Effect of addition of Additives in Emulsified Biodiesel Fuel : a Review

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***Abstract*— Researchers look for new source of fuel alternating to the petrol and diesel, petrol and diesel are very expensive in the world, alternating fuel must be renewable, locally available and environmentally benign. From the alternative source, the significance of biodiesel fuel as technically and commercially viable alternative to petrol and diesel fuel. Depending on the availability of the different stocks biodiesel is made. Due to water emulsified in biodiesel fuel there is increase in ignition probability. This paper contains literature survey which provides reduction in NOx and carbon dioxide using emulsified biodiesel instead of petrol fuel. By adding additives in emulsified biodiesel performance of engine should be increases.**

Keywords*— *Additives,emulsified biodiesel.

I. INTRODUCTION

Now a days worldwide petroleum consumption is increase, resulting in increase transportation and trucking, and increased use of plastics and other petro chemicals. The petroleum is a finite source for fuel that is rapidly becoming more expensive. Biodiesel is an eco-friendly alternate fuel and it is made by transesterification of vegetable oils and animal fat. Particulate matter (PM), hydrocarbons (HCs), and carbon monoxide (CO) emissions are reduced in the environment by using alternative fuel for diesel fuel without any modification in engine. Biodiesel is now playing an important role on the alternative fuel. Water emulsified in biodiesel fuel has been confirmed to play an important role in liquid fuel engines. This is because when the temperature of water in emulsified biodiesel went up to 105^0C rapid evaporation of water broke fuel into smaller droplets and hence increased their surface area causing well mixing of air and fuel droplets. The use of water emulsified diesel can not only improve the brake efficiency, but also significantly reduce the formation of nitrogen monoxide (NO), soot, HCs, and PM in diesel engines [21]. In this additives play a very valuable role in reducing potential operational problems and meeting fuel specification requirements. Additives are the chemical that mixed with fuel such as diesel, biodiesel, gasoline, aviation oil etc. to improve the efficiency and fuel economy. Additives help the fuel to improve the engine performance and meeting environmental emission control standard. The selection of additives for the biodiesel fuel is depends on fuel blending property, economic feasibility, additive solubility, toxicity, viscosity of the fuel blend, flash point of the fuel blend, solubility of water in the blend and water partitioning of the additive [11]. In many literature gap shows the experimental investigation of ignition probability of biodiesel fuel with or without additives. Emulsified biodiesel or blended biodiesel is use in the engine to reduce emission in the atmosphere, and this is done for well mixing of air and fuel which improve the performance. On the other hand various types of additives are added in the biodiesel fuel to improve the efficiency and performance of engine which also increases the ignition probability. In very few papers addition of additives in emulsified biodiesel or blended biodiesel fuel are use to get better performance in engine.

II. ADDITIVES

Classification of additives are as follows

A. Metal based additives

Various types of metal based additives are added with biodiesel to improve the property of diesel fuel. These additives are added in biodiesel for reaching more complete combustion and reducing exhaust emissions. Some metal additives are very effective in improving the ignition probability by lowering the oxidation temperature. The principle of these additives consist of a catalytic effect on the combustion of hydrocarbons. Cetane number of biodiesel will improve by adding additives in biodiesel which is helpful for improving ignition characteristics of biodiesel. The metal based additives include platinum (Pt), platinum–cerium (Pt–Ce), cerium (Ce), cerium–iron (Ce–Fe), iron (Fe), barium, calcium, manganese (Mn) and copper. Using additives in a biodiesel there is a reduction in exhaust emission this is may be due to metals either react with water vapor to generate hydroxyl radicals or directly react with carbon atoms as a catalyst thereby releasing oxidation temperature. Metal based additives are added in diesel as metal organic compound and the metal is formed as nano particle. Nano metal oxide as fuel additives playing an important role to enhance the engine performance and efficiency of engine [11].

B. Oxygenated additives

Oxygenated additives containing oxygen which is nothing more than fuel. The idea of using oxygen to produce a cleaner burning of diesel fuels. This additives increase the amount of oxygen in the biodiesel due to which there is faster ignition in biodiesel. Consideration of oxygenated additive is reduce the ignition temperature of particulates. Oxygenated additives are use for enhancing the octane rating and combustion quality. The oxygenate additives are alcohol (ethanol, methanol, butanol and propanol etc.), ether (ethyl tertiary butyl ether methyl-tert butyl ethe, diisopropyl ether, dimethyl ether, diethyl ether etc.) and ester (dicarboxylic acid ester and acetoacetic esters) functional group. Oxygenated additives are considered for lowering ignition temperature of biodiesel fuel and decrease of smoke emission is depends on oxygen content and molecular structure of fuel. Oxygenated additives directly affect the properties such as viscosity, density, behavior at low temperature, volatility and cetane number. Oxygenated additives assist fuel to inflame very fastly as well as minimize the atmospheric pollution. Due to oxygenated additives in the engine fuel is completely burn in which most of the fuel is burn and harmful chemicals are rescued into the atmosphere [11].

C. Antioxidant additives

Antioxidant chemistry consist of hindered phenols, aromatic diamines or mixture of alkyl phenols and aromatic diamines. Oxidation of fuel leads to deterioration, resulting information of gums darkening of fuel. Antioxidant additives in biodiesel enhance the biodiesel stability and inhibit its tendency to deteriorate in storage. If unsaturated fatty acid is entered into the biodiesel, oxidation is start when long time storage of biodiesel is done. After oxidation of biodiesel properties like density, viscosity and acid value is increases, as the iodine value is decreases with rising storage time. In biodiesel Unstable species produce free radicals which combine with oxygen to produce free radicals in chain reaction which react with olefinic compounds to form gums. Antioxidant work by disordering the chain propagating steps, by separating peroxides and by acting as free radical traps [11].

D. Cold flow improver additives

Cold flow improver additives use in biodiesel fuel consist of vinyl eater co-polymer such as ethylene vinyl acetate. Low molecular weight polymers having different ranges with a variety of structure is employed to treat fuels from different sources with different hydrocarbon compositions. Other additive chemistries use olefin-ester copolymers and dispersants which may be combined ethylene vinyl acetate. In biodiesel cold filter plugging point temperature is higher related to the actual cold weather. As the temperature drop continuously there is increase in crystal size and begin to adhere to each other, due to that they blocking fuel filters and feed lines its lead to power loss. For preventing these problem cold flow improver is use in middle distillates [11].

E. Lubricity improver additives

Lubricity additives are surface active compounds, having an active polar head group which permits the formation of a protective film on the moving metal surface and a hydrocarbon tail to use fuel solubility. Standard chemistries are use in lubricity improver include fatty acid, ester and amides. Biodiesel and diesel fuel injector pumps have confidence on fuel itself to lubricate there moving parts. In modern vehicles emission reduction technology demands elemination of sulfure from biodiesel fuel, for these they require severe refining processes and primarily hydro treating.

These processes cause to reduce natural lubricating quality of middle distilled component. Lubricity improver additives are useful in restoring lubricating lost in severe refinery processing [11].

F. Cetane number improver additives

Cetane number improver additives are consist of alkyl nitrates, of which 2-ethyl hexyl nitrate (2-EHN) is the most common, to increase the cetane number of biodiesel fuel. As the cetane number in biodiesel increase resulting improvement in ignition probability of fuel. Peroxide such as tertiary butyl peroxide can also be used as additives. Cetane quality in biodiesel can be increase by using cetane number improver. Cetane quality of diesel fuel is defined in terms of the confertable with which the fuel ignites, increased in cetane number with reduction in ignition delay. Specially in cold weather when diesel engine operating at lower cetane number resulting in significant white smoke emission, higher noise levels, increased fuel consumption and higher exhaust emissions [11].

III. REVIEW OF WORK CARRIED OUT

M. Abu-Zaid., [1] they investigated the evaporation time of a single droplet, on hot surfaces (stainless-steel and aluminum) with effect of water in diesel and kerosene emulsion. At atmospheric pressure experiment can be performed, initial water volume concentrations of 10, 20, 30, and 40%. Range of wall temperature from 100–460 ^{0}C, to cover the entire spectrum of heat transfer characteristics. Result shows that the curves of emulsion evaporation is very similar to the pure liquid. There is a significant difference in evaporation time, total evaporation time for the emulsion droplets is lower than that for diesel and kerosene fuels. Evaporation time decreased with water initial concentration increases. As the initial concentration of water increase, value of the critical surface temperature (maximum heat transfer rate), decreases. Evaporation time for emulsion droplet is higher than for diesel and kerosene droplet.

*T. Korakianitis et al.,[2]*They studied on Hydrogen dual-fuelling of compression ignition engines with emulsified biodiesel as pilot fuel. Hydrogen dual-fuel operation with neat pilot fuels would produces the high NOx emissions; and pressure rise in high combustion chamber pressure tends to diesel knock. In this experiment during hydrogen dual-fuel operation two water-in-biodiesel emulsions are tested as pilot fuels. Hydrogen dual-fuel operation is produces the best thermal efficiencies compared with normal CI engine operation, thermal efficiencies increases with emulsified biodiesel pilot fuel compare to neat biodiesel pilot fuel during dual-fuel operation. With the use of emulsified pilot fuel there is a complete reduction in NOx emission compared to neat pilot fuel. Due to use of emulsified biodiesel in engine there is a micro explosion which enhance the mixing of air and fuel promote for better ignition. Use of emulsified biodiesel instead of clean biodiesel resulting in reduction of NOx emission, lowering pressure rise rate and increases thermal efficiency.

A.M. Namasivayam et al., [3] They studied on Biodiesel, emulsified biodiesel and dimethyl ether as pilot fuels for natural gas fuelled engines. When dual-fuelling in compression–ignition (CI) engines, the small pilot injection having high-cetane fuel (i.e. diesel) ignites a premixed high-octane fuel (i.e. methane) and air mixture cause reduction in emission of smoke and nitrogen oxide (NOx). If there is poor ignition in main fuel–air charge results in increased emissions of unburnt hydrocarbons (HC) and carbon monoxide (CO). For this work Conventional pilot fuels such as diesel and biodiesel (methyl esters transesterified from raw plant oil) have been researched showing that there is similarity in performance and emission, because of physical, chemical and combustion properties of various methyl esters are compared with conventional diesel. Alternating pilot fuel need to be consider for reducing emission of HC and CO. If fuels use during normal CI engine operation, both dimethyl ether and water-in-fuel emulsions (conventional biodiesel mixed with varying concentrations of water) shows the reduction in smoke and NOx emissions with improving combustion quality. In this experiment dimethyl ether, a gaseous high-cetane fuel and two water-in-fuel emulsions with different water concentrations (5% and 10% water by volume) were tested as pilot fuels during dual–fuel combustion with natural gas. Result shows pilot fuel emulsification reduced NOx emissions by about 20%, and smoke formation.

Wei Zhang et al., [4] had studied on Influence of water emulsified diesel & oxygen-enriched air on diesel engine NO-smoke emissions and combustion characteristics. To check NO-smoke emission and combustion characteristics the experiment is conducted on turbo-charged direct injection diesel engine under the two conditions of 2000 rpm and 180 Nm equivalent power (57% of the original max load at 2000 rpm) as well as 100% load of this speed. They use the combination of oxygen enrichment air and water emulsified diesel to improve NO-smoke emission without any change in brake specific fuel consumption. Result shows that the NO-smoke emission is lower than the original under operating condition of 2000 rpm and 180 Nm torque, diesel engine fueled with 10% and 20% water emulsion ratios and 21% O2 as well as 30% water emulsion ratios and 21%e23% O2. Combustion temperature decreases with increase in water emulsion ratio and with higher emulsion ratio combustion delay period is stay longer.

D.H. Qi et al., [5] studied on combustion and emission characteristics of ethanol–biodiesel–water micro-emulsions used in a direct injection compression ignition engine. They use efficient amount of ethanol–biodiesel–water micro emulsions in single cylinder direct injection diesel engine. Compare with pure biodiesel result indicate that at medium and high engine load the peak cylinder pressure of the micro-emulsions is almost identical, and the peak pressure rise rate and peak heat release rate are higher. At low load engine condition combustion of micro-explosion start later than the biodiesel and requirement of brake specific fuel consumption is slightly higher. With the use of micro- emulsion at high engine load there is a reduction in smoke and slightly lower in nitrogen oxide (NOx) emission. At low engine load condition carbon monoxide (CO), and hydrocarbon (HC) emission are slightly higher for micro emulsion.

Emre Yilmaz et al., [6] studied on preparation of diesel emulsion using auxiliary emulsifier mono ethylene glycol and utilization in a turbocharged diesel engine. Now diesel engine are mostly use due to there lower fuel consumption and higher thermal efficiency in transportation sector. Many researchers search an alternative fuel to reduce emission of high NOx, CO and soot emissions. Use of diesel fuel emulsion help to reduce the exhaust emission. In this work for exhaust emission investigated by affecting diesel fuel emulsions containing 5% (E5) and 10% (E10) water on engine performance. For the preparation of emulsion they use mono ethylene glycol as an auxiliary emulsifier. This experiment is done on full load condition and at 2500, 3250 and 4000 rpm engine speeds. Torque and power of engine increases at the range of engine speed between 2400 and 3600 rpm when emulsified fuel is use. Result shows that the with the use E5 and E10 fuel there is a reduction in (NOx) emission by 5.42% and 11.01% respectively when engine at 2500 rpm, and soot emissions are reduced up to 12.39% and 22.97%.

M. Ebna Alam Fahd et al., [7] investigated on the performance and emission characteristics of direct injection diesel engine by water emulsion diesel under varying engine load condition. This experiment is conducted to evaluate effect of 10% water emulsion diesel on engine performance and emission and compare with diesel fuel. Performance of experiment were taken on four cylinder 2.5 L DI turbocharged Toyota diesel engine at four different engine loading conditions (25%, 50%, 75% and 100% load) with engine speed was varied from 800 rpm to 3600 rpm by increase of 400 rpm for each load condition. In results various parameter like heat release rate, engine power output, brake thermal efficiency and brake specific fuel consumption are presented as engine performance parameters and measurement of exhaust gas temperature, nitric oxide (NO) and carbon mono-oxide (CO) output is reported as emission parameters. Result shows that the at low load condition 10% water emulsion diesel suffering from higher emission of CO, however at higher engine speed and high load the CO emission reduces significantly and which produces better engine efficiency as compared to diesel fuel.

Yung-Sung Lin et al.,[8] studied on Spray characteristics of emulsified castor biodiesel on engine emissions and deposit formation. Castor plants are poisonous plant having high viscosity and water content, due to that castor oil cannot be used as a fuel for DI engine. To improve the spray characteristics of castor oil two processes transesterification and emulsion technologies have been utilized. Under ambient temperature without any heat supply the castor biodiesel completes the transesterification reaction. The aim of this work is to investigate the emulsified biodiesel spray characteristics on DI engine emission and deposit formation. To analyze the emulsified biodiesel deposit formation mechanisms they utilize scanning electron microscope. Result shows that the by using water-biodiesel emulsion technology high NOx emission of caster biodiesel was solved, spray characteristics of castor biodiesel were improved with emulsion technology.

Biplab K. Debnath et al., [9] studied on Adjusting the operating characteristics to improve the performance of an emulsified palm oil methyl ester run diesel engine. Emulsified fuel is alternative fuel to the diesel, and water in diesel emulsion is mostly use. Due to water use in emulsion micro-explosion is occur which reduces emission in the atmosphere. Oxygenated biodiesel in engine emits high NOx than diesel. The investigation of this work is to find performance, combustion and emission characteristics of emulsified biodiesel in a diesel engine at an elevated compression ratio (CR) and retarded injection timing (IT). With the combination of CR-IT objective of this experiment to achieve a faster combustion, lower ignition delay (ID), improved performance and emission characteristics. In this biodiesel use is palm oil methyl ester and emulsion is tested on diesel engine at CR = 18 and IT = 20^0 BTDC. Result shows that with emulsified palm oil methyl ester there is reduction in carboniferous emission, NOx formation and the hazardous emissions created by oxygenated biodiesels.

Ali Alahmer, *[10]* investigated on the effect of emulsified diesel fuel on the engine performance and on the main pollutant emissions for a water-cooled, four stroke, four cylinders, and direct injection diesel engine. Emulsified diesel fuels having water range 0–30% by volume were used. This experiment is taken in the speed range from 1000-3000 rpm. Result was found that the use of emulsified fuel which improves the engine performance and reduces emissions. At 5% water content and 2000 rpm brake specific fuel consumption has a minimum value. And at same condition torque (T), the break mean effective pressure and thermal efficiency are found to have maximum values. As the engine speed increase CO_2 emission is also increases, and it decrease with water content. At same condition emission of NOx from emulsified fuel is slightly less than pure diesel.

H.K. Rashedul et al., [11] experimented on The effect of additives on properties, performance and emission of biodiesel fuelled compression ignition engine. Now number of vehicles are increases due to that emission of CO_2 in the atmosphere is also increase, so for reducing CO_2 emission they use renewable fuel instead of diesel fuel in the emgine. Biodiesel fuel is the renewable and alternative fuel use in compression ignition engine compare to diesel fuel. Biodiesel have the several factor like decreasing the dependence on imported petroleum, reducing global warming, increasing lubricity, and reducing substantially the exhaust emissions from diesel engine. There are some major disadvantages of using biodiesel in diesel engine like lower heating value, higher density and higher viscosity, higher fuel consumption and higher NOx emission. So to overcome all these drawbacks additives are added in the biodiesel to meet specification and quality like metal based additives, oxygenated additives, antioxidants, cetane number improvers, lubricity improvers and cold flow improver. Result shows that addition of additives in biodiesel improve the properties, better engine performance and emission control.

S.S. Daood, et al., [12] studied on Fuel additive technology – NOx reduction, combustion efficiency and fly ash improvement for coal fired power stations. Solid fuel additives like iron, aluminium, calcium and silicon based oxides are use to reduce NOx emission, improve the quality of fly ash and result in 1–3% coal savings for pulverised coal combustion. This experimental study is taken on 100 kW down fired-combustion test facility and partially on a commercial 260 tons/h steam producing water tube pf boiler. For the combined effect of reducing NOx from the combustion of hydrocarbon fuels (mainly coal) and more specifically to improve the combustion process of fossil fuels they use these type of additives. Result shows that the use of these additives would improve the loss of ignition, combustion thermal efficiency, lower carbon content and NOx reduction.

A.M. Ashraful et al.,[13] they evaluated the effect of anti-corrosion additives such as 8% and 16% (vol.%) palm olein oil (PO) with ordinary diesel (OD) fuel on engine operation, emission behavior, engine part wear, and lubrication characteristics. The experimental study was taken on 4-cylinder and 4-stroke IDI diesel engine at different engine speed ranging from 1200 to 2800 RPM with 30% throttle setting under full load condition. Result shows that at 2000 rpm the POD8A (0.2% Additive + 8% PO + 92% OD) and POD16A (0.2% Additive + 16% PO + 84% OD) blended fuels produced 0.5% and 0.51% higher brake power as well as 1.45% and 1.25% higher torque than same blends without additive. Effect of anti-corrosive additives in engine enhancing the engine performance as such additive helps in timely ignition for complete burn in the combustion chamber.
By using POD8A and POD16A blended fuel there is a reduction in CO emissions by 11% and 6.6% and NOx emission by 2.5% and 1.09%, respectively in compared with

OD fuel, also for blended fuel HC emission is not higher than the ordinary diesel.

Maryam Hajbabaei et al., [14] studied on Impacts of biodiesel feedstock and additives on criteria emissions from a heavy-duty engine. For the reduction of emission in diesel engine they had choose biodiesel is an alternative fuel to diesel, but it have tendency to increase nitrogen oxides (NOx) emissions. In this study they investigated the effect of low blend level biodiesel fuels and fuel additives on emissions. Result show that with three B5 biodiesel fuels and six B20-soybean oil methyl ester there was measurable increases in NOx emissions, and no change in NOx emission B5-animal fat methyl ester. Additives provided in heavy duty engine with biodiesel feedstock shows reduction in NOx emission compare to diesel fuel.

Carmen C. Barrios et al., [15] evaluated the influence of use of oxygenates as additives to diesel fuel on the combustion process, the specific fuel consumption, effective efficiency and emissions, especially particle emissions in the range 5.6–560 nm in size distribution and number of a diesel engine. Etil Terbutil Eter and Diglyme are the oxygenated compound which were added in diesel. Performance of engine test were taken with 7 additives in different steps 5%, 10% and 15% of oxygenated additive added to the base commercial diesel fuel. The experiment were perform on 2.0 TDI diesel engine VW Euro 4, in 9 stationary operating conditions (1500, 2250 and 3000 min^{-1} to 15%, 30%, 45% load). Result shows that the greatest influence occur on the particle emission NOx emission compared by adding additives in a mixture, and there is a dramatic decrease in the total particle concentration with the addition of oxygenated additives. Oxygenated additive in the diesel fuel reduces the total concentration of particles in the exhaust.

V. Arul Mozhi Selvan and R.B. Anand, M. Udayakumar [16] they investigated on the performance, combustion and emission characteristics of a variable compression ratio engine using effect of cerium oxide nanoparticles and carbon nanotubes as fuel-borne nanoparticles additives in diesterol (diesel–biodiesel–ethanol) blends. Stability of blends were studied using Cerium Oxide Nanoparticles (CERIA) and Carbon Nanotubes (CNT) each 25, 50, 100 ppm in the Diesterol blends subjected to high speed mechanical agitation followed by ultrasonic bath stabilization. This experimental study were taken on the performance, combustion and emission characteristics are carried out on a variable compression ratio engine using the stable Diesterol–CERIA–CNT blends under various loading conditions at an optimum compression ratio of 19:1 to estimate the emission reduction potential of CERIA and CNT as catalyst in Diesterol blends. Result shows the addition of CERIA and CNT in Diesterol blend increases the cylinder gas pressure and burning rate due to this there is reduction in ignition delay. And combined effect of CERIA and CNT as fuel-borne nanoparticles additives use in the diesterol fuel blend contributes the cleaner combustion and significantly reduces the harmful exhaust gas emissions,

Yajuan Wei et al., [17] they investigated on effect of three types of Mg-based additives on reducing the emissions of particulate matter with an aerodynamic diameter smaller than 2.5 μm (PM2.5) during pulverized coal combustion. This test were carried out in a lab-scale drop tube furnace at 1723 K in air. Result shows that the use of three different Mg-based additives significantly increase the coalescence probability between sub-micron mineral particles which reduces the PM2.5 emission during combustion. With the use of superfine dispersed Mg-based additive, 60% reduction in concentration of PM1 and PM2.5 emission were occurred compare to raw coal combustion.

G.R. Kannan et al., [18] investigated on use of ferric chloride (FeCl3) as a fuel borne catalyst for waste cooking palm oil based biodiesel, at a dosage of 20 lmol/L metal based additive was added to biodiesel. This experiment were carried out to study the effect of addition of ferric chloride in biodiesel on performance, emission and combustion characteristics of a direct injection diesel engine operated at a constant speed of 1500 rpm at different operating conditions. Result shows that the addition of FBC in biodiesel decreased brake specific fuel consumption of 8.6% while the brake thermal efficiency increased by 6.3%, and it lower nitric oxide (NO) emission and slightly higher carbon dioxide (CO2) emission as compared to diesel. When the fuel bome catalyst added in biodiesel Carbon monoxide (CO), total hydrocarbon and smoke emission decreased by 52.6%, 26.6% and 6.9% respectively compare to biodiesel without fuel bome catalyst. At 280 bar injection pressure and 25.5^0 bTDC injection timing condition higher cylinder gas pressure, heat release rate and shorter ignition delay period were observed with fuel bome catalyst added in biodiesel.

Suyin Gan and Hoon Kiat Ng ., [19] they studied on Effects of antioxidant additives on pollutant formation from the combustion of palm oil methyl ester blends with diesel in a non-pressurised burner. For lowering exhaust emission and global warming biodiesel is used as alternative fuel to the diesel. This experiment was carried out the effect of antioxidants addition on pollutant emissions from the combustion of palm oil methyl ester blends with No. 2 diesel in a non-pressurised, water-cooled combustion chamber. Butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT) and tert-butyl hydroquinone (TBHQ) are the antioxidant additives were individually dissolved at varying concentrations in B10 and B20 fuel blends for testing effect of BHT and TBHQ lowering the nitric oxide (NO) emission produced. Result shows the addition of antioxidant additives in biodiesel blend lowering the generation of unwanted pollutants, and for lowering NO and CO emission BHA antioxidant was use in the combustion of palm oil biodiesel blends.

D.H. Qi et al., [20] investigated the effect of diethyl ether and ethanol as additives to biodiesel/diesel blends on the performance, emissions and combustion characteristics of a direct injection diesel engine. The experimental test was carried out with B30 (30% biodiesel and 70% diesel in vol.), BE-1 (5% diethyl ether, 25% biodiesel and 70% diesel in vol.) and BE-2 (5% ethanol, 25% biodiesel and 70% diesel in vol.) respectively. Result shows that there is slightly lower brake specific fuel consumption for BE-1 compare to BE-2. BE-1 and BE-2 at higher engine loads slightly reduction in smoke is observed. For BE-2 nitrogen oxide (NOx) emissions are found to be slightly higher, and for BE-1 and BE-2 hydrocarbon (HC) emissions are slightly higher but carbon monoxide (CO) are slightly lower. At high engine load BE-1 and BE-2 having high oxygen content eliminates the smoke emission.

Kang-Shin Chen et al., [21] They studied on saving energy and reducing pollution by use of emulsified palm-biodiesel blends with bio-solution additive. For saving energy and reduce emission in diesel engine advances in biodiesel, emulsified diesel and artificial chemical additives are driven by consumer. Experimental result shows that the use of emulsified palm-biodiesel with bio-solution additives have the advantage in saving energy and reducing emissions of both polycyclic aromatic hydrocarbons PAHs and particulate matter (PM) from diesel engines. E16P20 fuel (16 vol% bio-solution + 20 vol% palm-biodiesel + 64 vol% P0, an additional 1 vol% surfactant) saved 12.4% fuel consumption and reduced emissions of PM by 90.1%, total PAHs by 69.3% comparing with P0 (premium diesel fuel as base fuel). Emulsified palm-biodiesel with bio-solution is an alternative and clean fuel which enhance the combustion efficiency.

CONCLUSION

From most of the review, they use emulsified biodiesel instead of pure biodiesel in the diesel engine. Due to emulsified biodiesel in the diesel engine high mixture of air and fuel is occur promote for better ignition, which reduces the exhaust emission in the atmosphere. Water emulsified diesel can not only improve the brake efficiency, but also significantly reduce the formation of nitrogen monoxide (NO), soot, HCs, and PM in diesel engines. At low engine load condition carbon monoxide (CO), and hydrocarbon (HC) emission are slightly higher these emission were reduce by using emulsified biodiesel. In some papers they added various type of additives in biodiesel to overcome the problem on lower heating value, higher density and higher viscosity, higher fuel consumption and higher NOx emission. Use of additives in biodiesel would improve the loss of ignition, combustion thermal efficiency, and lower carbon content. In very few papers various types of additives were use in the emulsified biodiesel, which enhance the thermal and combustion efficiency, and highly reduces the exhaust emission in the atmosphere. They concluded that the use of different types of additives in emulsified biodiesel increases the performance of engine. From the review we conclude that the if we use carbon base additives in the biodiesel, which gives a better performance in diesel engine and highly reduces all emission in the atmosphere.

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