Review Paper on Combustion Characteristics of a Cottonseed Biodiesel Fuelled Diesel Engine

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Abstract: Diesel engines are very well known for their high torque and high initial thermal efficiency. But the increase in demand of energy rapid depletion of fossil fuels and meeting the stringent emission regulations, the researchers take interest to derive the alternative fuels from renewable sources. Due to the petroleum shortage the researchers take interest in finding the alternative fuels for internal combustion engine. There are various types of alternative fuels available for internal combustion engine but biodiesel is most important alternative to diesel engine. Biodiesel is popular due to its renewability, lower exhaust emissions, and biodegradability In a Shirpur region the mostly fast growing, very easily available and very cheap plant available is Cottonseed Plant. The cottonseed crop is a fast growing plant and that grows even on drought and poor soils. Cotton was the third biggest crops grown worldwide as measured by acreage: soybean which is 47%, occupying 75.4 million hectares; biotech maize (51 million hectares at 32%), biotech cotton (around 24.7 million hectares at 15%) and biotech canola (8.2 million hectares at 5%). So, we can easily utilize Cottonseed by generation of Biodiesel. Most of the researchers have defined transesterification is one of the process for production of biodiesel. Transesterification process is most suitable method used for the production of biodiesel. Biodiesel is a nontoxic, biodegradable and renewable alternative as compared with diesel fuel. The properties of biodiesel are somewhat similar with the diesel fuel. Therefore with few or no any engine modifications are required to use biodiesel in diesel engine. It was also found that additives improved the fuel blend properties like density and viscosity which in turn of improved in the atomization of fuel and showed better combustion characteristics. It results in to higher brake power (BP), lower brake specific fuel consumption (BSFC) and higher brake thermal efficiency (BTE) than diesel.

Index Terms - Combustion Characteristics of a Cottonseed Biodiesel, Cottonseed Biodiesel Fuelled Diesel Engine.

I. Introduction

Diesel fuel is very important for country’s economy because it has a wide area of usage such as transportation, rail road, agriculture, construction equipment etc. India being an agricultural country produces a wide, variety of vegetables, a thorough and wide investigation is required to find the appropriate vegetable source to produce biodiesel.

Vegetable oil as a suitable alternate fuel for Compression Ignition engine is either in its pure form or is blended with petroleum diesel. Moreover biodiesel is better than diesel based on some of its physical properties like sulphur content, flash point, aerometric content and biodegradability. From the previous studies, it could be observed that most of the studies are mostly related to the performance and emission characteristics of diesel engine using biodiesel as fuel.

The performance and emission control characteristics of various biofuels have been carried out. Vegetable oil as a suitable alternate fuel for compression ignition engine is in its pure form or blended with petroleum diesel. Moreover biodiesel is better than diesel based on some of its physical properties like Sulphur content Flash Point aromatic content and biodegradability. The B100 gives the lower emissions Characteristics of diesel engine with B0 and B100 Fuel. From the previous studies it could be observed that most of the studies are mainly related to the performance and emission characteristics of diesel engine using biodiesel as fuel.

II. REVIEW

The CO, HC and smoke emissions [1] decreased with biodiesel whereas oxides of nitrogen, carbon dioxide and BSFC increased with biodiesel. Sulphur dioxide emissions decreased by an average of 86% and 94% by using B.100 and B50 biodiesel blended with ultra- low Sulphur diesel. The higher oxygen content of biodiesel improved premixed combustion phase to progress in a better way which leads to better combustion. It is also mentioned that premixed combustion phase is responsible for higher NOx emission. B15 blend shows 2.67%, 3.81%, 4.22% and 5.31% higher peak pressure than diesel at 20%, 40%, 60% and 80% load respectively. However, most of literatures revealed that combustion starts earlier for base biodiesel and its blends with diesel. The peak heat release rate of biodiesel fuels is lower than conventional diesel fuel because of shorter ignition delay period and lower calorific value (CV) of biodiesel that contributes to lower heat release rate. Combustion for biodiesel starts earlier which results in to shorter ignition delay period and advanced injection timing at all engine loads. The biodiesel gives similar power output as that for diesel. It is also observed that ignition delay period decreases with biodiesel than diesel due to the complex and rapid preflame chemical reaction which generally takes place at high temperatures. As a result of the high cylinder temperature and existing fuel injection condition, biodiesel may go through thermal cracking and results in formation of lighter compounds. This earlier ignition result in a shorter ignition delay. For all fuels, the peak heat release rate increases as the load increased which tends to high temperature, high cylinder pressure, better fuel-air mixing, and higher flame velocity at higher loads.

The cotton seed methyl ester was prepared in laboratory scale arid it was blended with commercially available diesel such as B5, B10, Bl5 and B20. The physico-chemical properties such as viscosity, density and calorific value were measured using Kinematic Viscometer.

The combustion analysis has been carried out by analysing the pressure traces acquired in the combustion chamber with respect to crank angles.

The biodiesel has higher bulk modulus results in early start of injection and higher cetane number reduces the ignition delay, this finally results in early start of combustion with biodiesel blends as compared base diesel.
It is observed that rate of pressure rise is decreased with all biodiesel blends as compared to base diesel. It is mainly due to higher cetane number of biodiesel tends to lower ignition delay.

The heat release rate lowers in case of biodiesel than diesel due to the lower calorific value of the diesel results in lower brake thermal efficiency of biodiesel fuelled Diesel engine.

The experimental results of the diesel engine with cottonseed biodiesel blend as compared to base diesel. Cottonseed biodiesel can be used in blended form as an alternative fuel in any diesel engine without any modification.

- Ignition delay decreased from 11 °CA with diesel to 9.5 °CA, 8.5 °CA, 7.5 °CA and 6.5 °CA with B5, BIO, B15 and B20 biodiesel blends respectively.
- The start of combustion advanced from 349 °CA with base diesel to 347.5 °CA, 346.3 °CA, 345.5 °CA and 344.5 "CA with B5, BIO, B15 and B20 biodiesel blends respectively.
- The peak in-cylinder pressure increased from 52.28bar with base diesel to 55.61 with B20 biodiesel blends.
- The rate of pressure rise is decreased with all biodiesel blends as compared to base diesel. It is mainly due to higher cetane number of biodiesel tends to lower ignition delay.
- The premixed combustion phase increases in case of biodiesei which is mainly responsible for higher NOx emission. Combustion duration increases as the percentages of biodiesel increases.

The main Material i.e. Cottonseed Biodiesel [2] can be made by following transformations. The cotton seed oil is commercially available in the local market and is used as the raw material. Transestcrification process is the reaction between a triglyceride and alcohol in the presence of a catalyst to produce glycerol and ester. To complete the transesterification process stoichiometrically. 3:1 molar ratio of alcohol to triglycerides is needed. However in practice, higher ratio of alcohol to oil ratio is generally employed to obtain biodiesel of low viscosity and high conversion. Among all alcohols that can be used in the transestcrification process are methanol, ethanol, propanol and butanol. Methanol and ethanol are widely used and especially methanol because of its low cost. Vegetable oil is made to react with methanol in the presence of catalyst which produces mixture of alkyl ester and glycerol Tills oil can be produced by a base catalyst process. Cotton seed oil is transesterified using methanol as reagent and NaOH as catalyst to yield biodiesel (Cotton Seed Oil Methyl Ester).

Experiments have been conducted on a 4 stroke kirloskar Tangentially Vertical single cylinder TVI) direct injection (OI) diesel engine developing power output of 5.2 KYV at 1500 rpm connected with water cooled eddy current dynamometer.

Oxygen:

Both B0 and B10G give lowest emissions of O; in % by volume of 9.84 and 10.06 respectively for Static injection Timing of 22° bTDC under steady state condition. However, for Static Injection Timing of 23" bTDC, the emission of CT for both B0 anti B100 is comparatively higher and produce 11.24 and 10.76 % by volume respectively.

Carbon monoxide:

Both BO and B100 produce less CO emission in % by volume for the Static Injection Timing of 22° bTDC with, the % of 0.21 and 0.3 respectively. It may be noted that both BO and B100 produce less Commissions at Static Injection Timing of 22° as compared to 23° and 24°. There is a considerable increase in CO emission by using B100 fuel for Static Injection Timing of 23° which corresponds to 0.55 % by volume, whereas B0 produces 0.28%. With 24° bTDC Static Injection Timing the CO emissions for both B0 and B100 are 0.27 and 0.35 respectively.

Carbon-di-oxide:

CO2 emissions are lower at Static Injection Timing, of 22°bTDC as compared to both 23" and 24” bTDC respectively producing 7% and 7.2 %for B0 and B1OO fuels respectively. At Static Injection Timing of 23° and 24° bTDC, the CO2 emissions are 7.6% and 7.9% for B0 respectively and 7.2% and 7.7% respectively.

Smoke Density:

It is observed that the Smoke Density remains almost the same for B100 fuel with 76.8 HSU, 755 HSU, and 75.6 HSU for Static Injection Timing of 23°. 22° and 24°bTDC respectively. Whereas the Smoke Density reduces in case of 80 from 73.9 HSU at Static Injection Timing of 23° bTDC to 62 HSU at Static Injection Timing of 22° bTDC and 63 HSU at Static Injection Timing of 24° bTDC. The Smoke Density almost remains the same because in diesel engine which is a quality governed engine, the combustion depends on local air fuel ratio. As the loads remain constant, the air fuel ratio also remains constant. Only Static Injection Timing determines die Smoke Density. It is interesting to note that B0 emits lower smoke compared to B100 at Static Injection Timing of 22° bTDC.

Hydrocarbon:

It is evident that the maximum HC is 55 ppm and 45 ppm for BO and B100 fuels respectively at Static Injection Timing of 23° bTDC. Static Injection liming of 22° bTDC has reduced HC figures as compared to other two Static Injection Timings of 23° bTDC and 24° bTDC.

Oxides of Nitrogen:

Static Injection Tinting of 22° bTDC has lower NOx, emissions for both BO and B100 fuels with 830 ppm and 718 ppm respectively. The variation of NOx is higher for Static Injection Timing of 24° bTDC as compared to other timings. There is a greater % reduction in NOx for Static Injection Timing of 22° bTDC in both B0 and B100 cases.

The following conclusions are drawn based on the experimental results of the diesel engine with cottonseed biodiesel blends as compared to base diesel. Cottonseed biodiesel can be used in blended form as an alternative fuel in any diesel engine without any modification.

Static Injection Timing of 22° bTDC gives optimum lower emissions in each category of emissions fuelled with Cotton Seed Oil Methyl Ester, It can be used to operate four stroke tangentially vertical single cylinder direct injection diesel engine with nozzle operating pressure of 230 bar to reduce emissions.

The properties of the oil were first measured [3] to determine if pre-treatment is necessary or not before alkaline transesterification. It was found that the free fatty acid value of the oil is 0.23% of NaOH by volume which is high for direct alkaline transesterification as it can react with the catalyst to form soap which can inhibit methyl ester yield. The water content is 10% which is a little bit too high for uninhibited transesterification hence the oil is heated to 110°C and held constant for 30 minutes to allow some of the water to evaporate.

Generally vegetable oils contain fatty acids (palmitiç, stearic, olenic linoleic, lingtioceric, eicosenoic and behenic) of these cotton seed oil contains the saturated fatty acids paimitic (hexadecanoic acid)and stearic (octadecanoic acid) and the unsaturated acids oleic and linoleic. The cotton seed oil is commercially available in the local market and used as the raw material. Transestcrification process is the reaction between a triglyceride and alcohol in the presence of a catalyst to produce glycerol and ester to complete the Transestcrification process stiochiometrically 3:1 molar ratio of alcohol to triglycerides is needed. However, in practice, higher ratio of alcohol to oil ratio is generally employed to obtain biodiesel of low viscosity and high conversion. Among all alcohols that can be used in the Transesterification processes are methanol, ethanol, propanol and butanol. Methanol and ethanol are widely used and especially methanol because of its low cost. Vegetable oil is made to react with methanol in the presence of catalyst which produces mixture of alkyl ester and glycerol. This oil can be produced by a base catalyst process. Cotton seed oil is Transesterified using methanol as reagent and NaOH as catalysts, to yield biodiesel (Cotton Seed Oil Methyl Ester).

Specific fuel consumption (SFC):

It is seen that the B0 give lowest specific fuel consumption of 0.54 and 0.29 kg/kWh respectively for both the fuel at no load and full load. However the B 100 gives the highest specific fuel consumption of 0.64 and 0.32kg/kWh respectively at No Load and full load. The specific fuel consumption decreases with increase in load for all brands of field however at each Load B0 and B25 have the lowest specific fuel consumption and thus increases with the blend value this is due to comparatively higher viscosity and lower calorific value. This is due to increase in fuel quantity with increase in load which causes better utilization of the leading to better combustion. At no load diesel engines operate with very lean mixture.

Brake thermal efficiency (BTE):

B0 and b25 have almost the same maximum brake thermal efficiency of 14.72% and 29.34% for both the fuel at no load and full load condition respectively. It may be noted that at all loads B100 gives lower brake thermal efficiency. At no load and full load the brake thermal efficiency for B100 is 7.35% and 6.35% is slower as compared to B0 and B25 field the same traind is observed for all blends of fuel. The brake thermal efficiency depends on heating value and specific gravity. The combination of heating value and mass flow rate indicate energy input to the Engine. This energy input to the engine in case of B50, B75 and B100 are more compared to neat diesel. This may the reason to have lower brake thermal efficiency for all blends of fuel as compared with BO.

Smoke Density (SD):

In diesel engine is a quality governed engine. The combustion depends upon the local air fuel ratio. Increase in load at Constant Speed is achieved by increasing the fuel quality. This may be due to the chemistry of fuel blend which may promise conducive atmosphere for lower smoke density for B25 compared to B0. Further at no load the engine is operating at very lean mixture. As the load is increased from no load to 75% there is only Gradual increase in smoke density. However the smoke density for B 25 is lower than b0 over there load range for reasons explained above B 75 and B 100 are almost bunching together in this load range. It can also be seen from figure 3 as the load increases from 75% to 100 percent, there is a steep rise in the smoke density for all the blends, as well as need diesel. This is to be expected because more cereal is injected into the engine to take care of the l o a d. As the engine is running at constant speed of 1500 RPM, there is less time for complete combustion to take place which can cause an increase in smoke density.

Oxides of Nitrogen (NOx):

The variation in NOx at full load is higher at no load condition of the B100 as compared with B0 fuel. At full load, the percentage reduction in NOx for B100 is 8.45 percent as compared with B0 whereas no load the variation in NOx is 2.45 percent. However the B75 blend gives better Reduction in NOX as compared with B0, B25, B50, and B100 at full load condition. The percentage reduction in NOX for B 75 is 9.56% as compared to B0 serial at full load condition off the engine whereas at no load, the percentage reduction in NOX is 4.54 % for B 75. The temperature percentage reduction in NOX for the B100 is 1.14 % as compared to B75 Fuel. This is due to decrease in exhaust gas temperature. It is well known that vegetable based fuel contains small amount of Nitrogen. This contributes towards the NOx production.

The B25 gives optimum performance and lower emissions of SD and NOX. Finally, I can be concluded that the B25 could be used as a viable alternative fuel to operate four stroke tangentially vertical single cylinder direct injection diesel engine with nozzle opening pressure of 230 bar and static injection timing 23 degree bTDC. There by saving 25% of the precious Petrol diesel fuel.

Increase in energy demand, stringent emission norms and depletion of oil resources [4] led to find alternative fuels for internal combustion engines. Many alternative fuels like alcohols, bio-diesel, liquid petroleum gas (LPG), compressed natural gas (CNG), etc. have been already commercialized in the transport sector. In this context cotton seed oil renewed interest. The cotton seed oil can be converted in bio diesel using a process called as trans-esterification. The cotton seed oil is blended with diesel and used as an alternate fuel tor Cl engines.

Compression ignition engines are employed particularly in the field of heavy transportation and agriculture on account of their higher thermal efficiency and durability. However, diesel engines are the major contributors of oxides of nitrogen and particulate emissions. Hence more stringent norms are imposed on exhaust emissions.

A single cylinder compression ignition engine is used to compare the Performance and Emission and Combustion characteristics between pure diesel and Colton seed blends. The Cotton seed oil blends are in percentage of 0%, 10%, 20%, 30%, 40%, 50%and60% of Cotton seed oil to 100%, 90%, 80%, 70%, 60%, 50% and 40% of diesel. Results show that methyl esters of Cotton seed oil (CSOE) Exhaust emissions and Combustion characteristics of methyl esters of Cotton seed oil (MEON) were within limits. Hence methyl of Cotton seed blend can be used in existing diesel engines without compromising the engine performance.

In the present investigation, Cotton seed oil was considered as a potential alternative fuel for compression ignition engines. Specifications of the Cotton seed oil investigated and compared with other vegetable oils and this was the basic motivation behind the research in this project. The engine tests were earned out on a direct injection diesel engine fuelled with diesel fuel and 10%, 20%, 30%, 40%, 50% and 60% Cotton seed oil-diesel blends by volume.
The main Material i.e. Cottonseed Biodiesel can be made in laboratory. Biodiesel is renewable and environmental friendly alternative diesel fuel for diesel engine. It can be produced by trans-esterification process. Trans-esterification is a chemical reaction in which vegetable oils and animal fats are reacted with alcohol in the presence of a catalyst. The products of reaction are fatty acid alkyl ester and glycerin, and were the fatty acid alkyl esters known as biodiesel. Experiments were conducted when the engine was fuelled with Cotton Seed Oil and their blends with diesel in proportions of 20:80, 30:70 and 40:60 (by volume) which are generally called as CSO-20, CSO-30 and CSO-40 respectively. The experiment covered a range of loads.

The performance of the engine was evaluated in terms of brake specific fuel consumption, brake thermal efficiency and volumetric efficiency. The emission characteristics of the engine were studied in terms, concentration of HC and CO. The results obtained for Cotton Seed Oil and their blends with diesel were compared with the results of diesel.
While operating single cylinder air cooled diesel engine fuelled with Cotton Seed Oil and its diesel blends.

- The blends of Cotton Seed Oil show lowest specific fuel consumption than the diesel at part loads. B.S.F.C is decrease with the blend of CSO.
- Brake Thermal efficiency of the tested diesel engine is improved when it is fuelled with cotton seed oil-diesel blends.
- Mechanical efficiency of engine with CSO blends is higher compared to Diesel fuel operation is observed.
- Brake mean effective pressure is also increased as the percentage of the Cotton Seed Oil increases with the diesel. But this increment in Brake mean effective power is insignificant.
- Actual Breathing capacity of the engine also slightly increased which leads to increase in volumetric efficiency. It is noted that the volumetric efficiency is raised as the blend of the Cotton seed oil increases in the diesel.
- CO emission decrease with increase in percentage of Cotton Seed Oil in the fuel.
- HC emissions of Cotton Seed Oil and its diesel blends are lower than that of diesel.

III. CONCLUSION

From the analysis of above literature review the main conclusion is Cotton Seed oil and its diesel blends are suitable substitute for diesel as they produce lesser emissions than diesel up to a load of 3000W and have satisfactory combustion and performance characteristics. And also we can observe that Cotton Seed Oil blend of 50% gives better performance in various aspects, hence it is better to use CSO50 for optimum usage.

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