Effect of Nano Particle Addition on the Performance and Emission Characteristics of a Compression Ignition Engine

Vignesh S, Ramamoorthi R

Abstract: ***Inorganic nanotubes are attracting the attention of many scientists and investigators, due to their outstanding application potential in different fields. Researches have been performed in the field of internal combustion engines by adding nanoparticles into the diesel fuel and in biodiesel and blends and their effect on overall performance were studied. It is understood that doping of nanoparticles tend to decrease the emission levels from the engines. Owing to that idea, this project is directed to investigate the effect of doping nanoparticle over the performance and emission characteristics of a compression ignition engine. Nanotubes are mixed with diesel fuel as a fuel additive at different compositions that are 25 ppm, 50 ppm, 100 ppm to find the variation in performance and emission characteristics and results indicate that nanoparticle doped fuel shall be used as an alternate fuel without any modifications to engine structure.***

Index Terms: ***Fuel additive, nanoparticle, engine performance, emission reduction.***

I. INTRODUCTION

In variety of locomotives, Diesel engines are installed for effective operation as they possess high thermal efficiency. Be that as it may, diesel engines are one of the prime contributors of harmful emissions such as unburnt hydrocarbons, oxides of nitrogen, carbon monoxide, oxides of sulphur, particulate matters, etc. These emissions are so harmful that these are responsible for causing health issues by affecting lungs, skin and other sensory organs. Also these emissions are responsible for acid rain and photochemical contamination. Hence, reduction of these emissions is subject to strict environmental legislation. In the modern era, the performance and emission characteristics of diesel engines have to be improved as their usage in various fields is inevitable. Efforts are being taken by various researchers to provide solution to tackle this problem. In this paper, the outcomes of the experiment such as variation of performance and emission characteristics due to the usage of doped fuel without any changes in physiochemical properties of the fuel are being presented.

Revised Manuscript Received on July 10, 2019.

Mr. Vignesh S, Assistant professor in the department of mechanical engineering at Sri Krishna College of Engineering and Technology, Coimbatore, India.

Dr. Ramamoorthi R, Professor in the department of mechanical engineering at Sri Krishna College of Engineering and Technology, Coimbatore, India.

II. LITERATURE REVIEW

Numerous experiments have been conducted on doping fuel to increase the performance and emission characteristics of the compression ignition engines [1-4].

An experiment was conducted to explain the preparation and characterization of cerium oxide nanoparticles of uniform size with mono dispersion in hydrocarbon solvents by applying heat to cerium oleate complex in an organic solvent with boiling point of higher magnitude, to decompose and form nanocrystals. The factors that influence the size of the nanoparticles are solvent type, reaction time, concentration of the reactant, and so forth [5].

The effect of addition of alumina nanoparticles with emulsified biodiesel fuel on the performance and emission characteristics was studied [6]. An ultrasonicator was used in the study to vary the concentrations of alumina nanoparticles. The outcomes showed that the peak pressure, the rate of pressure rise and the rate of heat release were reduced due to the doping of the nanoparticle to emulsified biodiesel blends. This effect resulted in shortened ignition delay and enhanced combustion characteristics. Reduction in BSFC was observed due to the improved surface area-volume ratio. Improvement in combustion was recorded due to the enhanced fuel-air mixing. Doping of the nanoparticles resulted in remarkable reduction of emissions such as oxides of nitrogen, unburnt hydrocarbon, carbon monoxide and soot.

Basha and Anand [7] studied the diesel engine's performance and emission characteristics with the help of fuel additive namely Carbon Nano Tubes (CNT) experimentally. Two concentrations of nanoparticles were used with the help of an ultrasonicator and a mechanical homogenizer. A decrease in the peak pressure and the rate of maximum heat release were recorded due to the addition of the CNT and also the reduced ignition delay. Reduced BSFC is observed due to the higher surface area to volume ratio and improvement in combustion process due to improved air-fuel mixing. Desirable emission characteristics were obtained with reduction in emissions such as NOx, CO, UHC, and soot, owing to the greater catalytic activity which boosted the combustion characteristics of the compression ignition engine.The foreseen literature review showed that nano-particles doped diesel have an opportunity to make progressive effects on the performance and emission of engines fuelled with diesel. Studies were found regarding the experimental

study of the engine performance and the exhaust emissions of nanoparticles doped diesel mixture. The objective of this work is to investigate such effects with the help of alumino silicate nanotubes. Nanoparticles were mixed to the diesel at three varying concentrations such as 25, 50 and 100 ppm. The engine performance parameters such as Total fuel consumption, Indicated Power, Indicated mean effective pressure, Total heat input and the emissions such as carbon monoxide, unburnt hydrocarbons, Oxides of nitrogen and smoke capacity were also analyzed.

III. EXPERIMENTAL ARRANGEMENT

The experimental test rig model is a Kirloskar make DM10 model single cylinder four stroke direct injection water cooled diesel engine with rated speed of 1500 rpm and is coupled directly to the electrical dynamometer.

Fuel preparation is done with the help of a magnetic stirrer. It is used to disperse the nanoparticles of required quantity uniformly into the fuel. The working principle is that a stir bar (or beads or flea) is immersed into the liquid and the device generates a magnetic field hence causing the bar to rotate and thereby generating a vortex stirring the liquid. The frequency of rotation (rpm) can also be adjusted manually based on the requirement of the researcher. Acetone is used as a binding agent between the nanoparticles and the diesel fuel. The administering level of alumino silicate nanoparticle by weight in diesel was diverse as 25, 50 and 100 ppm. The catalytic nanoparticle mixed with acetone added diesel was agitated for about half an hour in the magnetic stirrer to attain a steady nano fluid. The modified fuel was used in the experiments immediately after preparation, so that considerable time is not allowed for sedimentation to set in. For effective analysis of the prepared nano-doped fuel, it is crucial to assess the fuel for adequate number of times in a compression ignition engines by varying load conditions and the performance and emission characteristics were analyzed.

IV. METHODOLOGY

As mentioned earlier, a single cylinder direct injection diesel engine coupled with electrical dynamometer was run using the modified fuel with varying load conditions. Experiments were performed in a randomized design. A total of 20 tests with 4*5 fuel and loading combination respectively were performed in three repetitions to acquire a precise reading. In order to achieve steady state condition, the experimental engine was pre-run for 30 minutes which was confirmed on evaluating the temperature of lubricant and coolant used. The exhaust emissions were analyzed by an Enerac 700AV 5 gas analyzer and a smoke meter.

V. RESULTS AND DISCUSSION

The performance characteristics of diesel doped with alumino silicate (also known as HNT) nanoparticle run compression ignition engine were obtained from the experiment and the important discussion on the result obtained is featured here.

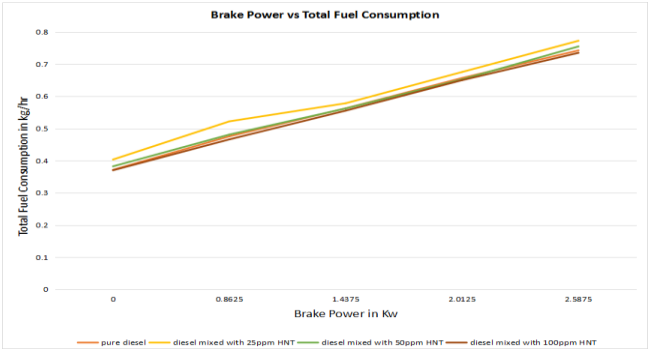

Fig. (a)

The variation of total fuel consumption with respect to the brake power is displayed in fig. (a). It is very clear that the diesel mixed with 100 ppm of nanoparticle shows almost the same characteristic that of a pure diesel whereas the fuel mixture composing of diesel with 25 ppm showed greater values of total fuel consumption.

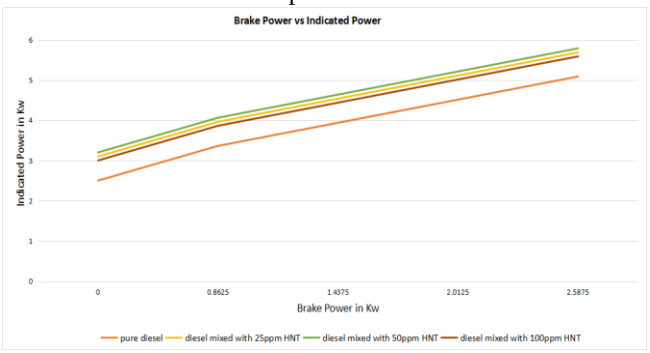

Fig. (b)

The rise in the indicated power is observed when diesel fuel is mixed with 50 ppm of nanoparticle through fig. (b). Also it proves that the diesel fuel when doped with nanoparticle provides higher indicated power when compared with diesel fuel run mode.

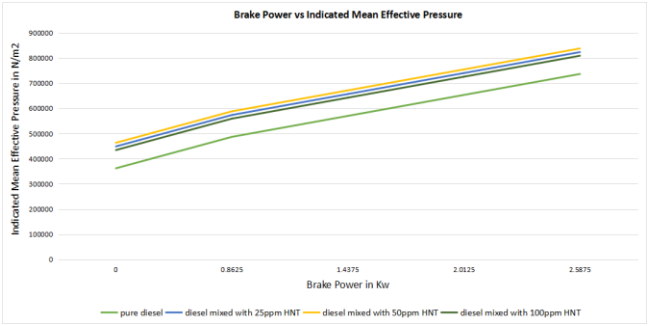

Fig. (c)

The indicated mean effective pressure value holds good for diesel fuel mixed with 50 ppm nanoparticle when compared to other mixing proportions which is shown in fig. (c).

The total heat input of doped diesel fuel is almost in line with that of the diesel fuel especially in 50 ppm doping composition as displayed in fig. (d).

The emission characteristics were obtained with the help of the gas analyzer, smoke meter and the characteristic curves were drawn as shown in the fig. (e) – fig. (h). It is evident that the emission reduction has occurred when the experiment is carried out with fuel in doped mode rather than in normal mode.

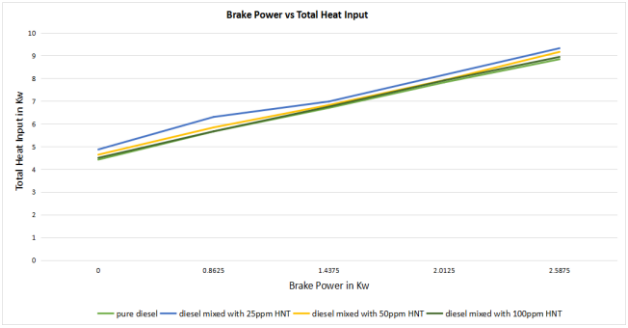

Fig. (d)

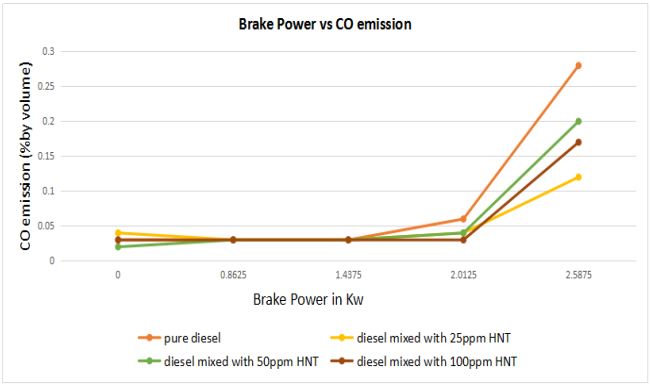

Fig. (e)

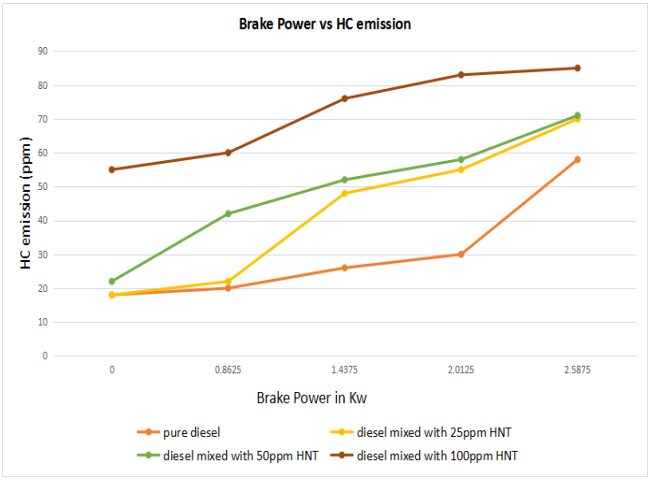

Fig. (f)

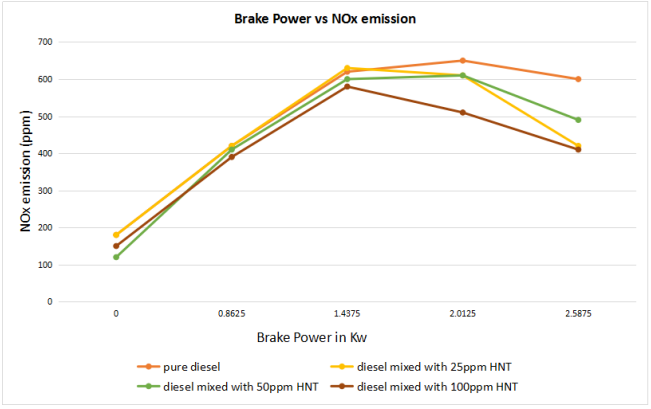

Fig. (g)

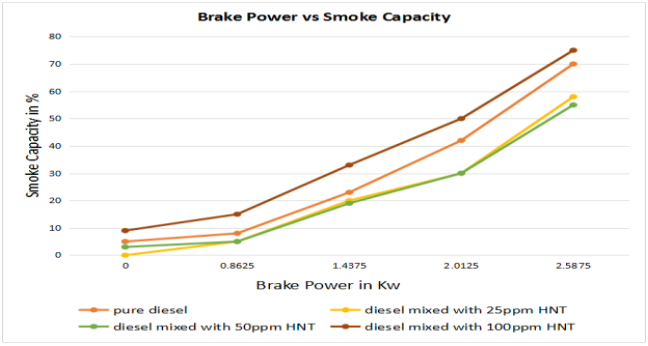

Fig. (h)

VI. CONCLUSION

On through examination, it is understood that the emission characteristics of the doped diesel fuel with 50 ppm composition exhibited better results when compared to other compositions and as well as diesel, with minor variation in engine performance. Hence, it is suggested that the diesel fuel run with 50 ppm doped mode can be used as an alternate fuel without any engine modifications.

REFERENCES

1. Basha JS, Anand RB. Effects of alumina nanoparticles blended jatropha biodiesel fuel on working characteristics of a diesel. Int J Ind Eng Technol 2010, (2), (pp. 53–62).
2. Basha JS, Anand RB. An experimental study in a CI engine using nano additive blended water-diesel emulsion fuel. Int J Green Energy, 2011, vol. 8, (pp. 332–348).
3. Ghafoori M, Ghobadian B, Najafi G, Layeghi M, Rashidi A, Mamat R. Effect of nano-particles on the performance and emission of a diesel engine using biodiesel-diesel blend. Int J Automot Mech Eng, 2015, vol. 12, (pp. 3097–3108).
4. Basha J Sadhik and Anand RB, "Performance, emission and combustion characteristics of a diesel engine using carbon nanotubes blended jatropha methyl ester emulsions", Alex Eng J, 2014, vol. 53, (pp. 259–273).
5. H. Gu and M. D. Soucek, "Preparation and characterization of mono disperse cerium oxide nanoparticles in hydrocarbon solvents", Chemistry of Materials, 2007, vol. 19, no. 5, (pp. 1103–1110).
6. Basha SJ, Anand RB, "Role of nanoadditive blended biodiesel emulsion fuel on the working characteristics of a diesel engine", J Renew Sustain Energy, 2011 (3).
7. Basha JS, Anand RB, "An experimental investigation in a diesel engine using carbon nanotubes blended water-diesel emulsion fuel", Proc Inst Mech Eng Part A-J Power Energy, 2011, vol. 225, (pp. 279–288).

AUTHORS PROFILE

Mr. Vignesh S is currently working as Assistant professor in the department of mechanical engineering at Sri Krishna College of Engineering and Technology, Coimbatore, India. His specialization is Heat Power Engineering which he graduated from Coimbatore Institute of Technology, Coimbatore, India. His research area is study on performance and emission characteristics of internal combustion engines.

Dr. Ramamoorthi R is currently working as Professor in the department of mechanical engineering at Sri Krishna College of Engineering and Technology, Coimbatore, India. His area of research includes the application of nano particles in various fields of mechanical engineering. He has a teaching experience of 15 years. He has published various papers in international and national journals. He is a university recognized supervisor for research.