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PERFORMANCE CURVE AND EMISSION CHARACTERISTICS USING–ETHANOL–BIODIESEL FUEL BLENDS ON A TURBOCHARGING DIESEL ENGINE

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ABSTRACT

We take Opportunity to present this paper of „Performance curve and Emission Characteristics using alternative fuels Ethanol and Biodiesel in turbocharging Diesel engine' and put before readers some useful information regarding our project. We have made since attempts and taken every engineer to present this matter in precise and compact form ,the language being as simple as possible. We are sure that the information contained in this volume would certainly prove useful for better insight in the scope and dimension of this project in its true perspective. The task of completion of project through being difficult was made quit simple, interesting and successful. Drawan by a list of priorities like fast decreasing oil resourses.We are going to use alternative fuels Ethanol and Biodiesel in turbocharging Diesel engine It will increase overall system efficiency and save considerable amount of money by decreasing of fuel consumption accordingly.

Keywords: Turbocharging diesel engine, Ethanol and Biodiesel, Brake power (B.P), ethanol-diesel blend (DE), ethanol-biodiesel-diesel blends (DBE).

INTRODUCTION

The importance of the world's environmental pollution and the strict governmental regulations on exhaust emissions has led us to seek alternative fuels to automotive manufacturers. Ethanol is an important alcohol-based alternative fuel used to reduce air pollution level and consuming petroleum fuels. Moreover, ethanol is recognized as an environmentally friendly alternative fuel because previous studies have shown that there is a substantial reduction of CO, unburned hydrocarbons and particulate matter emission in ethanol compared to conventional diesel engines.

Heating value of blend fuel

The heating value influences the power output of the engine. The energy content of ethanol-diesel blends decreases approximately 2% for each 5% addition of ethanol by volume, assuming that any additive included in the blend has same energy content as diesel fuel [1]. Heat of combustion of a fuel blend is another very important property to determine its suitability as an alternative to diesel fuel. Lower heating value influences the power output of an engine directly. The calorific value of both the biodiesel and bio-ethanol is lower than diesel fuel. Thus their addition to diesel fuel lowers the calorific value of final blend. However , the blends containing ethanol, lower than 10 % are seemed to have a heating value nearer to fossil diesel fuel [2].

Cetane Number of Blend Fuel

Cetane number of a CI engine fuel can be defined as the measurement of a combustion quality of a fuel during compression ignition. Ignition delay of a 30% diesel-ethanol blends as same as diesel fuel by adding 4.5 % octyl nitrate ignition improver. Due to very low cetane number of ethanol, the cetane number of the diesel-biodiesel-ethanol blend decreases. However, due to the high cetane number, biodiesel can recuperate this property, thus the fuel blend can achieve the cetane number requirement for diesel which is 51 CN. The cetane number of bioethanol was extremely low(5-8) compared to diesel fuel cetane number(47). Using 12% bio-ethanol to the diesel fuel reduces fuel blend cetane number to 40. But adding sunflower methyl ester to the blend the cetane number improves due to the higher cetane number of sunflower methyl ester (54) in the present case. This cetane number could be regarded as suitable one to be used in diesel engine [2]. With the inverse relationship of octane number and cetane number, ethanol exhibit the lower cetane rating. Hence increasing concentrations of ethanol in diesel lower the cetane number proportionately. Lower cetane number means longer ignition delays, allowing more time for fuel to vaporize before combustion starts. It is preferable to add an ignition improver to raise the cetane number of ethanol-diesel blends so that they fall within the acceptable range [1].

Solubility of Blend Fuel

Ethanol solubility in diesel is affected mainly by two factors, temperature and water content of the blend. At warm ambient temperatures, dry ethanol blends readily with diesel fuel. However, below about 10°C the two fuels separate, a lower limit that is easily exceeded in most parts of the USA for a large portion of the year. 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 that acts as a bridging agent through molecular compatibility and bonding to produce a homogenous blend. 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 [1]. One major drawback with ethanol in diesel blends is that ethanol is immiscible in a diesel fuel over a wide range of temperatures. A vegetable oil mythyl ester has been added on purpose to the blend, to prevent phase separation. Indeed, Fatty Acid Mythyl Ester stabilizes ethanol and diesel blends by acting as an amphiphile (a surface active agent) [3]. One of the main targets of using fuel blends in the diesel engines is to keep the engine modification minimal. A solution is single-phase liquid system, homogenous at the molecular level. Some diesohol formulations may be a solution of ethanol/bio-ethanol plus additives with diesel fuel. It was seen that such blends are technically suitable to run existing diesel engines without modifications. At normal ambient temperature anhydrous/dry ethanol readily mixes with fossil diesel fuel. But below 10ºC the two fuel become separate. To prevent parting of two fuels three possible ways can be considered. They are
(i) Adding an emulsifier which performs to suspend small droplets of ethanol within the diesel fuel.

(ii) Adding a co-solvent that performs as a linking agent through molecular compatibility and bonding to yield a homogenous blend or

(iii) Adding iso-propanol

To stabilize the ethanol and fossil fuel blend, surface active agent, i.e. an amphiphile, like fatty acid methyl ester can also be used. To generate blend through the emulsification process usually heating and blending steps are required where on the other hand using co-solvents simplifies the blending method as it permits to be splash blended [2]. M. Al-Hassan et.al were performed experiments on two stages: Firstly, ethanol-diesel blends with (%v/v) 5,10,15 and 20 of ethanol with 95, 90, 85, and 80 of diesel respectively, which were named as DE05, DE10, DE15 and DE20. Secondly, ethanol-biodiesel-diesel blends with (%v/v) 5, 10, 15 and 20 of ethanol, 85, 80, 75 and 70 of diesel respectively, and with a fixed 10 % volume of biodiesel as a co-solvent, which were named as DBE5, DBE10, DBE15% and DBE20. The fuels with a predetermined volume were mixed into a homogenous mixture by a magnetic stirrer for five minutes. Then the final blend was kept in a gradual glass vial for observing the solubility and the physical stability and it is observed that DE05, DE10, DE15 and DE20 blends stable up to 80, 24, 5 and 2 hours respectively and DBE10, DBE15 and DBE20 blends stable up to 9, 3 and 1 days respectively.

EFFECTS OF DIFFERENT BLENDS ON ENGINE PERFORMANCE PARAMETERS

Brake Power (BP)

According to M. Al. Hassan et.al the variation of the engine brake power obtained with different fuel blends at various engine speeds is shown in Fig. 1. As the figure shows the engine power increases with the increasing of the engine speed for all fuels. Comparing with diesel fuel, the blend including 5% ethanol (DBE5) gives the same engine power. However, as the ethanol concentration increases above 5%, the engine power decreases. This can be explained as follows: for a small amount of ethanol, the large cetane number of the biodiesel compensates the reduction of cetane number from addition of ethanol to diesel fuel. Therefore, the heat of combustion and the cetane number of the DBE5 blend remained steady, and thus the engine power remains the same as the engine operates with pure diesel fuel. On the other hand, as the ethanol concentration increases the cetane number of the blended fuel decreases and the auto ignition temperature and heat of vaporization (the latent heat of vaporization of ethanol is higher than diesel fuel) of blended fuels increases. Therefore, longer ignition delays occur and the combustion process may extend to the expansion stroke and the fuel cannot be completely burned as results the engine power decrease. Another reason for decreasing engine power can be related to the decreasing lower heating value of DBE blends due the lower heating value of the ethanol and biodiesel than that of diesel fuel.

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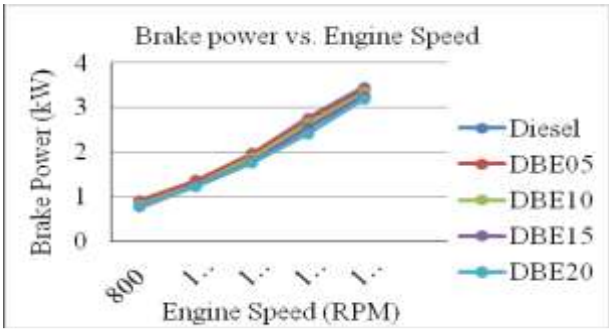

Fig..1 The variation of brake power with pure diesel with diesel [5].

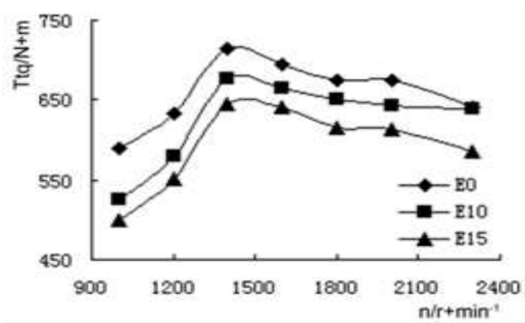

Fig..2 Variation of Brake Torque different speeds for DBE blends and with Speed for different ethanol blends fuel [4].

Without any modification of engine parameters, the effects on the power of the diesel engine were investigated as shown in Figure 2.3.1.2. It is observed that the torque decreases greatly with increasing ethanol content in the blend. At the maximum torque, the torque output of the diesel engine fueled with E10 and E15 fuel decreased by 5% and 10%, respectively, compared with that of diesel fuel. This is due to the LHV of the ethanol-diesel blends. The LHV of E10 fuel is 96.4% that of diesel fuel, while the LHV of E15 is 94.6% that of diesel fuel. Therefore, under the same volume of fuel delivered, the torque output of the diesel engine must be decreased [5].

It confirms 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. Thus, at the same rated power output, the overconsumption of ethanol blends in relation with diesel fuel alone is only 3 %. [7].

Brake Specific Fuel Consumption (BSFC)

According to D.C. Rokopoulos et.al for ethanol diesel fuel blends, the b.s.f.c is a little higher than the corresponding diesel fuel case, with the increase being higher the percentage of ethanol in the blend. This is the expected behaviour due to the lower calorific value of the ethanol compared to the neat diesel fuel at same load [7].

According to De-Gang Li et.al it is obvious that the BSFC decreases with the increasing of load at 2200 rpm, but slightly increases after 75% load at 1760 rpm as shown in fig.3 In general, the BSFC increased with increasing ethanol content in blend fuel. This is due to the fact that the low heat value of ethanol is about 2/3 of that of diesel. The second explanation, which has been offered for the remarkable increase at low load, is the incomplete combustion due to the ignition delay of ethanol–diesel blend fuel [8].

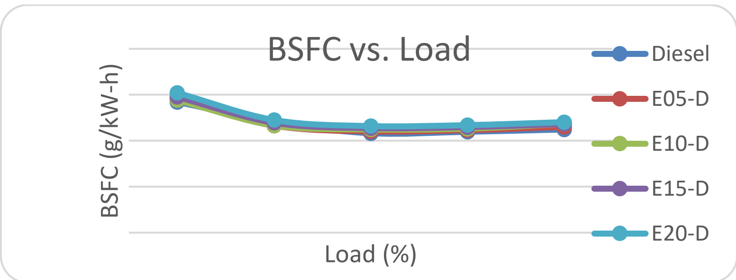

Fig. 3 BSFC of the engine using different blend fuels under various operating condition [8].

Dattatray Bapu Hulwan et.al shows that the brake specific fuel consumption trend for diesel and blends are similar in nature. The results showed that increasing ethanol proportion in the fuel blend increased the BSFC. This behavior is attributed to heating value per unit mass of the ethanol, which is noticeably lower than that of the diesel fuel. Therefore, the amount of fuel introduced into the engine cylinder for a desired fuel energy input has to be greater with the ethanol. These results agree with those found by other authors [08].

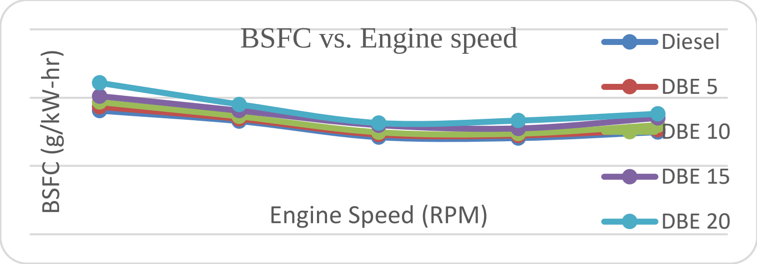

Fig. 4 The variation of BSFC with Engine Speeds for DBE blends and diesel fuel

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 [10].

EFFECTS OF DIFFERENT BLENDS ON ENGINE EMISSION CHARACTERISTICS

CO Emissions

D.C. Rokopoulos observed that the CO emitted by the ethanol-diesel fuel blends is in two cases equal and all others lower than the corresponding neat diesel fuel case , with the reduction being higher the percentage of ethanol in the blend and follows similar case to soot emissions [7].

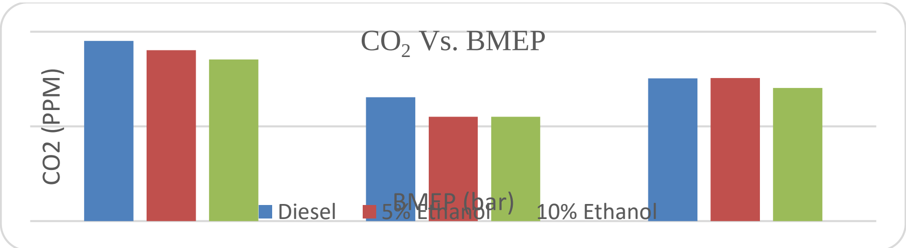

Fig. 5 Emitted carbon monoxide for the neat diesel fuel and the 5% and 10% ethanol blends, at the three loads (b.m.e.p.), for the speed of 1200 rpm [7].

Dattray Bapu Hulwan et.al observed that the CO emissions increased drastically at lower loads and decreased slightly at higher loads for the blends compared to diesel fuel. The drastic increase in the CO percentage at low load for blend is due to decrease in the cylinder gas temperature and delayed combustion process. The lower temperature and delayed combustion would have suppressed the oxidation process even though enough oxygen was available for combustion. Slight reduction in CO emissions is noticed for blends at high load and that would be due to inbuilt fuel oxygen and improved combustion process due to better mixing. Some studies reported the reduction of CO emissions by using ethanol–diesel blends [9].

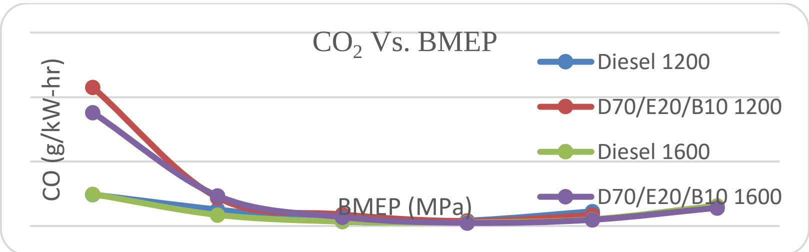

Fig. 6 Effect of various diesel-ethanol-biodiesel blends on CO emissions for various loads [9].

The variations of CO emission with respect to fuels, loads and engine speeds are measured. The overall test results showed that BE20 reduced CO emissions by an average of about 19% at Run 1 and 20% at Run 2. B20 and BE15 showed similar CO emissions characteristics and reduced CO emissions slightly compared with the base diesel fuel. This is understandable because the blends fuels have higher oxygen content than diesel fuel. BE20 contains 3.1% oxygen and produced the smallest amount of CO among the four fuels. The CO emissions of the four fuels showed similar trends at all the selected operation conditions. For a steady engine speed of 1900 rpm, CO emissions increased markedly at lower and higher loads. For a full load, high CO emissions were observed at lower speeds and higher speeds. Normally, better combustion can be achieved at a medium speed and with a medium-sized load. The addition of oxygenates into the diesel fuel results in a slight benefit in the reduction of CO [10].

The increase in the CO level with increasing ethanol fraction is a result of incomplete combustion of the ethanol-air mixture at low loads. The factor causing combustion deterioration at the low loads is the lower combustion temperature; in addition, the higher latent heat of vaporization of ethanol and large distillation in the low temperature range would help to reduce the combustion temperature and result in the reduction of the CO oxidation reaction rate. Thus, a thickened quench layer created by the cooling effect of vaporizing ethanol could have played a major role in the increased CO production at the low loads. However, the combustion temperature increases gradually with the increase of engine load, which weakens the cooling effect of vaporizing ethanol, and the higher oxygen content of the blend fuels would further help to increase the oxygen-to fuel ratio in the fuel-rich regions, all of which would speed up the CO oxidation reaction rate. Thus, the CO emissions decrease with increasing ethanol fraction at high loads [5].

HC Emissions

D.C. Rokopoulos observed that total unburned hydrocarbons (HC) emitted by the ethanol blends are higher than those of the corresponding neat diesel fuel case with the increase being higher the percentage of ethanol in the blend [7].

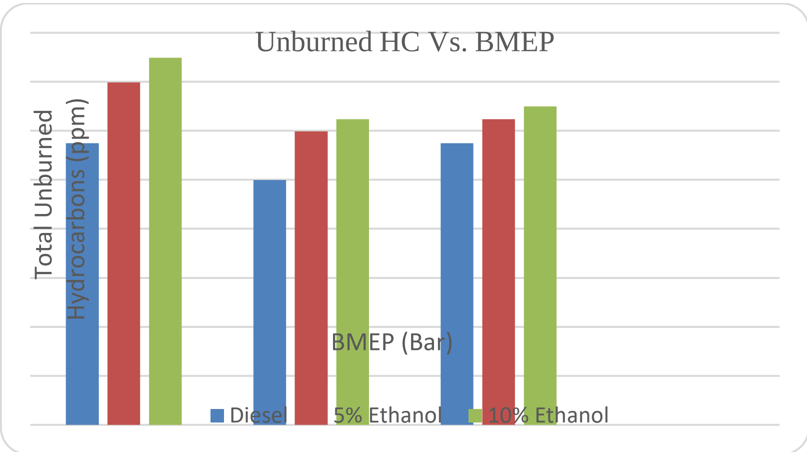

Fig. 7 Emitted total unburned hydrocarbons for the neat diesel fuel for the 5% and 10% ethanol blends, at the three loads (b.m.e.p.), for the speeds of 1200 rpm [7].

HC emissions decreased when the diesel engine was fueled with B20, and the reduction rates were about 21% at Run 1 and about 23% at Run 2 operation conditions. On the other hand, the THC emissions with BE15 and BE20 increased significantly relative to that with diesel fuel at all selected operation conditions. This indicates that the presence of ethanol might be the essential factor for the increase of THC emissions with BE15 and BE20. High THC emission means that there is some unburned ethanol emitted in the exhaust due to the larger ethanol dispersion region in the combustion chamber. Methyl soyate has a higher cetane number than diesel, which will result in more complete combustion in the cylinder. Thus, B20 had less THC emissions than diesel fuel [10].

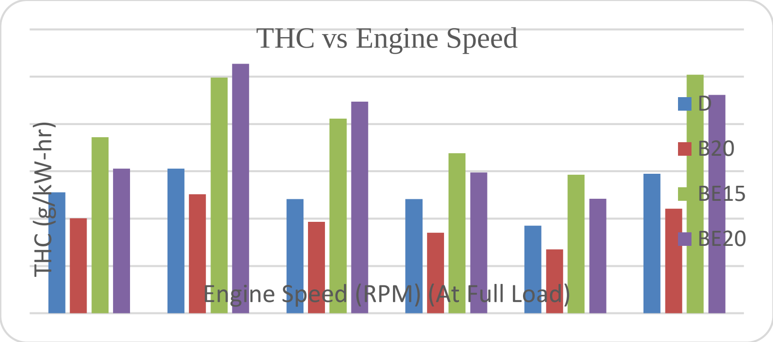

Fig. 8 THC emissions for various speeds using various blends of ethanol/ diesel/biodiesel blends [10].

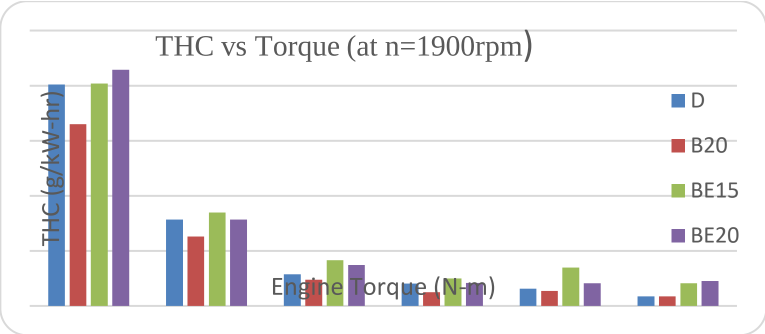

Fig. 9 THC emissions for various loads using various blends of ethanol/ diesel/biodiesel blends [10].

The increase in the hydrocarbon emissions with the increase of ethanol fraction is the result of the ethanol having a lower CN, which deteriorates the combustion performance of the blend fuel. Especially at the low load conditions of the diesel engine, the combustion temperatures are much lower, and the air/fuel ratios are relatively larger, all of which form the poor combustion conditions of the blend fuel and deteriorate the BSEC of the blend fuel and the hydrocarbon emissions. Because the main component of the soluble organic fraction (SOF) is unburned hydrocarbon, the increase in the HC levels results in a high BSSOF [5].

Unburned HC emissions (UHC) are generated due to incomplete combustion. As the load increases, more complete combustion is achieved and less UHC is generated. Also, the figure shows that the fuels do not contribute to any significant difference in UHC emissions at full load whereas there are large differences, especially below 50% load, and the maximum difference is seen at no load conditions. Ethanol blended biodiesel–diesel fuels indicate a reduction of UHC emissions at low concentrations and an increase at high concentrations. But, at over 50% load, all of the ethanol blends show a reduction of UHC emissions. These results strongly indicate that emission characteristics depend on engine operating conditions and/or concentrations [11].

NO_x Emissions

D.C. Rokopoulos observed that NO_x emitted by the ethanol blends are essentially the same or very slightly lower than those of the corresponding neat diesel fuel case. This may be attributed to the temperature lowering effect of ethanol, almost counterbalancing the opposite effect of the ethanol oxygen content and lower cetane number [7].

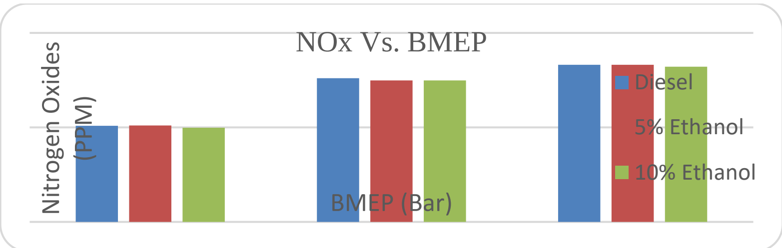

Fig. 10 Emitted nitrogen oxides for the neat diesel fuel for the 5% and 10% ethanol blends, at the three loads (b.m.e.p.), for the speeds of 1200 rpm [7].

Dattatray Bapu Hulwan et.al observed that the NO emissions are decreased for blends at low load (0.1 MPa BMEP) at both speeds and all injection timings. The significant decrease in the peak cylinder pressure is also observed for blends at this load indicating the decrease in-cylinder gas temperature owing to higher latent heat of vaporization of ethanol and increased ignition delay due to lower Cetane index [9].

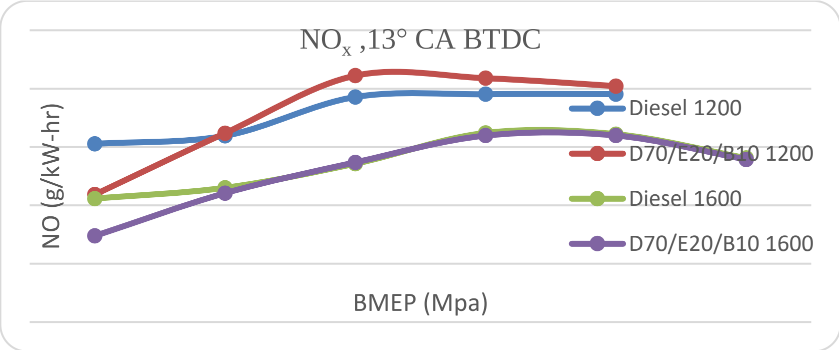

Fig11 NO emissions vs. Load for various blends [9].

In the current investigation, it is apparent that NO_x emissions varied considerably with the test fuels at selected operating conditions. All fuel blends increased NO_x relative to diesel fuel. Normally, if we can organize a more complete combustion, we can get a higher combustion temperature, which will cause a high NO_x formation. It should be noted that oxygenates are blended with the fuel at the same volume percent level for B20 and BE20; however, the NO_x increase with BE20 was more significant than that with B20, which means that the ethanol might have a more complete combustion than the methyl soyate. On the other hand, B20 and BE15 have equal oxygen content weights; however, the NO_x emissions with BE15 were measurably higher than those with B20, which again proved the ethanol's effect on combustion. From Fig. 2.6(d), it is evident that the NO_x emissions decreased with increasing torque. At a full load, NO_x emissions varied with engine speeds and the peak of NO_x emissions occurred from 1600 to 2900 rpm, where the highest combustion temperature was occurred in maximum torque region. The highest NO_x emissions among the fuels tested were observed with the use of BE20. NO_x emissions with BE20 increased about 19% at Run 1 and increased about 30% at Run 2, compared with diesel fuel [10].

CONCLUSION

In the current scenario it is not possible to replace the diesel fuel totally by ethanol and biodiesel in the existing diesel engine without modifications. As we have seen physical and chemical properties of any fuel decides its use in engine applications. So whenever new fuel exists it is required to compare the physical and chemical properties of it in comparison with base diesel fuel. From the literature review it is found that properties of ethanol are not suitable with diesel engine because of its low cetane number, lower flash point, low viscosity, lower miscibility and high auto-ignition temperature. Ethanol blend is limited in diesel because of its poor physiochemical properties. But biodiesel as a additive and co-solvent solves the above problem because it has higher cetane number, higher viscosity, higher flash point, better 29

Miscibility and low autoignition temperature among the three fuels. It also helps in increasing the ethanol fraction in diesel engine. Blends of diesel-ethanol-biodiesel has approximately same properties compared with base diesel fuel hence this blends are acceptable. Engine performance with diesel-ethanol-biodiesel blends reduces brake power and increases specific fuel consumption because of low calorific value of ethanol and biodiesel. Emission characteristics of diesel-ethanol-biodiesel blends shows that CO emissions increased for all blends at low load because of lower temperatures and incomplete combustion but reduces at high load due to high combustion temperatures and CO reduction in blends is low due to inbuilt oxygen content in the blended fuels. HC emissions increased for all blends compared with diesel fuel because of low cetane number of blends, high fuel consumption and high latent heat of vaporization which lowers combustion temperatures leading to unburned hydrocarbons. NOx emissions increases at high loads for all fuels due to high combustion temperatures but it is slightly lower at light loads for blends compared with base diesel due to temperature lowering effect of ethanol and lower heating value of ethanol and biodiesel but it varies according to blend and load. Smoke emissions are found to be lower in all cases compared with base diesel fuel because of inbuilt oxygen content of ethanol and biodiesel. PM emissions trend is similar to smoke emissions.

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