EFFECT OF ETHANOL BLENDED WITH COTTONSEED OIL METHYL ESTER ON ENGINE PERFORMANCE AND EMISSION IN A DI DIESEL ENGINE BY VARYING INJECTION PRESSURE

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Abstract - *The depletion of fossil fuel in the world is major problem for the automobile industry. The usage of biodiesel rapidly increasing in the world. As the biodiesel is the renewable source of energy. The cottonseed oil methyl ester is the bio diesel blended with the ethanol and diesel. The B20+E10 is composition of diesel 70%, cottonseed oil methyl ester 20% and ethanol 10%. The biodiesel will have high viscosity when in comparison to diesel and gasoline. The transesterification will help to reduce the viscosity and by varying injection pressure will lead to better performance, combustion and emission characteristics. The injection pressure is varied at 200 bar, 220 bar and 240 bar respectively. The result indicates that the CO and NO_x is reduced compared to diesel and HC is increased gradually when compared to diesel.*

***Key Words*: Biodiesel, Cottonseed oil methyl ester, Ethanol, Injection pressure, Alternative fuel.**

1. INTRODUCTION

Traditional automobile fuels were extracted from non-renewable fossil oil and emits huge amount of pollutants such as NO_x, PM, CO, HC and CO_2. Electric automobiles have been considered as a most effective way to protect the environment and the ease of climate change. Biofuels are locally available, sustainable, reliable and non-polluting, obtained from renewable sources. Biodiesel is known fatty acid methyl esters made from vegetable oil or animal fats and it can be used as ideal alternative fuel for diesel. Compared to diesel, biodiesel have higher cetane number about 10% intramolecular oxygen. The use of biodiesel in conventional diesel engine brings out a considerable reduction in CO, PM, CO_2.Biodiesel is an ideal and renewable alternative fuel for diesel [1-2]. Vegetable oil used for energy purposes is not new. The present availability of vegetable oils in this world is enough to meet edible oil requirements [3]. Many researches have concluded that vegetable oils can be used as alternative fuels in diesel engines. Cottonseed oil methyl ester can be used due to low cost of the oil compared to diesel. The low volatility and increased viscosity of vegetable oils lead to injection chocking, piston ring sticking and engine deposits. However, these effects can be eliminated through Transesterification of vegetable oil to form methyl ester. Transesterification provides a fuel viscosity close to that of diesel fuel. The process of reacting a triglyceride with an alcohol in the presence of catalyst to produce glycerol and fatty acid esters. Vegetable oil has a viscosity of 10-20 times greater than that of diesel fuel. [4-5]. At constant speed of 1500rpm it was observed that brake thermal efficiency of cotton seed oil methyl ester was slightly greater compared with conventional diesel fuel and it is also observed that indicated thermal efficiency of cotton seed oil methyl ester was 20.70% was considerably greater compared with diesel fuel [6]. Compared to neat diesel fuel 20% of biodiesel mixtures reduces Carbon monoxide and PM emissions 24%. Approximately 10% increase in NO_x emission was realized with 20% biodiesel mixture. However, reduction of NOx may be possible by using EGR technique and adjustment of injection timing [4]. Ethanol has been considered as alternative fuel for IC engines in which it contains 34% higher oxygen content by weight. ethanol can be used as fuel or fuel additives in diesel engines due to the miscibility problems, low cetane number, low lubricity it is limited. A mixture of biodiesel- diesel-ethanol is used to improve poor cold flow properties and to improve phase stability of blends. Like petroleum ethanol contains carbon, hydrogen and oxygen in chemical structure and ethanol makes clean burning fuel than fossil fuels. Since biodiesel blended with ethanol will have a greater potential for reducing emissions and particulate matters [7-8]. CO_2 emissions have vital effect in global warming and average CO_2 was decreased about 67 and 67.5 compared to neat diesel fuel. CO and SO_2 emissions were reduced while using biodiesel-ethanol blends compared to neat diesel [9]. An increased in injection pressure may results in improvement of performance, emission and combustion parameters for all loads. The fuel injection pressure for the standard diesel engine is between 200-1700 atm. The benefits of high injection pressure may result in improved fuel atomization producing fine fuel droplets and high spray penetration and better air utilization. [9]. The main objective of this study is to improve the performance, emission and combustion characteristics of cottonseed oil biodiesel(B20) by blending with ethanol(E10) in diesel engine by varying the injection pressure of 220 and

240 bar. Effect of cottonseed oil obtained biodiesel–ethanol fueled on diesel engine for the performance, and exhaust emissions were investigated in a single cylinder, four stroke, unmodified direct injection diesel engine and experimental results were compared with standard diesel fuel.

2. MATERIALS AND EXPERIMENTAL PROCEDURE

The rapid depletion of energy sources along with the increasing demand for conventional energy sources is a matter of serious concern. To solve both the energy concern and environmental concern, the renewable energies with lower environmental pollution impact should be necessary. Biodiesel is renewable and environmentally friendly alternative diesel fuel for diesel engine. It can be produced by trans-esterification process. Trans-esterification is a chemical reaction in which in the presence of a catalyst, animal fats and vegetable oils are reacted with alcohol. The products of reaction are fatty acid alkyl ester and glycerine were the fatty acid alkyl esters known as biodiesel.

2.1 Materials

2.1.1 Transesterification of Cottonseed Oil Methyl Ester

To reduce the viscosity of the COTTON SEED OIL, trans-esterification method is adopted for the preparation of biodiesel. The procedure involved in this method is as follows: 1000 ml of Cottonseed Oil is taken in a three-way flask. 15 grams of sodium hydroxide (NaOH) and 250 ml of methanol (CH_3OH) are taken in a beaker. The alcohol and sodium hydroxide (NaOH) are thoroughly mixed until it is properly dissolved. The solution obtained is mixed with Cottonseed Oil in three-way flask and it is stirred properly. The methoxide solution with Cottonseed Oil is heated to 60°C and it is continuously stirred at constant rate for 1 hour by stirrer. The solution is poured down to the separating beaker and is allowed to settle for 5 hours. The glycerine settles at the bottom and the methyl ester floats at the top (coarse biodiesel). Methyl ester is separated from the glycerine. This coarse biodiesel is heated above 100°C and maintained for 10-15 minutes to remove the untreated methanol. Certain impurities like sodium hydroxide (NaOH) are still dissolved in the obtained coarse biodiesel. These impurities are cleaned up by washing with 300 ml of water for 1000 ml of coarse biodiesel. This cleaned biodiesel is the methyl ester of Cotton Seed Oil.

2.1.2 Ethanol

Ethyl alcohol is also known as Ethanol [CH_3CH_2OH]. the most important property of the ethanol is highest octane number. It contains higher oxygen by weight nearly 34% more than conventional fuel. From various sources ethanol can be prepared from Corn, Sugarcane etc by fermentation process. Table shows the basic characterization of 99.99% pure ethanol tested as per IS 1448 standards in the NABL accredited laboratory.

Table -1: Properties of fuels

S.no	Properties	Diesel	Ethanol	CSOME	B20E10
1	Density @ 15°C (kg/m^3)	840	821	871	842
2	Kinematic viscosity @ 40°C (mm^2/s)	2.6	1.1	4.3	2.3
3	Flash point (C)	56	13	199	106
4	Fire point (C)	68	-	208	112
5	Cetane number	50	8	52	23

2.2 Experimental Setup

The experimental setup which was used for this work has single cylinder, four stroke, direct fuel injection diesel engine of Kirloskar, TV1 model and it is water cooled. The engine has rated power of 5.2 kW @ 1500 rpm and displacement volume of 661 cubic centimetres (CC). It has 20kW eddy current dynamometer. The Experimental setup for this work was shown in the Fig.1. The specification of setup was listed in the table 1. The engine was used as it is for this work; no modification is done on the engine for this work. The experimental setup was fully computerized for measuring and collecting and analysing the data. The software used for this setup was 'Engine soft' which gives the output in the of graphical and numerical values. The gases like HC, CO and NO_x was measured by AVL India gas analyser. The smoke density was measured by the AVL India Smoke meter.

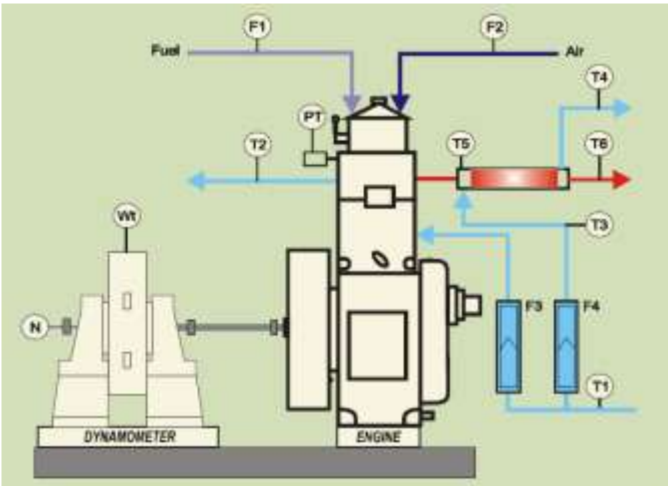

Fig -1: Engine setup layout

Table-2: Engine setup

T1 Engine cooling water inlet	F1 Fuel in
T2 Engine cooling water outlet	F2 Fuel out
T3 Calorimeter water inle**t**	F3 Engine cooling water
T4 Calorimeter water Outlet	F4 Calorimeter water
T5 Calorimeter Exhaust gas In	PT Pressure transmitter
T6 Calorimeter Exhaust gas Out	N Crank angle Encoder

2.3 Experimental Procedure

The fuel was blended at the ration of the experiment to carried out. The fuel blend ratio is D70+B20+E10 (70% diesel + 20% cottonseed oil methyl ester + 10% ethanol) which was used for this work. The fuel blends are same for all tests but the injection pressure of fuel was varied for checking which injection pressure gives the better. The varied injection pressure was 200bar, 220 bar, 240bar respectively. The fuel blend with injection pressure D70+B20+E10 200, D70+B20+E10 220, D70+B20+E10 240. The experiment was carried out from load condition zero to full condition. The result of cottonseed oil methyl ester blended with ethanol and diesel was compared with the diesel at normal pressure on this paper.

2.4 RESULT AND DISCUSSIONS

2.4.1 Performance Characteristics

The cottonseed oil biodiesel and ethanol is blended with diesel is used as a fuel for the compression ignition engine without any engine modification. The performance, combustion and emission characteristics of engine with diesel and biodiesel and ethanol blends. The brake power is defined as usable energy available in the crankshaft. It is the power after the loss of friction. For an applied load for an applied load, the brake power is similar for both diesel and biodiesel ethanol blends.

2.4.1.1 Break Thermal Efficiency

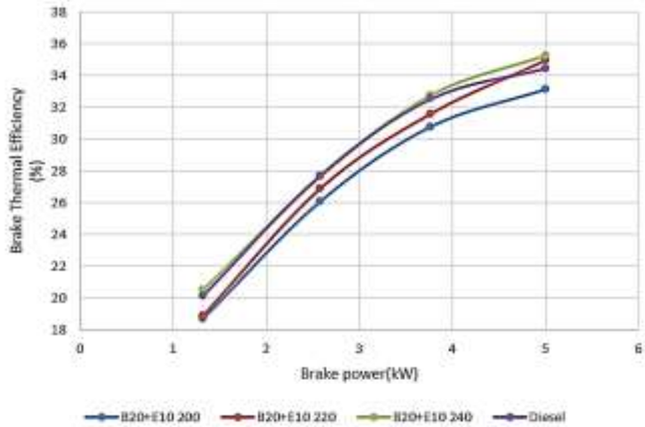

Chart -1: variation of brake thermal efficiency with brake power

The brake thermal efficiency variation is shown in Chart-1 the increase in load increase brake thermal efficiency due to biodiesel blended ethanol and Nano additives. The combustion process is influenced by flash point and poor volatility. The brake thermal efficiency of the biodiesel is less than that of diesel fuel. Among the cottonseed biodiesel, (D70+B20+E10 240) blend shows the higher brake thermal efficiency of 35.27% and it is 0.79% higher than diesel fuel. The brake thermal efficiency of (D70+B20+E10 200) and (D70+B20+E10 220) are 33.14% and 34.95% respectively.

2.4.1.2 Brake Specific Fuel Consumption

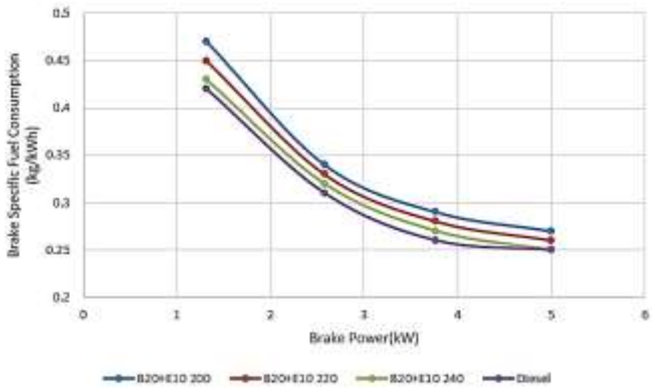

Chart -2: variation of brake specific fuel consumption with brake power

The brake specific fuel consumption has shown in Chart-2. Increase in load decreases the brake specific fuel consumption for all test fuels. It is found from the result D70+B20+E10 240 cottonseed biodiesel blend having equal brake specific fuel consumption to that of diesel. The brake specific fuel consumption for D70+B20+E10 200, D70+B20+E10 220 and D70+B20+E10 240 at full load are 0.27kg/kWh, 0.26kg/kWh and 0.25kg/kWh, whereas for diesel is 0.25kg/kWh.

2.4.2 Combustion Characteristics

2.4.2.1 Pressure Vs Crank Angle

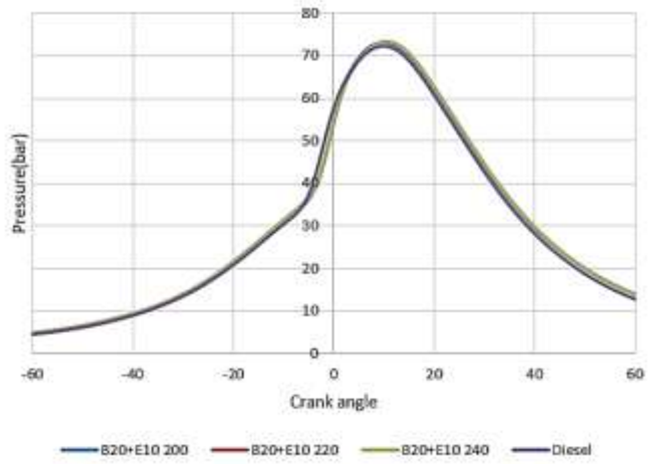

Chart -3: variation of pressure with crank angle

The variation peak pressure with crank angle is shown in Chart-3. The (D70+B20+E10 240 bar IP) biodiesel blend has a higher peak pressure at its full condition than the diesel. This is due to ignition delay period by vaporization in combustion, which turns the premixed combustion period increases for cottonseed biodiesel fuel, which lead to high peak pressure. The peak value for (D70+B20+E10 200 bar IP), (D70+B20+E10 220 bar IP) and (D70+B20+E10 240 bar IP) is 73.02 bar, 73.1 bar and 73.36 bar. From this it is clear that (D70+B20+E10 200 bar IP) and (D70+B20+E10 220 bar IP) have less peak pressure when compared with diesel.

2.4.2.2 Heat Rejection

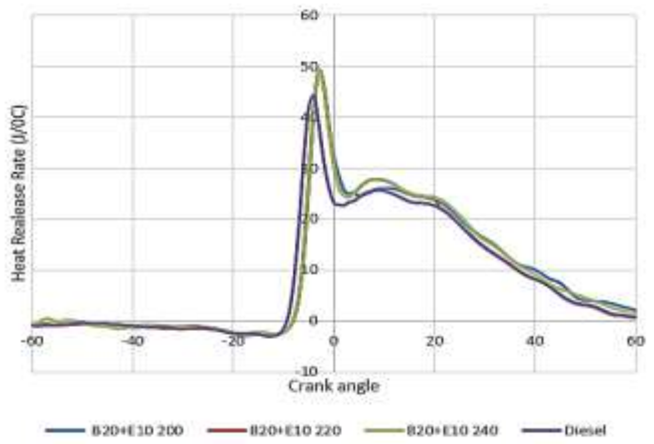

Chart -4: variation of brake heat release rate with crank angle

The release rate is affected by higher ignition delay period delay period because of vaporization in the combustion chamber. As a delay period increases for cottonseed biodiesel blended fuel which increase premixed combustion period and let's to higher heat release rate. The variation of heat release rate is shown in Chart-4. The graph shows that the heat release rate is higher for (D70+B20+E10 240 bar IP) for cottonseed biodiesel blended with ethanol in full load conditions. The heat rejection rate for (D70+B20+E10 200 bar IP), (D70+B20+E10 220 bar IP) and (D70+B20+E10 240 bar IP) is 42.50 J/^{0}C, 43.4 J/^{0}C and 49.18 J/^{0}C respectively at its full load and for diesel is 41.32 J/^{0}C at its full load.

2.4.3 Emission Characteristics

2.4.3.1 Carbon Monoxide (CO)

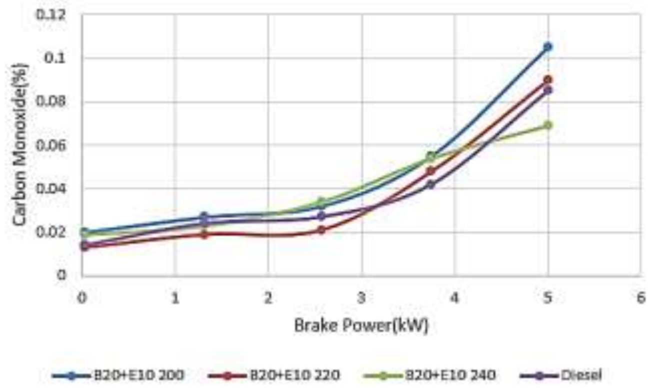

Chart -5: variation of carbon monoxide with break power

The variation of carbon monoxide with break power is shown in Chart-5. This shows the increase in load increase the CO emission. From graph it is found the CO emission at full load for (D70+B20+E10 240 bar IP) is less than the diesel engine. Since CO emission depend on the carbon contents incomplete combustion. The (D70+B20+E10 240 bar IP) blended fuel shows nearly the 0.069% when compared to diesel which emits 0.085% CO emission. The (D70+B20+E10 200 bar IP) and (D70+B20+E10 220 bar IP) blended fuels test shows 0.105 and 0.090 respectively.

2.4.3.2 Hydrocarbon Emission (HC)

The variation of hydrocarbon with brake power is shown in Chart-6. It seems that the hydrocarbon is slightly increased when compared with the diesel. All the biodiesel tested shows the increase in hydrocarbon when compared to the diesel. The hydrocarbon emission for (D70+B20+E10 200 bar IP), (D70+B20+E10 220 bar IP) and (D70+B20+E10 240 bar IP) is 40ppm, 35ppm and 21ppm at full load condition respectively and for diesel 19ppm at full load condition.

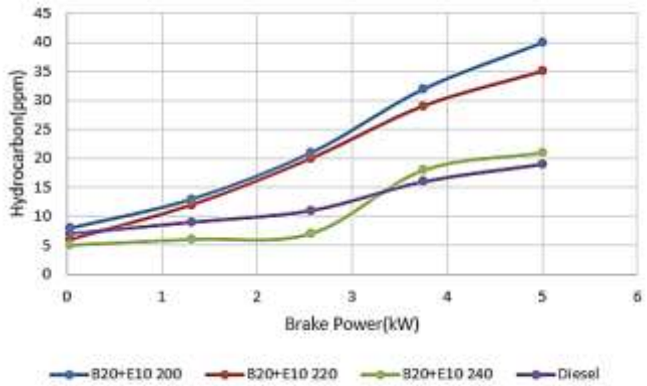

Chart -6: variation of hydrocarbon with brake power

2.4.3.2 NO_x Emission

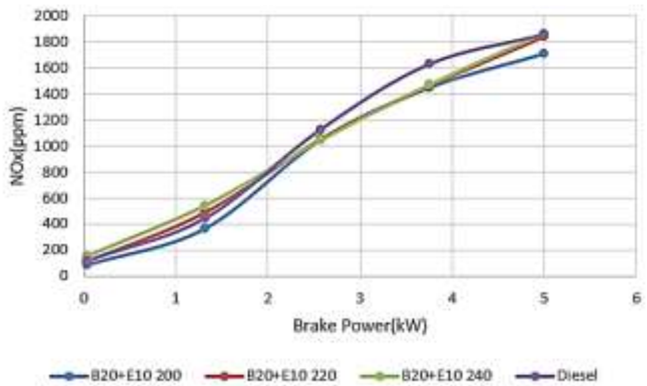

Chart -7: variation of NO_x with brake power

The variation of NO_x with brake power is shown in the Chart-7. The increase in load increases the NO_x emission for all the tested fuels. The more oxygen molecule in the fuel is the reason for increase of NO_x at full load condition. It is shown in the graph that (D70+B20+E10 200 bar IP) is less when compared to the diesel NO_x emission. The NO_x emission for (D70+B20+E10 200 bar IP), (D70+B20+E10 220 bar IP) and (D70+B20+E10 240 bar IP) is 1709ppm, 1839ppm and 1866ppm respectively at full condition. And the NO_x emission for diesel is 1857ppm. The reduction of NO_x emission is due to the low peak combustion temperature.

2.4.3.4 Carbon Di Oxide (Co_2) Emission

The variation of carbon di oxide with brake power is shown in Chart-8. It is shown in the graph that CO_2 emission of (D70+B20+E10 240 bar IP) blend is less when compared to the diesel fuel. The CO_2 emission for (D70+B20+E10 200 bar IP), (D70+B20+E10 220 bar IP) and (D70+B20+E10 240 bar IP) is 10.2%, 9.74% and 8.98% respectively at full condition. And the CO_2 emission for diesel is 9.26%.

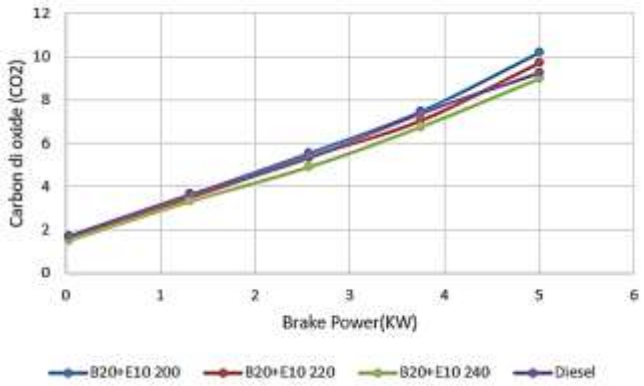

Chart -8: variation of Carbon di oxide (CO_2) with brake power

2.4.3.5 Smoke Emission

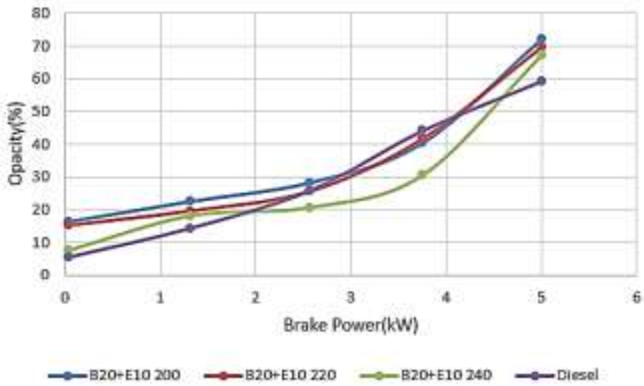

Chart -9: variation of the smoke with brake power

The variation of the smoke emission with brake power is shown in Chart-9. From the graph increase in load increases smoke emission. The smoke emission of the test fuel is higher than the diesel fuel. The (D70+B20+E10 200 bar IP), (D70+B20+E10 220 bar IP) and (D70+B20+E10 240 bar IP) biodiesel blends have fuel opacity value of 72.1%, 69.8% and 67.3% and whereas for diesel is 59.3%.

3. CONCLUSION

It is clear from the experimental results of this research work, an increase in the injection pressure on engine, performance was increased for the Blends of Biodiesel-ethanol. The main conclusion derived by this research is that using ethanol with biodiesel can potentially remove serious problem revealed with the use of high percentages of biodiesel in operation of unmodified diesel engines. Besides, the exhaust emissions for B20+E10 were fairly reduced. HC emissions of the fuel blends are higher with increase of load compared with diesel fuel emission. These emissions are reduced with various other emission controlling techniques.

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