Effect of Nano additive on properties, performance and emission of CI engine fuelled with diesel, biodiesel and its blends- A Review

Miss. Pallavi V. Ghogare[1]*, Dr. N. W Kale[*2]
1Scholar M.E. (Thermal), PRMIT&R, Badnera, India,
[1]*pallavighogare04@gmail.com*
2Principal & profeser, Dept. of Mech Engg. PRMIT&R, Badnera, India,
[2]*nwkale@gmail.com*

Abstract: **The various environmental and economic benefits has made the biodiesel preferable as compare to diesel in diesel engine, in past two decades. There is a lot of scope for further improvement in the performance and emission reduction with biodiesel as the fuel. The emission reduction properties of biodiesel have gained the importance to increase the performance of a diesel engine. Further to these inclusive properties of biodiesel; several efforts are being made to improve the properties of biodiesel in recent years. It includes the use of nanoparticles as additives in diesel improve the thermo physical properties, such as high surface area-to-volume ratio, thermal conductivity, and mass diffusivity, when dispersed in any base fluid medium. As per the experimental result available in literature it has been found that use of Nano additives with diesel, Biodiesel and its blends improves the kinematic viscosity, flash point, fire point and other properties depending upon the proportionate use of Nano additives. In the present work a review has been made to study the effect of dispersion of various Nano additives on the enhancement of the performance and emission reduction characteristics of a CI engine fuelled with diesel, biodiesel, and its blends and a summary of the observation based on the literatures are reported in the conclusion.**

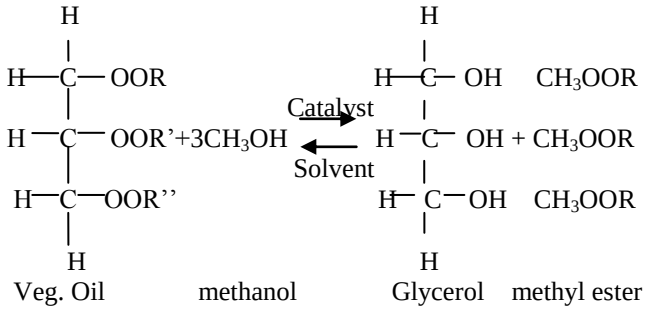
***Keywords*—Biodiesel, nanoparticles, emission, performance, IC engine.**

I. INTRODUCTION

Now a day the rapid growth in industrialization has made the transportation sector of a magnificent importance. This transportation sector is dependent upon availability of fossil fuel i.e petrol and diesel and require it in abundant for its sustainability. Hence there is ever growing need of the fossil fuel and it need to be satisfied. But due to their limited resources and increased demands has made the costs of these fuels increase continuously. Apart from these higher costs, this fossil fuelled vehicle has led to increase the pollutants such as CO_2, NOx, lead, soot, and degrades the environment. In this context, biodiesel has emerged as one of the most potential renewable energy to replace current commercial diesel. Also, it is renewable, biodegradable and non-toxic fuel which can be easily produced through trans-esterification reaction. However, such biodiesel based fuel cannot directly use in diesel engine due to high ignition delay, low cetane number, high brake specific fuel consumption, low calorific value, and low brake thermal efficiency. Further to this, it is observed that, we can improve the performance and emission properties of fuel by dispersion of Nano additives in fuel hence reduce ignition delay and better combustion. It has been found in many researches that the additions of nanoparticles to biodiesel fuel improves the engine performance in terms of peak power, ignition delay, and heat release rate and reduce emissions. Many researchers conducted experiments on the characteristics of the diesel engine and showed that by using the biodiesel emulsion fuel containing nanoparticles the engine performance in term of heat release rate, peak power, ignition delay and emission characteristics of the diesel engine can be improved as compared to the pure biodiesel. Some of these researches are discussed in the review paper as below.

II. BIODIESEL AND NANO ADDITIVES

A potential diesel oil substitute is biodiesel, consisting of methyl esters of fatty acids produced by the trans esterification reaction of triglycerides of vegetable oils with methanol with the help of a catalyst. In general, vegetable oil contains 97% of triglycerides and3% di- and monoglycerides and fatty acids. The process of removal of all glycerol and the fatty acids from the vegetable oil in the presence of a catalyst is called trans esterification. The vegetable oil reacts with methanol and forms esterified vegetable oil in the presence of sodium/potassium hydroxide as catalyst. The Trans esterification represented as.



Nanoparticles: its types and requirements

Nano-additives are considered as a propitious fuel-borne catalyst to improve the fuel properties, owing to their enhanced surface area/volume ratio, quick evaporation and shorter ignition delay characteristics. The size of nanoparticles

varies from 1 to 100 nm [1]. Following are the main requirements of nanoparticles as fuel additive:

1. The nanoparticles act as catalyst should reduce exhaust emission as well as increase the oxidation intensity in the engine and in the particulates filters.
2. It should maintain the typical operational properties of engine.
3. The stability of additive in the fuel must be retained under all operational condition.

The type of nanoparticles is given in table1

SN	TYPE	EXAMPLE
1	Metal based nanoparticles	Aluminium, Iron ,Boron and ferric chloride
2	Metal oxide nanoparticles	Cerium oxide, alumina, TiO_2,MnO,CuO
3	Magnetic Nano fluid particles	Fe_3O_4
4	Carbon nanotube particles	Single walled and multi walled CNT

TABLE I
TYPES OF NANOPARTICLES

III. LITERATURE REVIEW

S.Karthikeyan et al [5] conducted experimentation on performance, combustion, emission characteristics using grape seed oil biodiesel blends with Nano additives. This study provides the effects of cerium oxide(c_eo_2) Nano fluid additives on the performance, combustion and emission characteristics of a Grape Seed Oil Methyl Ester (GSOME).Biodiesel blended fuel is prepared by the emulsification technique with the aid of mechanical agitator. Fuel properties of B20 (80% diesel+20% GSOME), B20$C_eO_2$50 (80%diesel+ 20%GSOME+ 50ppm C_eO_2), B20$C_eO_2$100 (80%diesel+20%GSOME+100ppm C_eO_2) and neat biodiesel were studied and compared according to ASTM standard test method for biodiesel. Three properties were studied that is fuel properties, combustion characteristics and performance characteristics. It was observed that calorific value of C_eO_2 Nano additive blend is higher than of B20. It leads to better thermal efficiency and lower fuel consumption. In combustion characteristics, it was observed that heat release rate increases with addition of cerium oxide Nanoparticles. Addition of cerium oxide Nanoparticles causes rapid combustion and longer ignition delay. The BSFC of B20 is higher than C_eO_2 nanoparticles present in the blends. Thus it was concluded that there is significant improvement in the performance and reduction in harmful emission for the C_eO_2 Nano additive biodiesel emulsion fuels compared to those of B20.

C. Syed Aalam et al [7] Experimented on engine performance, exhaust emissions and combustion characteristics of a single cylinder, common rail direct injection (CRDI) system assisted diesel engine using diesel with 25 percentage of zizipus jujube methyl ester blended fuel (ZJME25). Along with this ZJME25 aluminium oxide nanoparticles were added as additive in mass fractions of 25 ppm (AONP 25) and 50 ppm (AONP 50) with the help of a mechanical Homogenizer and an ultrasonicator.it was observed that The BSFC of the AONP blended biodiesel is lower than that of ZJME25 for all loads. Aluminium oxide Nanoparticles, oxidize the carbon deposits in the engine cylinder leading to reduced fuel consumption and also the results show that the brake thermal efficiency of the CRDI diesel engine is improved by the addition of AONP in the fuel. Again it was also observed that the load increases, the smoke density gradually increases in all cases. Overall, it was clear that the aluminium oxide nanoparticles (Al2O3) are efficient in improving the properties of biodiesel blend. It also enhances the performance and reduces the emission of biodiesel blend used in the diesel engine.

Prajwal Tewari et al [6] carried out Experimental investigation to determine performance, emission, and combustion characteristics of diesel engine using multi walled carbon nanotubes (MWCNTs) blended biodiesel fuels. The fuel combinations used for the study were neat diesel for base line data generation, and CNT blended –biodiesel. The biodiesel was prepared from honge oil called Honge Oil Methyl Ester [HOME]. The MCNTs were blended with the biodiesel fuel in the mass fractions of 25 and 50 ppm with the aid of a mechanical homogenizer and an ultrasonicator. Subsequently, the stability characteristics of MWCNT blended –biodiesel fuels were analyzed under static conditions. It was observed that the brake thermal efficiency of the MWCNTs-HOME blended fuels was observed to be better compared to neat HOME operation. The HOME operation resulted in higher smoke opacity compared to diesel due to its heavier molecular structure and lower volatility. However reduced smoke opacity is observed in the case of MWCNTs-HOME blended fuels. This could be attributed to shorter ignition delay characteristics of MWCNTs-HOME blended fuel The CO emission for HOME operation is higher compared to diesel due to its lower thermal efficiency resulting in incomplete combustion. However CO emissions are marginally lower for the HOME-MWCNTs blended fuels than HOME. That is results revealed that a considerable enhancement in the brake thermal efficiency and substantial reduction in the harmful pollutants due to the incorporation of MWCNTs in the biodiesel fuels were observed.

S.Manibharathi et al [2] carried out Experimental Investigation of CI Engine Performance by Nano Additive in Biofuel. They studied the effect of Nano additives [rhodium oxides (Rh2O3)] on the performance and emission characteristics of pongamia bio diesel in a single cylinder direct injection diesel engine. The reduction of specific energy consumption at part load condition and full load condition by adding Nano additives. Nano additives reduce carbon deposit and wear of diesel engine. A rhodium oxide acts as oxygen which improves performance and reduces the emission. The addition of Nano additives in fuel it reduces NOx emission up to 37% when compare with diesel .it also

reduces the unburnt hydrocarbon (UBHC) up to 45%. Nano particles are reduces the energy consumption and improves the thermal efficiency, during combustion the additives release the energy to the fuel. They concluded that Biodiesel having lower efficiency and higher energy consumption, because of its lower heating value. The addition of Nano additives there is a significant improvement in efficiency compare to biodiesel operation without additives.

The investigations were conducted on effect of nanomaterial sizes on the dispersion stability of biodiesel based Nano fluid. Srinivas Rao.D., Raj Kishora Dash[3]. They investigated the effect of alumina (Al2O3) nanoparticles sizes on the stability of Nano fluid to achieve more stable nanoparticles dispersed Nano fluids having longer duration for potential use in alternative fuel energy applications. They prepared different volume fractions (VF) such as 0.1%, 0.2%, 0.3%, 0.4%, and 0.5% Nano fluids by using two different sizes of alumina nanoparticles that is 13nm and 28nm. The results revealed that the Nano fluids having the smaller average sizes alumina nanoparticles and 0.1% volume fraction were stable for more than one year as compared to the larger (two times) size nanoparticles having same 0.1% volume fraction. Such long term stable biodiesel based Nano fluids can be used as the alternative fuel energy for future automobiles and transportation sectors due to the fuel properties of such nanoparticles dispersed Nano fluids retaining the commercial diesel.

V. Arul Mozhi Selvan et al [4] An experimental investigation is carried out to establish the performance and emission characteristics of a compression ignition engine while using cerium oxide nanoparticles as additive in neat diesel and diesel-biodiesel-ethanol blends. In the first phase of the experiments, stability of neat diesel and diesel-biodiesel-ethanol fuel blends with the addition of cerium oxide nanoparticles are analyzed. After series of experiments, it was found that the blends subjected to high speed blending followed by ultrasonic bath stabilization improves the stability. In the second phase, performance characteristics are studied using the stable fuel blends in a single cylinder four stroke computerized variable compression ratio engine coupled with an eddy current dynamometer and a data acquisition system. It was observed that the specific fuel consumption is higher for the diesel ethanol blends than neat diesel at all the bmep. The brake thermal efficiency of the neat diesel is higher among all the fuel blends. The brake thermal efficiency of the diesel ethanol blends are lower due to lower calorific value of the blend .Also it was observed that the peak pressure increases with the addition of cerium oxide and ethanol in diesel. The heat release rate increases with the addition of ethanol in diesel. The addition of cerium oxide accelerates combustion and cause for the lower heat release rate when comparing with diesel-biodiesel-ethanol blend. The carbon monoxide emission decreases with the use of diesel-biodiesel-ethanol blends than neat diesel. The addition of cerium oxide decreases the HC emission when comparing with neat diesel and diesel-biodiesel-ethanol blends. The NO emission is lower for the neat diesel when comparing to all the fuel blends. The smoke decreases with diesel ethanol blends when comparing with neat diesel. Also the addition of cerium oxide in neat diesel and diesel ethanol blends decreases the smoke further. Under all the loads, the addition of cerium oxide with neat diesel and the diesel-biodiesel-ethanol blend helps the engine to operate at lean mixtures than the neat diesel. Thus it was concluded that cerium oxide nanoparticles can be used as additive in diesel and diesel-biodiesel-ethanol blend to improve complete combustion of the fuel and reduce the exhaust emissions significantly.

J. Sadhik Basha et al[8] An experimental investigation was conducted in a single cylinder constant speed diesel engine to establish the effects of Carbon Nanotubes (CNT) with the Jatropha Methyl Esters (JME) emulsion fuel.The Carbon Nanotubes were blended with the JME emulsion fuel in the various dosages systematically. The whole investigation was conducted in the diesel engine using neat JME, neat JME emulsion fuel and CNT blended JME emulsion fuels.It was observed the addition of CNT to the JME emulsion fuel (25, 50 and 100 ppm) has exhibited a gradual decrement in the cylinder pressure on the account of shortened premixed burning phase. It was observed that the brake thermal efficiency of the emulsion fuels was higher than the JME fuel due to the high heat release rate at all the loads. The JME emulsion fuels produced lower NOx emissions due to the significant heat sink effect during the combustion in the diesel engine. Also it was observed that the HC emissions for the emulsion fuels were high compared to that of neat JME operation. And It was observed that the JME2S5W fuel produced higher CO emissions when compared to that of CNT blended emulsion fuels and JME. It was observed that there is a significant reduction in the smoke emissions for the JME emulsion fuels when compared to that of neat JME. Overall, it has been observed that the CNT blended emulsions has potential advantages on improving the performance and reducing the emissions from the diesel engine.

K. Balamurugan et al [10] carried out investigation on Nano-Copper Additive for Reducing NOx Emission in Soya Bean Biodiesel-Fuelled CI Engine. Nano-copper particles were synthesised using electrolysis method and the characterisation (x-ray diffraction and scanning electron microscope) studies confirmed the particle sizes to be around 40 and 50 nm. Nano-copper particles were added to soya bean methyl ester through span 80 surfactant and further mixed with diesel as B10 blend. Various formulations (diesel, soya bean B10, soya bean B10+1.5% 30 nm Cu, soya bean B10+1.5% 42 nm Cu) were tested in a single-cylinder, water-cooled diesel engine. indicate that the brake thermal efficiency of the diesel engine was improved by the addition of copper in the fuel. The brake thermal efficiency of B10 with 40 nm copper particle fuel blend was higher than other B10 fuel formulations and pure diesel. A maximum improvement of 1.03% in the brake thermal efficiency was obtained in B10 with 40 nm copper

particle compared with pure diesel. In addition, it was observed that the decrease in the size of the nanoparticle increases the surface area for reaction and increases the efficiency. A maximum increase of 1.01% in the brake thermal efficiency was obtained when the particle size was decreased from 50 to 40 nm. Nitrogen oxide emissions for B10 with nano-copper was low compared with pure diesel at all the levels of loads. A maximum of 7.46% reduction in NOx emission was achieved by using B10 nano-copper compared with pure diesel at maximum loading condition. It was also found that the decrease in size of the nanoparticle increases the surface area for reaction and decreases the NOx emissions. A maximum of 16.33% reduction in NOx was achieved when using B10 with 40 nm copper particle than B10 with 50 nm copper particle. There was a significant reduction in the smoke levels and a slight increase in the CO2 level observed while using soya biodiesel (B10) with nano-copper in comparison with diesel. Thus it was concluded that there was a significant reduction in NOx emission and smoke and improvement in the performance of the engine.

Investigation was carried out to study performance Analysis of DI Diesel Engine Fuelled with Diesel along with Nano Additives. Ch. Rao.C., M.Srinivasa Rao[9]. Various blends were prepared by varying the nanoparticles i.e. cerium oxide and zinc oxide to study its operating characteristics of a single cylinder, constant speed CI engine.It was observed that the specific fuel consumption decreases with an increase in the engine loads. The addition of nanoparticles i.e. cerium oxide and zinc oxide leads to an improvement in thermal efficiency compare to diesel operation at full load. It was observed that all the nanoparticle added blends are having less exhaust temperature than the diesel values at higher load. It was seen that, the smoke emission was reduced using nanoparticle additives.

IV. CONCLUSIONS

From the above literature review it has been concluded that:

1) The Nano additives act as combustion catalyst which reduce delay period and promote complete combustion when added to base fuel and hence increase efficiency of engine and lower brake specific fuel consumption.
2) 2) It was found that, there is a benefit of adding fuel additive in biodiesel in terms of improved Brake power and reduced emissions of CI engine.
3) 3)Nano particle reduces the energy consumption and improves the thermal efficiency, during combustion the additives release the energy to the fuel
4) 4)It was observed that all the nanoparticle added blends are having less exhaust temperature than the diesel values at higher load. It was seen that, the smoke emission was reduced using nanoparticle additives.
5) 5)The Nano fluids having the smaller average sizes nanoparticles were stable for more than one year as compared to the larger (two times) size nanoparticles
6) 6) Decrease in size of the nanoparticle increases the surface area for reaction and increases the efficiency and also decreases the NO_x emission.

ACKNOWLEDGMENT

Authors of present study are thankful for precious support provided by the college and department of mechanical engineering for giving this opportunity to do this research work.

REFERENCES

1.Nagaraj Banapurmath[1], T. Narasimhalu[1], Anand Hunshyal[2], Radhakrishnan Sankaran[3],Mohammad Hussain Rabinal[4], Narasimhan Ayachit[5], Rohan Kittur[1] (2014) "Effect of silver nano-particle blended biodiesel and swirl on the performance of diesel engine combustion", IJSGE vol 3, pp. 150-157.

2.S.Manibharathi, B.Annadurai, R.Chandraprakash.(2014). "Experimental Investigation of CI Engine Performance by Nano Additive in Biofuel", IJSETR, vol 3, 2014.

3.D. Srinivas Rao, Raj Kishora Dash (2015). "Effect of nanomaterials sizes on the dispersion stability of biodiesel based nanofluids", Adv.Mater.Lett.vol 6(3),pp.247-251.

4.V. Arul Mozhi Selvan, R. B. Anand and M. Udayakumar.(2009). "effects of cerium oxide nanoparticle addition in diesel and diesel-biodiesel-ethanol blends on the performance and emission characteristics of a ci engine",ARPNJEAS,vol 4,pp.1-6.

5.S. Karthikeyan*,A. Elango[1],P.Marimuthu[2]&A.Prathima[3](2014). "Performance, combustion and emission characteristics of marine engine running on grape seed oil biodiesel blends with nanaoadditive",IJOGMS,vol43(12).

6. Prajwal Tewari[1],Eshank Doijode[1], N.R. Banapurmath[2], V.S. Yaliwal[3](2013). "Experimental investigations on a diesel engine fuelled with multiwalled carbon nanotubes blended biodiesel fuels", IJETAE,vol3,pp.72-76.

7.C. Syed Aalam *, C.G.Saravanan, M. Kannan(2015). "Experimental investigations on a CRDI system assisted diesel engine fuelled with aluminium oxide nanoparticles blended biodiesel", AEJ(2015),vol54,pp.351-358.

8.J. Sadhik Basha[a,*], R.B. Anand[b,1](2014). "Performance, emission and combustion characteristics of a diesel engine using Carbon Nanotubes blended Jatropha Methyl Ester Emulsions", AEJ(2014),vol53,pp.259-273.

9. S.Ch. Rao[1], M.Srinivasa Rao[2] (2015). "Performance Analysis of DI Diesel Engine Fuelled with Diesel along with Nano Additives", IJETT (2015), vol24, pp.107-110.

10. K. Balamurugan[1], A. Tamilvanan[2], M. Anbarasu[3], S. Akil Mohamed[3], S. Srihari[3](2013). "Nano-Copper Additive for Reducing NOx Emission in Soya Bean Biodiesel-Fuelled CI Engine", JOB(2013),vol4,pp.1-8.

