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PERFORMANCE, COMBUSTION AND EMISSION CHARACTERISTICS OF COMPRESSION IGNITION ENGINE USING NANO-FUEL: A REVIEW

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ABSTRACT

The limited fossil fuel resources along with the need to reduce emissions are major impulse to the development of sustainable, renewable and alternative fuel instead of diesel in CI engine. The main objective of this paper is to study the performance and emission characteristics of CI engine using biodiesel with additives as alternative fuel. Biodiesel have not shown significantly improvement in performance, but shown decreasing trend in emission parameters, especially in Sox, CO and CO2 except to NOx. Nanoparticle added fuel improves the emissions and performance of CI engine due to the positive effect of nanofuels on the fuel properties and ignition delay.

KEYWORDS: Biodiesel, performance, emission, CI Engine, Additives.

INTRODUCTION

The large increase in number of vehicles, depletion of fossil fuel reserves and rising oil price in recent years has resulted in great demand for petroleum products. Currently Indian annual requirement for petroleum products is about 120 million metric tons of which the diesel consumption is approximately 40 million tones [1]. The United States alone consumes about 21 million barrels of oil per day, of which, about 65% is used in transportation, while the world's oil consumption amounts to 90 million barrels per day [2]. The exhaust gases from the automobiles affect human body and give rise to contagious diseases. Besides substantial CO_2 emissions, significant quantities of CO, HC, NOx, PM and other air toxins are emitted from automobiles in the atmosphere which cause serious health problem. The use of biodiesel has shown substantial reduction in unburned HC, PM and CO emissions [3]. Due to the problems and situation we have encountered now, we need to overcome challenges as well as an opportunity to look for substitutes of fossil fuels for both economic and environmental benefits for the society and the country itself.

Biodiesel

Biodiesel refers to any diesel fuel alternative derived from renewable biological resource. More specifically, biodiesel is defined as oxygenated, sulfur-free, biodegradable, non-toxic and eco-friendly alternative diesel oil.

Nanofluid fuel [4]

Application of nanoscale energetic metal particle additives in liquid fuel is an interesting concept yet unexplored to its full potential. Depending on the physical, chemical, and electrical properties of the added nanomaterials, nanofluid fuels can achieve better performance and emission characteristics for diesel engine. Such formulated nanofuels offer shortened ignition delay, decreased burn times and rapid oxidation, enhanced catalytic effect, microexplosion behavior which leads to complete combustion. Overall calorific value of the liquid fuel increases due to higher energy density of metal particles, eventually improving the performance of engine by boosting power output. The study of evaporation rate and ignition probability plays an important role in determining two critical properties: ignition delay and ignition temperature which characterizes the performance of a diesel engine and are also instrumental in limiting emissions. They may reduce diesel emissions by two ways. First, the metals either react with water to produce hydroxyl radicals, which enhance soot oxidation, or react directly with carbon atoms in the soot, thereby lowering the oxidation temperature

Problem with nanofuels

Certain drawbacks such as strong particle aggregation, and stability and metal oxide particles may limit applications

of nanofluid fuels .To overcome this problem one more chemical called surfactant is used to bind the molecules of the constituent liquids. Then a mechanical agitator and ultrasonicator is used to mix the liquids thoroughly.

TYPES OF NANOMATERIAS USED IN FUEL

Later, many experimental studies have been carried out on performance and emission of CI engine using a variety of nanomaterials like:

- Oxide ceramics: alumina (Al2O3) , copper oxide ,(CuO) , magnetite (Fe3O4) , zinc oxide (ZnO), manganese oxide (MnO) and ceria (CeO2)
- Metals: copper (Cu), iron (Fe),Cobalt(Co),Magnisium(Mn),Boron(Br) and aluminum (Al)
- Single and multi-walled carbon nanotubes (SWCNTs, MWCNTs)

ENGINE PERFORMANCE AND EMISSION CHARACTERISTICS OF BIODIESEL

Thermal efficiency of an engine operating on biodiesel is generally better than diesel. Brake-specific fuel fuel consumption (BSFC) is a more because fuels having low calorific values . The hydrocarbon emissions are much lower in case of biodiesel as compared to diesel due to the oxygenated nature of fuel. CO is a toxic combustion product resulting from incomplete combustion of hydrocarbons. Since biodiesel is free from sulfur hence less sulfate emissions and particulate drop is found in the exhaust. Many researchers have evaluated the engine performance of different biodiesel blends. Yage Di et al. investigated the waste cooking oil methyl esters in the diesel engine. They observed that the engine performance, especially the brake power output and exhaust emission characteristics improved significantly. The brake thermal efficiency of biodiesel was found to be slightly higher as compared to diesel at medium and higher loading conditions. For combustion and emission characteristic slightly shorter ignition delay and slightly reduction was found in major emission like HC and CO while NOx and NO_2 increases, as shown in the Table 1.

Table1: The performance and emissions of diesel and B100 [3]

Parameter / Fuel	BTE(%)	BSFC(g/kwhr)		HC(ppm)	CO(ppm)	NOx(ppm)
Diesel	34.44	239.2		122	363	590
B100	36.81	260.7		80	316	680

NANOPARTICLE WITH BIODIESEL

To improve the performance and emission especially NOx and particulate matter of diesel and diesel blended with biodiesel nanofuels have become an essential part of today's fuels. With use of fuel additives in the blend of biodiesel and diesel fuelled in CI Engine which furthers more improve performance, combustion, and diminish emission characteristics and also improved fuel properties which enhance the combustion characteristics.

LITERATURE REVIEW

3.1-Performance and emission characteristics of the CI engine using diesel and biodiesel with nanoparticle:

Selvaganapthy.et al.[5], evaluated the performance and emission characteristic of single cylinder four stroke vertical water cooled diesel engine using diesel fuel and the zinc oxide nano particles which were mixed with the diesel fuel at the rate of 250 ppm and 500 ppm. The higher cylinder peak pressure was observed for blend of nano particles with diesel. The addition of zinc oxide further increased the heat release rate by 12.8% for 250ppm and20% for 500ppm of Zinc Oxide. The Nox emission was lower for the neat diesel compared to all the fuel blends. Least smoke opacity was observed for diesel fuel. The BTE was found to improve by 4.53% for blended fuel. **Ajin C. Sanjeevan.et al. [6]** The performance and emission were compared with diesel and diesel having cerium oxide nano particle with 5, 15, 25 and 35PPM concentration . It was seen that the viscosity, flash and fire point increases with addition of nano particle. The BTE was found to be increase at the dosing level of 35 ppm of cerium oxide with 2% surfactant. The HC emission decreased on addition of catalytic nano particle by about 40 to 45%, especially at higher load. The NOx emission was found to decrease by a maximum of 50% with surfactant treated nano particle. **V.ArulMozhiSelvan.et al. [7],** investigated the performance and emission characteristics of neat diesel and diesel-biodiesel-ethanol blends with 25 PPM cerium oxide as fuel borne additive on a single cylinder four stroke variable compression engine. The lower BSFC was observed for Cerium oxide blend of neat diesel. The higher brake thermal efficiency was observed for neat diesel. The addition of cerium oxide further decreased the CO, HC emission when compared to neat diesel. The NOx

emission was lower for the neat diesel as compared to all the fuel blends. **V.Sajith.et al. [8],** had studied the influence of dosing level ranging from 20 to 80 PPM of cerium oxide nano particles in biodiesel derived from jatropha, on a single cylinder water-cooled direct injection diesel engine. Increasing trend was observed in the physiochemical properties of fuel like flash point, viscosity and volatility with addition of nano particle. The results revealed that an average decline of 25% to 40% in the HC emission was attained for the additive dosing level ranging from 40 to 80 PPM of the additive. The NO_x emission was reduced by 30% on the addition of cerium oxide nano particle to biodiesel with dosing level of 80 PPM. The reduction in CO emission was not so good fuel additives. **Rakhi N. Mehta.et al.[9],** Investigated the burning characteristics, engine performance and emission parameters of a single-cylinder Compression Ignition engine using nano fuels aluminum(Al),iron(Fe) and boron(Bo) in base diesel. The nano fuels reduced ignition delay, longer flame sustenance. Peak cylinder pressures decreased at higher load for nanofuels. SFC was reduced by 7% with A1. BTE was increased by 9% for Al at higher loads. At higher loads, the emission study showed a decline of 25–40% in CO (vol.%), along with a drop of 8% and 4% in HC emissions for A1 and Fe nanofuels respectively. Higher Nox were observed with A1 and Fe. **S. Karthikeyan .et al [10],** had evaluated the performance and emission characteristics of Promolin Stearin wax oil(B) biodiesel blended with 80% diesel(D) and 50PPM and 100PPM concentration of Zinc Oxide(ZnO) on a single cylinder air-cooled and direct injection diesel engine. The zinc oxide additive blends improved the CV. The BSFC and BTE for B20,D80B20ZnO50 and D80B20ZnO100 was found to be 0.284,0.278,0.272 in kg/kw-hr and 28%,28.8%,29.96% during experimentation. The CO and HC had appreciably reduced with the increase of the nano particle as compared to B20. The Nox emissions of all blended fuels did not have any considerable effect. **M.A.Lenin.et al[11],** performed the experiments on a single cylinder air cooled Direct Injection diesel engine for evaluation of diesel doped with metal additives MnO (200 mg/L) and CuO (200 mg/L). The changes in diesel fuel properties (viscosity, flash point and fire point) due to introduction of nano metal oxide additive were observed. BTE was increased marginally by 4% from the conventional diesel fuel. The HC emissions were observed highest at lower load but at full load 1% decline observed. The manganese additive showed that CO is reduced by 37%, and NOX is reduced by 4%. **KaroonFangsuwannarak. et al. [12],** had compared effect of the different fuel additives as polymer based-bio-solution, natural organic based-bio-solution and nano-titanium metalloid (TiO2) compound on the performance parameters and exhaust emissions of a pickup Diesel engine, operating on commercial Diesel fuel (D) and B5 palm biodiesel (95% D+5% palm oil).. It was found that TiO2 based-additive is more effective for improving engine power than pure Diesel and B5 fuels by 7.78% and 1.36%, respectively. The TiO2 and natural organic additives is significantly effective on Diesel fuel for reducing brake specific fuel consumption reached by 13.22% and10.01%, respectively as compared with pure Diesel. Moreover, the exhuast emissions (NOx, CO and CO2) is decreased from the engine using the TiO2 additive in Diesel fuel and natural organic additive in Diesel fuel. **N.R Banapurmath.et. al. [13],** had conducted the test to determine the combustion, performance and emission characteristics of single cylinder four stoke direct injection diesel engine using Hinge oil methyl ester (HOME) biodiesel fuel blended with multi walled carbon nano tube (MWCNT) with 25 and 50 PPM concentration. The maximum brake thermal efficiency for HOME50MWCNT was 25.0% whereas it was 24% for HOME25MWCNT as compared to 23% for HOME and 28% for neat diesel at 80% load respectively. Additive blended fuel reduced the smoke opacity as compared to HOME. The NO_x emission for HOME25MWCNT was 600 PPM where it was 750 PPM for HOME50MWCNT, compared to 580 PPM for HOME and 800 PPM for neat diesel at the 80% load respectively.

S. Karthikeyan .et al [14],. The nano size zinc oxide nano particle was mixed in diesel(D) and canola oil methyl ester biodiesel(B) in various proportions and fueled in diesel engine to check the performance and emission characteristics. The results showed that slight improvement was observed in calorific value and kinematic viscosity. The BSFC was decreased with increase in the dosing level of ZnO to the fuel. The BTE of additive fuel was improved at higher load. It was observed that minimum CO and HC measured with the ZnO blend fuel compared to B20 while the maximum NOX emission was recorded with the use of ZnO blended fuel. **G.R.kannan.et al.[15]** examined the use of ferric chloride (FeCl3) as a fuel borne catalyst (FBC) for waste cooking palm oil based biodiesel on single cylinder diesel engine. The results revealed that the FBC added biodiesel resulted in a decreased BSFC of 8.6% while the BTE increased by 6.3%. FBC added biodiesel showed lower NO emission and slightly higher CO2 emission as compared to diesel. CO, HC and smoke emission of FBC added biodiesel decreased by 52.6%, 26.6% and 6.9% respectively compared to bio diesel without FBC at an optimum operating condition of 280 bar injection pressure and 25.5^0 TDC injection timing. Higher cylinder gas pressure, heat release rate and shorter ignition delay period were observed with FBC added biodiesel at these conditions. **Ali Keskin et al.[16**],had investigated the influences of tall oil biodiesel with Mg and Mo based fuel additives on single cylinder DI diesel engine at variable speed upto 3600rpm.The performance of engine did not change considerably with biodiesel fuels, but exhaust emission shown

drastic change. Maximum increase of fuel consumption was 5.51% with B60 at 2800 rpm, and minimum increase was 3.08% with B60–8Mo at 1800 rpm. CO emissions and smoke opacity decreased by 56.42% and by 30.43%, respectively. In general, low NOx and CO2 emissions were measured with the biodiesel fuels. **Metin Guru et al.[17]**,had studied the engine performance and exhaust emissions of chicken fat biodiesel with synthetic Mg(magnesium) additive in a single-cylinder, direct injection (DI) diesel engine. Organic based synthetic magnesium additive was mixed into the biodiesel blend(B10) by 12 µmol Mg.The additive causes reductions in the flash point, viscosity and pour point compared to the fuel without additive. The results revealed that, the engine torque was not changed notably of B10, while the specific fuel consumption enhanced by 5.2% due to the lower heating value of biodiesel. In-cylinder peak pressure slightly rose and the start of combustion was earlier. CO and smoke emissions decreased by 13% and 9% respectively, but NOx emission increased by 5% with the addition of biodiesel to diesel fuel. **A.Keskin et al.[18]**,had performed the experiment on single cylinder diesel engine to determine the effect of tall oil biodiesel(T) with cobalt (Co)-based additive .On the addition of additives the fuel properties like pour point and viscosity significantly decreased.Specific fuel consumption values declined slightly with the addition of Co-based additive. Additive added biodiesel shown decreasing trend in CO emission which was ranged from 19.52 to 53.37%.The Co-based additive did not affect CO2 concentration. Higher NOx emissions were measured at low engine speed whereas lower NOx emissions were obtained at higher speed with all biodiesel fuels. The maximum reduction in smoke level was 29.47% with T60-12 at 1,800 rpm. **Ranaware A.A. et al.[19],**had investigated by correlating the cerium oxide nanoparticles (D+CERIA25) and water-based ferrofluid as additive to diesel fuel. The cerium oxide work as an oxygen donating catalyst and provides oxygen for the oxidation of CO or soak up the oxygen for the reduction of NOx. The lowest BSFC was examined for the D+CERIA25 blend .It was found out that all the ferrofluid added to diesel fuel decreased the BSFC relatively by 3.23–10.85%.Also , from the analysis of engine exhaust emissions, it was seen that NOx emissions were lower than that of diesel fuel of D+4F and D+8F at all loads. But the CO emissions were increased when used ferrofluid and in opposite case cerium oxide nanoparticle added fuel shown the decreasing trend for the CO. Samarjeet Bagri et al.[20] ,experimental work had done on single cylinder, CI engine using SC5D additive in different -different proportions at varying speed. The blends were prepared D0(pure diesel), D1 (1000:1)ml , D2 (1500:2)ml, D3 (2000:3)ml, D4 (2500:5)ml, D5 (3000:7)ml. By adding of this additive, it was found out that cetane index number was increased from 46.22 as of base fuel to 47.63, 49.40, 51.91, 54.91 and 60.66 respectively. The results revealed that HC, CO& NOX emissions were reduced by 35%, 30% & 4% respectively. Brake power was boosted 6% whereas brake specific fuel consumption and smoke density were reduced by 23% and 35%. **Lu Xing cai et al.[21],**had determined the influence of cetane number improver on performance ,combustion characteristic, heat release rate and emissions of a high-speed DI ,four cylinder diesel engine fueled with diesel ,ethanol–diesel and different percentage of cetane number enhancer (0,0.2,0.4%) blend fuel. It seen that the BSFC and thermal efficiency improved remarkably when engine operated with CN improver. From the emission results it was found that CO increased at lower and medium load , while the increasing trend decreased at higher load with CN improver. The HC was very lower at all loads. The NOx and smoke emissions decreased at all loads simultaneously for all blends as compared to diesel. **V. Arul Mozhi Selvan et al.[22]**The experimentation was carried on variable compression ratio engine using Cerium Oxide Nanoparticles and Carbon Nanotubes as an additives in Diesterol (diesel–biodiesel–ethanol) blends. The brake thermal efficiency was improved with the addition of CERIA and CNT in Diesterol blend when comparing with the Diesterol blend (E20).It was found that peak cylinder pressure and peak heat release rate were advanced of additive added fuel when compared with Diestrol blend.In the emissions carbon monoxide was increased very drastically but hydrocarbons were reduced on the addition CERIA and CNT in Diesterol blends. The addition of CERIA and. The addition of CNT and CERIA in E20 fuel blend did not shown significant reduction on the nitrogen oxide emission.

CONCLUSION

There has been plenty of research done so far on biodiesel production method, production optimization and diesel engine performance and emission analysis by varying the biodiesel content in diesel engine. After the dawn of the nanotechnology many researchers has investigated engine performance and emission characteristics using nanofuels in CI engine. A lot of work is being done using diesel as a base fuel and nanoparticle as a catalyst, additive over compression ignition engine. From the literature concluded that Addition of nanoparticles in diesel and diesel-biodiesel blends not only enhances the calorific values but also promotes complete combustion due to higher evaporation rates, reduced ignition delay, higher flame temperatures and prolonged flame sustenance. Nanometal oxide additives are reported to be effective in lowering diesel emissions. Based on literature study it is concluded that the effect of varying dose level of cerium oxide in different diesel-biodiesel blend can be analyzed for performance and emission of four cylinders, four stroke diesel engines.

REFERENCES

[1] B. Anjan Kumar Prusty, Rachna Chandra and P. A. Azeez, "Biodiesel: Freedom from dependence on fossil fuels", Nature Precedings,2008;pp. 1-27.
[2] W.M. Yang, H. An, S.K. Chou, S. Vedharaji, R. Vallinagam, M. Balaji, F.E.A. Mohammad, K.J.E. Chua., "Emulsion fuel with novel nano-organic additives for diesel engine application", Fuel ,2012;.
[3] Yage Di, C.S. Cheung, Zuohua Huang," Experimental investigation on regulated and unregulated emissions of a diesel engine fueled with ultra-low sulfur diesel fuel blended with biodiesel from waste cooking oil" Science of the total environment, 2009;407,pp.835-846.
[4] Rakhi N. Mehta , Mousumi Chakraborty , "Parimal A. Parikh, "Nanofuels: Combustion, engine performance and emissions", Fuel(2013),pages 7
[5] A.Selvaganapthy, A.Sundar, B.Kumaragurubaran, P.Gopal, "An Experimental Investigation to Study the Effects of Various Nano Particles with Diesel on Di Diesel Engine", ARPN Journal of Science and Technology, Volume 2013,4 pages
[6] Ajin C. Sajeevan and V. Sajith, "Diesel Engine Emission Reduction Using Catalytic Nanoparitcles: An Experimental Investigation", Hindawi Publishing Corporation ,Journal of Engineering ,Volume 2013, Article ID 589382, 9 pages
[7] V .Arul MozhiSelvan, R.B Anand and M. Udayakumar, "Effects of cerium oxide nanoparticle addition in diesel and diesel-biodiesel-ethanol blends on the performance and emission characteristics of a CI Engine", ARPN journal of Engineering and Applied Sciences, Vol. 4 (2009), No. 7, Pages 6
[8] V. Sajith, C. B. Sobhan and G. P. Peterson, "Experimental Investigations on the Effects of Cerium Oxide Nanoparticle Fuel Additives on Biodiesel", Hindawi Publishing Corporation, Advances in Mechanical Engineering, Volume 2010, Article ID 581407, 6 pages
[9] Rakhi N. Mehta , Mousumi Chakraborty , "Parimal A. Parikh, "Nanofuels: Combustion, engine performance and emissions", Fuel(2013),pages 7
[10] S.Karthikeyan,A.Elango,A.Prathima, "Performance and Emission Study on Zinc Oxide Particles Addition with Promolion Stearin Wax Biodiesel of Engine", Journal of Science and Industrial Research,Volume 73 (2014),pp 187-190
[11] M.A. Lenin , M.R. Swaminathan , G. Kumaresan, "Performance and emission characteristics of a DI diesel engine with a nanofuel additive",Fuel (2013)
[12] Karoonfangsuwannarak and KittichaiTriatanasirichai, "Effect of metalloid compound and bio-solution additive on Biodiesel Engine performance and exhaust emission", Science Publication, American journal of Applied Sciences 10 (10) (2013) 1201-1213
[13] Prajwal Tewari, Eshank Doijode, N.R. Banapurmath, V.S. Yaliwal, "Experimental Investigation on a Diesel Engine Fuelled With Multiwall Carbon Nanotube Blended Biodiesel Fuels", International Journal of Emerging Technology and Advanced Engineering Volume 3, Special Issue 3: ICERTSD 2013,(2013), pages 72-76
[14] S.Karthikeyan,A.Elango,A.Prathima, "Diesel engine performance and emission analysis using oil methyl ester with the nano sized zinc oxide particles", Journal of Science and Industrial Research,Volume 21 (2013),pp 83-87
[15] G.R. Kannan, R. Karvembu, R. Anand, "Effect of metal based additive on performance emission and combustion characteristics of diesel engine fuelled with biodiesel", Applied Energy(2011)
[16] Ali Keskin,Metin Guru,Duran Altiparmak, "Influence of tall oil biodieselwith Mg and Mo based fuel additives on diesel engine performance and emission ", Bioresource Technology,Volume 99 (2008),pp 6434-6438
[17] Metin Guru,Atilla Kocka,Ozer Can,Can Cinar,Fatih Sahin "Biodiesel production from waste chicken fat based soureces and evaluation with Mg based additive in a diesel engine", Renewable Energy,Volume 35 (2010),pp 637-643
[18] A. Keskin,M. Guru,D. Altiparmak, "The investigation of Performance and Emissions Characterstics of Tall Oil Biodiesel With a Co-based additive", Taylor & Francis,Volume 32 (2010),pp 1899-1907
[19] Ranaware A. A.,Satpute S. T., "Correlation Between Effects of Cerium Oxide Nanoparticle and Ferrofluid on the Performance and Emission Characterstics of a C.I. Engine", Journal of Mechanical and Civil Engineering,(2012),pp 55-59
[20] Samarjeet Bagri,Dr. Alok Chaube," Effect of SC5D Additive on the Performance and Emission Characteristics of CI Engine", International Journal of Modern Engineering Research ,Volume 3(2013),pp 2831-2835

[21] Lu Xing-cai , Yang Jian-guang, Zhang Wu-gao, Huang Zhen , "Effect of cetane number improver on heat release rate and emission of high speed diesel engine fueled with ethanol–diesel blend fuel", Fuel,Volume 83(2004),pp 2013-2020
[22] V. Arul Mozhi Selvan, R.B. Anand, M. Udayakumar "Effect of Cerium Oxide Nanoparticles and Carbon Nanotubes as fuel-borne additives in Diesterol blends on the performance, combustion and emission characteristics of a variable compression ratio engine", Fuel ,Volume130 (2014), 160–167.