International Journal of Recent Engineering Research and Development (IJRERD)
Volume No. 02 – Issue No. 04, ISSN: 2455-8761
www.ijrerd.com, PP. 121-126

IMPROVEMENT OF FUEL PROPERTIES AND EMISSION REDUCTION BY USE OF OXYGENATED FUEL WITH DIESEL ON A HEAVY DUTY DIESEL ENGINE

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Abstract: In this project, it is aimed to investigate the study of improvement of fuel properties and emission characteristics by use of oxygenated fuels with diesel blend. This project is intended to emphasis on performance and emission characteristic for standard diesel and oxygenated blended fuels. Research is carried out at different engine load conditions. Three different oxygenated fuels such as Dimethyl carbonate, ethyl acetate, isopropyl acetate are blended with diesel fuel. In first & second phases, Tests were performed on a single cylinder, four stroke, direct injection, diesel engine with blend ratios such as 15%, 30% and 45% oxygenated diesel fuel blends. The results showed was increasing on specific fuel consumption (SFC) and increasing brake thermal efficiency (BTE). There was a increasing NOx emission and decreasing the CO and HC emission on exhaust gas, when compared to standard diesel fuel at different engine load conditions.
Keywords: properties, oxygenated fuels, Emissions.

1. Introduction

One of the most important research topics on diesel engines is the reduction of emissions. But the suppression of emission formation in-cylinder is normally hindered by the seemingly inherent trade-off between NOx and other emissions. Without fundamental changes in combustion systems. One method alone has difficulty to significantly reduce NOx and other emissions simultaneously. The strategy of present research aims at reducing emissions and succeeds by gaining a better trade-off between NOx and particulate reductions. In order to suppress emissions, it is most important to use oxygen efficiently. One effective way is to contain some oxygen in the fuel. Which reduces the tendency to generate the higher emissions from the fuel. Either vapour or liquid. This method is the subject of the present research – the use of oxygenated fuel to reduce smoke formation.

The development of new alternative fuels such as dimethyl ether based fuels provides diesel engines with ultralow emissions prospects. Specifically, the proper use of oxygenated fuel provides a practical method toward running a very low emission diesel engine. In this study, extensive experiments were conducted on a DI diesel engine by using diesel fuel blend with Dimethyl carbonate, Ethyl Acetate, isopropyl acetate. This oxygenated fuels are blend in diesel by various proportion like 15%, 30% & 45%. The readings are taken by various load too.

2. Oxygenates

The oxygenate included ethers, acetates. Ether have an oxygen atom connecting two hydrocarbon groups, where O is an oxygen atom and R is a hydrocarbon group:

R – O – R

Acetate have two (or more) oxygen atom linkages attached to a single carbon atom, as in:

R – O – C – O – R

More complex ether has a multiple carbon atoms with oxygen – atom linkages, as in:

R – O – R – O – R

The selection of oxygenates were guided by several considerations:

- **Boiling point and flash point in Diesel fuel range:**

Because this was study of diesel fuel oxygenates. The oxygenate boiling point was required to be in the range of temperature commonly observed for diesel fuel components and the flash point of the oxygenate was required to be greater than 52°c, to meet commonly adopted diesel fuel fire safety requirements.

- **Variety of Chemical Structures.**

Oxygenates were selected to represent a variety of chemical structures, including both ethers and esters. Different number of carbon atoms in the – O – R – O – linkage are represented.

- **Existing Reviews and Experimental Data.**

Some oxygenates have been the subject of previous investigations, including the generation of engine emission data. For example Bertola et al, recently considered 27 oxygenates as diesel fuel additives.

3. Oxygenate – Diesel Fuel Blends

Oxygenate diesel fuel blends were prepared gravimetrically; the required masses were calculated from the density values of the different components. Each blend was shaken well to promote mixing. There were a total of 3 samples included in this study 15%, 30% & 45% diesel fuel blends.

4. Oxygenated Fuel Additive:

Oxygenated fuel is nothing more than fuel that has a chemical compound containing oxygen. It is used to help fuel burn more efficiently and cut down on some types of atmospheric pollution. In many cases, it is credited with reducing the smog problem in major urban centers. It can also reduce deadly carbon monoxide emissions. Oxygenated fuel works by allowing the diesel in vehicles to burn more completely. Because more of the fuel is burning, there are fewer harmful chemicals released into the atmosphere. In addition to being cleaner burning, oxygenated fuel also helps cut down on the amount of non-renewable fossil fuels consumed. Various additives used for oxygen enrichment of fuel are as below.

Dimethyl carbonate, often abbreviated DMC, is a flammable clear liquid boiling at 90 °C. It is a carbonate ester which has recently found use as a methylating reagent. It was also classified as an exempt compound under the definition of volatile organic compounds by the U.S. EPA in 2009. Its main benefit over other methylating reagents such as iodomethane and dimethyl sulfate is its much lower toxicity and its biodegradability. Also, it is now prepared from catalytic oxidative carbonylation of methanol with carbon monoxide and oxygen, instead of from phosgene. This allows dimethyl carbonate to be considered a green reagent.

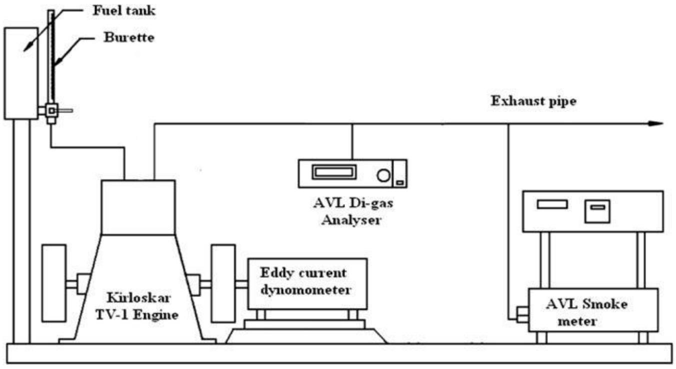
Ethyl acetate, is a clear, colourless, aprotic, and liquid ether that is used as a solvent. Ethyl acetate is miscible with water. Ethyl acetate is often used as a higher boiling alternative to diethyl ether and THF. Ethyl acetate forms chelate complexes with cations and acts as a bidentate ligand. It is therefore often used in organometallic chemistry like Grignard reactions, hydride reductions, and palladium-catalyzed reactions like Suzuki reactions and Stille coupling. Ethyl acetate is also a good solvent for oligo- and polysaccharides.

Isopropyl acetate is a colourless liquid with an aromatic fruity odor with moderate solubility in water and a low flash point. It is readily polymerized and displays a range of properties dependent upon the selection of the monomer and reaction conditions. Isopropyl acetate is used in the production of homopolymers. It is also used in the production of co-polymers, for example acrylic acid and its salts, esters, amides, methacrylates, acrylonitrile, maleates, vinyl acetate, vinyl chloride, vinylidene chloride, styrene, butadiene and unsaturated polyesters. Isopropyl acetate is also used in pressure sensitive adhesives.

Among alcohol fuels, ethanol has good solubility, biodegradability, causticity and emissions performance, and is therefore more appropriate than methanol for a diesel engine. A merit of ethanol is that the oxygen content is as high as 34.8%, but it's disadvantageous cetane number is as low as merely eight and its viscosity as low as less than 1/3 of a diesel fuel. Additionally, the boiling point of ethanol is relatively low, and therefore its transportation and storage safety control should be treated the same as diesel.

Dimethyl carbonates, Ethyl acetate and Isopropyl acetate also have high oxygen content and have been considered as diesel fuels. Dimethyl carbonates, Ethyl acetate and Isopropyl acetate contain 53.3%, 42.1% & 35.8% of oxygen by mass respectively; and both of which are higher than the ethanol oxygen content. Their cetane numbers are 36, 38 & 30, respectively, higher than ethanol's cetane number too. Therefore, according to the above basic principles – a high oxygen content and a high cetane number – these three oxygenates are both better than ethanol especially ideal for DMC. The boiling point of Dimethyl carbonates and Isopropyl acetate is 91° C & 88.1°C which is higher than ethanol's 78 C and, Ethyl acetate is 77.5°C.

5. Experimental Setup

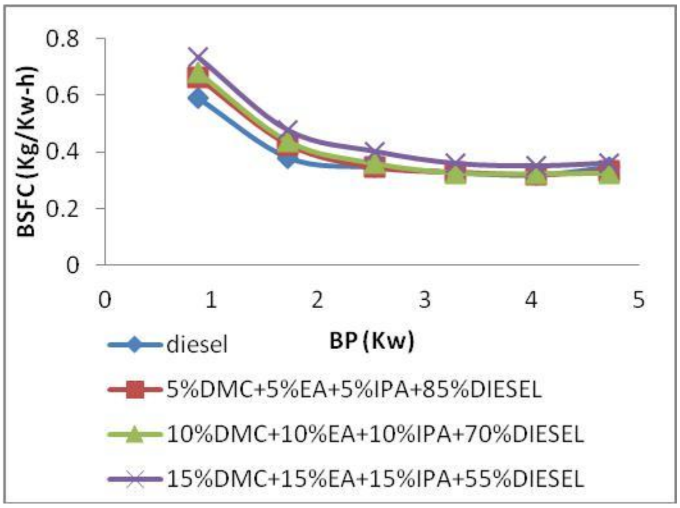


The setup consists of single cylinder, four stroke, Diesel engine connected to eddy current type dynamometer for loading. It is provided with necessary instruments for combustion pressure and crank-angle measurements. These signals are interfaced to computer through engine indicator for Pθ−PV diagrams. Provision is also made for interfacing airflow, fuel flow, temperatures and load measurement. The set up has stand-alone panel box consisting of air box, fuel tank, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and engine indicator.

Rotameters are provided for cooling water and calorimeter water flow measurement. The setup enables study of engine performance for brake power, indicated power, frictional power, BMEP, IMEP, brake thermal efficiency, indicated thermal efficiency, Mechanical efficiency, volumetric efficiency, specific fuel consumption, A/F ratio and heat balance. Labview based Engine Performance Analysis software package “EnginesoftLV” is provided for on line performance evaluation. A computerized Diesel injection pressure measurement is optionally provided.

6. Results and Discussion

6.1 BRAKE POWER VS BSFC

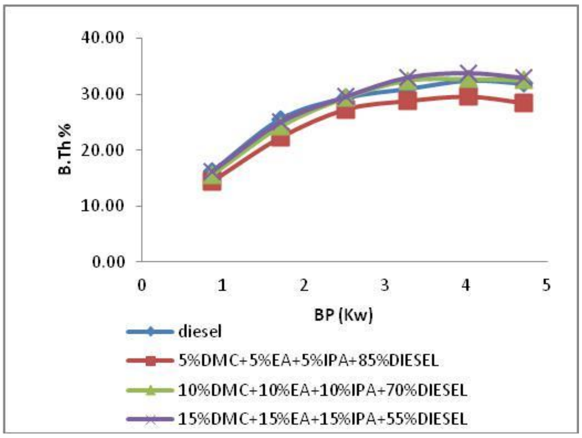


The study found that increase of brake specific fuel consumption with the addition of oxygenated blend with the diesel as compared to neat diesel without any additive. The primary reason for the increase of oxygen content in the blended diesel and also calorific value of the oxygenated fuel is decreased. Also other supplementary factors like low volatility, slightly higher viscosity and high density which affect mixture formation and thus lead to slow combustion play in increasing the brake specific fuel consumption.

6.2 BRAKE POWER VS BRAKE THERMAL EFFICIENCY

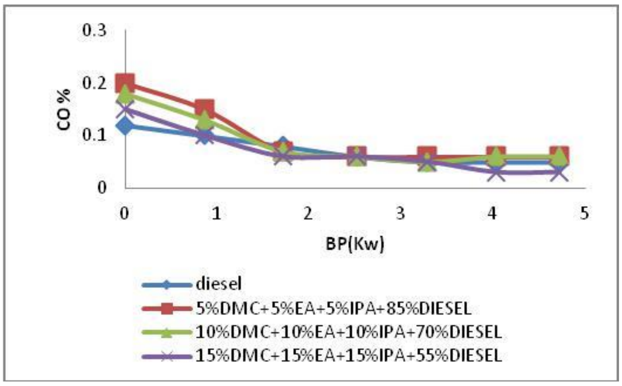
The figure shows that the plot of brake thermal efficiency against brake power for the oxygenated fuels. Brake thermal efficiency is based on the calorific value of the fuel. There are three different oxygenated fuels used to carried out the performance and emissions. Hence, the calorific values of the 15%, 30% and 45%

oxygenated fuels are reduced such as 38067, 34134 and 30267 kJ/kg respectively. In these three fuels, 45% oxygenated blended diesel have higher brake thermal efficiency compared to others. The reason could may be due to increase of oxygen level and cetane number of the fuels. The density of the oxy fuels are higher than the standard diesel which may be increase the ignition delay period than the efficiency also decreased.

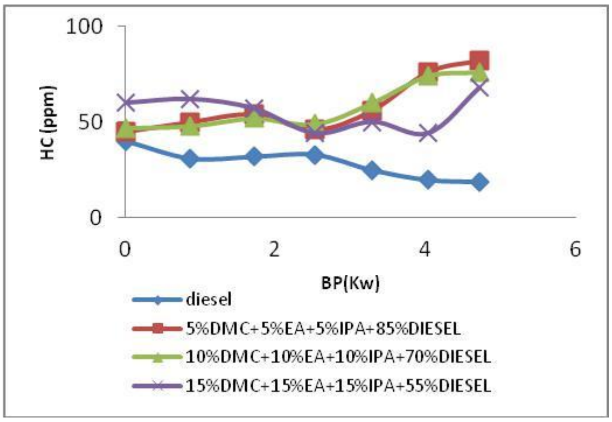


6.3 BRAKE POWER VS CO

The CO emission indicates the shortage of oxygen in the combustion process. When there is a shortage in the oxygen the combustion will not take place properly and leads to the more CO formation. This could reduce the overall performance of the system. On the other hand, there is a decrease of CO emission with the increase of oxygenated fuel blend ratio is observed in this study. The CO emission for 45% oxy fuels is lower than the diesel alone as a fuel at full load. This could be due to extra oxygen supplied by the oxygenated fuel during the combustion process of diesel with oxy fuel blend as compared to diesel itself as a fuel.

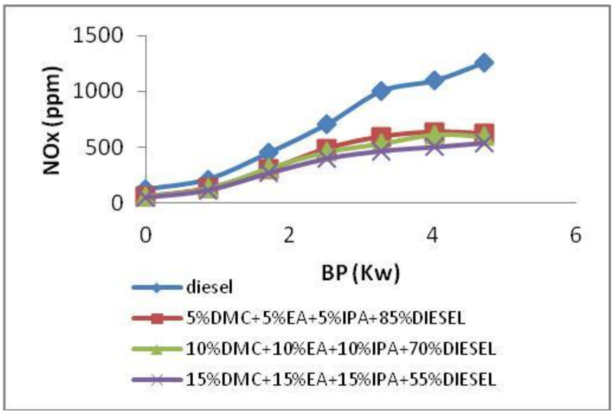


6.4 BRAKE POWER Vs HC



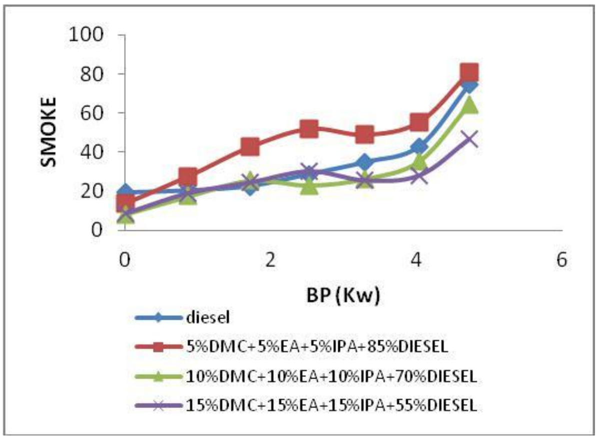
Hydrocarbon emission in diesel engine indicates that the quality of the fuel-air mixture and incomplete combustion during the combustion process. Fig.10.5 shows that the HC emissions at different load conditions for blending with different ratios and without blending. The study explored that the increase in HC emissions with the blending as compared to the diesel alone as a fuel. There is a notable variation of HC emission within the oxy fuel blend 45% blend is quite lesser than other two ratio blended fuel. Due to higher density and increase the ignition delay of oxygenated fuel the incomplete combustion are happen. So it leads to increase the HC emissions. The HC emission for full load with the diesel and diesel –oxy fuel blends with 45% is increased in 30% of HC emission than the diesel.

6.5 BRAKE POWER Vs OXIDES OF NITROGEN



From the graph, we can see that the NOx emission for Oxy fuels is lower than the diesel. All we know increase the oxygen content in fuel leads to complete combustion and increase the heat release rate cause increase in NOx emission. But in this calorific value of oxy fuels are lower than the diesel so heat of combustion is low. The density of the oxy fuels is higher than the diesel so it is increase the ignition delay period cause incomplete combustion. These are the reason cause reduce NOx emission.

6.6 BRAKE POWER Vs SMOKE



Smoke formation occurs at the extreme air deficiency. Air or oxygen deficiency is locally present inside the diesel engines. It increases as the air to fuel ratio decreases. Fig shows variation of smoke emissions for 15%, 30% & 45% oxy diesel blend. Since at high load, oxygen present in fuels leads to better combustion may take place inside the engine cylinder trying to reduce the smoke emissions. That 30 & 45% of oxy fuels smokes are lesser than the diesel

7. Conclusion

On an energy basis, oxygenated fuels have lower calorific value than diesel hence it will consume more amount of fuel. It also has lower cetane number so the blends of oxygenated fuel & diesel require cetane improver. The density of the oxygenated fuels is higher than compared to diesel which increase the time of atomization which cause increase in ignition delay period. The main result of this experimental investigation leads to following conclusions:

- The total fuel consumption and break specific fuel consumption of oxygenated fuel diesel blended fuel increased for the reason that low heating value of oxygenated fuel is about half of that of diesel, and it is increasing with increase in blend ratio.

- The break thermal efficiency of oxygenated fuel blend is lower than the diesel cause of lower calorific value, lower cetane number. As the load is increased the 45% oxygenated fuel blend gives increase the efficiency.
- In the emission characteristics, the significant improvement of CO with increase in blend ratio. Whether increase in oxygen level leads the increase wall quenching effect. So incomplete combustion takes place. The HC emissions were increased due to may be incomplete combustion. increase in HC emission compared with diesel which dramatically decrease in Nox emission. Due to low calorific value heat release rate are also lower. So the NOx emission are not increase drastically its slightly vary the value of diesel NOx.

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