# Performance Analysis of DI Diesel Engine Fuelled with Diesel along with Nano Additives

S.Ch. Rao[1], M.Srinivasa Rao[2]

[1]*Assistant Professor, Department of Mechanical Engineering, GMRIT, Srikakulam, AP, India*
[2]*M.Tech Student, Department of Mechanical Engineering, GMRIT, Srikakulam, AP, India*

***Abstract:*** *An experimental investigation was carried out to study the performance of a compression ignition (CI) engine fuelled with diesel with nanoparticles as an additive. Various blends were prepared by varying the nanoparticles i.e. cerium oxide and zinc oxide to study its operating characteristics of a single cylinder, constant speed CI engine. The engine test results showed that addition of nanoparticles i.e. cerium oxide and zinc oxide leads to an improvement in thermal efficiency compare to diesel operation at full load. However, the brake specific fuel consumption of zinc oxide 250ppm blend is nearly same as cerium oxide 40ppm and also zinc oxide 500ppm blend is nearly same as cerium oxide 80ppm at higher loads, and also it is observed that all the nanoparticle added blends are having less exhaust temperature than the diesel values at higher load. The smoke is decreased with the addition nano additives and also 40ppm of* $CeO_2$ *as given the lowest rate of smoke.*

**Keywords:** *Zinc oxide and Cerium oxide nanoparticles, Performance, smoke meter.*

## I. INTRODUCTION :

India is one of the fastest developing countries with a stable economic growth, which multiplies the demand for transportation in many folds. Fuel consumption is directly proportionate to this demand. India depends mainly on imported fuels due to lack of fossil fuel reserves and it has a great impact on economy. Among the alternative fuels believed to be the solution of the energy and the environmental crisis, Nanofluids and Alcohol fuels were feasible fuels and much devotion was given to them. Since this time, a lot of researches have been conducted by different scientists of the globe and of course attractive and appreciable results have come out. These two fuels can be used as pure as well as blended with the fossil origin fuel in any concentration in existing diesel engines with little or no modification.

This time the trend of nanofluids is being practiced all over the globe. Although the, present reserves seem vast but the accelerating consumption will create a challenge before the world that a new type of fuels should replace the conventional fuels. The new reserves appear to grow arithmetically while the consumption is growing geometrically.

Experimental results have been reported on the influence of various fuel additives such as organic compounds of manganese, magnesium, copper, and calcium on fuel properties. It was observed that organic compounds of copper, magnesium, and calcium are less effective in comparison with that of manganese. Shi et al. [1] and Satge de Caro et al. [2] reported that the particulate matter emissions decrease with increasing oxygenate content in the fuels. The effect of methanol-containing additive (MCA) on the emission of carbonyl compounds, generated from the diesel engine, was studied by Chao et al. [3] and high emissions were observed with the use of MCA.

Metal oxides such as those of copper, iron, cerium, and cobalt have been used as fuel additives. Among these oxides, cerium oxide is the most abundant element in rare earth family with good thermal stability as well as cross-over efficiency which will undergo redox cycling between the trivalent and tetravalent oxidation states. Cerium oxide, when used in the nanoparticles form exhibits a high catalytic activity because of its high surface-to-volume ratio leading to improvement in the fuel efficiency and reduction in the emissions. Sajith et al. [4, 5] and Selvan et al. [6] investigated the effect of cerium oxide nanoparticles on the engine performance and the emissions, with diesel and bio-diesel as fuel. The brake thermal efficiency of the engine was found to be increased by 5% and a drastic reduction in both HC and NOx emissions was observed.

Naresh Kumar Gurusala et al. [7] reported that Aluminium oxide (Al2O3) nanoparticles were used as fuel born catalyst in order to enhance the combustion characteristics and reduce the harmful emissions. The engine test results showed less improvement in brake thermal efficiency and smoke reduction of 52.8 % was observed in B40 fuel blend with 50 ppm alumina nanoparticles under full load conditions.

Nagaraj Banapurmath et al. [8] studied that silver nano-particles were blended with HOME in the mass fractions of 25ppm and 50ppm using an ultrasonicator. Subsequently, the stability characteristics of silver nano-particles blended–biodiesel fuels were analyzed under static conditions for their homogeneity. Maximum brake thermal efficiency was obtained for HOME+ 50SILVER compared to HOME+25SILVER blends. With swirl intended slots provided on the piston crown surface the performance was further improved using HOME+50SILVER in general and for 6.5mm slot on the combustion chamber in particular.

S.karthikeyan et al. [9] reported that zinc oxide nano additive blends showed an improvement in calorific value. The addition of nanoparticles for blends has been reduced the brake specific fuel consumption, while the brake thermal efficiency increases with the increasing in all engine loads, and smoke opacity are appreciably reduced with the addition of zinc oxide nanoparticles were observed**.**

## II. NANO-DIESEL FUEL BLENDS PREPARATION:

The nano-particles diesel fuel is prepared by mixing the cerium oxide or zinc oxide nano-particles with the aid of an ultrasonicator. The ultrasonicator technique is the best suited method to disperse the both nano-particles in the base fuel, as it facilitates possible agglomerate nanoparticles back to nanometre range. The nano-particles are weighed to a predefined mass fraction say 40ppm and dispersed in the diesel with the aid of ultrasonicator set at a frequency of 20 kHz for 15-30 minutes. The resulting nanoparticles diesel is named as Diesel+40$CeO_2$. The same procedure is carried out for the mass fraction of 80ppm, 250ppm and 500ppm to prepare the cerium oxide and zinc oxide nanoparticles diesel fuel (Diesel+80$CeO_2$, Diesel+250ZnO, Diesel+500ZnO).

## III.EXPERIMENTAL STUDIES:

In the test setup a constant speed, single cylinder four strokes, water cooled, high speed diesel engine as shown in figure.1.and a rope brake dynamometer is used to measure the power of the engine. Adjacent to the engine there is a measurement board which contains read outs for temperature and a clear graduate tube i.e. fuel metering system which is used to measure the amount of fuel consumed per unit time. The temperature measurements can be made through the usage of thermocouples placed at appropriate places inside the engine. The rope brake dynamometer is used to measure the power of the engine. The load is varied and readings are taken accordingly. The experiments are conducted for different loads i.e. 0,4,8,12,16 kgs respectively.

Fig.1. Experimental setup of DI diesel engine

Table 1.Engine Specifications:

| | |
|---|---|
| Type of engine | High speed diesel engine |
| Make | Kirloskar AV-1 |
| No. of cylinders | 1 |
| Brake power | 5HP(3.72kw) |
| RPM | 1500rpm(constant) |
| Bore | 80mm |
| Stroke | 110mm |
| Loading type | Mechanical |
| Brake drum diameter | 0.315m |
| Orifice diameter | 20mm |
| Injection pressure | 200bar |

Table 2 Properties of nano-particles blended fuels:

| Nanofluids | Calorific value(kJ) | Flash point °C | Fire point °C |
|---|---|---|---|
| Diesel | 42850 | 52 | 54 |
| Diesel+250ppm ZnO | 42906 | 45 | 48 |
| Diesel+500ppm ZnO | 42956 | 43 | 45 |
| Diesel+40ppm $CeO_2$ | 42892 | 48 | 50 |
| Diesel+80ppm $CeO_2$ | 42948 | 46 | 49 |

Table.2 shows the variation of the flash & Fire point of the diesel as a function of the dosing level as illustrated, the diesel shows a decreasing trend for the flash & Fire point with the dosing level, which indicates that the ignition delay will be decreases.

## *IV. RESULTS AND DISCUSSIONS:*

### *A. Variation of Brake specific fuel consumption:*

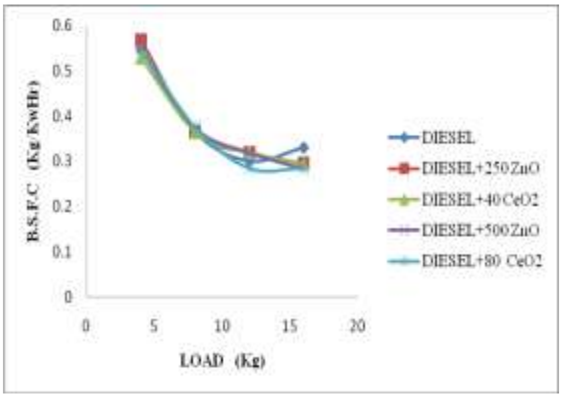


Fig. 2 Variation of brake specific fuel consumption with load

The results of brake specific fuel consumption using different nanoparticles blends are given in Fig. 2. The specific fuel consumption decreases with an increase in the engine loads. All the Nano additives used in the experiment have less specific fuel consumption when compared with diesel at higher loads. The brake specific fuel consumption of zinc oxide 250ppm nanoparticle is nearly same as cerium oxide 40ppm and also zinc oxide 500ppm blend is nearly same as cerium oxide 80ppm at higher loads. This is due to the enhanced surface area to volume ratio by the catalytic effect during the combustion inside the engine cylinder.

### *B. Variation of Brake thermal efficiency:*

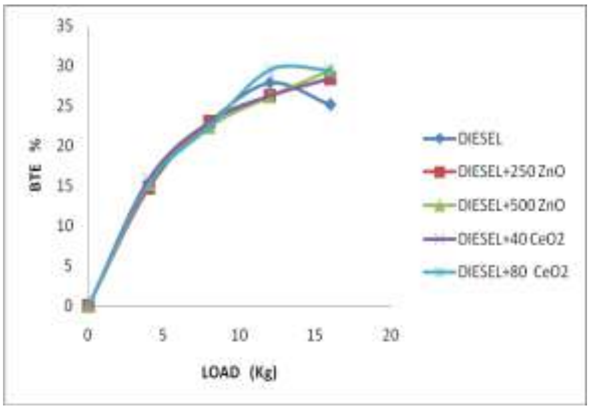


Fig. 3 Variation of brake thermal efficiency with load

The results of engine thermal efficiency using different nanoparticles additives are given in Fig. 3. The addition of nanoparticles i.e. cerium oxide and zinc oxide leads to an improvement in thermal efficiency compare to diesel operation at full load. There is a marginal improvement in thermal efficiency by adding nanoparticles at full load. Because metal/metal oxide additive reduces the evaporation time of the fuel and hence it reduces the physical delay. All the Nano additives used in the experiment have high brake thermal efficiency when compared with diesel. However, higher brake thermal efficiency was recorded for 500ppm ZnO and 80ppm $CeO_2$ is 29.5% at higher loads.

### C. *Variation of Exhaust gas temperature:*

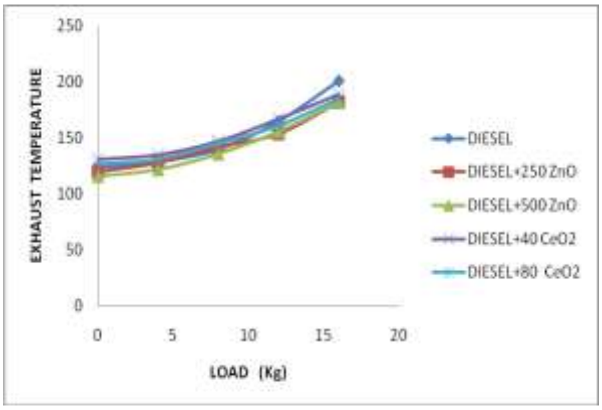


Fig. 4 Variation of Exhaust gas Temperature with load

The results of Exhaust gas temperature using different nanoparticles blends are given in Fig.3. It is observed that all the nanoparticle added blends are having less exhaust temperature than the diesel values at higher load. However 500ppm ZNO shows lesser Exhaust gas temperature as compared to other blends, due to its lower heating value and the improved oxygen content provided by the blends which increases better combustion. This may be due to, effective combustion is taking place, and there is minimum energy loss in the exhaust.

### D. *Variation of Smoke level:*

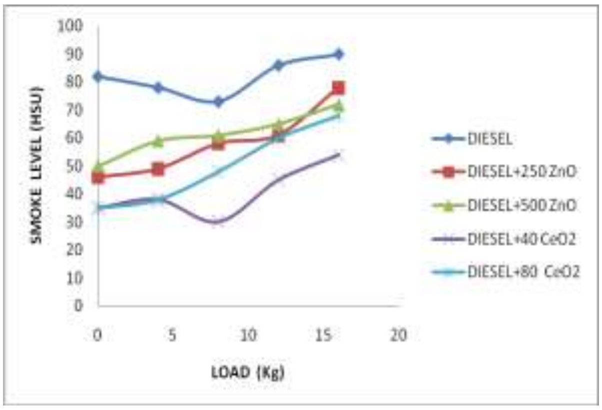


Fig. 5 variation of Smoke level with load

The results of smoke emission measurements are presented in Fig. 5. It is seen that, the smoke emission was reduced using nanoparticle additives. The availability of oxygen in the nanoparticles leads to better combustion and reduced the smoke emission. With the addition cerium oxide the smoke is decreased the fuel added with 40ppm of CeO2 as given the lowest rate of smoke.

## IV. CONCLUSION:

The experimental investigation was carried out to study the effect of both nanoparticles on the performance characteristics of a CI engine using various concentrations. Based on the work, the following major points were observed.

- ZnO and CeO2 based metallic additives reduced the flash and fire point depending on the rate of the additives. Better results were obtained with less dosing of CeO2 nanoparticle based additive.
- The brake specific fuel consumption for all the diesel fuel additives were found less when compared to the neat diesel due to the catalytic effect during the combustion inside the engine cylinder.
- The BTE increases when the both nanoparticles concentration in the fuel increases due to the better combustion characteristics of the nano-fuel additives. But CeO2 shows higher efficiency at small amount of concentration.
- The smoke was found lower when using the 40ppm cerium oxide nanoparticles compared to the neat diesel and other nano additives.

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## REFERENCES

[1]. S. Tajammul Hussain, M. Hasib-Ur-Rahman, "*Nano Catalyst for CO2 Conversion toHydrocarbons*", Journal of Nano Systems &Technology, Vol. 1 No. 1, PP. 1-9.

[2]. Yanan Gan, Li Qiao, "*Combustion Characteristicsof Fuel Droplets with Addition of Nano and Micron-Sized Aluminum Particles*", TheCombustion Institute. Published by Elsevier Inc.,Vol. 158, PP. 354–368, 2011.

[3]. Arul Mozhi Selvan, Anand and Udayakumar, "*Effects of cerium oxide nanoparticle addition in diesel and diesel-biodiesel-ethanol blends on theperformance and emission characteristics of a ci engine*", ARPN Journal Of Engineering AndApplied Sciences, Vol. 4, No. 7, PP. 1-6, 2009.

[4]. Sawyer B. Fuller, Eric J. Wilhelm, And Joseph M.Jacobson, Ink-Jet Printed "*Nanoparticle Micro electro mechanical systems*", Journal Of MicroElectro Mechanical Systems, Vol. 11 No.1, PP. 54- 61, 2002.

[5]. M.Mani, G.Nagarajan, S.Sampath, (2010), "*Characterisation And Effort Of Using Waste Plastic Oil And Diesel Fuel Blends InCompression Ignition Engine*", Energy,Doi:10.1016/J.Energy.Vol 10, PP.49, 2010.

[6]. Selvan Arul MozhiV., R.B. Anand and M. Udayakumar, "*Effects of cerium oxide nanoparticle addition in diesel and diesel-biodiesel-ethanol blends on the performance and emission characteristics of a C.I engine*", ARPN Journal of Engineering and Applied Sciences 4(7) (2009).

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[7]. Naresh Kumar Gurusala , V Arul Mozhi Selvan ,"*Effects of alumina nanoparticles in waste chicken fat biodiesel on the operating characteristics of a compression ignition engine*", Clean Techn Environ Policy DOI 10.1007/s10098-014-0825-5.

[8]. Nagaraj Banapurmath, T. Narasimhalu, Anand Hunshyal, Radhakrishnan Sankaran, Mohammad Hussain Rabinal, Narasimhan Ayachit ,"*Effect of silver nano-particle blended biodiesel and swirl on the performance of diesel engine combustion*", International Journal of Sustainable and Green Energy 2014; 3(6): 150-157.

[9] S.karthikeyan, A.Elango, A.prathima, "*performance and emission study of zinc oxide nanoparticle addition with Pomolion Stearin wax biodiesel of IC engines*", Journal of scientific & Industrial research, 2014, 73, 187-190.

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