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# Performance and Emission characteristics of Diesel Engine Using Nano Additive

K.Asaithambi[1] and S. Sivaprakasam[2]

[1]*Research Scholar, Department of Mechanical Engineering, Annamalai University,*
[2]*Associate Professor, Department of Mechanical Engineering, Annamalai University, India*

**Abstract —** *An experimental study was carried out on DI diesel engine using gadolinium oxide nano additive to promote the performance and emission characteristics. The experiment was also done systematically compare emission rates of harmful gases and smoke contents of fuel mixes with various concentrations of gadolinium oxide nano additive with diesel .The gadolinium oxide nano additive is mixed with diesel fuel in various proportions using ultrasonication method. The diesel fuel reformulated with gadolinium oxide nano additive to reduce the fuel to reduce these harmful emissions without affecting the physiochemical properties of fuel such as viscosity, flash and fire point. Diesel is blended with gadolinium oxide nano additive improves better combustion and also shortened ignition delay period were noticed.*

***Keywords***- *Gadolinium oxide; DI Diesel Engine; Emission; Nano additive; Ultrasonication;*

## I. INTRODUCTION

Diesel engines are widely used for their low fuel consumption diesel will deplete at an increased consumption and better efficiency rate estimated to be order of 3% per annum. The concept of nano scale energetic metal particle additives in liquid fuel is an emerging and less ventured idea. These altered nanofuels offer shortened ignition delay, decreased burn times and rapid oxidation that results in complete combustion blended with nanoparticles of aluminum, boron or carbon particles enhance ignition probability[1]. This research focuses on incorporating energetic metal nanoparticles of aluminum, iron and boron in petro-diesel as additives to increase combustion rates, reduce ignition delay, and boost calorific values. Burning mechanism of the nanofuel droplets at different combustion stages along with engine performance, emissions and combustion characteristics of CI engine is also studied [2]. Fuel parameters such as the volatility, density, and the sulfur content in the fuel that affect particulate emissions can be altered by the use of fuel additives. Properties such as the density, volatility, and viscosity often influence processes such as fuel injection and mixture preparation. Atomization and lubrication characteristics of diesel oil is determined by its viscosity, while the flash and fire points dictate the temperature below which the fuel can be safely handled. The low temperature characteristics of diesel have a direct impact in fuel handling than its combustion behaviour. So for optimal combustion process and safe handling of fuel, acceptable limits for appropriate physicochemical properties must be identified [3-4]. Aluminum nanopowder when blended with water/diesel emulsion fuel reacts with water at higher temperatures and generates hydrogen which promotes combustion in engine chamber [5]. The increased viscosity and low volatility of vegetable oils lead to severe engine deposits, injector chocking and piston ring sticking [6]. They also found that one percent NaOH or KOH was an effective reaction rate enhancer at room temperature, a 60 min reaction time was allowed. It was determined that a 6:1 molar ratio of methanol to oil gave the best conversion [6-8].

## II. EXPERIMENTAL INVESTIGATION

### 2.1 Preparation of nano additive blends with diesel

Gadolinium oxide is mixed with diesel fuel using an ultrasonicator to prepare the nano additive fuel blend. The ultrasonicator technique is used to disperse the nano additive in the base fuel because it facilitates possible agglomerate nano additive back to nanometer range. The nano additive particles are weighed to a predefined mass fraction say 10ppm and dispersed in the diesel with the aid of ultrasonicator set at a frequency of 20 kHz for 15-30 minutes. The resulting nano additive diesel is named as Diesel+10$Gd_2O_3$. The same process is repeated for the mass fraction of 20ppm, 30ppm, 40ppm, 50ppm, 60ppm and 70ppm to prepare the gadolinium oxide nano additive diesel fuel.

### 2.2 Experimental procedure

The experiments diesel with gadolinium oxide nano additive blends was carried out in DI diesel engine. The test engine is a single cylinder, direct injection, water cooled Compression Ignition engine. The experimental setup is shown in figure 1. Diesel engine was directly coupled to an eddy current dynamometer. The engine was always run at a constant rated speed of 1500rpm. A governor is used to control the engine speed. The dynamometer was interfaced to a control panel. Experimental tests have been carried out to evaluate the performance and emission characteristics of a diesel engine when fuelled gadolinium oxide nano additive blends in various percentages 10ppm, 20ppm, 30ppm, 40ppm, 50ppm, 60ppm, 70ppm and diesel at different load. The emission like HC, CO, and NOx were measured in the exhaust using gas analyzer and smoke density was measured using smoke meter. The specification of the engine is mentioned in table 1.

 

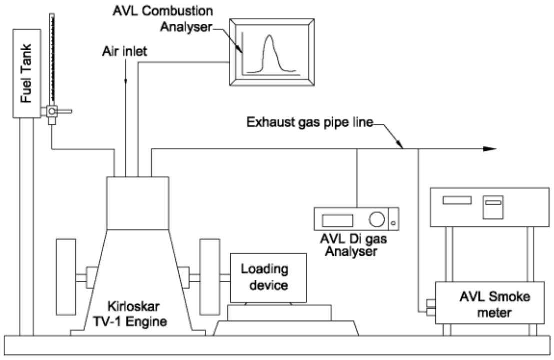


**Figure 1. Experimental setup**

**Table.1.Engine Specifications**

| | | |
|---|---|---|
| Type | : | Single cylinder vertical water cooled, 4 stroke Diesel Engine |
| Bore | : | 87.5 mm |
| Stroke | : | 110 mm |
| Cylinder diameter | : | 0.0875 m |
| Stroke length | : | 0.1m |
| Compression ratio | : | 17.5 : 1 |
| Power | : | 5.2 kW (7HP) |
| Speed | : | 1500 rpm |
| Loading device | : | Eddy current dynamometer |

## III. RESULT AND DISCUSSION

### 3.1 Performance Characteristics

Specific fuel consumption using different nano additive blends are shown in Fig. 2. This is obvious from the fact that the increase in fuel required to operate the engine is less than the increase in brake power at higher loads. Adding a nano additive to diesel fuel will decrease the SFC. Results show that 40ppm blends of nano additives have less specific fuel consumption when compared with other blends in all load range. The decrease in SFC can be due to the positive effects of nano particles on physical properties of fuel and also reduction of the ignition delay time, which lead to more complete combustion.

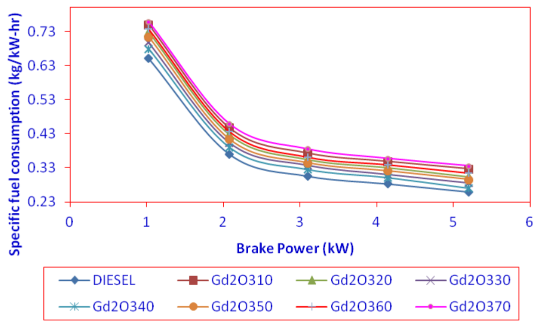


**Figure 2 Specific fuel consumption Vs Brake power**

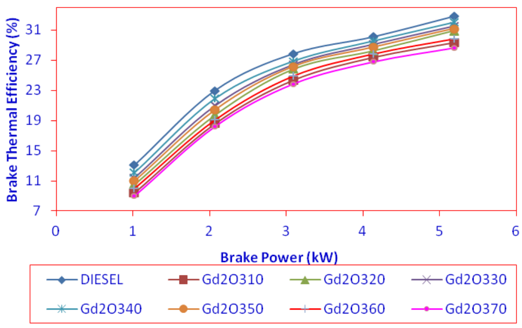


**Figure 3 Brake thermal efficiency Vs Brake power**

Addition of nanoparticles not only enhances the calorific values but also promotes complete combustion due to higher evaporation rates, reduced ignition delay, higher flame temperatures and prolonged flame sustenance. All these factors support the full release of thermal energy thereby leading to higher brake thermal efficiency. The results of engine thermal efficiency for different nano additives are given in Fig. 3. The addition of nano additive gadolinium oxide leads to an improvement in thermal efficiency compare to diesel operation at full load. Improvement in brake thermal efficiency is observed with the addition of Gadolinium oxide with diesel. The highest brake thermal efficiency is observed at full load is observed due to the reduction in evaporation time of fuel and thereby reducing the physical delay.

 

All the nano additives used in the experiment have low brake thermal efficiency when compared with diesel. However, higher brake thermal efficiency was recorded for 40ppm closer to diesel.

### 3.2 Emission Characteristics

Fig.4 represents smoke emission measurements that clearly indicate smoke emission was reduced using nanoparticle additives. This phenomenon is due to the availability of oxygen in the nano additive particles that leads to better combustion and reduced smoke emission. With the addition of gadolinium oxide the smoke is decreased, the fuel added with 40ppm given the lowest rate of smoke.

The variation of nitrogen oxides (NOx) emissions with brake power for neat diesel and nano diesel is shown in Fig. 5. NOx emission increased at higher loads when engine was fuelled with nanofuels. It could be argued that at the higher loads, burning temperatures in the combustion chamber increases with load and facilitates NOx emissions according to Zeldovich thermal mechanism. The greater catalytic it is found that blend has better performance and improved combustion characteristics and reduced emission on diesel engine.

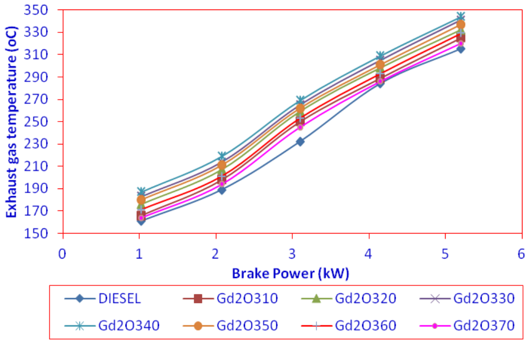


**Figure 4 Smoke density Vs Brake power**

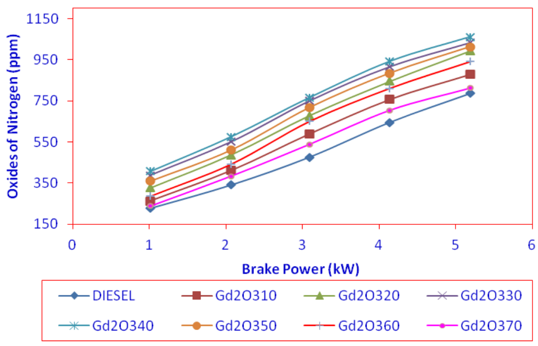


**Figure 5 Oxides of nitrogen Vs Brake Power**

Fig. 6 shows the effects of nano additives on HC emissions. Hydrocarbon emissions for nano additives are lower to that of neat diesel. This effective droplets are leads to rise in cylinder pressure and temperature. Such conditions accelerate oxidation reactions leading to controlled combustion during effective burning stage leaving unburnt HC.

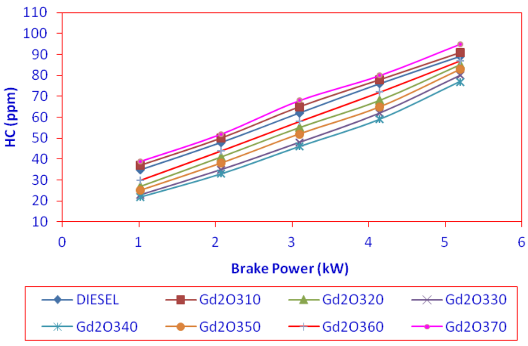


**Figure 6 Hydrocarbon Vs Brake power**

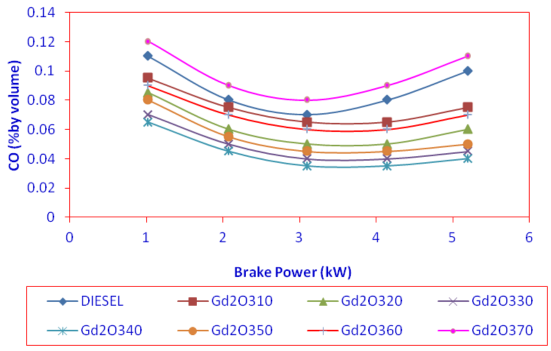


**Figure 7 Carbon monoxide Vs Brake power**

Fig. 7 shows the variation of carbon monoxide (CO) with brake power for neat and nanodiesel fuels. Increase in CO emission for increase in brake power for all fuels was observed. In all other cases CO emission decreased with addition of nano additives into neat diesel. The CO emission for nano diesel is lower than that of neat diesel, due to the oxygen conversion of CO to $CO_2$. These reductions of CO emission for the sample fuels are due to the ability of nano particles to convert CO to $CO_2$. Gadolinium oxide addition reduces ignition delay timing, which leads to more complete combustion.

Fig.8 shows the exhaust gas temperature for varying brake power and corresponding nano additives. At higher loads, nano additive blends exhibit less exhaust temperature than diesel. However 40ppm 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 can be explained by the fact that there is effective combustion taking place and minimum energy loss within the exhaust.

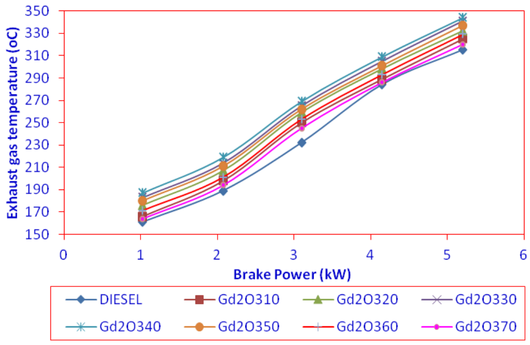


**Figure 8 Exhaust gas temperature Vs Brake power**

## IV. CONCLUSION

Experimental measurements and analysis were conducted on a four-stroke diesel engine to investigate the effects of adding gadolinium oxides to diesel fuel. Engine tests were done for blended with diesel of 10ppm, 20ppm, 30ppm, 40ppm, 50ppm, 60ppm and 70ppm at 1500 rpm. The test results indicated that adding nano additive to diesel fuel not only improves engine performance (increasing BTE and decreasing SFC) but also increase in NOx emissions. The is lower in HC, CO and Smoke. The results showed that increasing nano additive concentration will magnify the results.

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