EXPERIMENTAL INVESTIGATION ON THE PERFORMANCE AND EMISSION CHARACTERISTICS OF DI-DIESEL ENGINE USING DIESEL- ETHANOL BLENDS AND ALUMINIUM OXIDE NANO PARTICLES

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ABSTRACT

An experimental investigation was carried out to evaluate the performance and emission characteristics of four stroke, single cylinder, constant speed diesel engine using aluminium oxide nano particles as additive in diesel ethanol blends compared with neat diesel. N-butanol (normal butanol) is used to prevent the phase separation between diesel and ethanol. Aluminium oxide nano particle additives are used in every diesel and ethanol blends in the mass fraction of 50ppm. Final results are showing that the brake thermal efficiencies of the engine using diesel ethanol with nano additive blends are increased at higher loads compared to pure diesel and diesel-ethanol blends. Specific fuel consumption was slightly increased in diesel-ethanol blends compared to neat diesel due to lower heating value of ethanol. Emissions also controlled by using diesel, ethanol with nano additive blends compared to diesel-ethanol blends.

KEYWORDS: 4 Stroke Single Cylinder Diesel Engine, Ethanol, Diesel, Nano Particles, Performance & Emissions

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INTRODUCTION

Compression ignition engines exhibits high thermal efficiency in automobile application, due to their fuel economy compared to petrol engines. These fossil fuels out send harmful pollutants like CO₂, Knox and other particulate matter. This causes greenhouse effects. Search for alternative fuels. Alternative fuels are one of the best available sources, to fulfill the energy requirement of the world. In this ethanol is one of the renewable sources. It is derived from biomass. It is environment friendly source. It reduces the emissions of the engine. However, slightly increases the fuel consumption, because of low calorific value. In this experiment, ethanol is an alternative fuel with diesel as different proportions like 15%, 25% and 35%, respectively. These fuel blends used in four stroke, single cylinder, constant speed direct injection diesel engine, to estimate the performance and emission characteristics. Alumina nano particles are also used in this work. These nano additives are used to reduce the emissions of an engine and increase the power output. Nano particles, improves the oxidation rates. Due to this, complete combustion takes place. Nano particles hold unusual properties, resulting from their high surface area. These are also improving the combustion efficiency, during the combustion process.

Studied the effects of diesel-ethanol, blends on the performance and emissions of direct injection diesel

engine. The brake thermal efficiency of the engine increases and specific Fuel consumption is decreased slightly, for ethanol-diesel blends [1]. Conducted the experiment, using cerium oxide nano particles in diesel and diesel-biodiesel-ethanol, blends on the performance and emissions and emission characteristics of diesel engines. Cerium oxide nano particles are used as an oxygen donating catalyst [2]. The vegetable methyl ester is used to prevent the phase separation, between diesel and ethanol. Co emissions decrease in diesel-biodiesel-ethanol blends and peak pressure also increases [3], studied the effects of alumina nano particle additive, on the performance and exhaust emissions of C.I engine. Al_2O_3 improves the combustion characteristics of the engine, due to the rapid oxidation. These nano additives decrease the emissions of the engine and used for the complete combustion process [4], conducted the experiment on the DI-diesel engine, with the effects of different nano particles. The thermal efficiency of the engine increased and peak pressure was also increased, during this experiment. Zinc oxide and copper oxide nano particles are used in this work [5]. Studied the influence of alumina nano particles, on a single cylinder diesel engine, with cotton seed biodiesel blends, brake specific fuel consumption was decreased, with increase in brake power for diesel and other blends. Brake thermal efficiency also increased, with increase of brake power [6]. Conducted the experiment with the effects of Al_2O_3 nano particles, added to Mahua biodiesel blends on common rail direct injection diesel engine. The results are observed that, there is a significant enhancement in brake thermal efficiency and reduction of harmful pollutants [7],

Investigated the performance and emissions characteristics of a compression ignition engine, with cerium oxide nano additives to the diesel. It acts as catalyst and facilitates oxygen for the oxidation of CO, or absorbs oxygen for nitrogen oxide reductions [8], reviewed then on the result of aluminium oxide nano particles, ethanol and ISO propanol blend, as additive in diesel-soybean biodiesel blended fuel in diesel engine studied the performance, combustion and emission characteristics. Better mixing of nano particle additives, reduces the CO and unburned hydrocarbon emissions and a slight increase in nitrogen oxide emissions, at higher load conditions [9], studied the experiment investigated on the performance and emissions of the diesel engine, with the blends of diesel-ethanol [10], found that smoke emissions of the engine with ethanol, diesel were lower than the neat diesel fuel [11], investigated the effect of zinc oxide nano particles, added to the diesel-biodiesel-ethanol blends on the performance, emissions and combustion characteristics of diesel engines [12]. It is observed that, the brake thermal efficiency of the blends was lower than that of diesel, due to lower heating value of blends, as compared to diesel [13]. Reviewed on the effects of carbon nanotubes blended jatropha methyl ester emulsions. The test was conducted on a single cylinder, constant speed diesel engine and observed that, the performance, emissions and combustion characteristics of the engine was analyzed [14]. The stability characteristics of the tested fuels were also studied [15].

PROPOSED WORK

This work proposes an experimental investigation on the performance and emission characteristics of the DI - diesel engine, using diesel-ethanol blends and alumina nano particle additives. The sequence of steps involved in this work is as shown in flow chart figure 1.

Figure 1: Flow Chart for Proposed Work

MATERIALS AND METHODS

In this experiment diesel is purchased from a diesel filling station and ethanol is purchased from chemical lab stores. The blends are E15D85 (ethanol 15%, diesel 85%), E25D75 (ethanol 25%, diesel 75%) and E35D65 (ethanol 35%, diesel 65%) respectively. This blending process can be done by using a magnetic stirrer as shown in Figure 2. These blends are as shown in Figure 3. To form stable mixture of ethanol and diesel 5% n-butanol was added in all blends.

Figure 2: Magnetic Stirrer

Figure 3: Samples of Fuel Blends

Preparation of Nano Fluid blends

Nano particle blended fuel samples are prepared by using an OSCAR ultrasonic sonicator, as shown in figure 4. Ultrasonic sonicator is used to disperse the nano particle in the fuel blend. The frequency of sonicator is 40KHZ. 50ppm nano additives are added to each blend. The fuel blends are E15D85+50ppm, E25D75+50ppm and E35D65+50PPM, respectively.

Figure 4: OSCAR Ultrasonic Sonicator

The following fuels calorific values are observed below table

Table 1: Calorific Values for Diesel- ethanol- Nano Additives

Fuel Samples	Calorific Value (kj/kg)
Diesel	44800
E15 D85	41268
E25 D75	39292
E35 D65	37516
E15D85+50ppm	42300
E25D75+50ppm	40300
E35D65+50ppm	38600

EXPERIMENTAL SETUP

First, check the engine condition along with lubricating oil and fuel is supplied to the engine. Start the engine and run initially for 10 minutes, to pick up the rated speed as shown in Figure 5. In this experiment work conducted at different loads. The different loads are 0kg, 3kg, 6kg, 9kg and 12kg, respectively. In this, first neat diesel is applied to the four stroke, single cylinder diesel engine, to observe the performance and emission characteristics. Similarly diesel-ethanol and diesel-ethanol with nano additive blends are applied to the engine at different proportions, and also estimate the performance and emissions of the specific engine. The measurement of unburned hydrocarbon, carbon monoxide, carbon dioxide, oxygen and nitrogen oxides were done with help of exhaust gas analyzer. The INDUS 5 Gas Analyzer as shown in Figure.6ine.

Table 2: Specifications of the Engine

Type of Engine	Four Stroke, Vertical, Water Cooled, Single Cylinder High Speed Diesel Engine
Make and model	Kirloskar AVI
R.p.m	1500
Stroke	110mm
Diameter of rope	0.015m
Compression ratio	16.5 : 1
Brake power	3.75kw
Bore	80 mm
Diameter of brake drum	0.3 m
Loading system	Rope brake dynamometer

Figure 5: Single Cylinder Four-Stroke Direct Injection Diesel Engine

Figure 6: Gas Analyzer

RESULTS AND DISCUSSIONS

Performance Test

Brake Thermal Efficiency (BTE)

The variation of brake thermal efficiency versus load of neat diesel, E15D85, E25D75, E35D65, E15D85+50ppm, E25D75+50ppm and E35D65+50ppm relations, as shown in Figure 7. In this observed we that, the brake thermal efficiency increases with increasing the loads. In diesel, ethanol with nano additive blend's thermal efficiency increases, compared to pure diesel. In E25D75 and E35D65+alumina fuel blends the brake thermal efficiency is higher at full load condition compared to pure diesel. An increase in thermal efficiency of 9.9% in diesel-ethanol + alumina fuel blends compared to pure diesel and diesel-ethanol blends at full load condition.

Figure 7: Variation of brake thermal efficiency with load

Specific Fuel Consumption (SFC)

Figure 8. Shows the variation of the specific fuel consumption with loads of different fuel blends. It is seen from the figure, that's for all the tested fuels, the specific fuel consumption decreases with an increase in load and further it is seen that, the specific fuel consumption was found to be the lowest for pure diesel is 0.35 kg/kW-hr at full load condition and higher fuel consumption is 1.22 kg/kW-hr for E35D65 fuel blend. Specific fuel consumption is slightly increased in diesel-ethanol blends compared to pure diesel due to the lower heating value of diesel. Specific fuel consumption decreases with increasing the load. A drop of 4% and 5% specific fuel consumption was observed at full load, when the engine was fuelled with pure diesel and E15D85 blend compared to other blends.

Figure 8: Variation of Specific fuel consumption with load

Exhaust Emissions

NOX Emission

Figure 9. Shows the variation of the nitrogen oxide emissions with loads of different fuel blends. The nitrogen oxide emissions are increasing with increase in loads on the engine for pure diesel and diesel-ethanol blends with and without the nano additives. Nitrogen oxide emissions are lower at low loads for diesel-ethanol blends compared to other blends. NO_x emissions are lower in E15D85 and E25D75+alumina blends compared to pure diesel and other fuel blends. An increased emission of 6% was observed in E35D65 blend at full load condition. The NO_x emissions were lower in E35D65 blend of 20% at an engine ran below half load condition.

Figure 9: Variation of NOx emission with load

CO Emission

Figure 10. shows the variation of the CO emissions with loads for different fuel blends. It is observed that CO emissions are reduced at an engine ran at half load condition for pure diesel compared to other fuel blends. CO emissions are higher for diesel-ethanol blends when compared to pure diesel and nano additive fuel blends. In E15D85 blend CO emissions are reduced at an engine ran above half load condition compared to pure diesel and other blends. An lower emissions of 3% was observed in E15D85 blend an above half load condition compared to pure diesel and other fuel blends.

Figure 10: Variation of CO emission with load

HC Emissions

Figure11. shows the variation of hydrocarbon emissions with load for different blends. It is observed that the HC emissions are decreasing for diesel-ethanol with alumina nano blends compared to pure diesel and other fuel blends. Alumina nano particle additives are very useful to control the HC emissions from the engine. HC emissions are lower at an engine run at half load condition. These emissions are increased an engine run above half load condition. HC emissions are lower in E35D65+alumina blends and pure diesel compared to diesel- ethanol blends. HC emissions are lower in E35D65+alumina fuel blend of 6% compared to pure diesel and diesel-ethanol blends at half load condition

Figure 11: Variation of HC emission with load

CO₂ Emissions

Figure 12 shows the variation of CO₂ Emissions with load for different fuel blends. CO₂ emissions are lower in blends of diesel-ethanol with nano additives compared to pure diesel and diesel-ethanol blends. At no load condition E15D85 and E15D85+alumina blends have the lowest CO₂ emissions compared to other fuel blends. CO₂ emissions are lower an engine ran at half load condition. These emissions are higher an engine ran above half load condition. CO₂ emissions are lower in diesel-ethanol with alumina blends of 2.5% at half load condition compared to pure diesel and other fuel blends. CO₂ emissions are lower in diesel-ethanol+alumina blend (E35D65+alumina) of 2.7% compared to pure diesel and other fuel blends at full load condition

Figure 12: Variation of Co₂ EMISSION with LOAD

CONCLUSIONS

The proposed work was conducted on the performance and emission characteristics of diesel engines, at different loads by using the fuel blends. The operating speed of an engine was 1500rpm. From final test results, the following conclusions are drawn.

- Normal butanol (5%) was added to the all blends of diesel-ethanol. It was used to prevent the phase separation between diesel and ethanol.
- The brake thermal efficiency of the engine was increased in blends of diesel-ethanol with nano additives compared to pure diesel and other blends. In E25 and E35+alumina fuel blends the brake thermal efficiency is

higher at full load condition compared to pure diesel.

- Specific fuel consumption is slightly increased in diesel-ethanol blends compared to pure diesel due to the lower heating value of diesel. Specific fuel consumption decreases with increasing the load.
- Carbon monoxide (CO) emissions of the engine ran above half loads are lower for diesel-ethanol blends compared to pure diesel and diesel-ethanol with nano additive blends. In E15D85 blend CO emissions are reduced at an engine ran above half load condition compared to pure diesel and other blends.
- Nitrogen oxide (NO_x) emissions are lower at low loads for diesel-ethanol blends compared to other blends. NO_x emissions are lower in E15D85 and E25D75+alumina blends compared to pure diesel and other fuel blends.
- Hydrocarbon (HC) emissions are reduced in diesel-ethanol with nano additive blends compared to pure diesel and other blends. HC emissions are lower in E35D65+alumina fuel blend compared to pure diesel and diesel-ethanol blends at half load condition.
- Carbon dioxide (CO₂) emissions are lower in blends of diesel-ethanol with nano additives compared to pure diesel and diesel-ethanol blends. CO₂ emissions are lower an engine ran at half load condition. These emissions are higher at an engine running above half load condition.

REFERENCES

1. D.C. Rakopoulos, C.D. Rakopoulos, "Effects of ethanol–diesel fuel blends on the performance and exhaust emissions of heavy duty DI diesel engine", *Energy Conversion and Management*, 49,(2008):3155–3162
2. Jincheng Huang, Yaodong Wang, " Experimental investigation on the performance and emissions of a diesel engine fuelled with ethanol–diesel blends", *Applied Thermal Engineering*,29, (2009): 2484–2490
3. T. Shaafi, R. Velraj "Influence of alumina nanoparticles, ethanol and isopropanol blend as additive with diesel-soybean biodiesel blend fuel: Combustion, engine performance and emissions", *Renewable Energy*,80, (2015): 655-663
4. V. Arul Mozhi Selvan, R. B. Anand, "Effects Of Cerium Oxide Nano particle addition in Diesel and Diesel-Biodiesel-Ethanol blends on the Performance and emissions characteristics of a CI engine" ,*ARPJ Journal of Engineering and Applied Sciences*, Vo. 4, No.7,(2009):ISSN 1819-6608
5. S.P. Venkatesan, "Influence of Aluminum Oxide Nanoparticle Additive on Performance and Exhaust Emissions of Diesel Engine", *American-Eurasian Journal of Scientific Research*, 10 (2), 88-92, (2015): ISSN 1818-6785
6. A.Selvaganapathy, A.Sundar, "An Experimental Investigation to Study the Effects of Various NanoParticles with Diesel on Di Diesel Engine", *ARPJ Journal of Science and Technology*, Vol.3, No.1,(2013):ISSN 2225-7217
7. Pallavi Ghogare, Dr. N. W. Kale "Experimental Investigation on Single Cylinder Diesel Engine Fuelled With Cotton Seed Biodiesel Blends With Nano Additives", *International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT)*,(2016)
8. M. Srinivasa Rao N. Venkatesh, and A. Lakshumu Naidu. "A Review on Performance of Diesel Engines by using Biodiesel blends from Different oils."
9. Nithin Samuel, Muhammed Shefeek K, "Performance and Emission Characteristics of a C.I Engine with Cerium Oxide Nanoparticles as Additive to Diesel", *International Journal of Science and Research*, Volume 4 Issue 7, (2015): ISSN: 2319-7064 Index Copernicus Value (2013): 6.14 / Impact Factor (2013): 4.438

10. N. Venkatesh, M. Srinivasa RAO & A. Lakshumu Naidu, *Evaluation of High Speed Diesel Engine Performance and Charecteristics of its Emissions With Carbon Nanotubes Added Ethanol-Diesel Blends*, *International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)* ISSN (P): 2249-6890; ISSN (E): 2249-8001, Vol. 7, Issue 4, Aug 2017, 439-446.
11. B. Prabakaran, Anurag Udhoji, "Experimental investigation into effects of addition of zinc oxide on performance, combustion and emission characteristics of diesel-biodiesel-ethanol blends in CI engine", *Alexandria Engineering Journal* , 55, (2016): 3355–336
12. N. Madhan Raj, M. Gajendiran, "Investigation on aluminium oxide nano particles blended diesel fuel combustion, performance and emission characteristics of a diesel engine", *Journal of Chemical and Pharmaceutical Research*, 8(3), (2016); 246-257, ISSN: 0975-7384
13. N. Venkateswara Rao, M. V. S. Murali Krishna & P. V. K. Murthy, *Comparative Studies on Exhaust Emissions and Combustion Characteristics of Tobacco Seed Oil in Crude form and Biodiesel form in Direct Injection Diesel Engine*, *International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)*, Volume 3, Issue 4, September - October 2013, pp. 129-142
14. S.Ch. Rao, M.Srinivasa Rao, "Performance Analysis of DI Diesel Engine Fuelled with Diesel along with Nano Additives", *International Journal of Engineering Trends and Technology*, Volume 24, Number 2,(2015);ISSN: 2231-5381
15. Muddada Venkatesh, K., and A. Lakshmu Naidu. "ANALYSIS FOR NATURAL CIRCULATION LOOPS." *Asia Pacific Journal of Research* ISSN (Print) 2320: 5504.
16. Gurinder Singh, Sumeet Sharma, "Performance, Combustion and Emissions Characteristics of CI Engine Using Nano-Fuel: A Review", *International Journal Of Engineering Sciences& Research Technology*, 4(6)(2015): ISSN: 2277-9655 Publication Impact Factor: 3.785
17. A. Lakshumu Naidu, and PSV Ramana Rao. "A Review on Chemical Properties of Biodiesel from Sorghum Oils."