Analysis the Performance and Exhaust Emission of DI Diesel Engine using Barium Oxide

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Abstract - *Depletion of fossil fuels, increasing fuels prices and environmental considerations have encouraged engineers and scientists to develop alternative fuels and improve the efficiencies of energy systems. Nanofluids are a new class of solid-liquid composite materials consisting of nano-sized solid particles dispersed in any base fluid [1]. This study deals with an experimental work that aims to examine the effects of nano additive added to diesel fuels. Nano diesel fuels were prepared by adding barium oxide nano additive. These nano additives were blended with diesel fuel in varying mass fractions by the means of a mechanical homogenizer and an ultrasonicator. Physicochemical properties of nanodiesels were measured and compared with neat diesel fuel. The effects of the additive nano additive on the engine performance and emissions were also investigated. The engine test results indicated that the nanodiesel in terms of engine performance efficiency and environmentally friendly emissions could be recognized as the potential candidates in diesel engines.*

Keywords —*Barium oxide; Diesel Engine; Emission; Nano additive;*

I. INTRODUCTION

It is known almost to every resident of the planet Erath that fossil fuel resources are depleting day by day and hence, there is a need to search for alternative fuels to full the growing energy demands of the world [1]. More importantly, the environmental crises caused by vast combustion of fossil fuels have also led researchers towards finding strategies to address the critically worrying level of air pollution and its potentially tragic consequences e.g., climate change [2]. Among the various alternative fuels, bio fuels (in particular liquid bio fuels e.g., bio ethanol, bio buthanol and biodiesel), have received a great deal of attention as the most desirable fuel extenders for the transportation sector [1–6]. This is ascribed to the fact that these energy carriers are capable of powering machines on their own while their harmful emissions such as SO , HC, and CO are considerably less in comparison with those of the fossil fuels [7–10].

Based on various researches conducted earlier, it is found that the biodiesel fuelled engines emit less carbon monoxide, total hydrocarbon, and particulate matter (PM) as compared to diesel but there is a slight increase in nitric oxide (NO) emission [18,19]. Reduction of NO can be attained while using biodiesel can be achieved by improving the diesel engine design and combustion chamber. But the reduction rates achieved have not been adequate to meet the emission standards. Further reduction in emission and improvement in engine efficiency can be achieved by use of fuel additives. Metal based additives have been employed as combustion catalyst to promote the combustion and to reduce fuel consumption and emissions for hydrocarbon fuels. These metal based additives include cerium (Ce), cerium–iron (Ce–Fe), platinum (Pt), platinum–cerium (Pt–Ce), iron (Fe), manganese (Mn), barium, calcium and copper [20]. The reduction of emission while using metal based additive may be either due to the fact that the metals react with water vapour to produce hydroxyl radicals or serve as an oxidation catalyst thereby reducing the oxidation temperature that results in increased particle burnout [21–23].

II. EXPERIMENTAL INVESTIGATION

2.1 Preparation of nano additive blends with diesel:

The nano additive blends with diesel fuel are prepared by mixing the barium oxide with the aid of an ultrasonicator. The ultrasonicator technique is the best suited method to disperse the both nano additive in the base fuel as it facilitates possible agglomerate nano additive back to nanometer range. The nano additive 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+10BaO. The same procedure is carried out for the mass fraction of 20ppm, 30ppm, 40ppm, 50ppm, 60ppm and 70ppm to prepare the barium oxide nano additive diesel fuel.

2.2 Experimental procedure:

The experiments diesel with barium 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 its rated speed 1500rpm. The governor of the engine was 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 barium 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 gas analyzer and smoke density was measured in the smoke meter. The specification of the engine mention in table 1.

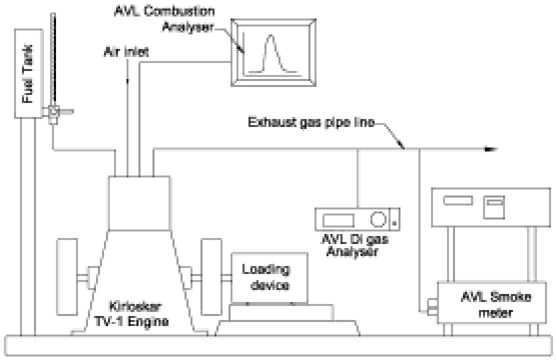

Figure 1 Experimental setup

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

The results of specific fuel consumption using different nano additive blends are given in Fig. 2. The specific fuel consumption decreases with an increase in the engine loads. The 30ppm blends of nano additives used in the experiment have less specific fuel consumption when compared with other blends in all load range. The specific fuel consumption of 30ppm nano additive is nearly same as diesel fuel at all loads. This is due to the enhanced surface area to volume ratio by the catalytic effect during the combustion inside the engine cylinder.

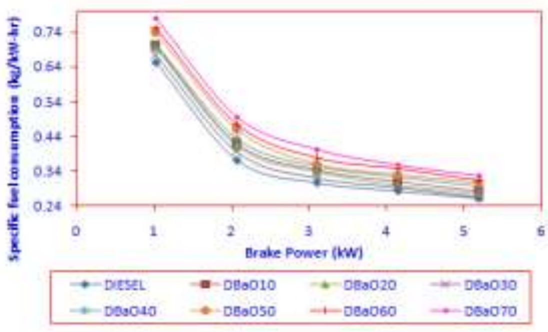

Figure 2 Specific fuel consumption Vs Brake power

The results of engine thermal efficiency using different nano additives are given in Fig. 3. The addition of nano additive barium 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 nano additive at full load. Because 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 low brake thermal efficiency when compared with diesel. However, higher brake thermal efficiency was recorded for 30ppm closer to diesel.

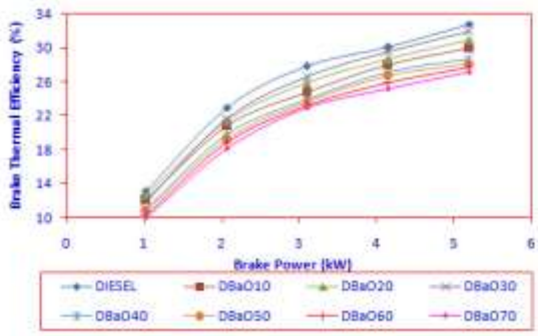

Figure 3 Brake thermal efficiency Vs Brake power

3.2 Emission Characteristics

The results of smoke emission measurements are presented in Fig.4. It is seen that the smoke emission was reduced using nanoparticle additives. The availability of oxygen in the nano additive leads to better combustion and reduced the smoke emission. With the addition of barium oxide the smoke is decreased the fuel added with 30ppm given the lowest rate of smoke.

The variation of nitrogen oxides (NOx) emissions with brake power for neat diesel and nanodiesels is shown in Fig. 5. NOx emissions increase with brake power for all fuels. The NOx emission is lower for the blends when comparing to higher nano diesel blends. Oxygenated additives enhance the combustion causes for higher combustion temperature and subsequently higher NO emission. However NO are appreciably reduced with the addition of oxygenated nano additive. Thermally stable promotes the oxidation of hydrocarbon and reduction of nitrogen oxide. The trend in the reduction of nitrogen oxide observed for nano diesel supports results obtained from literature [11].

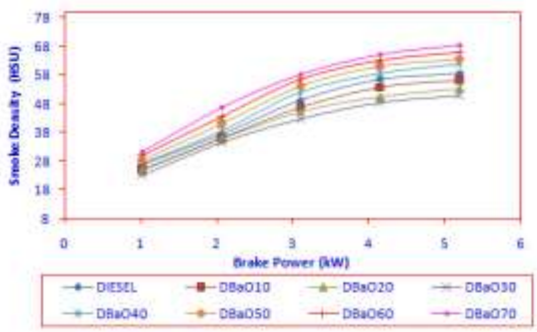

Figure 4 Smoke density Vs Brake power

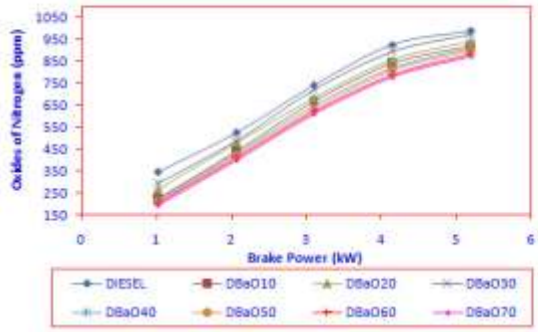

Figure 5 Oxides of nitrogen Vs Brake Power

Fig. 6 shows that the effects of the nano additive on HC emissions. The magnitude of HC emission for the nanodiesel including 30pmm is nano additive is lower compared to that of neat diesel and other nanodiesel. This could be probably due to more shorten ignition delay and improved ignition characteristics of Barium oxide nano additive.

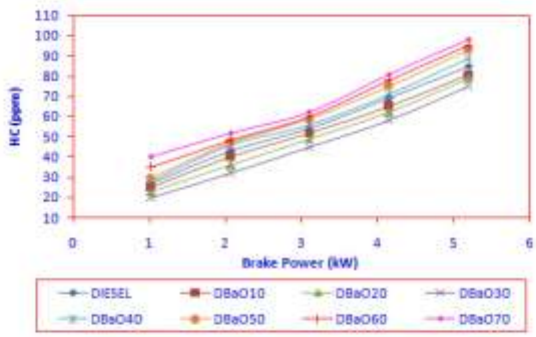

Figure 6 Hydrocarbon Vs Brake power

The variation of carbon monoxide (CO) with brake power showed in Fig. 7 for neat and nanodiesel fuels. It is observed that the CO emission increased with an increase in brake power for all fuels. Otherwise the CO emission decreases with addition of nano additive into neat diesel. Nano additive may have affected fuel propagation in the combustion chamber. This phenomenon is due to the result of barium oxide addition causes more reduction of the ignition delays time, which leads to more complete combustion. The metal oxide nano additive also acts as an oxygen donating catalyst and provides oxygen for the oxidation of HC and CO absorbs oxygen for the reduction of NOx.

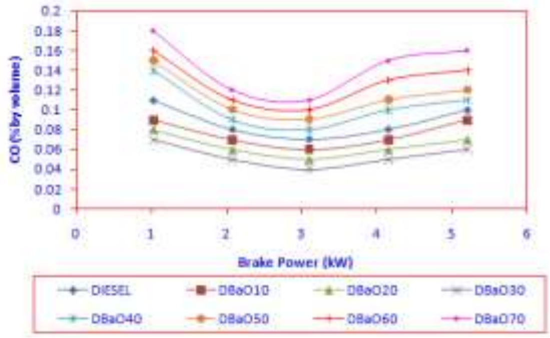

Figure 7 Carbon monoxide Vs Brake power

The results of Exhaust gas temperature using different nano additive blends are given in Fig.8. It is observed that all the nanoparticle added blends are having less exhaust temperature than the diesel values at higher load. However 70ppm 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.

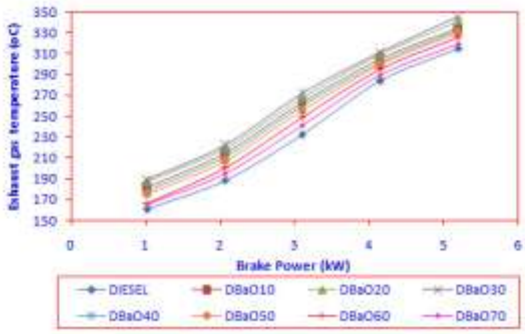

Figure 8 Exhaust gas temperature Vs Brake power

IV. CONCLUSION

The nano additive, their stability characteristics and the effects of adding nano additive on engine performance and exhaust emissions characteristics were investigated. From the analyses of the experimental study, the following conclusions are revealed.

- The fuel consumption increase with increase in percentage of nano additive blends due to lower calorific value.
- The brake thermal efficiency in 30 ppm blend is close to that of the diesel

- Smoke density and particulate matter is lower in 30ppm blends compared to diesel at all load condition.
- NOx value is lower in all nano additive blends than diesel.
- CO and HC is lesser in lower blends of nano additive.

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