilapilly, Kerala, India

Abstract: ***An experimental investigation is carried out to establish the performance and emission characteristics of a compression ignition engine while using cerium oxide nanoparticles as additive with neat diesel. The work has been divided into two phases. In the first phase, pure diesel is tested in a CI engine and preparation of nanoparticles. Then in the second phase, performance characteristics are studied using the fuel added with nanoparticle in a four cylinder four stroke engine. The cerium oxide acts as an oxygen donating catalyst and provides oxygen for the oxidation of CO or absorbs oxygen for the reduction of NOx.***

Keywords: diesel engine, cerium oxide, nanoparticles, engine emissions

1. Introduction

The compression ignition engines are widely used due to its reliable operation and economy. As the petroleum reserves are depleting at a faster rate due to the growth of population and the subsequent energy utilization, an urgent need for search for a renewable alternative fuel arise. The increasing use of diesel combustion for powering automobiles has led to considerable activity in methods for the reduction of particulate emissions. Also the threat of global warming and the stringent government regulation made the engine manufacturers and the consumers to follow the emission norms to save the environment from pollution. Diesel engines are one of the major contributors to the emissions such as hydrocarbons, particulates, nitrogen oxides, and sulphur oxides. These emissions are very harmful to human beings and also responsible for acid rain and photochemical contamination and hence subject to strict environmental legislation. Improvement in the performance of diesel engines is an important challenge to be addressed, in the current era due to the fast depletion of fossil fuel resources as well as due to the harmful hydrocarbon and nitrogen oxide emissions. Efforts are also made for the reformulation of diesel fuel to reduce these harmful emissions without affecting the physicochemical properties of fuel such as viscosity, flash and fire point.

At present, Diesel fuel additives, used to lower PM emissions and to enhance oxidation rates, are an approach that shows promise in improving emission reductions. Among these techniques available to reduce exhaust emissions, the use of fuel-borne catalyst is currently focused due to the advantage of increase in fuel efficiency while reducing harmful greenhouse gas emissions and the health-threatening chemicals such as NOx and particulate matter. The use of nanoparticles as additives to diesel fuel is a promising method for improving the efficiency and improving the exhaust emissions of a CI engine. The cerium oxide acts as an oxygen donating catalyst and provides oxygen for the oxidation of CO or absorbs oxygen for the reduction of NOx. The activation energy of cerium oxide acts to burn off carbon deposits within the engine cylinder at the wall temperature and prevents the deposition of non-polar compounds on the cylinder wall results reduction in HC emissions.

The influence of cerium oxide additive on ultrafine diesel particle emissions and kinetics of oxidation was studied by Jung et al. [6]. They found that addition of cerium to diesel cause significant reduction in number weighted size distributions and light-off temperature and the oxidation rate was increased significantly. Arul mozhi selvan et.al 6 carried out an experimental investigation to establish the performance and emission characteristics of a compression ignition engine while using cerium oxide nanoparticles as additive in neat diesel and diesel-biodiesel-ethanol blends. The tests revealed that cerium oxide nanoparticles can be used as additive in diesel and diesel-biodiesel-ethanol blend to improve complete combustion of the fuel and reduce the exhaust emissions significantly. Sajith et al 5 investigated the effect of cerium oxide nanoparticles on performance and emissions of diesel engine. Efficiency of the engine shows an increase up to 5% and a reduction of HC and NOx emissions by 45% and 30%, respectively.

The objective of the current work is to study the effect of addition of cerium oxide nanoparticles to fuel on the performance and emission characteristics of a CI engine. Aluminum oxide nanoparticles are also going to be added with diesel fuel as future work.

2. Experimental Setup

A four cylinder four stroke diesel engine is used to test pure diesel and nanoparticle added diesel fuel. Standard constant speed load tests were conducted on the engine. A brake drum dynamometer was used to load the engine. The sketch of test engine is as shown in fig.(1) and photograph of experimental set up is as shown in fig. (2)

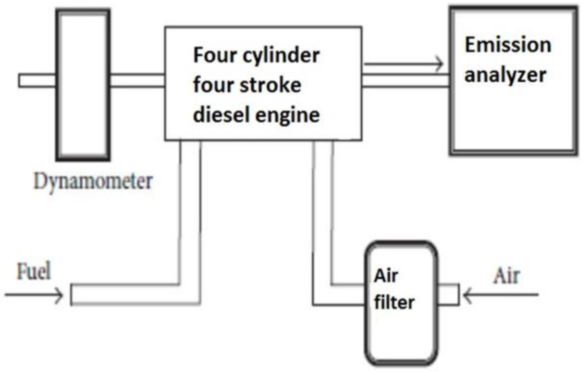

Figure 1: Schematic diagram of the experimental setup

Table 2: Properties of Fuel

Properties	Diesel	Diesel + cerium oxide
Kinematic Viscosity @ 40°C,cSt	2	2.35
Density @ 15°C, gm/cc	0.83	0.8275
Flash Point, °C	50	11
Fire Point, °C	56	14
Cetane Number	46	44.6
Net calorific value, MJ/kg	42.3	39

Figure 2: Photograph of the experimental setup

Table 1: Engine specification

No of strokes	4
No. of cylinders	4
Type of cooling	Water cooled
Bore	4 ½ "
Rated power	15 BHP
Brake drum radius	0.1 m
Rope thickness	0.8997*10-2 m
Rated RPM	1700

A. The specification of test rig is shown in table 1.
B. Properties of fuel.
C. Ultra Sonic Shaker.

The equipment used for mixing diesel fuel with cerium oxide nanoparticles is an ultra-sonic shaker. The catalytic nanoparticle added diesel was agitated for about 30 minutes in an ultrasonicator to obtain a stable nanofluid. The dosing level of nanoparticle samples (by weight) in diesel is varied from 10 to 40 ppm.

Figure 3: Photograph of ultrasonic shaker.

D. Orsat Apparatus

Orsat apparatus is used to analyses the exhaust gases from the CI engine. It is used to analyze a gas sample for its oxygen, carbon monoxide, carbon dioxide and nitrogen content. The apparatus consists essentially of a calibrated water-jacketed gas burette connected by glass capillary tubing to two or three absorption pipettes containing chemical solutions that absorb the gasses it is required to measure. For safety and portability, the apparatus is usually encased in a wooden box. The absorbents are Potassium Hydroxide, Alkaline pyrogallol and cuprous chloride. Each absorbent absorb carbon dioxide, carbon monoxide and oxygen in the given sample of flue gases.

Figure 4: Photograph of orsat apparatus

3. Results

The objective of the present work was to study the effect of cerium oxide nanoparticle addition in diesel fuel on the performance and emission characteristics of a diesel engine. Variation of specific fuel consumption with brake power is shown in fig 5.

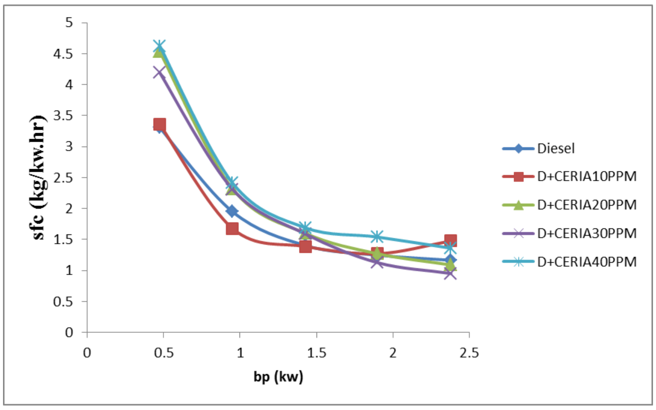

Figure 5: Variation of specific fuel consumption with brake power

The specific fuel consumption is found to be decreasing as the fuel is mixed with cerium oxide nanoparticles. This is due to the enhancement in combustion of fuel and therefore less amount of fuel is required for a particular power output. The lowest sfc is obtained as 0.952 kg/kw.hr for diesel + cerium oxide 30 ppm blend. The variation of various efficiencies with brake power is shown in fig 6, fig 7 and in fig 8.

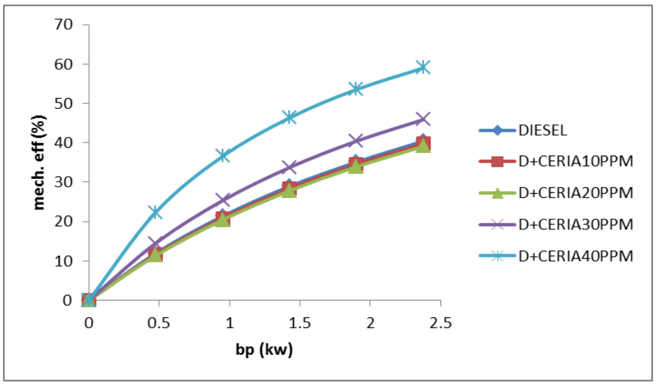

Figure 6: Variation of mechanical efficiency with brake power

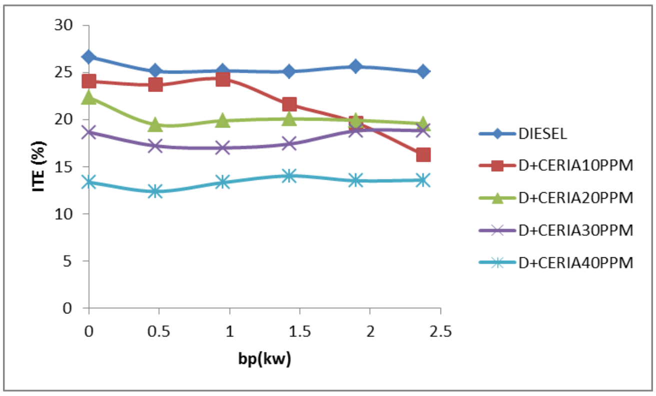

Figure 7: Variation of indicated thermal efficiency with brake power

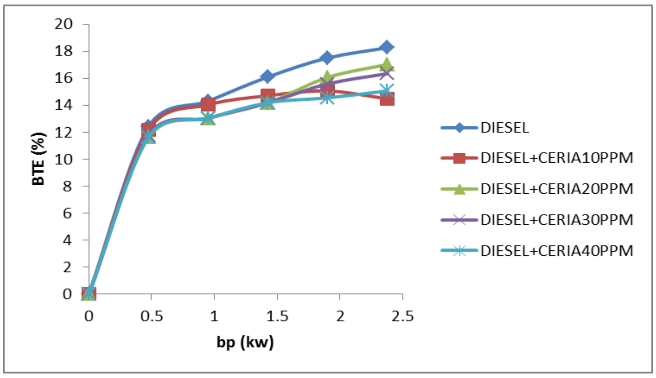

Figure 7: Variation of brake thermal efficiency with brake power

The mechanical efficiency of diesel fuel mixed with cerium oxide at 40 ppm was found to be higher than other blends. This phenomenon is due to the result of cerium oxide addition which promotes combustion. The highest mechanical efficiency obtained was 59% for DIESEL+CERIA40PPM.

The variation of indicated thermal efficiency and brake thermal efficiency with brake power is shown in fig 6 and in fig 7. The thermal efficiency of neat diesel is higher among all the fuel blends. Thermal efficiency of diesel fuel mixed with cerium oxide is less due to the reduction in calorific value of the fuel.
Results of Orsat gas analyser experiment is shown in table 3

Table 3: Exhaust Emission Analysis

	Neat diesel	D+ CERIA10 PPM	D+ CERIA20 PPM	D+ CERIA30 PPM	D+ CERIA40 PPM
CO_2 (%)	11	10	13	10	11
O_2 (%)	4	5	6	6	7
CO (%)	2	1.5	1.7	1	1.4
N_2 (%)	83	83.5	79.3	83	81.6

If the gases contain considerable amount of carbon monoxide_it indicates that incomplete combustion is occurring (i.e. considerable wastage of fuel is taking flue). It also indicates the short supply of oxygen for combustion. If the flue gases contain a considerable amount of oxygen, it indicates the oxygen supply is in excess, though the combustion may be complete. Here the carbon monoxide emission is lowest when we uses diesel mixed with cerium oxide at 30 ppm. Also the oxygen supply is moderate in this fuel blend. All these readings were taken at maximum load of the engine. Highest carbon monoxide emission is found to be 2% for neat diesel and lowest carbon monoxide emission is found to be 1% for D+CERIA30PPM.

4. Conclusion

The following conclusions are derived from the detailed analysis presented in the result and Discussions.

- Experimental study to determine the effect of cerium oxide on the performance and emission characteristics of CI engine shows that the performance of engine increases with the addition of nanoparticle to the fuel.

- Specific fuel consumption is decreased by 0.5 kg/kw.hr for diesel mixed with cerium oxide at 30 ppm.
- Mechanical efficiency of the engine is enhanced by 20% while using fuel added with 30 ppm cerium oxide.
- However thermal efficiencies are higher for neat diesel than the fuel mixed with nanoparticle.
- There is a significant improvement in the exhaust emissions while using diesel mixed with cerium oxide nanoparticle.

5. Acknowledgment

The authors wish to thank Department of Mechanical Engineering of College of Engineering, Adoor for its financial support to this work.

6. Nomenclature

Sfc	Specific Fuel Consumption
D+CERIA10PPM	Diesel + Cerium oxide nanoparticles of 10ppm
D+CERIA20PPM	Diesel + Cerium oxide nanoparticles of 20ppm
D+CERIA30PPM	Diesel + Cerium oxide nanoparticles of 30ppm
D+CERIA40PPM	Diesel + Cerium oxide nanoparticles of 40ppm
Bp	Brake Power

References

[1] Heejung Jung, David B. Kittelson, Michael R. Zachariah ((2005)) The influence of a cerium additive on ultrafine diesel particle emissions and kinetics of oxidation, Elsevier Journal of Combustion and Flame 142, 276–288.

[2] Yanan Gan, Li Qiao (2011) Combustion characteristics of fuel droplets with addition of nano and micron-sized aluminum particles, journal of Combustion and Flame 158 (2011) 354–368.

[3] V. Arul Mozhi Selvan, R. B. Anand and M. Udayakumar (2009) Effects Of Cerium Oxide Nanoparticle Addition In Diesel And Diesel-Biodiesel-Ethanol Blends On The Performance And Emission Characteristics Of A CI Engine, ARPN Journal of Engineering and Applied Sciences, VOL. 4, NO. 7.

[4] Ajin C. Sajeevan and V. Sajith (2012) Diesel Engine Emission Reduction Using Catalytic Nanoparticles: An Experimental Investigation, Journal of Engineering. Volume 2013, Article ID 589382, 9 pages.

[5] Stephen W. Chung a, Elena A. Guliants b, Christopher E. Bunkeret al.(2011) Size-dependent nanoparticle reaction enthalpy: Oxidation of aluminum nanoparticles, Journal of Physics and Chemistry of Solids 72, 719–724.

[6] Ranaware A. A.1, Satpute S. T. (2008) Correlation between Effects of Cerium Oxide Nanoparticles and Ferrofluid on the Performance and Emission Characteristics of a C.I. Engine, IOSR Journal of Mechanical and Civil Engineering. 2278-1684, PP: 55-59.

[7] A.Selvaganapthy, A.Sundar, B.Kumaragurubaran, P.Gopal (2012) An Experimental Investigation to Study the Effects of Various Nano Particles with Diesel on Di Diesel Engine, ARPN Journal of Science and Technology VOL. 3, NO. 1.

[8] Suthar Dinesh Kumar L.a, Dr. Rathod Pravin P.b, Prof. Patel Nikul K (2012) Performance And Emission By Effect Of Fuel Additives For Ci Engine Fuelled With Blend Of Biodiesel And Diesel - A Review Study, Ben-Gurion Journal of Engineering Research and Studies.

[9] Exhaust gas composition measurements Orsat gas analyzer, (2011) Division of Thermodynamics, Institute of Heat Engineering. Thermodynamics II – Laboratory Instructions Exercise No 8.

[10] Akira Numata, Takuya Kumagai, Yoshinori Nagae, Shinnosuke Osafune. (2001) Increase of Thermal Efficiency and Reduction of NOx Emissions in DI Diesel Engines, Mitsubishi Heavy Industries, Ltd. Technical Review Vol.38 No.3.

[11] Will Soutter (2011)Nanoparticles as Fuel Additives, http://www.azonano.com/article.aspx?ArticleID=3085P.