© IJEDR 2019 | Volume 7, Issue 1 | ISSN: 2321-9939

Diesel Engine Fueled by Ethanol-Diesel Blend with Additive - A Review

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Abstract - The Diesel Compression Ignition (CI) engine is widely used in the transportation and power plant sectors. The major problem of diesel engines are the high levels of Nitrogen oxides (NOx) and Particulate matter (PM) emissions due to the auto ignition of high cetane number fuel. Ethanol-Diesel blend is a good approach to resolve the environmental issues. Ethanol is an attractive alternative fuel because it is a renewable bio-based resource and it is oxygenated thereby providing the potential to reduce particulate emissions in compression–ignition engines. In this review the properties and specifications of ethanol-diesel blend with additives are discussed. Special importance is placed on the factors critical to the potential commercial use of these blends. These factors include blend properties such as blend stability, cetane number, viscosity and lubricity, materials compatibility and energy content . The effect of the fuel on engine performance, durability and emissions is also considered. The formulation of additives to correct certain key properties, maintain blend stability and reduce emission is suggested as a critical factor in ensuring fuel affinity with engines.

Keywords - Diesel, Ethanol, Additives, Blend Properties, Performance, Durability, Emissions.

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1. Introduction [1]

The development of the internal combustion engine began in the late eighteenth century. Slow but steady progress was made over the next hundred years. By 1892, Rudolf Diesel had received a patent for a compression ignition reciprocating engine. However, his original design, which used coal dust as the fuel, did not work.
Thirty-three years earlier, in 1859, crude oil was discovered in Pennsylvania. The first product refined from crude was lamp oil. Because only a fraction of the crude made good lamp oil, refiners had to figure out what to do with the rest of the barrel.
Diesel, recognizing that the liquid petroleum by products might be better engine fuels than coal dust, began to experiment with one of them. This fuel change, coupled with some mechanical design changes, resulted in a successful prototype engine in 1895. Today, both the engine and the fuel still bear his name.
The first commercial diesel engines were large and operated at low speeds. They were used to power ships, trains, and industrial plants. By the 1930s, diesel engines were also powering trucks and buses. An effort in the late '30s to extend the engine's use to passenger cars was interrupted by World War II. After the war, diesel passenger cars became very popular in Europe; but, they have not enjoyed comparable success in the United States yet.
Today, diesel engines are used worldwide for transportation, manufacturing, power generation, and farming. The types of diesel engines are as varied as their use – from small, high-speed indirect-injection engines to low-speed direct-injection behemoths with cylinders one meter in diameter. Their success comes from their efficiency, economy and reliability.
Diesel fuel keeps the world economy moving. From consumer goods moved around the world, to the generation of electric power, to increased efficiency on farms, diesel fuel plays a vital role in strengthening the global economy and the standard of living.
Diesel engines are considered as one of the largest contributors to environmental pollution caused by exhaust emissions, and they are responsible for several health problems as well. Many policies have been forced worldwide in latest years to reduce negative effects of diesel engine emissions on human health and environment. Many researchers have been carried out on both diesel exhaust pollutant emissions and after treatment emission control technologies. In this paper, the emissions from diesel engines and their control systems are reviewed. The four main pollutant emissions from diesel engines (carbon monoxide-CO, particulate matter-PM, hydrocarbons-HC, and nitrogen oxides-NO_x) and control systems for these emissions (diesel fuel with metal additives) are discussed.

2. Blend Properties

Many Fuel properties are very much importance to proper operation of compression ignition engine. The addition of additive into ethanol-diesel blend fuel affects properties like blend stability, viscosity and lubricity, energy content and cetane number. other importantant factors like Materials compatibility and corrosiveness that need to be considered.
Properties that affect safety should be leading in any fuel evaluation. These properties include flashpoint and flammability. And also biodegradability has become a significant fuel factor with respect to ground water contamination.

2.1 Blend stability

Fuel instability is an obvious problem when phase separation occurs. Thus, water tolerance of the ethanol-diesel blends was determined by blending supplementary water into samples of the mixtures. Solubility of Ethanol in diesel is affected mainly by two factors, water content and temperature of the blend. Avoidance of this separation can be summarized in two ways: by adding a co–solvent that acts as a bridging agent through molecular compatibility and bonding to produce a homogeneous blend or by adding an emulsifier. which acts to suspend little droplets of ethanol within the diesel fuel. Because of ethanol is soluble in diesel fuel in only small quantities (<12.5%Vol.) Emulsification usually requires heating and blending steps to generate the final blend, whereas co-solvents allow fuels to be ''splash-blended'', thus simplifying the blending process.
Both emulsifiers and co-solvents have been evaluated with ethanol and diesel fuel. P. Satge de Caro et al. (2001) investigated that the stability of a diesel–ethanol mixture left in air is increased in the presence of 1-octylamino-3-octyloxy-2-propanol (A1) and 2-nitrato-3-octyloxy propyl (A2). The hydrocarbon moieties of these molecules constitute the hydrophobic portion of the structure due to their strong attraction with diesel fuel. The glyceryl skeleton bearing the ether, hydroxyl and amine groups represents the hydrophilic head which becomes oriented towards the ethanol–water phase. These surfactants are therefore non-ionic and lead to the formation of stable, homogeneous emulsions. In fact, introducing additives with emulsion-forming properties increases the flexibility of use of ethanol in diesel fuel.[2]
Eliana Weber de Menezes et al (2006) investigated that the one possible way to improve the compatibility of diesel and ethanol is to use ethers such as ethyl ter-butyl ether (ETBE) and ter-amyl ethyl ether (TAEE). These ethers are semi-renewable products resulting from the reaction of isobutene and isoamylenes (2-methyl-butene-1 and 2-methyl-butene-2) with ethanol. In addition to being excellent additives for gasolines, they increase the solubility of ethanol in diesel. [4]
Krzysztof Górski et al (2013) investigated These tests reveal that the diesel–ETBE(ethyl-tert-butyl ether) blends are more easily mixed and are more stable in a wide range of temperatures than the diesel–ethanol blends. We also found that water does not promote phase separation of diesel–ETBE blends. These observations collectively suggest that, from the standpoint of miscibility and stability, ETBE compared to ethanol, is a more effective oxygenate for use an additive with diesel oil. [14]
Haifeng Liu et al (2016) investigated that the combining all analysis results, n-hexanol and n-octanol can be recommended as a co-solvent additive for hydrous ethanol/diesel system due to the acceptable fuel properties and soluble performance. [7]
Mohamed Nour et al (2018) investigated that the Al2O3 - JE20D blended fuels were prepared in two steps. In the first step, the mechanical disperser (PRO400DS Digital Benchtop Homogenizer, Volume range: 0.05 ml - 30 l, speed range: 0 - 23,000 rpm) was utilized to prepare the homogeneous fuel mixtures of Al2O3- JE20D and dismantle the agglomeration of Al2O3 nanoparticles. In the second step, Al2O3- JE20D blends were kept in an ultrasonic bath (Hielscher ultrasonic UP400S, 400W, 24 kHz) set at a frequency of 24 kHz for 30 min to boost the stability of the fuel blend All Al2O3-JE20D blend samples were poured in a long glass tube under static conditions to observe blend stability, and it was observed that there was no mixture separation for approximately 5 days. The properties of the diesel base fuel, Jojoba biodiesel, and ethanol were measured according to ASTM standard. [12]

2.2 Cetane Number

The cetane number indicates the lag time of the fuel's self ignition, exerting a direct effect on the start-up of the engine and on its operation when fully loaded. The lower the cetane number, the greater the lag time of the ignition and hence the greater the amount of non-burning fuel in the chamber before the beginning of combustion, leading to an abrupt increase in pressure without work being done.
P. Satge´ de Caro et al. (2001) investigated that the linear changes in cetane number that occur in relation to ethanol content. It should be remembered that a high cetane number ensures good cold starting, reduced noise and an increase in engine life. the cetane numbers for mixtures containing 10,15 or 20% ethanol, measured on the CFR engine. The additives (1-octylamino-3-octyloxy-2-propanol and 2-nitrato-3-octyloxy propyl) keep the cetane number above 45, which ensures suitable ignition.[2]
X. Shi et al (2005) investigated Methyl soyate has a higher cetane number than diesel, which will result in more complete combustion in the cylinder [3]
Fathollah Ommi et al (2009) investigated that the ignition improver was used to increase the cetane number of blends. The three-ignition improver used was 2–Methoxy ethyl ether (MXEE), Nitro Methane and Nitro Ethan. The amount of ignition improver was 2,5% of the amount of ethanol in each blend. This provided similar ignition delay as diesel fuel[5]
E. Sukjit et al (2012) investigated that the increase of fatty acid chain length shows a slight increase in the peak cylinder pressure and an advance in the start of combustion. This is thought to be due to an increased cetane number as the chain length increases. [6]
B. Prabakaran et al (2016) investigated that the cetane number of Diesel-Ethanol-Biodiesel blend have 57 and Diesel-Ethanol-Biodiesel blend with additive zinc oxide have 55 Cetane number both the blends are higher than that of diesel. [8]
Mostafa Mohebbi et al (2018) investigated that the higher cetane index of DEE is adequate to initiate auto-ignition and governs the premixed combustion process The higher cetane number and better overall fuel-air mixing DEE will improve the combustion process over that of the neat ethanol/diesel fuel combustions[10]

2.3 Viscosity and lubricity

All diesel fuel injection equipment has some reliable on diesel fuel as a lubricant. The lubricating properties of diesel fuel are main, particularly for rotary and distributor type fuel injection pumps. In these pumps, moving parts are lubricated by the fuel itself as it moves during the pump not by the engine oil. Other diesel fuel systems which include unit injectors, unit pumps, and in-line pumps are partially fuel lubricated. In these systems the mechanism typically consists of a needle or plunger operating in a sleeve or bore, where the fuel is used to lubricate the walls between the reciprocating piece and its container. The lubricity of the fuel is an indication of the amount of scarring or wear that occurs between two metal parts covered with the fuel as they come in contact with each other. Low lubricity fuel may cause high wear and scarring and high lubricity fuel may provide reduced wear and longer component life.

P. Satge´ de Caro et al. (2001) investigated that with ethanol contents of 10–20%, this viscosity does not exceed the required minimum for diesel fuel (2cSt at 40C). The use of an additive is nevertheless suggested to improve lubrication. At ambient temperature 1/3rd of the viscosity lost by adding ethanol can be recovered by using an additive. It can be seen that above 40C, the increase in viscosity acquired by using additives is further enhanced. [2]

X. Shi et al (2005) were found that the lubricity of using methyl soyate–ethanol–diesel blend fuel was superior to conventional diesel fuel and this property was imparted to blends at levels above 20 vol% by volume. [3]

Eliana Weber de Menezes et al (2006) investigated that the formulation with 5% v/v of TAEE/diesel showed a better viscosity than those of the other formulations and compared with the viscosity of the base diesel. [4]

Fathollah Ommi et al (2009) investigated that Fuel viscosity play important role in the lubrication of fuel injection systems. The addition of ethanol to diesel lowers fuel viscosity. show the experimental results of blend fuels. the addition of ethanol to diesel lowers fuel viscosity. It is also seen that additive and ignition improver can restore the viscosity of the blends. [5]

E. Sukjit et al (2012) investigated that The beneficial effect of fatty acid methyl esters (FAMEs) on lubricity is evident. In general, the longer the carbon chain length, the smaller the wear scar diameter (better lubricity). This trend is also seen in the incremental viscosity as the chain length increases. The mixture of several fatty acids contained in RME showed better lubricity in the fuel blends than the individual fatty acid esters. Regarding the unsaturation effect, FAMEs with double bonds have better lubricating properties than similar chain lengths without unsaturations. [6]

Mohamed Nour et al (2018) investigated that JME has high viscosity and molecular weight. The high viscosity of JME leads to poor fuel atomization which in turn increases the amount of fuel burned in the diffusion mode and reduces the combustion efficiency[12]

2.4 Materials compatibility

The use of ethanol in gasoline engines in the early 1980s resulted in numerous materials compatibility studies, many of which are also applicable to the effect of ethanol–diesel blends in diesel engines and mainly in the fuel injection system. The ethanol has a strong quality influence on its corrosive effects. In addressing the problems of ethanol corrosion associated with gasoline blends

P. Satge´ de Caro et al. (2001) were found that the tests showed steel and copper cylinders immersed in the ternary mixture were not corroded (score 1A), even in the presence of hydrated ethanol. Blends have been performed with hexadecane as hydrocarbon base in order to prevent the need for anticorrosion additives in commercial diesel fuel. Although there is no real risk of corrosion from the ethanol, the metallic structures always need to be protected from any traces of water present in the fuel. The test mixture was therefore compatible with these requirements. [2]

Saravana Kannan et al (2016) were found that the corrosiveness of B20D75E5 fuel is less than B20D70E10 fuel. At 60 _C, the corrosion of metals in BDE blends is higher than at room temperature. Corrosion rate of metals in BDE blends is in the order: aluminum < mild steel < copper at both temperature conditions.[21]

2.5 Energy content

The energy content of a fuel has a direct influence on the power output of the engine. P. Satge´ de Caroet al (2001) stated that the presence of 20% by volume of absolute ethanol reduced the maximum power by approximately 11% due to the loss of heat content. At the same rated power output, the over- consumption with the blends was around 7%. [2]

Eliana Weber de Menezes et al (2006) stated that the additives evaluated in concentrations of 5% v/v, TAEE can be used in diesel without a significant decrease in the engine's power. [4]

Mohamed Nour et al (2018) investigated that the addition of alumina nanoparticles to Diesterol blend reduced the ignition delay and accelerated the start of combustion, which led to a reduction in the magnitude of peak heat release rate. [12]

3. Engine Performance with blends

In unmodified engines, The comparisons of engine performance between ethanol–diesel blends and standard diesel generally show reductions in power that are approximately the same as the reductions in energy content of the blends relative to diesel fuel. Increased leakage in the fuel injection pump with the lower viscosity of fuels also contributes to reduced power in the load control range of the engine. But adding additives with Diesel-Ethanol blend improve performance of engine and also reduce leakage in fuel injection pump with increase viscosity of fuels also increase power of the engine.

P. Satge´ de Caro et al. (2001) investigated that the presence of 10% ethanol led to a little reduction in maximum power (full load) of approximately 5% due to the loss of heat content and the presence of 20% by volume of ethanol reduced the maximum power by approximately 11% due to the loss of heat content. [2]

X. Shi et al (2005) investigated that Their results showed that there was no significant reduction in engine power output on methyl soyate blends up to 30% in volume. The differences in BSFC reflected the differences in some of the physical properties of the fuels such as density and calorific values. Calorific values of ethanol and methyl soyate are lower than that of diesel fuel. The gross heat value of diesel was 42.5 MJ/kg, whereas that of BE20 was only 41.2 MJ/kg, a drop of about 3%. In theory, the BSFC should increase with an increase in the oxygenate content in the fuel blends because of the reduced energy content. In the current study, the fuel blends showed very slight change in BSFC compared with diesel fuel. The engine performance was little affected by the lower gross heat value of the oxygenate fuels. [3]

Eliana Weber de Menezes et al (2006) investigated that the additives evaluated in concentrations of 5% v/v, TAEE can be used in diesel without a significant decrease in the engine's power. [4]
B. Prabakaran et al (2016) investigated that the fuel was injected was 23 degree before TDC. The operating speed of engine was 1500 rpm and the maximum power generated by the engine was 4.4 kW. The conclusions drawn from the results of an experimental study for utilizing the renewable fuels (ethanol and POME) were conducted in three stages such as solubility in three different temperatures, property testing, addition of ZnO nano particle, performance, combustion and emission characteristics of the blend in a diesel engine are analyzed and presented as follows. At full load, as compared to diesel, the characteristics of C6 and nano C6 are BTE reduced by 21% and 9%, BSFC increased by 39% and 14% Maximum pressure increased by 8% and 13% and HRR increased by 118% and 129%.[8]
Mohamed Nour et al (2018) investigated an energy point of view, the energetic analysis and economic performance for Al2O3 -Diesterol blends should be conducted. This analysis should include the power consumed and the production costs of biodiesel, ethanol and nanoparticles. The Al2O3 - Diesterol blend preparation should also considered in assessing the overall energy efficiency allowing us to better understand the potential of using this blends in the future. The change of engine brake specific fuel consumption (bsfc) and the brake thermal efficiency(BTE) versus engine bmep for different tested fuels are shown in Fig. 1. It can be observed that the bsfc for Diesterol blend (JE20D) is higher than that of pure diesel fuel by 02% at bmep of 0.11 MPa. The bsfc for JE20D at medium load (0.22 MPa bmep) is higher than that of neat diesel by 40%. However, at higher loads (0.33 MPa and 0.44 MPa) the bsfc for Diesterol is higher than that of diesel by 11%. The main factors that affect the bsfc are the fuel calorific value and the combustion efficiency. [12]

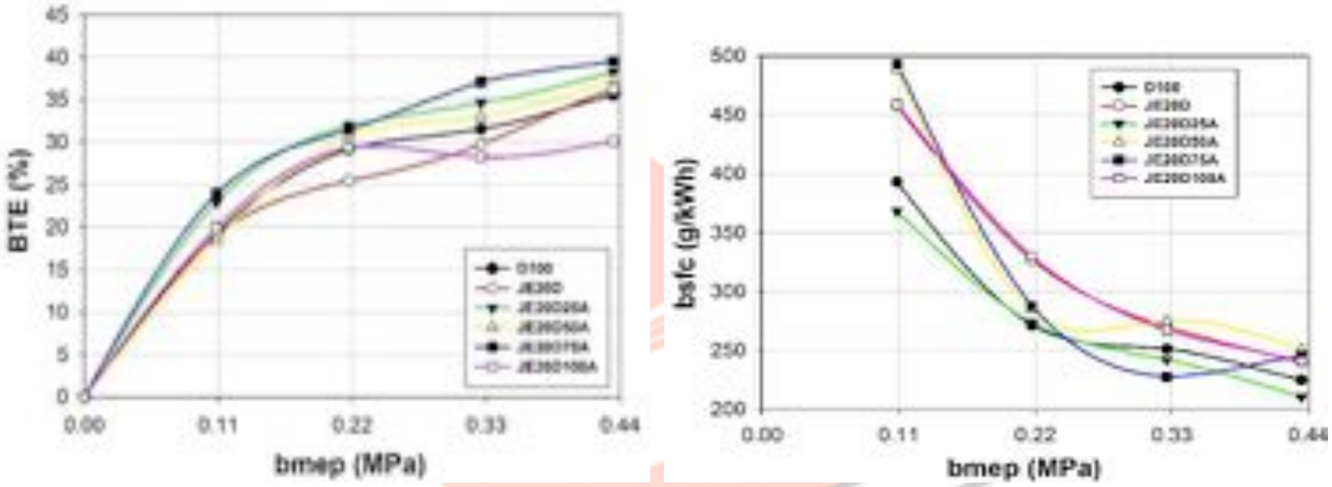

Fig. 1. The variation of BTE and bsfc with engine load for different tested fuels

4. Engine Durability

In the laboratory and in the field a limited range of durability tests have been conducted on ethanol–diesel blends with additives. In early studies, tests with blends containing approximately 10% and 15% dry ethanol indicated no abnormal wear in engines correctly adjusted for injection timing
P. Satge´ de Caro et al (2001) investigated taht the engines were different, an air-cooled single cylinder and a water-cooled multi-cylinder, running in both were not affected by the presence of ethanol in blends. No problem of vaport-lock in injection pumps and lines, no knocking or trouble shooting appeared. [2]
Fathollah Ommi et al (2009) Fuel viscosity play important role in the lubrication of fuel injection systems. The addition of ethanol to diesel lowers fuel viscosity. the experimental results of blend fuels. the addition of ethanol to diesel lowers fuel viscosity. It is also seen that additive and ignition improver can restore the blends viscosity. and increase the CI (e.g. of E–NM2 in 5% and E–NM5–10 to 57.5 and 57.08, respectively), which can improve combustion process, ensure good cold starting, reduced noise and long durability for diesel engines. [5]
E. Sukjit et al (2012) investigated that The use of RME resulted in an increased rate of the fuel burnt in the premixed phase with the combustion advanced to earlier crank angle positions and the peak pressure value increased over ULSD combustion. This is likely to be a consequence of the compressibility of biodiesel fuel which is lower than that of ULSD resulting in the advance of the start of injection. In addition the oxygen content of RME may also contribute to improve fuel oxidation and reduce the ignition delay. The higher bulk modulus of longer chain methyl esters also increases the rate of injection pressure rise with respect to shorter chain length methyl esters (resulting in an advance of injection). [6]
Haifeng Liu et al (2016) investigated that The heat of vaporization of alcohols is significantly higher than that of diesel, which means that the ability to start the engine in cold weather will be reduced with the addition of any alcohol. In addition, the density of straight alcohol increases with the enhancement of carbon and hydrogen content. In general, the higher density contributes to much stronger flow resistance, resulting in higher viscosity. The appropriate viscosity, which can be obtained by mixing a higher carbon-number alcohol into ethanol/diesel blends, has positive impacts on reducing the wear of fuel pump and injector. Meantime, the size of fuel drop, atomization quality and jet penetration will be more similar to conventional diesel fuel as higher carbon alcohols are added into ethanol/diesel blends. [7]

5. Emissions

P. Satge´ de Caro et al. (2001) investigated that The Bosch smoke number was measured for all three fuels(Diesel-Ethanol-Additives(1-octylamino-3-octyloxy-2-propanol and 2-nitrato-3-octyloxy propyl) with the engine at full load. With the diesel 1 ethanol mixture, an average reduction of 45% in this number was apparent for the entire range of engine operations. The introduction of 20% ethanol then generates a lower soot emission. Because of the oxygenated fraction contributed by the ethanol, which means that the excess air is then 16% higher than that of diesel. The additives bring the smoke number up again although it still remains 35% lower than that of diesel alone. The ignition delays are longer, the cyclic irregularity is increased, and the CO and HC contents are augmented. Only the NO*x* and smoke contents are reduced. Introducing a specific additive improves ignition delay, reduces cyclic irregularity, brings back the CO and HC contents and at the same time conserves the decrease in NO*x* and smoke contents. [2]

X. Shi et al (2005) investigated that the PM emissions were largely dependent on the oxygen content of the fuel. BE20, which has the highest oxygen weight content in all tested fuels in this study, showed excellent ability to eliminate soot emissions, and the maximum reduction of PM was observed at 48%. NOx emissions were observed to increase when oxygenated fuels were used. An average increase in NOx emission was 25% at Run 1 and 32% at Run 2. The CO emissions with BE15 and B20 were slightly lower than that with diesel fuel.

BE20 decreased CO emissions relative to diesel fuel. BE15 and BE20 increased THC emissions while B20 decreased the THC compared with diesel fuel. In this case, ethanol content may be the essential factor in the THC emission. Despite the unwanted results of the increase in NOx emissions and THC emissions on the biodiesel/ethanol/ diesel blends, the apparent large decrease in PM emission for these blended fuels is promising and should attract the interest of some researchers. [3]

Eliana Weber de Menezes et al (2006) investigated that The use of oxygenated compounds (ethyl ter-butyl ether (ETBE) and ter-amyl ethyl ether (TAEE)) are an alternative to reduce the emission of particulates diesel/ethanol mixtures increase the emission of unburned hydrocarbons and aldehydes. [4]

Fathollah Ommi et al (2009) invesgated that Blending ethanol to the Tehran1 diesel fuel show a profound effect on soot reduction (25% soot reduction with 10% ethanol) The soot formation can be reduced by more than 50%, 30% and 27% with the diesel formulations E–NE5–10, E–NM5–10 and E–MX5–10, respectively. the total emission results obtained from the blend fuels at the Free Acceleration Test, at the Idle Speed. Comparison of the emission results shows a slight increase on NOx and slight reduction on CO emission when moving from pure diesel fuel–to–fuel blends.The increase of the NOx emissions can be explained by the decrease of the CI and CN with the addition of the ethanol. In addition, the E–NM5 and E–NE5 highly increased NOx emission cause NO content in material's structure of NM and NE. NOx emission related to T–GAS that it could be seen T–GAS reduction at E–NE5 cause NOx reduction in emission. [5]

E. Sukjit et al (2012) investigated that The study of carbon chain length recommends that the combustion of short chain length methyl esters reduce CO, THC and soot emissions. This is mainly due to lower viscosity and bulk modulus and higher oxygen content. Unsaturated compounds reduce THC, CO and soot emissions compared to C18:0 (same chain length), as a result of their lower viscosity and higher volatility. On the other hand, they clearly produce higher NOx, soot, CO and THC emissions than short chain length saturated methyl esters. As a consequence, it is suggested the use of short chain length methyl esters in alcohols blends. [6]

B. Prabakaran et al (2016) investigated that the conclusions drawn from the results of an experimental study for utilizing the renewable fuels (ethanol and POME) were conducted in three stages such as solubility in three different temperatures, property testing, addition of ZnO nano particle, performance, combustion and emission characteristics of the blend in a diesel engine are analyzed and presented as follows. At full load, as compared to diesel, the characteristics of C6 and nano C6 are

-- CO decreased by 62% and 92%.
-- HC increased by 21% and reduced by 9%.
-- NOx reduced by 35% and 16%.
-- Smoke decreased by 54% and 82%.[8]

Mostafa Mohebbi et al (2018) were investigated that the three different fuels, i.e., DEE0, DEE20, and DEE40, were used in the experiments. At each setting of the combustion phasing, due to earlier injection of diesel fuel in higher DEE fractions, the local equivalence ratio and fuel reactivity were not sufficient to promote auto-ignition. As a result, further ignition delay developed and leads to incomplete oxidation of CO emission.With regard to the RCCI hypothesis, higher reactivity of DEE will enhance oxidation of hydrocarbons, thus resulted in lower HC Emissions The main reason for a lower PN by increasing DEE could be attributable to twin heat release and dominant premixed combustion that enhanced the fuel oxidation and reduction of soot precursors. [10]

Mohamed Nour et al (2018) investigated that The influence of adding Al2O3 nanoparticles with Diesterol blend on the performance and emissions characteristics of a diesel engine were examined under a constant engine speed of 1500 rpm and various engine loads. The JE20D25A and JE20D75A blends improved the combustion process and reduced the temperature in diffusion combustion mode which resulted in lowering NOx emission by up to 50% compared to the JE20D blend. However, the addition of 50 and 100 mg/l of Al2O3 into Diesterol blend increased the NOx emission by up to 25% compared to that of the JE20D blend. Engine emission of CO with the addition of 75 and 100 mg/l of Al2O3 into Diesterol blend was reduced significantly by up to 30%. In contrast, the CO emission with the addition of 25 and 50 mg/l of Al2O3 into Diesterol blend was increased by up to 35% compared to that the JED20D blend. [12]

6. Conclusion

The properties of ethanol–diesel blends with additive have a important effect on safety, engine performance and durability and emissions. Ethanol miscible in diesel is affected mainly by two factors, water content and temperature of the blend. Prevention of this separation can be summarized in two ways: by adding an additive that acts as a bridging agent through molecular compatibility and bonding to produce a homogeneous blend or by adding an emulsifier.

Durability tests have been conducted on ethanol–diesel blends with additives. In studies, tests with blends containing approximately 10% and 15% dry ethanol indicated no abnormal wear in engines accurately adjusted for injection timing. Viscosity of fuel play important role in the lubrication of fuel injection systems. The addition of ethanol to diesel lowers fuel viscosity. It is also seen that additive and ignition improver can reinstate the viscosity of the blends. Which can improve combustion process, good cold starting, reduced noise level and long durability for diesel engines. and also No problem of vaport-lock in injection pumps and lines, no knocking or trouble shooting appeared.

In engines, The comparisons of engine performance between ethanol–diesel blends and standard diesel normally illustrate reductions in power that are approximately the same as the reductions in energy content of the blends comparative to diesel fuel. Increased leakage in the fuel injection pump with the lower viscosity of fuels also contributes to reduced power in the load control range of the engine. But adding additives with Diesel-Ethanol blend improve performance of engine and also reduce leakage in fuel injection pump with increase viscosity of fuels also increase power of the engine.

It is usual that the addition of ethanol to diesel fuel will have a beneficial effect in reducing the emissions. The addition of ethanol to diesel naturally reduces the content of sulphur in the fuel. It is accepted that the addition of ethanol to diesel fuel will have a useful effect in reducing the PM emissions at least. The amount of improvement varies from engine to engine and also within the working range of the engine itself.

In literature review showed excellent ability to eliminate soot emissions, and the maximum reduction of PM was observed. NOx emissions were observed to increase when oxygenated fuels were used. But when using Ethanol-Diesel blend with additive to reduce NOx emissions.

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