ISSN: 0974-2115
www.jchps.com Journal of Chemical and Pharmaceutical Sciences

Experimental investigation of performance and emission characteristics on a diesel engine using aqueous aluminium oxide and iron oxide nanoparticles as additives

P.Ravichandra Ganesh[1]* and K.Hemachandra Reddy[2]
[1]Department of Mechanical Engineering, JNTUA, Ananthapur, Andrapradesh, Dr.M.G.R.Educational and Research Institute, University, Chennai-95,
[2]Department of Mechanical Engineering, JNTUA, Ananthapur, JNTUA, Andrapradesh.
***Corresponding author: E-Mail: prcganesh@gmail.com**

ABSTRACT

This research paper presents the correlation effects (performance and emission) of nano particles as additive to the diesel, ethanol and surfactant blended fuel on a DI (Direct Injection)-diesel engine. The test fuel contains ethanol at the ratio of 15%, diesel 83% and surfactant 2% (Span80) is denoted as D83E15S2. The aqueous aluminium oxide nano particles (AAONP) and iron oxide nano particles (IONP) are added to D83E15S2 blended fuel in 50 ppm and 75 ppm using an ultrasonicator denoted as (AAONP50, AAONP75, IONP50 and IONP75 respectively).The nano particles acts as an oxygen donating catalyst and it improve the oxidation of unburned hydrocarbons (HC) and carbon monoxide (CO) for complete combustion. It is observed that in the present work there is an improvement and significant increase in brake thermal efficiency (BTE) and decrease of brake specific fuel consumption(BSFC),exhaust emissions like HC, CO, smoke and slight increase in Nitrogen oxides (NO_X) with compared to diesel fuel at all engine operating loads .

KEY WORDS: DI-Diesel engine, Diesel, Ethanol, Aqueous aluminium oxide nano particles (AAONP), Iron oxide nano particles (IONP), Surfactant, performance, emission.

1. INTRODUCTION

In India the demand of diesel fuel is five times more than the petrol fuel it is because of all transport and heavy trucks and earth mover vehicles are used as diesel engines. There are many possible alternative energy sources for use of diesel fuel as bio-diesel, alcohol and bio-gas. Bio-gas is required higher pressure to storage and can be used as automobile fuel. Using Bio-gas it is very difficult to arrest the leakage of gas from the engine cylinder and may be involved more expensive process. Bio fuels yet to development are required on research to extract at lower price. Next fuel very easy to develop is ethanol and its industries. Alcohols seem to be the most attractive alternative fuel from its availability, easy storage and handling point of view. Ethanol and Methanol two alcohols can be used as automobile fuels, but methanol has certain disadvantages, such as lower calorific value and toxic effect .The auto ignition temperature of ethanol is higher than the diesel fuel, which makes it safer for automobile fuel. Due to all the advantages described above in this research 15% ethanol is used with diesel fuel. From the literature it is observed that addition of various nano particles in diesel engine was enhances the performance characteristics and successful reduction in exhaust emissions.

Adding $Al_2 O_3$ as main combustion product in diesel engine is environmentally stable and may be recycled back to pure aluminium with an electrolytic reduction also using aluminium oxide with ethanol could potentially be regarded as more environmentally sustainable fuel (Mathew Jones, 2011). Previous studies suggested that after few years, there may be depletion of fossil fuels and environmental considerations let to investigate on the renewable fuels such as ethanol and biodiesel (Yu, 2004). Ethanol is used as fuel in diesel engine has higher oxygen and high volatility of the fuel blend which can be used without any modifications of the engine, it gives better performance and reduced exhaust emissions like hydrocarbon (HC), smoke (Qi, 2011). Some researchers are focused on ethanol with diesel fuel in diesel engine and results showed decrease the density and viscosity of the blends results lower BSFC and reduced exhaust emissions like HC and smoke (Pusparaj, 2013). Using aluminium nano particles as catalyst in diesel engine can improve combustion and reduce the exhaust emissions (Senthilraja, 2010). Aluminium nano particles in waste chicken fat as fuel born catalyst which improve the combustion characteristics and reduce the harmful exhaust emissions (Gurusala Naresh Kumar, 2015). Some researchers determined emulsifier can avoid phase separation and reduce the interfacial tension also increases emulsion stability of the fuel blends. The effect of ethanol and surfactant (Tween80) blended fuel in diesel fuel increases the brake thermal efficiency (BTE), and decrease of smoke emission (Parthasarathi, 2012). It is proved by some analyzers at part load conditions diesel nano particle (aluminium oxide) emulsion exposes improved BTE as compared to diesel fuel, also significant reduction in oxides of nitrogen and smoke as compared to diesel fuel for all its engine power output (SasiKumar, 2015). In our previous studies shown that increase of NO_X emission by the addition of aqueous cerium oxide nanoparticles on diesel and ethanol blends with compared diesel fuel is compensated by reduction of emissions like HC, CO and smoke (Ravichandra Ganesh, 2015). According to this study adding n-Al_2O_3 as additive reduces the evaporation time of the fuel blend and reduces the physical delay, this cause the complete combustion of fuel bend may increase BTE

and reduces the exhaust emissions like HC, NOx and smoke (Venkatesan, 2015). Experimental studies shown that Al_2O_3 nanoparticles in diesel engine with biodiesel and observed that there is an improvement in performance and reduces the emissions like HC, CO, smoke but there is slight increase of NO_X as compared to diesel fuel (Syed Aalam , 2015).

Present research work the stable diesel ethanol fuel blends prepared by using nano particles (aqueous aluminium oxide and iron oxide nano fluid) as additives. The auto ignition temperature of ethanol is higher than the that of diesel fuel, which makes it safer to storage and transportation and can use as diesel engine fuel (Fuery , 1991; Nageli, 1997). Nano particles are new class of additives which are in nano size(less than 40nm) suspended within them. The aluminium oxide nano particles and iron oxide nano particles addition in the blends promote complete combustion and acts as an oxygen buffer, thus increasing the brake thermal efficiency.

2. EXPERIMENTAL SETUP AND PROCEDURE

The performance and emission characteristics of diesel, ethanol and surfactant fuel blends with the addition of aqueous aluminium oxide nano particles (AAONP50, AAONP75, IONP50 and IONP75) were carried out on a single cylinder, four stroke direct injection, naturally aspirated, air cooled diesel engine and the characteristics are compared with the diesel fuel. The fuel tank is connected to a graduated burette to measure the quantity of fuel consumed in unit time. The engine was coupled to an eddy current dynamometer to control engine speed and load. The schematic layout of the experimental set-up is shown in Figure 1.

The details of engine specifications are shown in table 1.Further to prepare the engine fuel blends of diesel, ethanol and aqueous aluminium oxide nano fluids were used and the properties of the fuels are shown in table 2. The phase separation of diesel and ethanol fuel is prevented by using surfactant (span80).

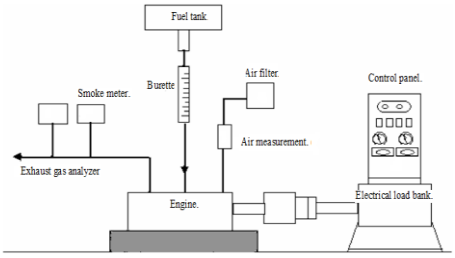

Figure.1.Schematic diagram of engine setup

The mixture was prepared by using ultrasonicator which is subjected to high speed blending in ultrasonic bath to improve the stability of the blended mixture. In an ultrasonicator applying constant agitation time of 30 minutes to form uniform mixture without segregation of nano particles. Exhaust gas temperature is measured by using a calibrated K- type chromel - alumel thermocouple. The exhaust emissions CO, HC and NOx were measured by using AVL-444Digas analyzer. Smoke opacity is measured by using Botch RTM 430 infrared opacity meter. All the tests are conducted by starting and warming up the engine with neat diesel and then switching to blended mixtures.

Table.1. Engine Specifications

Brake power	4.4 kW
Speed	1500 rpm
Compression ratio	17.5: 1
Bore	87.5 mm
Stroke	110 mm
Type of Ignition	Compression Ignition
Type of Engine cooling	Air Cooling
Loading System	Eddy current Dynamometer

At the end of the test, the engine is made to run with the neat diesel to flush out the blended fuels from the fuel line and the injection system.

Table.2. Properties of Ethanol and Diesel

Fuel	**Ethanol**	**Diesel**
Formula	CH_3CH_2OH	$C_{14}H_{30}$
Molecular weight[g/mol]	46.07	198.4
Density[g/cm^3]	0.785	0.856
Normal boiling point[^{0} C]	78	125-400
LHV[Mj/Kg]	26.87	41.66
Carbon content [Wt%]	52.2	87
Cetane number	6	46

Experimental fuels: The commercial diesel fuel used in the fuel preparation is obtained in local diesel outlet. AAONP fluid and IONP are purchased from Reinste nano Ventures Pvt.Ltd. New Delhi. Ethanol (99.9% purity) and span80 are purchased at local markets in Chennai.

Preparation of Fuel Blends: The dosing levels of the nano particles (AAONP, IONP) in the fuel blend were varied from 50 to 75 ppm. Nanoparticles are mixed with fuel blend using an ultrasonicator by applying constant agitation time of 30 minutes to form uniform mixture without segregation of nano particles. The phase separation of diesel and ethanol fuel is prevented by using 2% of span80 surfactant.

3. RESULTS AND DISCUSSION

Performance Characteristics

Brake Specific Fuel Consumption (BSFC): Fig.2 shows the variation of brake thermal efficiency with Load. The fuel consumption mainly depends on engine power, density and viscosity of the fuel. From the graph it is clear that there is reduction of BSFC by the addition of AAONP and IONP as compared to diesel fuel, which shows the positive effect of nano particles on physical properties. At the maximum load the BSFC of diesel fuel is 0.243 Kg/kW.h and 0.216 Kg/kW.h for AAONP75 blend fuel, it is also observed that very less amount of reduction of BSFC by the addition of IONP as compared to diesel and AAONP.

Brake Thermal Efficiency (BTE): Fig.3 shows the brake thermal efficiency variation with load. The thermal efficiency is directly proportional to the engine load for all the fuels, if the load increases the BTE of the fuel increases. From the graph it is observed that there is better BTE by the addition of both nano particles (AAONP and IONP) as compared to diesel fuel. The maximum BTE of AAONP75 is 7% higher as compared to the diesel fuel at maximum load of the engine. Similarly it is noticed that there is a significant change in BTE of IONP addition as compared with the diesel fuel.

Emission Characteristics

Carbon Monoxide Emission (CO): The variation of carbon monoxide (CO) emission with Load as shown in Fig.4 the CO emission is reduced in case of adding both the nano particles (AAONP and IONP) as compared to diesel fuel. It is observed from the graph at maximum engine load there is 19% reduction of CO emission for the blend of AAONP75 as compared to diesel fuel. It is because of nano particles catalyzing the combustion process and cause of complete combustion of fuel blends.

Hydrocarbon Emission (HC): Fig.5 shows the variation of hydrocarbon emission with load. By the addition of nano particles (AAONP and IONP) increase the oxygen content in the fuel blend which enhances the fuel blend and reduces the HC emission. At max load condition AAONP75 blend HC emission is 41 ppm as compared to diesel fuel 46 ppm. IONP blends having higher viscosity to overcome the adverse effect there is 23-25% increase in HC emission as compared to diesel fuel.

Nitrogen oxides Emission (NO_X): Figure 6 shows the effect of NO_X emission with load. It is observed from the graph NO_X emission is lowered for diesel fuel at various engine load conditions as compared to AAONP, it is because of oxygenated fuels enhance the complete combustion are the cause of higher combustion temperature and subsequent higher in NO_X .As per the Zeldovich mechanism, the formation of NO_X emission is not only depends on oxygen enrichment also depends on residence time and temperature. Addition of IONP decrease of NO_X emission, this reduction cause due to high thermal capacity and latent heat of evaporation of water, which can reduce the combustion chamber temperature consequently reduce the NO_X emission (Shafii, 2011).

Smoke Opacity: Fig.7 shows the variation of smoke opacity with load. The addition of nano particles will cause accelerated combustion which shortened the ignition delay, enhances the degree of air-fuel mixing and uniform burning of fuel blend. At maximum load for diesel fuel the smoke opacity is 56.4% where as 45.3%, 44.2% for AAONP50 and IONP50 respectively. Further increasing the dosage of nano particles improve the combustion may cause reduction in smoke opacity, for AAONP75, IONP75 is 32.5% and 31.8% respectively. It is observed that using IONP there is 2% decrease of smoke as compared to AAONP at maximum load condition.

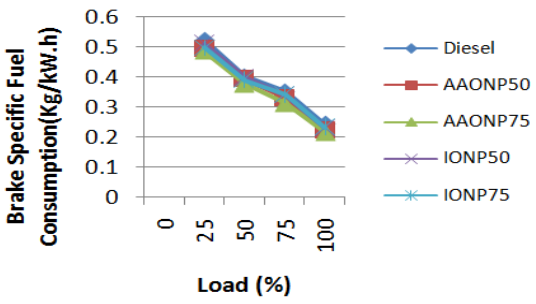

Figure.2.Variation of BSFC with Load

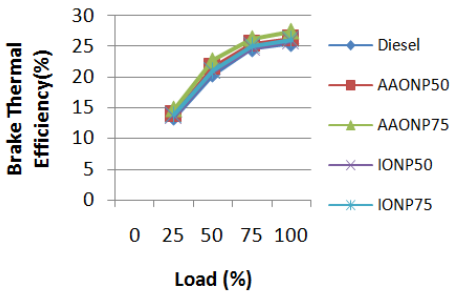

Figure.3.Variation of BTE with Load

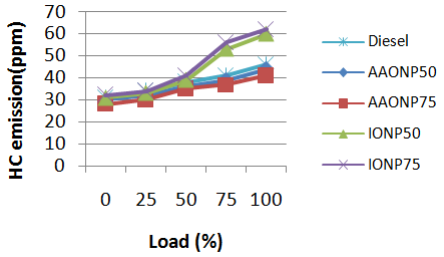

Figure.4.Variation of CO emission with Load

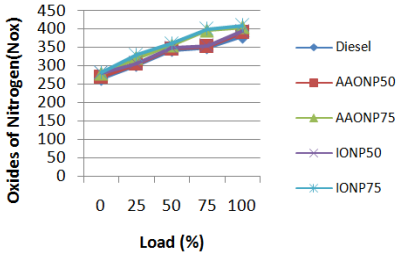

Figure.5.Variation of HC emission with Load

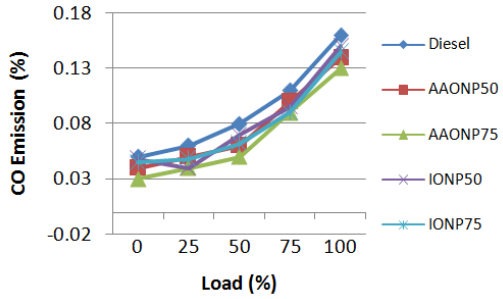

Figure.6.Variation of NOx emission with Load

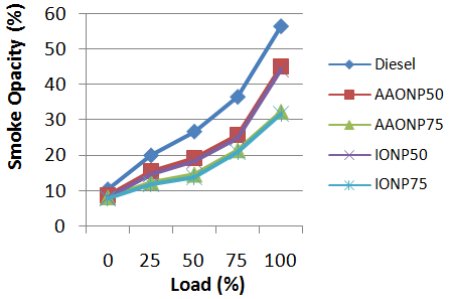

Figure.7.Variation of Smoke Opacity with Load

4. CONCLUSION

The ultrasonic sonicator improves the mixing property of nano fluids (IONP and AAONP) with diesel, ethanol and surfactant fuel blends and gives the uniform mixture of the fuel. The addition of nano particles (AAONP and IONP) in diesel engine, due to the catalytic effect and enhanced surface area to volume ratio during the combustion inside the engine cylinder brake specific fuel consumption (BSFC) at higher loads comparable with diesel fuel and also reduces the evaporation time which reduces the physical delay causes the higher brake thermal efficiency (BTE) of nano particles blends with compared to diesel fuel. Ethanol blended nano particles (AAONP and IONP) containing nano sized aluminium particles acted as combustion catalyst, which gives complete combustion of fuel and cause the reduction in exhaust emissions. It is observed from the results and there is a conclusion of mixing both AAONP and IONP to the fuel blends at a particular quantity may be obtain better performance and emission characteristics of Di diesel engine as compared to diesel fuel.

REFERENCES

Gurusala Naresh Kumar, Arul Mozhi Selvan V, Effects of aluminium nanoparticles in waste chicken fat on the operating characteristic of a compression ignition engine, Clean Techn EnvironPolicy, 17, 2015, 681-692.

Mathew Jones, Li H, Calvin , Abdollah Affeh, GP Peterson, Experimental study of combustion characteristics of nano scale metal and metal oxide additives in biofuel (ethanol), nano scale Research Letters, 6, 2011, 246.

Nageli DW, Lacey PI, Alger M, Surface corrosion in ethanol fuel pumps, SAE Paper, 1997, 971648.

Parthasarathi R, Gowri S, Sarvanan C.G, Experimental investigation of performance, emission and combustion characteristics of Kirloskar TVI Di diesel engine using diesel-ethanol-surfactant as fuel, ARPN Journal of engineering and Applied sciences,7, 2012, 1468-1472.

Pusparaj T, Ramabalan S, Green fuel design for diesel engine, combustion and performance and emission analysis, Procedia Engineering, 64, 2013, 701-709.

Qi D.H, Chen H, Geng L.M, Bian Y.Z, Effect of diethyl ether and ethanol additives on the combustion and emission characteristics of biodiesel-diesel blended fuel engine, Renewable energy, 36, 2011, 1252-1258.

Ravichandra Ganesh P, Hemachandra Reddy K, Experimental investigation on the performance and emission characteristics of Di-Diesel engine using diesel- ethanol blends with aqueous cerium oxide nanofluid as additive, Applied Mechanics and Materials, 787, 2015, 741-745.

SasiKumar N, Senthilkumar M, Investigation on the performance and emission characteristics of a diesel engine using water-diesel-nano fluid emulsion as fuel, Journal of chemical and pharmaceutical sciences, 6, 2015, 37-40.

Senthilraja S, Karthikeyan M, Gangadevi R, Nanofluid applications in future automobiles, Comprehensive review of existing data, Nano-Micro Letters, 2, 2010, 306-310.

Shafii MB, Daneshvar F, Jahani N, Mobini K, Effect of ferrofluid on the performance and emission patterns of a four-stroke diesel engine, Hindawi Publishing Corporation, Advances in mechanical engineering, 2011.

Syed Aalam C, Sarvanan C.G, Kannan M, Experimental investigations on a CRDI system assisted diesel engine fuelled with aluminium oxide nanopartocles blended biodiesel, Alexandria Engineering Journal, 2015.

Venkatesan SP, Influence of aluminium oxide nanoparticles additive on performance and exhaust emissions of diesel engine, American-Eurasian journal of scientific research, 2, 2015, 88-92.

Yu KF, Yu KB, The use of ethanol –gasoline blends as fuel in a Si engine Renewable Energy, 29, 2004, 1181-91.