Ethanol – Diesel and Bio-Diesel Blend as Substitute Fuel to CI Engines
A Comprehensive Review

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Energy is an essential for existence, attaining betterment in quality of life, economic growth and social development of a country. Energy consumption is worldwide well accepted tool for assessment of development status of any country. Since, their exploration, fossil fuels have been an important conventional energy source. The increasing trend of industrialization and modernization of services are continuously enhancing the energy demand at a much faster rate in almost every part of Glob. Majority of developing countries, in spite of their crumbling economy, are forced to import fossil fuels to satisfy their energy demand. Consequently, these countries have to spend a major part of their export income to buy petroleum products [Hanbey Hazar, 2010].

India accounts for only about 2.4 % of the world’s geographical area but support s about 17 % of the world’s human population and 15 % of the livestock. Agriculture is an important sector of the Indian economy as it accounts for 14% of the nation’s GDP and about 11% of its exports However, about half of the Indian population still relies on agriculture as its principal source of income and it is a source of raw material for a large number of industries. Accelerating the growth of agriculture production is therefore necessary not only to achieve an overall GDP target of 8 per cent during the 12th Plan and meet the rising demand for food, but also to feed the increasing population of the country.

The country consumes only 4 % of World’s crude oil annual supply and 2 % natural gas (Pathak, 2013). India’s own reserve of crude oil and natural gas are grossly inadequate and it depends heavily on imports to meet the present needs of these fuels. The country ranks sixth in terms of energy demand accounting for 3.5 % of global energy demand. Energy consumption level is likely to increase further considering the high growth in GDP (7-8% annually), growing population and increasing industrial & agricultural activities. Oil provides energy for 95% of transportation and it increasing steeply with increase in vehicular fleets. The demand of diesel in India increased to 66 MT during 2011-12 from 40 Mt. The domestic supply of crude oil satisfies only 22% of the demand and rest is met by imports.

The crude prices and availability are subject to great volatility depending upon the international situation and so attempts are essential to reduce dependence on imported fossils. Now a giant question is waiting that how to cater the increasing energy demand?

The compression ignition engines are widely used in the transport sector, a standby power unit in industries and in agricultural fields due to their long life, reliability and fuel economy. Due to the increasing energy utilization trend in the recent years, scarcity of diesel to meet the enhancing demand is being faced. In addition, the stringent governmental regulations on emission control forcing for search of environmentally benign alternative fuels which are renewable [Hansen, et. al., 2005].

Bio-fuels seem to be an ideal alternative to dwindling fossil resources as they are renewable and environmentally safer compared to fossil fuels. Among the feasible alternative fuels, bio-ethanol, biodiesel, diesohol and to a lesser extent pure vegetable oils are considered as most promising bio-fuels. Out of these, biodiesel and diesohol have received much attention in recent years for diesel engines and could be one remedy in many countries to reduce their dependence on fossil oil. Ethanol is used as an alternative fuel, a fuel extender, an oxygenate and an octane enhancer. It is a low cost oxygenated compound with high oxygen content (34.8%). Ethanol is an alcohol most often chosen because of the ease of production, can be obtained from various kinds of biomass such as maize, sugarcane, sugar beet, corn, cassava, red seaweed etc., relatively low-cost and low toxicity [Lapuerta, et al., 2007].

However, a major drawback in ethanol–diesel fuel blends is that ethanol is immiscible in diesel over a wide range of temperatures and water content because of their difference in chemical structure and characteristics. These can result in fuel instability due to phase separation. The blending of ethanol to diesel affects fuel properties of the blends such as viscosity, lubricity, Cetane number, energy content and mainly, volatility and stability. Phase separation occurs at relatively low temperatures, which are still used in the blending of anhydrous ethanol.
Biodiesel is an alkyl (e.g. methyl, ethyl) ester of fatty acids made from a wide range of vegetable oils, animal fat and used cooking oil via the transesterification process. Moreover, biodiesel has been used not only as an alternative for fossil diesel, but also as an additive for diesohol – a blending of ethanol with fossil diesel [Fernando, et. al, 2004 and Cheenkachorn, et. al, 2004]. Biodiesels are used because of their similarity to diesel oil, which allows the use of biodiesel-diesel blends in any proportion. The biodiesel allows the addition of more ethanol-blended fuel, keeps the mixture stable and improves the tolerance of the blend to water, so that it can be stored for a long period. The large Cetane number of the biodiesel offsets the reduction of Cetane number from addition of ethanol to diesel, thus improving the engine ignition. The addition of biodiesel increases the oxygen level in the blend. Also biodiesel have lubricating properties that benefit the engine, and are obtained from renewable energy sources such as vegetable oils and animal fats. Similar to ethanol, biodiesel have a great potential for reducing emissions, especially particulate materials [Ribeiro, et al., 2007].

Biodiesel and ethanol have many advantages over regular diesel as renewable and domestically produced energy resources. Studies have shown that there is a substantial reduction of CO, unburned hydrocarbons and particulate matter emission, when they are used in conventional diesel engines [Li et. al., 2005; Shi et. al, 2005 and Srivastava, et. al, 2000]. However preparation of stable blends of bio-diesel and ethanol is most frequently faced problem. To solve the problem, scientists have conducted several studies. The efforts have been made in this paper to present the gist of work done in preparation of diesel – ethanol and ethanol – biodiesel stables which could be used as alternate to convention diesel fuel.

I. DIESEL-ETHANOL BLEND AS SUBSTITUTE FUEL FOR CI ENGINES

Since 19th century, ethanol has been used as a fuel for diesel engines. Ethanol is an alcohol most often chosen for fuel due to its ease of production from various kinds of substrates (maize, sugarcane, sugar beet, corn, cassava, etc.) and relatively low cost and toxicity. The fuel blending technique is an ideal choice to use ethanol in diesel engines as they do not require any engine modification. But the major challenge in employing this technique is the phase separation.

Goering and Schrader, 1988 investigated the effect of ethanol proof on engine performance with the purpose to determine the effect of water in the fuel on the performance of the engine and ethanol of 200°, 190° and 180° proof in an engine which was designed to run ethanol.

The study revealed that the engine consumed 1.4 percent more air and 1.3 per cent more fuel when the engine was running on 190° proof ethanol and 2.5 percent more fuel when the more air and 5.0 per cent more fuel running on 180° proof ethanol compared to operation on anhydrous ethanol. The power output of the engine reduced by 5.5 and 4.8 per cent when the proof of the ethanol were lowered from 200° to 190° and 180° proof ethanol, respectively. The water 190° proof ethanol contributed an average of 0.9 per cent to the power producing capabilities of the fuel while occupying 5.0 per cent of the fuel volume; and 6.3 per cent to the power producing capabilities of the fuel while occupying 10.0 per cent of the fuel volume and 12.5 per cent of the fuel mass.

Hansen et al., 1989 investigated the heat release in the CI Engine by composition of ethanol and conducting tests on a 3 cylinder Perkins engine, having displacement volume of 3152 cc installed on a Massey Ferguson 135 tractor. The engine was tested over a range of load settings at each of two constant speeds coinciding with rated speed and maximum torque. The diesel, diesel-ethanol blends (with cetane improver) and ethanol with 6.0 per cent blend (a fuel additive) were as fuel. The tests revealed that the effect of adding ethanol to diesel resulted in increase in ignition delay, increased rated of premixed combustion, thermal efficiency and reduction in exhaust smoke. These effects were pronounced during maximum fueling. The addition of ignition improver to the diesel-ethanol blends reduced the rates of premixed heat relapse by reducing the ignition combustion behavior. The volumetric consumption of ethanol fuel was between 37 to 43 % greater than that of diesel fuel at maximum fueling.

Ajov, 1997 conducted tests on a 10 BHP constant speed C.I. Kirloskar make (model tv-110) single cylinder, water cooled engine having displacement volume of 1102 cc and compression ratio of 15.6:1 to determine the engine performance and emission characteristics using dual fuels comprising ethanol-diesel blends and fumigated ethanol. It was reported that, the use of ethanol-diesel blend up to 20 per cent ethanol could be suggested for use in constant speed CI Engine because, for the same load conditions the engine developed similar brake power with lower CO and NOx emissions. It was reported that with the use of ethanol-diesel blend, there was no problem with fuel handling, no engine modification was required and the technology could be easily adopted.

Bihari, 1998 studied the effect of ethanol proof on the performance of a 10 BHP Kirloskar make (model tv-110) single cylinder, water cooled compression ignition engine having a displacement volume of 1102 cc and compression ratio 15.6:1 at 1500 rpm of engine speed.
The revealed that the diesel-ethanol blends prepared from 170 to 200 degree proofs showed similar power producing capabilities, reduced BSFC increased thermal efficiency compared to diesel fuel. It was recommended that the use of ethanol as supplementary fuel is feasible in small, constant speed, low BHP CI engines. A blend comprising 15 % ethanol of 170 degree proof and 85 per cent was suggested for use in CI engines.

Ajay et al., 1999 conducted performance and emission test using ethanol diesel blends and found that no significant power reduction in engine operation and the CO, NOx were lower than that of neat diesel.

Ozer Can et al., 2000 investigated the effects of ethanol addition to No. 2 Diesel on the performance and emissions of a four stroke, four cylinder, turbocharged indirect injection diesel engine with different fuel injection pressures at full load. They reported that the ethanol addition reduces Carbon monoxide (CO), soot and Sulphur Dioxide (SO2) emissions, but increases Oxides of nitrogen (NOx) emissions. It was also found that increased injection pressure, reduced the CO and smoke emissions with some reduction in power.

Beyerleion et al., 2001 investigated the effect of using a mixture of ethanol and water (68.8 % anhydrous ethanol, 30 % water and 1.2 % isopropanol) on a converted Ford van (35.1 kW). The converted van was operated on the road up to several hundreds of miles following the EPA federal test protocol to determine the emissions characteristics. The vehicles were operated in weather condition that ranged from subzero in the winter to temperature around 37.78°C in the summer. It was reported that the converted vehicles could start and run normally under all conditions.

Andrzej Kowalewicz, 2004 conducted investigation and reported that that the injection of ethanol into the inlet port reduced CO2, NOx and CO emissions and smoke at higher loads with both diesel fuel and rape oil methyl ester.

Gonsalves et al., 2006 investigated the manufacturing cost of ethanol and biodiesel in India and reported that it was about Rs. 21/l ($0.46/l), roughly the same as petrol and diesel. This indicates biofuels in a favorable position for meeting India’s energy needs, especially as the cost of petroleum is expected to continue its upward trend. In India ethanol is produced by the fermentation of molasses – a by-product of sugar manufacture. India is the fourth largest ethanol producer after Brazil, the United States and china, its average annual ethanol output amounting to 1,900 million liters with a distillation capacity of 2,900 million liters per year.

Agarwal, 2007, reported that ethanol diesel blends up to 20% can be used in the constant speed engines without any hardware modifications and leads to significant reduction in CO and NOx emission.

Ruizhi Song, et al., 2008 determined the performance and emissions of a diesel engine fuelled with methanol and reported that methanol and diesel is not very miscible, which makes it difficult to mix them together as a diesel engine fuel. Dual-fuel operation is favored, and there is potential to reduce particulate matter (PM) and NOx emissions simultaneously. The experimental results show that the full-load power of the dual-fuel engine can reach or even exceed that of the original diesel engine when a suitable minimum pilot diesel quantity is used. Under dual-fuel conditions, smoke reduced significantly, while a modest reduction in NOx, was observed. The equivalent brake-specific fuel consumption is improved under high-load operating conditions. Especially, the dual-fuel engine shows a better fuel economy when run at a high rate of methanol addition. However, unburned hydrocarbon (HC) and carbon monoxide (CO) emissions for dual-fuel operation increase when methanol is added.

Jincheng Huang et al., 2009 studied the performance and emissions of a diesel engine using ethanol-diesel blends. They reported that the thermal efficiencies of the engine fuelled by the blends were comparable with that fuelled by diesel, with some increase of fuel consumption. They also found reduced smoke emissions, CO emissions above half loads, and increased HC emissions with the blends comparing with the diesel fuel.

Canakci, et al., 2009 experimentally investigated the effect of injection pressure on the engine performance, exhaust emissions and combustion characteristics of a single cylinder, four stroke, direct injection, naturally aspirated diesel engine when using methanol-blended diesel fuel from 0 to 15% with an increment of 5%. The experimental test results proved that brake thermal efficiency, heat release rate, peak cylinder pressure, smoke number, carbon monoxide and unburned hydrocarbon emissions reduced as brake-specific fuel consumption, brake specific energy consumption, combustion efficiency, and nitrogen oxides and carbon dioxide emissions increased with increasing amount of methanol in the fuel blend.

Tsang, et al., 2010 conducted experiments on a four-cylinder direct-injection diesel engine with part of the engine load taken up by fumigation ethanol, which was injected into the air intake of each cylinder, to investigate the combustion and emissions of the engine under five engine loads at an engine speed of 1800 rpm. It was reported that in comparison to Euro V diesel fuel, fumigation ethanol gives a higher peak in-cylinder pressure and heat release rate. Increasing the fumigation ethanol would increase the ignition delay.
II. MISCEIBILITY PROBLEM OF DIESEL-ALCOHOL BLENDS

Ethanol and diesel fuel are inherently immiscible because of their difference in chemical structures and characteristics. The addition of ethanol to diesel affects properties such as viscosity, lubricity, cetane number, energy content and mainly, volatility and stability. Phase separation occurs at relatively low temperatures, which are still used in the blending of anhydrous ethanol. The phase separation can be prevented in two ways. First is the addition of an emulsifier, which acts by lowering the surface tension of two or more substances and the second is the addition of a co-solvent, which acts by modifying the power of solvency for the pure solvent [Pang, et al., 2006]. Diesel and ethanol fuels can be efficiently emulsified into a heterogeneous mixture of one micro-particle liquid phase dispersed into another liquid phase by mechanical with suitable emulsifiers. The emulsifier would reduce the interfacial tension force and increase the affinity between the two liquid phases, leading to emulsion stability [Lin, et al., 2003]. A suitable emulsifier for ethanol and diesel fuel is suggested to contain both lipophilic part and hydrophilic part, in order to obtain an emulsion of diesel and alcohol. Such chemical structures can be found in biodiesel [Kraipat, et al., 2004].

2.1 Investigations to Check Phase Separation in Diesel-Ethanol Blends

Generally, ethanol can be blended with diesel with no engine modifications required [Ajov, et. al, 2002]. However, a major drawback in ethanol–diesel fuel blends is that ethanol is immiscible in diesel over a wide range of temperatures and water content because of their difference in chemical structure and characteristics. These can result in fuel instability due to phase separation. Prevention of this separation can be accomplished in two ways: by adding an emulsifier, which acts to suspend small droplets of ethanol within the diesel fuel, or by adding a co-solvent, which acts as a bridging agent through molecular compatibility and bonding to produce a homogenous blend [Letcher, et. al, 1983]. Emulsification usually requires heating and blending steps to generate the final blend, whereas co-solvents allow fuels to be “splashblended”, thus simplifying the blending process [Hansen, et. al, 2005]. Additionally, the cetane number of the blend is low, making it difficult to burn by the compression ignition technology employed in diesel engines. As a result, a number of studies have been carried out to improve the solubility of ethanol in diesel, as well as to improve the cetane number of the blends.

There are several studies concerning diesohol production and utilization. Recent studies in the US have revealed the use of additives from different manufacturers. Pure energy corporation (PEC) of New York was the first manufacturer to develop an additive package using a 2–5% dosage with 15% anhydrous ethanol, and proportionately less for 10% blends [Marek, et. al, 2001]. A small amount of commercially available cetane improver (<0.33% by volume) also was added to restore the cetane value of the blend. The second additive manufacturer was AAE Technologies of the United Kingdom, which has been testing 7.7% and 10% ethanol–diesel blends containing 1% and 1.25% AAE proprietary additive in different stages in the US [Marek, et. al, 2001]. The third manufacturer was GE Betz. They developed a proprietary additive derived purely from petroleum products; compared to the previous two, which are produced from renewable resources [Marek, et. al, 2001 and Hansen et. al, 2001] has announced the successful development of an emulsification technique using its innovative emulsifier. Their diesohol contained regular diesel fuel at 84.5 vol%, hydrate ethanol (5% water) at 15 vol%, and their emulsifier at 0.5 vol%. Engine tests for the diesohol were conducted by using a truck and a bus to compare it with regular diesel fuel. It was found that higher levels of alcohol in the diesohol maximizes the reductions in regulated exhaust emissions (HC, CO, NOx, PM), and a reduction in net greenhouse gas emission is achieved by the use of diesohol.

Letcher, 1980 suggested the use of an emulsifier or a co-solvent to prevent the phase separation of diesel-ethanol blends.

The additives such as tetrahydrofuran, ethyl acetate [Letcher,1980 and Meiring, et al., 1981], [O.sub.2] Diesel [TM] Lapuerta, Octavio Armas, 2007, isopropanol [Ozer, et a., 2004], ethyl ter-butyl ether (ETBE) and ter-amyl ethyl ether (TAAE) [Eliaana Weber de Menezes, Rosangela da Silva, Renato Cataluna, and Ortega, R.J.C., 2006] are used to prevent phase separation among diesel ethanols blends. Caro et al., 2001 selected additives which had a glycerol skeleton bearing hetero atoms and amino-ether, hydroxyl, nitrate and nitramine functional groups to study the behaviour of diesel ethanol blend. It was observed that the engine behavior improved in the presence of additives with reduction of pollutant emission, cycle irregularities and ignition delay.

Chandra, 2003 conducted investigations on the use of ethyl acetate surfactant for diesel-alcohol microemulsions as C.I engine fuel. The investigations on the stability of microemulsions were conducted using anhydrous and aqueous ethanol and diesel using ethyl acetate as surfactant.
It was reported that ethanol – ethyl acetate microemulsions prepared using 200, 190, 180 and 170° proof ethanol were observed stable and homogeneous at selected temperature conditions. It was further reported that the requirement of ethyl acetate as surfactant to prepare stable and homogeneous microemulsions was observed to be very high with aqueous ethanol. The requirement of ethyl acetate was found to increase with decrees in proof level of ethanol.

III. DIESEL-ETHANOL-BIODIESEL BLENDS AS FUEL FOR CI ENGINES

Biodiesel has been used not only as an alternative fuel, but also an additive for diesohol [Fernando, et al., 2004 and Cheenkachorn, et al., 2004]. This homogeneity is due to the fact that the biodiesel can act as an amphiphile and form micelles that have nonpolar tails and polar heads. These molecules are attracted to liquid/liquid interfacial films and to each other. These micelles acted as polar or non-polar solutes, depending on the orientation of the biodiesel molecules. When the diesel fuel was in the continuous phase, the polar head in a biodiesel molecule oriented itself to the ethanol, and the non-polar tail was oriented to the diesel [Kwancharareon, et al, 2007 and Violeta, et al., 2005].

Fernando, et al., 2004 investigated the advantages of using oxygenated diesel fuel blend over regular diesel. It was reported that oxygenations significantly reduced particulate matter (pm) and toxic gases such as CO, sulfur oxides (SO\textsubscript{x}).

X. Shi et al., 2005 used 20% methyl soyate as additive with diesel ethanol blend to prepare a stable fuel blend and the performance and emission test on a multi cylinder variable speed engine shown significant reduction in smoke and particulate emission.

Violeta et al., 2005 conducted solubility test on multi-component biodiesel fuel system. They found that Rapeseed oil ethyl and methyl esters are soluble in ethanol and diesel without limits and the addition of ethanol increases the inter-solubility of ethanol and fossil diesel.

Kwancharareon, et al., 2006 studied the phase diagram of diesel–biodiesel-ethanol blends at different purities of ethanol and different temperatures. It was found that the fuel properties were close to the standard limit for diesel fuel; however, the flash point of blends containing ethanol was quite different from that of conventional diesel. The high cetane value of biodiesel could compensate for the decrease of the cetane number of the blends caused by the presence of ethanol. The heating value of the blends containing lower than 10% ethanol was not significantly different from that of diesel.

As for the emissions of the blends, it was found that CO and HC reduced significantly at high engine load, whereas NO\textsubscript{x} increased, when compared to those of diesel. Taking these facts into account, a blend of 80% diesel, 15% biodiesel and 5% ethanol was the most suitable ratio for diesohol production because of the acceptable fuel properties (except flash point) and the reduction of emissions.

Pang et al., 2006 reported that use of biodiesel-ethanol- diesel blend could slightly increase the emissions of carbonyls and NO\textsubscript{x} but significantly reduce the emissions of PM and THC.

Prommes Kwancheareon et al., 2007 conducted solubility test on diesel-biodiesel-ethanol blend using palm oil methyl ester as additive and reported emission test results of the fuel blend. They found that 5% ethanol, 15% Biodiesel and 20% diesel blend was most suitable for diesohol production due to its lower emissions and acceptable fuel properties.

Núbia et al., 2007 reported that around the world, there is a growing increase in biofuels consumption, mainly ethanol and biodiesel as well as their blends with diesel that reduce the cost impact of biofuels while retaining some of the advantages of the biofuels. However, there are major drawbacks in the use of biofuel blends as NO\textsubscript{x} tends to be higher, the intervals of motor parts replacement such as fuel filters are reduced and degradation by chronic exposure of varnish deposits in fuel tanks and fuel lines, paint, concrete, and paving occurs as some materials are incompatible. Here, fuel additives become indispensable tools not only to decrease these drawbacks but also to produce specified products that meet international and regional standards like EN 14214, ASTM D 6751, and DIN EN 14214, allowing the fuels trade to take place.

Lapuerta et al., 2008 used E10 blend without any additives and conducted performance test on stationary engine test bed. They found improvement in the efficiency of the engine and reduction in particulate matter emission. They suggest using cetane number enhancers and co-solvent additives for the blend stability and better performance and emission reduction.

Kim, Hwanam and Choi, Btungchul, 2008 investigated the exhaust gas characteristics and particulate size distribution of PM on a CRDI diesel engine using diesel, biodiesel and ethanol blends. They observed the reduced CO, HC, smoke emissions and total number of particles emitted, but increased NO\textsubscript{x} emissions. Pang et al., 2006 reported that the use of biodiesel-ethanol- diesel blend could slightly increase the emissions of carbonyls and NO\textsubscript{x} but significantly reduce the emissions of PM and THC.
Shi, et al., 2008 experimented combination of biodiesel-ethanol-diesel fuel blend and selected catalyst reduction (SCR) catalyst assembly to reduce emissions from a heavy duty diesel engine. It was reported that compared to diesel fuel, use of BE-diesel increased PM emissions by 14% due to increase in the soluble organic fraction (SOF) of PM, but it greatly reduced the Bosch Smoke Number by 60-80% according to the results from 13-mode test of European stationary Cycle (ESC) test.

Selvan, et al., 2009 used biodiesel (Jatropha Methyl Ester) produced through transesterification as a bridging agent between diesel and ethanol to prevent phase separation. It was reported that phase separation of ethanol-diesel blend can be prevented using desired quantity of biodiesel (Jatropha methyl ester) as additive. The stability of the blend increases with the increase in the temperature. 10% biodiesel by volume prevents the phase separation at 30°C for the blends E5, E10, E15, E20 and E25. The brake thermal efficiency of the engine fueled with dieselohol blends is slightly higher or equal with lower ethanol and higher biodiesel proportion and found decreases with the increases in percentage of ethanol at the compression ratios 15, 17 and 19. Highest brake thermal efficiency is observed as 26.15% for neat diesel under the compression ratio of 17 at the brake mean effective pressure of 0.44MPa, whereas the lowest brake thermal efficiency is observed as 22.61% for the E25 blend under the compression ratio of 15 under the same loading condition. The least CO emission is observed as 0.37% for the E25 blend at the compression ratio of 15 and the highest CO emission is 0.88% for neat diesel under the compression ratio of 17 at the beme of 0.44MPa. The least hydrocarbon emission is found as 110 ppm for the E5 blend under the compression ratio of 19 and highest as 198 ppm for the E25 blend under the compression ratio of 17 at the bme of 0.44MPa.

Pugazhvadivu, 2009 studied the effect of ethanol addition to biodiesel by conducting experiments on a single cylinder diesel engine using B25, B50, B75 and B100 biodiesel diesel blends with 5% and 10% ethanol addition. It was reported that the addition of ethanol to biodiesel diesel blends did not alter the engine performance significantly. The engine produced lower NOx and smoke emission with ethanol addition.

Weerachanchai, et al. 2009 studied the phase behaviors and fuel properties of bio-oil-diesel-alcohol blends using bio-oil derived from palm kernel pyrolysis by blending it with diesel fuel and alcohols. It was reported that the alcohol types showed a significant influence on the phase characteristics with palm kernel bio-oil-diesel-butanol system giving larger soluble area than that of palm kernel bio-oil-diesel-ethanol system.

Lapuerta, et al., 2010 studied the stability, lubricity, viscosity, and cold filter plugging point (CFPP) to increase the knowledge about the implications of the use of short- and long-chain alcohols/diesel fuel blends in diesel engines. The investigation revealed that short-chain alcohols depict poor blending stability and low viscosity (mainly for concentrations of ethanol and propanol in diesel fuel blends beyond 22 and 45%, respectively. A synergistic effect was observed in viscosity when moderate concentrations of butanol and pentanol were mixed with diesel fuel. The lubricity of the blends decreases with the alcohol content, but this effect is partially compensated by the alcohol volatility. It was concluded that alcohols can be blended with diesel fuel under low and high concentrations, although to improve the blending stability of short-chain alcohols in medium concentrations, the use of additives or fatty acid esters would be necessary.

Nagarhalli, 2010, conducted experimental work to analyze the emission and performance characteristics of a single cylinder 3.67 kW, compression ignition engine fuelled with mineral diesel and diesel-biodiesel blends at an injection pressure of 200 bar. The results indicate that the CO emissions were slightly higher, HC emissions decreased from 12.8 % for B20 and 2.85 % for B40, no x emissions decreased up to 39 % for B20 and 28 % for B40. The efficiency decreased slightly for blends in comparison with diesel. The BSFC was slightly more for B20 and B40. From the investigation it can be concluded that biodiesel can be used as an alternative to diesel in a compression ignition engine without any engine modifications.

Torres et al., 2010 determined the physical and chemical properties of Ethanol- Biodiesel blend for diesel engine. It was reported that cold weather properties were improved by adding ethanol to biodiesel. In general, the results show that ethanol in biodiesel influences beneficially the most important fuel properties of the blended fuel. Potentially, this may offer a possibility to impure engine characteristic. However, to confirm this assumption, further engine tests have to be prepared.

REFERENCES


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