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INFLUENCE OF ADDITIVES ON THE PERFORMANCE AND EMISSION CHARACTRISTICS OF CI ENGINE - A REVIEW

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ABSTRACT

The main objective of this paper to discuss the research output for getting better engine performance with lower noxious emissions by improving the fuel quality. The control of diesel fuel properties as a means of Regulated pollutants continues to be charged with reaching various air quality goals. Some additives play effective role in diesel fuel for improving fuel's quality and minimize the problem without modification engine technology. This paper is a brief review of the possible additives to improve energy conversion quality of diesel fuel used in industries, transportation and domestic utilizations.

Keywords: Air pollution, diesel engine, diesel additives, carbon monoxide.

1. INTRODUCTION

Air pollution now a day's serious problem in many countries some researcher are working in the same way to reduce engine emissions. The increasingly use of CI engine vehicles has lead to deterioration of the quality of air to a level. The formation of deposit on the inside of the engine cylinder could affect the exhaust emissions from vehicles. One prospective method to solve this issue is to use the fuel additives [2]. Due to low cost of Diesel fuel , diesel engine are more common and economical than gasoline engines but suffer from inherent higher Particulate Matter(PM) and nitride oxide (NOx) emissions. Reduction of exhaust emissions is extremely important for diesel engine development in view of increasing concern regarding environmental protection and stringent exhaust gas regulations. Diesel engines are the major contributors of air polluting exhaust gases such as particulate matter, carbon monoxide, oxides of nitrogen and other harmful compounds. Increasingly stringent regulations governing particulate emissions, nitric oxides from diesel engines have prompted research directed toward methods for reducing the in-cylinder formation of pollutants by modifying fuels or controlling particles by after treatment technologies. The diesel fuel properties have become even more stringent controlling diesel exhaust emissions through fuel modification seems to be promising because it would affect both the new and old engines. Modification of diesel fuel to reduce exhaust emission can be performed by increasing the cetane number, reducing sulphur content, reducing aromatic content, increasing fuel volatility and decreasing the fuel density to have the compromise between engine performance and engine out emissions, one such change has been the possibility of using diesel fuels with oxygenates. These blends usually enhance the combustion efficiency, burn rates, power output, and the ability to burn more fuel, but first of all, these blends offer the reduction of exhaust emissions the reduction of diesel engine emissions could be considered from three aspects: the combustion improvement technique, the exhaust after treatment technology, and the fuel melioration. However, the relevant research on fuels especially on liquid fuels was still less investigated until very recently. The research on dimethyl ether (DME) as an alternative fuel produced great enlightenment.

2. LITERATURE SURVEY

Ruijun Zhu, et al. (2013) has used the dimethoxymethane (DMM) additive with 15%, 30%, and 50%value fraction respectively. We investigate that using diesel –DMM additive can improve thermal efficiency and is beneficial to the reduction of smoke and CO emissions as well as particle number of both nanoparticle and ultrafine particles in exhaust gas but increase NO_X emission .when increasing the DMM fraction in diesel – DMM blends CO emission is reduced greatly under high engine load conditions. Though DMM additive has less significant at low engine load operations. Compare with the baseline case of using pure diesel when fueling the engine with DMM15, DMM30, and DMM50 there was about 15%, 50% and 80% smoke reduction respectively. When using diesel – DMM blends engine performance and emissions can be optimize by adjusting fuel injection timing , advancing fuel injection timing brings in improved thermal efficiency and fuel efficiency, decreased smoke emission and particle number at the cost of increased NO_X emission [1]. Xiangang Wang, et al. (2012) has used oxygenate additive on a 4-cylinder direct-injection diesel engine. In this study investigate that the particulate emissions of the engine under different load conditions at engine speed is 1800 rpm. The diesel ethanol blends with oxygen concentration of 2%, 4% and 8%. Diesel- biodiesel blends and diesel – diethylene glycol dimethyl ether (DGM) or named as diglyme blends with oxygen concentration of 2%, 4%, 6%, 8%and 10% were studied. The increase of oxygenate concentration in the blends the particulate matter (pm) emission decreases. Diesel fuel increases HC, CO, NO_X and NO_2 emission and decreases particle number concentration with the addition of ethanol into the diesel fuel. Adding diglyme into diesel fuel NO_X emissions and particulate matter decreases. The study suggest that the ester structure of biodiesel is less effective in reducing the soot precursors than the alcohol structure of ethanol, leading to relatively higher smoke emissions for di-butyl blends [2].W.M. Yang et al. (2012) has used nano-organic additives and we observed that the torque of the engine fueled by emulsion fuels is less than that of pure diesel. The torque reduces with the increase of water content because the emulsion fuels contain less energy than pure diesel due to the presence of water and organic additives. The heating value of E15 is 19.6% lower than that of pure diesel and E10 is also less than 15%energy. Here also observed that emulsion fuel increased thermal efficiency. The brake thermal efficiency can be improved by 14.2%. Emulsion fuels can not only increase the efficiency but also reduces the NO_X emission. The higher the concentration of water content in the fuels is the lower the flame temperature is as a result E15 can reduce more NO_X emission than E10. At full load condition the NO_X reduction for E15 IS 30.6% less than that of pure diesel. The HC and CO emission is also reduces [3]. Ruiju Zhu, et al. (2011) has used diethyl adipate additive in four cylinder direct-injection diesel engine. The diethyl adipate Concentration is 8.1%, 16.4%, 25%and 33.8% by volume and corresponding to 3%, 6%, 9%, and 12%by mass of oxygen in the additives. The results indicates that an increase of brake specific fuel consumption and brake thermal efficiency when using the blended fuel. For each fuel in general, the CO emission increases when the engine load is increased from 0.08 to 0.20MPa, while it decreases with further increase of engine load. The particulate mass concentration increases with engine load but decreases with an increase of diethyl adipate (DEA) in the fuel. The particulate mass reduction is 19%, 33%, 55% and 65%for DEA8, DEA16, DEA25 and DEA34 respectively. In case of NO_X emission the DEA16 gives highest NO_X concentration while DEA8 gives the lowest. The HC concentration increased by 2%, 5%, 9%and 18%for DEA8, DEA16, DEA25, DE34 respectively in different load condition. For unregulated gaseous emissions, formaldehyde and acetaldehyde increases with increase of DEA in fuel [4]. Yi Ren, et al. (2008) has used oxygenate additive we investigate that the addition of oxygenate additives in diesel fuel can decreases the exhaust smoke percentage without decreasing the effective thermal efficiency. Here found that smoke can be decreased by adding the oxygenate additive in diesel fuel without increasing the NO_X percentage and exhaust gas recirculation can be used to minimize the NO_X emissions. Smoke percentage reduces with the increase of the oxygen content in the additives without increasing NO_X, CO and HC and decrease with the increase of the oxygen content in the additives [5]. Z.H. Huang, et al. (2006) has used the Di-methoxy methane (DMM) additive the diesel fuel is the base fuel, while DMM is used as the oxygenated additive. Four fractions of the diesel-DMM blends are using for the experimental study the fuel blends are 5%, 10%, 15%and 20%respectively. The result suggest that diesel-DMM additives would be helpful for the reduction of engine exhaust, CO and smoke, since it could increase the cylinder gas temperature and oxygen enrichment NO_X slightly decreases with the increase of DMM in the diesel fuel, and decrease the heating value and increase in fuel injection duration of the additives is contributed to the lowering of the NO_X concentration. At all engine loads and constant speed the CO concentration decrease with the increase of the oxygen mass fraction of the diesel-DMM fuel additives. The combination of diesel –DMM additives with exhaust gas recirculation can make a further decrease of NO_X without increasing the smoke emission [6]. Heejung Jung, et al. (2005**)** has used cerium additive in a medium –duty direct injection four-cylinder, four-stroke cycle turbocharged diesel engine. This additives used was a nanoparticulate cerium oxide dispersed in an organic solvent to make it directly miscible with diesel fuel. The cerium additive is most effective role play for reducing the number concentration of particles in the accumulation mode. We investigate that a 50% reduction in peak concentration at the 25ppm level and a 65% reduction at the 100ppm level [7]. X.Shi, et al. (2005) has used Methyl Soyate - ethanol in commercial DI diesel engine. We observed that the calorific values of ethanol and soyate are less than that of diesel fuel. The brake specific fuel consumption of blends compared with diesel very slight change. The total pm emission results obtained from the fuels at the maximum torque and at the highest engine speed. The result confined that B20, BE15 and BE20 decreased the total pm emission effectively. In the current investigation all fuel blends increased NO_X relative to diesel fuel. It should be noted that oxygenates are blended with the fuel at the same value percent level for B20and BE20. However, the NO_X increase with BE20 was more significant than that withB20 which means that the ethanol might have a more complete combustion than methyl soyate. The overall test result showed that BE20 reduced CO emission by an average of about 19% and 20% B20 and BE15should similar CO emissions. Characteristics and reduced CO emission slightly compared with the base fuel when the diesel engine was fueled with B20 and the reduction rate were about 21% on the other hand the THC emission with BE15 and BE20 increased significantly relative to that with diesel fuel at all condition [8]. Wang Ying, et al. (2005) has used oxygenated DME additive. The three types of oxygenated blends with different fraction of DME in diesel fuel are DM10, DM20and DM30. We noted that higher the DME content smaller the amount of heat release during the premixed combustion. This is due to good at ignition and atomization characteristics which improves the engine combustion process. We found that blends can reduce the smoke density significantly, especially at higher loads. At the 0.7MPa, BMEP, smoke reduction is 55%and at 0.5MPa BMEP 43% reduction for DM10. at the 0.6MPa BMEP, the smoke reduction is 73% and at0.5MPa BMEP, smoke reduction is68% for DM20. At the 0.6MPa BMEP, smoke reduction is 75% and at0.5MPa BMEP, smoke reduction is 74% for DM30. Overall the emission is reduced and performance is increase by increasing the concentration of additives [9]. F. K. For son, et al. (2004) has used jatropha oil as additives in diesel fuel and investigate that the amount of jatropha oil increases the brake thermal efficiency increases with engine loads. The 2.6% jatropha oil additive indicates that gives higher efficiency at all loads. We observed that the 2.6%of jatropha oil mixed into the diesel fuel enhances the performance of the engine and reducing the exhaust temperature then reducing the NO_X [10]. Edwin Corporan, et al. (2004) has used soot particulate mitigation additives in T63-A-700 turbo shaft engine. We investigate that the nitrate compounds were ineffective in reducing particle number density in the T63. The calculation of performance 17 additives is used in a T63 helicopter engine. It was found that the diesel cetane improver and commercially available additives to reduce emissions in internal combustion engines were ineffective in reducing particulate emissions from the T63 engine. The detergent type additive is most suitable for in this type of engine for reducing emissions [11]. Yakup Icingur, et al. (2003) has used to aniline nitrate additive for increasing cetane number (CN). We investigate that the CN affects the exhaust emissions, and engine performance. It can be noted that the NO_X and SO_2 emissions reduce when the CN is increased. The minimum value of NO_X is obtained for 1000/min. engine speed. The NO_X reduction can be observed for all speeds, 1000, 2000, 3000, and 4500/min. by increasing the CN. We find out fuel CN increased, engine torque and power are improved. The engine performance is increased for the CN_S between 51-54.5and 54.5-61.5 are not significant [12]. Bang-Quan He, et al. (2003) we investigate that if ethanol blends increases, oxygen content is also increases and aromatics fractions decreases. It is also seen that additive and ignition improver increase the cetane number (CN) of E10AI and E30AI to 48.7and 45.8respectively, which can ensure good cold starting, reduce noise and long durability for diesel engines. Emissions vary with engine operating conditions at high load ethanol blended fuels effects on smoke, and NO_X emissions. Overall in this study find that engine performance increases, smoke and NO_X emissions reduces [13]. C.-Y.Lin, et al. (2003) in this paper we investigate that the total fuel conversion efficiency increased with the increase in engine speed. Greater the ethylene glycol monoacetate in diesel fuel higher the brake specific fuel consumption output and decrease the CO, CO_2 and NO_X emissions [14].

3. TYPES OF ADDITIVES

3.1 METAL- BASED ADDITIVES

Some metal-based additives are reported to be effective in lowering diesel emissions. They may reduce diesel emissions by two ways. First, the metals either react with water to produce hydroxyl radicals, which enhance soot oxidation, or react directly with carbon atoms in the soot, thereby lowering the oxidation temperature [28], [32], [33]. When these are used after combustion in the engine, the metal acts as a nucleus for soot deposition. Usually, the additive is added as a metal-organic compound, and it is emitted in the particulate phase as oxide, on soot particles or forming new nanometer-sized particles by homogeneous nucleation of the additive [34], [35]. Particle traps are suitable tools for minimizing soot emissions [7]. However, a technical challenge is the regeneration of clogged filters because online regeneration demands a minimum temperature of 550 ^{0}C and an oxygen content of 5%, which cannot be attained without additional burners or catalytic combustion. The principle of this additive action consists of a catalytic effect on the combustion of hydrocarbons. Transition or noble metals (e.g., Ce, Fe, Cu, Sr, or Pt) in the form of fuel additives or coatings can substantially lower the soot ignition temperature [41]. A large variety of metal additives have been investigated. Some examples are a catalytic phase based on eutectic mixtures of Cs2O, V2O5, and MoO3; [37] succinimide dispersant; calcium alkylsulfonate and zinc dithiophosphate; [38] additive Mg-based [39] compounds based on Mg, Ca, Mn, and Cu [27] ferrocene [32] Ce- Cu-, and Fe-based additives [35] and a Ce additive [7]. A serious problem associated with diesel emissions is the presence of polycyclic aromatic hydrocarbons (PAHs). Several PAHs are known to be mutagenic and/or potentially carcinogenic toward humans [42]. Manganese-based additives have been used to investigate the effects on PAH emissions. Yang et al. [28] showed that Mn-based additives might reduce the emission of regulated pollutants (PM, CO, HC, and NOx) as well as unregulated pollutants (PAHs). By adding 400 mg/kg of Mn based additive into the diesel fuel, the mean reduction fraction of the mean total PAH emission was 37.2%, while for the 10 higher molecular weight PAHs, the mean reduction fraction was 64.5%. These results indicate that Mn-based additives in diesel engines can act as catalysts enhancing the oxidation process and reducing a considerable amount of PAH emission [28].Particles smaller than 50 nm are more abundant during the use of these additives, and the total particle number concentration can even be larger. No PAHs or elemental carbon is detectable in the particle fraction below a 50 nm diameter [40]. The freezing point is affected when Mn-based additives are used. There is a linear relation between lower dosages of additives and reduction of the freezing point. This is attributed to Mn compounds' effects on fuel colligative properties, and a stronger attraction effect occurs between the ions when the concentration is increased. Gu¨ru et al. [27] showed that cetane number, CO2, and net efficiency were increased and CO and SO2 were decreased when Mn additives were added to the diesel fuel.

3.2 OXYGENATED ADDITIVES

Another group of fuel additives is oxygenated compounds. The idea of using oxygen to produce a cleaner burning of diesel fuels before a half century [44]. Since that early work, numerous researchers have reported the addition of a variety of oxygenated compounds to diesel fuel. Some oxygenate compounds used are ethanol [13],[45],[46],acetoacetic esters and dicarboxylic acid esters,[47] ethylene glycol monoacetate,[16], 2-hydroxy-ethyl esters,[48] diethylene glycol dimethyl ether, sorbitan monooleate and polyoxyethylene sorbitan monooleate [49] dibutyl maleate and tripropylene glycol monomethyl ether,[50] ethanol and dimethyl ether [44] dimethyl ether (DME) dimethyl carbonate (DMC) and dimethoxy methane,[65] 1-octylamino-3-octyloxy-2-propanol and N-octyl nitramine,[45],dimethoxy propane and dimethoxy ethane,[66] biodiesel,[8],[67],[68] and a mixture of methanol and ethanol [69]. Oxygenated additives have been considered for reducing the ignition temperature of particulates. However, the reduction of particulate emissions through the introduction of oxygenated compounds depends on the molecular structure and oxygen content of the fuel32 and also depends on the local oxygen concentration in the fuel plume. To reduce particulate emissions, fuel-compatible oxygen-bearing compounds should be blended with diesel to produce a composite fuel containing 10-25% v/v of oxygenate[50]. Therefore, the composition of diesel and the use of additives directly affect properties such as density, viscosity, volatility, behavior at low temperatures, and the cetane number. Zabetta et al.[30] showed that the ignition temperature of particulates from seed-derived oils (SO) and from blends of SO with diesel fuel (DO) can be lower than that of particulate from neat DO. According to De Menezes et al.[29] by increasing the concentration of additives (e.g., ethanol and ethyl tert-butyl ether or tert-amyl ethyl ether), there is a reduction in the cetane number, and an increase in hydrocarbons leads to a decrease of CO up to 20% in relation to diesel fuel alone. The fuel cetane number decreases with an increase of ethanol content in the fuel because of the low cetane number of this alcohol. Another factor that influences the decrease in cetane number level is the incomplete combustion of the ethanol-air mixture. Factors causing combustion deterioration, such as high latent heats of evaporation, could be responsible for the increased CO emission. Another reason for the high CO emission is the increase in ignition delay. This leads to a lower combustion temperature at lower and medium loads [69], [8], [46]. NOx emissions decrease with ethanol addition[46]. In addition, a measurable increase of the concentration of oxygen in combustion products from the blends was observed. This may be another cause of the NO_X increase [8], [55]. The presence of some oxygenated additives (ethanol, 1-octylamino- 3-octyloxy-2-propanol, and N-octyl nitramine) results in the formation of a lubricant film with beneficial antiwear properties. The increase volatility of the mixture is also apparent as a lower flash point at ambient temperature. Although this does not have a direct effect on engine performance, such mixtures would be subject to the legislation concerning fuel handling [13],[45],[8],[55]. DME is a potential ultraclean diesel fuel. Dimethyl ether burns without producing the smoke associated with diesel combustion and can be manufactured from synthesis gas or methanol. However, DME has a low viscosity compared to diesel fuel and has insufficient lubricity to prevent excessive wear in fuel injection systems. A strategy in order to obtain cleaner-burning fuels with satisfactory properties is the use of diesel-DME blends. The viscosity of blends of DME with various fuels and additives, including low-sulfur diesel fuel, soybean oil, biodiesel, and various lubricity additives, was characterized over a range of blend ratios. It was observed that none of the additives or fuels provides adequate viscosity when blended with more than 50% DME.

3.3 DEPRESSANTS AND WAX DISPERSANTS

Petroleum distillate fuels contain *n*-paraffin waxes that tend to be separated from the oil at low temperatures. The waxes generally crystallize as an interlocking network of fine sheets, thereby trapping the remaining fuel in cagelike structures and causing cold-flow problems such as clogging of fuel lines and filters in engine fuel systems. Several techniques have been used to minimize the problems caused by the wax deposition, and the continuous addition of polymeric inhibitors is considered to be an attractive technological alternative. The addition of copolymers such as polyacrylates, polymethacrylates, or poly(ethylene-*co*-vinyl acetate) (EVA) inhibits the deposition phenomenon; those copolymers are composed of a hydrocarbon chain, which provides the interaction between additives and paraffin, and a polar segment that is responsible for the wax crystal morphology modification necessary to inhibit the aggregation stage. Those copolymers are known as cold-filter plugging point (CFPP) additives or pour point depressants (PPDs). EVA copolymers present a good efficiency as diesel fuel CFPP additives [56]. The addition of PPDs has been proved to be an efficient way to inhibit the wax deposition of diesel fuels. However, the complexity of the oil is far beyond current commercial PPD products. So far, it mainly depends on syntheses of numerous candidate compounds followed by repeating experimental measurements in order to improve the efficiency of PPDs. Wu et al. [31] used molecular dynamic simulation to investigate the interaction between crystal planes of wax and EVA, as well as its derivatives with different branches, on the basis of the model of wax. Side-chain effects on adsorption energy and equilibrium adsorption conformations were studied under different kinds and numbers of branches. They concluded that side chains introduced by propylene were a benefit to the affinity between the EVA-type molecules and alkanes in the wax plane, comparing with those branches introduced by butylenes. Molecular dynamic simulation calculations indicated that EVAP with one branch adjacent to the VA (vinyl acetate) group would be a better PPD additive than EVA in diesel fuels. Wax dispersant additives are especially important in countries with long winters. It was shown that traditional depressants (polyacrylates and copolymers of olefins and vinyl acetate) do not prevent separation during cold storage by reducing the solid point of the fuels. As a result, the fuel separates into two layers: an upper, clear layer and a lower, cloudy layer rich in waxes. Both layers are mobile, but when fuel is taken off of the lower layer, the engine misses. Special additives wax dispersants or precipitators solve the problem.

3.4 IGNITION PROMOTERS

In internal combustion engines operating on diesel fuel, the cetane number of the fuel is one of the most important characteristics of the combustion process. Improved ignition is detected as a decrease in the ignition delay time, the ignition delay time being measured as the time between the start of fuel injection and detectable ignition. Shorter ignition delay times have been directly correlated with a faster startup in cold weather, reduced NOx emissions, and smoother engine operation [58]. This parameter is a function of the composition and the structure of the hydrocarbons present in the diesel. It decreases with an increase in the aromatic hydrocarbon content and increases with an increase in the *n*-paraffin and olefin content [59]. The utilization of cetane-improving additives is necessary to avoid difficulties in cold starting and other performance problems associated with low cetane numbers. Ignition promoters have traditionally been given to alkyl nitrates (e.g., amyl nitrate, hexyl nitrate, and octyl nitrate), but azo compounds and alkyl peroxides have also been proposed [28],[60]. The commercial market considers several factors when selecting and using cetane improvers; these include efficiency toward improving ignition properties, hazards associated with storage and transport, additional costs associated with diluting cetane improvers to allow safe transport, and nitrogen content [58]. Alkyl nitrates are characterized by relatively high efficiency and, simultaneously, many serious drawbacks. They are toxic and corrosive and worsen the color of the fuels during storage. For this reason, the attempts to create ignition promoters based on other compounds are ongoing, and organic peroxides have received the most attention. Among the organic peroxides, symmetric dialkyl and diaryl peroxides are of practical interest. They are more stable in storage and heating and do not decompose on contact with water, olefins, and others compounds which can be present in commercial fuels [61]. In another work, nitrate derivatives of soybean oil were synthesized and evaluated as an alternative to 2-ethylhexyl nitrate (EHN), which currently dominates the cetane improver market. The synthesized additive exhibited NOx-reducing capabilities similar to that of EHN when used in a diesel fuel. They also provided significant lubricity enhancement to the fuels at the same concentrations used to provide the cetane enhancement. Depending on the product, these additives exhibit increased stability and lower volatility than EHN. Commercially competitive enhancements of both ignition-related properties and lubricity were achieved in a single product [58].

3.5 DIESEL -VEGETABLE OIL BLENDS

The heating value of vegetable oils is similar to that of diesel fuel. However, their use in direct injection diesel engines is restricted by some unfavorable physical properties, particularly their viscosity. The viscosity of vegetable oil is approximately 10 times higher than that of diesel fuel. Therefore, the use of vegetable oil in direct injection diesel engines creates poor fuel atomization, incomplete combustion, carbon deposition on the injector, and fuel buildup in the lubricant oils, resulting in serious engine fouling. The possible treatments employed to improve the oil viscosity include dilution with a suitable solvent, emulsification, pyrolysis, and transesterification to obtain biodiesel [62]. Several studies have been conducted using biomass and vegetable oils as alternative fuels or blended with diesel fuel. A study in Indonesia is an example, where palm oil was used as an additive to fuels. A study in which oil was extracted from Pistachia Palestine (PP) fruits is another example. Mixtures of such oil with diesel fuel were tested to determine the potential of the oil as a diesel additive, and successful results were obtained without any engine modifications. It was shown that the addition of PP oil to diesel fuel decreases both the brake power and thermal efficiency of the test engine and increases the brake-specific fuel consumption. This is due to the lower heating value of the PP oil compared to diesel fuel [63]. Jatropha oil was blended with diesel in a proportion of 2.6% by volume, and it was found that the oil can be used as an ignition-accelerator additive for poor diesel fuels [10]. Hydro processed vegetable oils can be used for diesel fuel improvement as well. In 1996, Canadian researchers investigated the use of conventional refinery technology to convert vegetable oils into a product resembling diesel fuel. It was found that the use of a medium severity refinery hydro process yielded a product (“super cetane”) in the diesel boiling range with a high cetane value (55-90) and the impact of the “super cetane”/ diesel mixture on engine emissions is similar to the impact cetane enhancement via a nitrate additive when added to conventional diesel fuel. An attractive advantage of hydro processing over esterification includes lower processing cost [64].

4. EXPERIMENTAL SETUP

The experimental system is shown in Fig. 1. The test engine is a naturally aspirated, water-cooled, 4-cylinder direct-injection ISUZU diesel engine. The engine was coupled with an eddy-current dynamometer and engine operation was controlled by the Ono Sokki diesel engine test system. An Engelhard CCX8772A diesel oxidation catalyst (DOC) was used for after-treatment of the exhaust gas. Diesel fuel was used as a baseline fuel in this study. The properties of diesel fuel, DEA and the blended fuels are compared to the diesel fuel the blended fuels have lower cetane number and lower calorific value. The gaseous species in the engine exhaust were measured using online exhaust gas analyzers. A heated flame ionization detector (HFID) was used for HC; a heated chemiluminescent analyzer (HCLA) for NOx/NO; and non-dispersive infra-red analyzers (NDIR) for CO and CO2; exhaust gas temperature was measured with K-type thermocouple. The gas analyzers were calibrated with standard gases and zero gas before each test. Unregulated emissions including formaldehyde, acetaldehyde, 3-butadiene, ethene, ethyne, propylene and BTX (benzene, toluene and xylene) were measured with an Airsense multi-component gas analyzer. The Airsense gas analyzer is an Ion Molecule Reaction mass spectrometer, which allows dynamic studies of gaseous emission in low concentration (Dearth, 1999; Villinger et al., 1993, 1996). Standard benzene, toluene, methanol and formaldehyde gases were used to calibrate the Airsense multi-component gas analyzer while the other unregulated gases were calibrated indirectly with information provided by the equipment supplier. Particulate mass concentration was measured with a tapered element oscillating microbalance (R&P TEOM 1105), in which the main sample flow rate was 1.5 l/min and the inlet temperature was held at 47 ^{o}C. The exhaust gas from the engine was diluted with a Dekati mini-diluter before passing through the TEOM. The application of the Dekati mini-dilutor and the TEOM for particle measurement has been covered in the literature (Patashnick and Rupprecht, 1991; Wong et al., 2003). The dilution ratio was determined from the measured CO2 concentrations of background air, undiluted exhaust gas and diluted exhaust gas. The measured dilution ratio varied from 6.15 to 6.5 in this study [4].

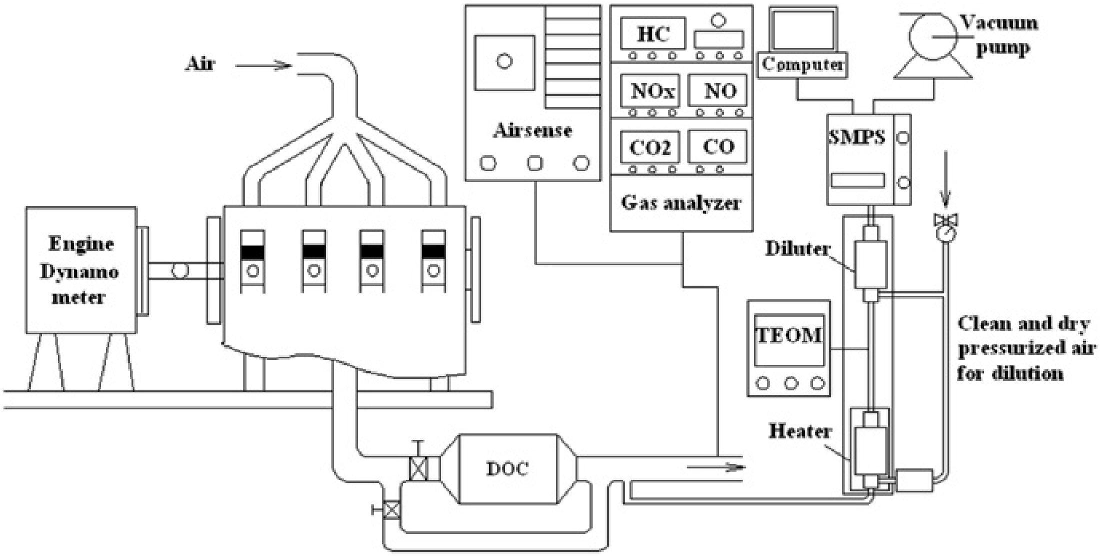

Fig.1 Schematic diagram of experimental setup [4].

5. EXPERIMENTAL PROCEDURE

In most of paper, the engine tests were conducted at a constant engine speed and full load condition. After stable operating conditions were experimentally achieved, the engines were subjected to similar loading conditions. Starting from no load the observations were recorded at 20%, 40%, 60% and 80%, all as percentages of the rated load. The engine was stabilized before taking all measurements. All measurements were taken at constant static injection timing. An attempt was made to conduct all experiments without significant fluctuations in inlet air temperature and lubricating oil temperature as a method to prevent possible discrepancies in engine operation during the tests and mainly, to avoid variations in engine loading. The experimental procedure consisted of the following three steps:

1. Initially, engine tests using the base reference diesel fuel were conducted covering all engine loads examined to determine the engine operating characteristics and pollutant emissions constituting the engine base line operations.

2. The previous procedure was repeated at the same operating conditions with the engine fueled consecutively with fuels of different additives.

3. Taking the mean value by repeating the measurements at each operating conditions.

6. OBSERVATIONS

After literature survey, it is found that different additive has different effect on engine performance which has compare in table as following below:

Table 6.1 Effect of Additives on performance of diesel Engine

Additives	Smoke Density	HC	CO	NO_X	PM	CO_2	SO_2
Dimethoxymethane (DMM)	▲		▲	🔺	▲		
Diethylene glycol Dimethyl ether (DGM)	▲			▲	▲		
Diethyl adipate			🔺		▲		
Cerium					▲		
Methyl Soyate- ethanol		🔺	▲	🔺	▲		
Dimethyl ether	▲						
Aniline Nitrate	▲			▲			▲
Ethylene glycol monoacetate	▲		▲	▲		▲	
Ethanol fumigation	▲	🔺	🔺				
Soot Particulate Mitigation	▲				▲		

▲ -Decreases 🔺 - Increases

7. CONCLUSION

From the literature review, it is understood that the diesel additives will play extremely important role slightly to increase engine performance and emission reduction in diesel engine. The characteristics of performance and emission of a compression ignition engine fuelled with different oxygenated fuel diesel blends were investigated and compared with those fuelled with diesel fuel as shown in table in 6.1. It is observed that Brake thermal efficiency increases, the oxygen enrichment provided by the additive leads to smoke reduction. The smoke reduction rate and smoke emission show linear relationship with additive percentages. The additives offer several significant benefits including:-

1. It atomize the fuel hence improve spray quality by injector in combustion chambers thereby improving power generated by same quality of fuels.
2. Due to atomization by additives the load on piston decreases.
3. Improves viscosity index helps in smooth flow of fuel.
4. Considerable reduction in engine emissions and increasing engine performance.

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REFERENCES

1. Ruijun Zhu, Haiyan Miao, Xibin Wang, Zuohua Huang. Effects of fuel Constitutes and injection timing on combustion and emission characteristics of a compression-ignition engine fueled with diesel-DMM blends. Proceedings of the combustion institute 34(2013)3013-3020.

2. Xiangang Wang, C.S. Cheung, Yage Di, Zuohua Huang. Diesel engine gaseous and particle emissions fueled with diesel-oxygenate blends fuel 94(2012) 317-323.

3. W.M. Yang, H.An, S.K. Chau, S. Vedharaji, R.Vallinagam, M. Balaji, F.E.A. Mohammad, K.J.E. Chua. Emulsion fuel with nano-organic additives for diesel engine application. Fuel xxx(2012)xxx-xxx.

4. Ruijun Zhu, C.S. Cheung, Zuohua Huang, Xibin Wang. Regulated and unregulated emissions from a diesel engine fueled with diesel fuel blended with diethyl adipate. Atmospheric Environment 45(2011)2174-2181.

5. Yi Ren, Zuohua Huang, Haiyan Miao, Yage Di, Deming Jiang, Ke Zeng, Bing Liu, Xibin Wang. Combustion and emissions of a DI diesel engine fuelled with diesel-oxygenate blends. Fuel 87(2008)2691-2697.

6. Z.H. Huang, Y. Ren, D.M. Jiang, L.X. Liu, K. Zeng, B. Liu, X.B. Wang. Combustion and emission characteristics of a compression ignition engine fuelled with diesel-dimethoxy methane blends. Energy Conversion and Management 47(2006)1402-1415.

7. Heejung Jung, David B. Kittelson, Michael R. Zachariah. The Influence of a cerium additive on ultrafine diesel particle emissions and kinetics of oxidation. Combustion and Flame 142(2005)276-288.

8. X.Shi, Y.Yu, H. He, S. Shuai, J. Wang, R. Li. Emission characteristics using methyl soyate-ethanol-diesel fuel blends on a diesel engine. Fuel 84(2005)1543-1549.

9. Wang Ying, Zhou Longbao, Wang Hewu. Diesel emission improvement by the use of oxygenated DME/diesel blends.School of energy and power engineering, Xian Jiaoteng University710049 P.R. China.

10. F.K. Forson, E.K. Oduro, E.Hammond-Donkoh. Performance of jatropha oil blends in a diesel engine. Renewable Energy 29(2004)1135-1145.

11. Edwin Corporan, Matthew Dewitt, Matthew Wanger. Evaluation of soot Particulate mitigation additives in a T63 engine. Fuel Processing Technology 85(2004)727-742.

12. Ykup Incingur, Duran Altiparmak. Effect of fuel Cetane number and injection pressure on a DI Diesel engine performance and emission. Energy Conversion and management 44(2003)389-397.

13. Bang-Quan He, Shi- Jin Shuai, Iian-Xin Wang Hong He. The effect of ethanol blended diesel fuels on emissions from a diesel engine. Atmospheric Environment 37(2003)4965-4971.

14. C. – Y. Lin, J.-C. Huang. An oxygenating additive for improving the Performance and Emission Characteristics of marine diesel engines. Ocean Engineering 30(2003) 1699-1715.

15. Lapuerta M, Armas O, Jose RF. Effect of biodiesel fuels on diesel engine emissions. Prog Energy Combustion Sci 2008: 34:198-223.

16. Fung F., He, H., Sharpe, B., Kaamakate, F., Blumberg, K., 2010. Overview of China's Vehicle Emission Control Program-past Successes and Future Prospects. International Council on Clean Transportation.

17. Lange WW. The effects of fuel properties on particulate emission in heavy duty truck engines under transient operating conditions. SAE Paper No. 912425, 1991.

18. Nu´bia M. Ribeiro, et al. The Role of Additives for Diesel and Diesel Blended (Ethanol or Biodiesel) Fuels: A Review Energy & Fuels 2007**,** 21, 2433-2445.

19. G.R. Kannan et al. Experimental investigation on diesel engine with diestrol-water micro emulsions Energy 36 (2011) 1680-1687.

20. S. Kalligeros et al. An investigation of using biodiesel/marine diesel blends on the performance of a stationary diesel engine Biomass and Bioenergy 24 (2003) 141 – 149.

21. Avinash Kumar Agarwala et al. Particulate emissions from biodiesel vs diesel fuelled compression ignition engine Renewable and Sustainable Energy Reviews 15 (2011) 3278– 3300.

22. HulyaErdener et al. future fossil fuel alternative, Di-methyl Ether (DME) A Review International Journal Of Renewable Energy Research, IJRER.

23. Alex M.K.P. Taylor Science review of internal combustion engines Energy Policy 36 (2008) 4657–4667.
24. M. Al-Hasan Effect of ethanol–unleaded gasoline blends on engine performance and exhaust emission Energy Conversion and Management 44 (2003) 1547–1561.

25. Shyam Pandey experimental investigation on the performance and emission characteristic of a diesel engine fulled with ethanol, diesel and jatropha based biodiesel blends International Journal of Advances in Engineering & Technology, Sept 2012.

26. Heywood JB. Internal combustion engine fundamentals. USA McGraw Hill Co. 1998.
27. Gu¨ru, M., Karakaya, U., Altiparmak, D., Alicilar, A. Energy ConVers. Manage. 2002, 43,1021-1025.
28. Yang, H. H., Lee, W. J., Mi, H. H., Wong, C. H., Chen, C. B. EnViron. Int. 1998, *24*, 389-403.
29. De Menezes, E. W., Da Silva, R., Cataluna, R., Ortega, R. J. C. Fuel 2006, *85*, 815-822.
30. Zabetta, E. C., Hupa, M., Niemi. S. Fuel 2006, *85*, 2666-2670.
31. Wu, C., Zhang, J-L. Li, W., Wu, N. Fuel 2005, *84*, 2039-2047.
32. Kasper, M. Sattler, K. Siegmann, K., Matter, U. Siegmann, H. C. J. Aerosol Sci. 1999, 30, 217-225.
33. Myamoto, N., Hou, Z., Ogawa, H. H., Murayama, T. SAE Tech. Pap. Ser. 1987, 871612.
34. Burtscher, H., Matter, U., Skillas, G. J. Aerosol Sci. 1999, 30, S851- S852.
35. Jelles, S. J., Krul, R. R., Makkee, M., Moulijn, J. A. Catal. Today 1999, 53, 623-630.
36. Labeckas, G.; Slavinskas, S. Energy ConVers. Manage. 2006, 47, 1954-1967.
37. Van Setten, B. A. A. L.,Van Dijk, R., Jelles, S. J. Makkee,M., Moulijn, J. A. Appl. Catal. B 1999, 21,51-61.
38. Gautam, M., Chitoor, K., Durbha, M.; Summers, J. C. Tribol. Int. 1999, 32, 687-699.
39. Lyyra¨nen, J., Jokiniemi, J., Kauppinen, E. J. Aerosol Sci. 2002, 33, 967-981.
40. Matter, U., Siegmann, K. J. Aerosol Sci. 1997, 28, S51-S52.
41. Ulrich, A., Wichser, A. Anal. Bioanal. Chem. 2003, 377, 71-81.
42. Pereira, P. A. P., De Andrade, J. B., Miguel, A. H. J. EnViron. Monit. 2002, 4, 558-561.
43. McCormick, R. L.; Graboski, M. S.; Alleman, T. L.; Herring, A. M.; Tyson, K. S. EnViron. Sci. Technol. 2001, 35, 1742-1747.
44. Song, K. H., Nag, P., Litzinger, T. A., Haworth, D. C. Combust. Flame 2003, 135, 341-349.
45. Satge de Caro, P., Mouloungui, Z., Vaitilingom, G., Berge, J. C. Fuel 2001, 80, 565-574.
46. Xing-Cai, L., Jian-Guang, Y., Wu-Gao, Z., Zhen, H. Fuel 2004, 83, 2013-2020.
47. Anastopoulos, G., Lois, E., Zannikos, F., Teas, C. Tribol. Int. 2001, 34, 749-755.
48. Rezende, M. J. C., Perruso, C. R., Azevedo, D. A., Pinto, A. C. J. Chromatogr., A 2005,1063,211-215.
49. Lin, C. Y., Wang, K. H. Fuel 2004, 83, 507-515.
50. Marchetti, A. A., Knize, M. G., Chiarappa-Zucca, M. L., Pletcher, R. J., Layton, D. W. Chemosphere 2003, 52, 861-868.
51. Kitamura, T., Ito, T., Senda, J., Fujimoto, H. JSAE ReV. 2001, 22, 139-145.
52. Bhatnagar, A. K.; Kaul, S.; Chhibber, V. K.; Gupta, A. K. Energy Fuels 2006, 20, 1341-1344.
53. Ladommatos, N., Parsi, M., Knowles, A. Fuel 1996, 75, 8-14.
54. Karonis, D.; Anastopoulos, G.; Lois, E.; Stournas, S.; Zannikos, F.; Serdari, A. SAE Tech. Paper Ser. 1999,SP-1461 (Fuel and Additiv Performance in SI and CI Engines), 1-6.
55. Hansen, A. C., Zhang, Q., Lyne, P. W. L. Biores. Technol. 2005, 96, 277-285.
56. Yu-Hui, G., Ben-Xian, S. Energy Fuels 2006, 20, 1579-1583.
57. Marie, E., Chevalier, Y., Brunel, S., Eydoux, F., Germanaud, L., Flores, P. J. Colloid Interface Sci. 2004, 269, 117-125.
58. Suppes, G. J., Goff, M., Burkhart, M. L., Bockwinkel, K. Energy Fuels 2001, 15, 151-157.
59. Zinenko, S. A., Egorov, S. A., Makarov, A. A., Sharin, E. A., Manaenkov, V. M., Bakaleinik, A. M. Chem. Technol. Fuels Oils 2002,38,303-308.

60. Schabron, J. F., Fuller, M. P. Anal. Chem. 1982, 54, 2599-2801.
61. Danilov, A. M., Mitusova, T. N., Kovalev, V. A., Churzin, A. N. Chem. Technol. Fuels Oils 2003, 39, 330-333.
62. Dmytryshyn, S. L., Dalai, A. K., Chaudhari, S. T., Mishra, H. K., Reaney, M. J. Biores. Technol. 2004, 92, 55-64.
63. Al-Hasan, M. Biomass Bioenergy 2002, 23, 381-386.
64. Stumborg, M., Wong, A., Hogan, E. Biores. Technol. 1996, 56, 13-18.
65. Yanfeng, G., Shenghua, L., Hejun, G., Tiegang, H., Longbao, Z. Appl. Therm. Eng. 2007, 27, 202-207.
66. Jiang, T. Liu, C. J., Rao, M. F., Yao, C. D., Fan, G. L. Fuel Process. Technol. 2001, 73, 143-152.
67. Geller, D. P., Goodrum, J. W. Fuel 2004, 83, 2351-2356.
68. Knothe, G., Matheaus, A. C., Ryan, T. W., III. Fuel 2003, 82, 971-975.
69. Chao, H. R., Lin, T. C., Chao, M. R., Chang, F. H., Huang, C. I., Chen, C. B. J. Hazard. Mater. 2000, B73, 39-54.