International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 2 Issue 5 ǁ May. 2014 ǁ PP.37-41

An Experimental and Analytical Study of Emission Characteristics of a Diesel Engine Fuelled With Cotton Seed Oil Methyl Ester and Petro-Diesel for Different Static Injection Timings

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ABSTRACT: *The engine emission characteristics of B100 Cotton Seed Oil biodiesel (Cotton Seed Oil Methyl Ester) and fossil diesel are presented. The engine tests are conducted on a Four Stroke Tangentially Vertical (TV1) single cylinder Kirloskar 1500 rpm water cooled direct injection diesel engine with eddy current dynamometer at nozzle opening pressure 230 bar maintained with different Static Injection Timings of 22^o, 23^o, 24^{o}bTDC throughout the experiment under steady state conditions at full load condition. From the test results, it could be observed that the Static Injection Timing of 22^{o}bTDC gives optimum lower emissions in each category of O_2 (% by volume), CO_2 (% by volume), CO (% by volume), Smoke Density (HSU), HC (ppm) and NO_x (ppm). The research finding shows that Static Ignition Timing of 22^o gives lowest emissions for both Cotton Seed Oil Methyl Ester and fossil diesel to operate diesel locomotives without any modification in existing diesel engine.*

Keywords: *Cotton Seed Oil; Biodiesel; Nozzle Opening Pressure; Static Injection Timing; Combustions; Emissions*

I. INTRODUCTION

The resources of petroleum as fuel are dwindling day by day and increasing demand of fuels, as well as increasingly stringent regulations pose a challenge to science and technology. Due to rapid increase in energy demand, developing countries spend their export income earned under severe conditions to buy petroleum products. So there is a very increasing importance for the substitution of these fossil fuels and biodiesel represents a promising alternative to petroleum diesel fuel. Researchers of I.C engine group have always focused towards engine performance and emission control in economical and environmental aspects. 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. In forth coming decades, the ecofriendly and vital biofuels will serve as an alternative for conventional petroleum fuel which will be under hectic shortage. A brief literature review of researchers is presented below. The Cotton Seed Oil Methyl Ester gives optimum performance compared to Neem Oil Methyl Ester [1]. The performance and emission control characteristics of various biofuels have been carried out [2, 3]. 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 sulfur content, flash point, aerometric content and biodegradability [4]. The diesel engine operation carried out with 1.4 dioxine-ethanol-diesel blends on diesel engines with and without thermal barrier coating and with blend ratio of 70% diesel, 20% ethanol and 10% dioxane blend gives better performance and lower emissions [5]. The B100 gives the lower emissions as compared to B0 in which the tests were carried out on a DI diesel engine fuelled with pure Mahua Oil Methyl Ester (B100) and neat diesel (B0) [6]. The Mahua Oil Methyl Ester (B100) burn more efficiently than diesel (B0) and the emissions of B100 is lower than that of B0 [7]. The neat Marroti Oil Methyl Ester (MOME) gives lower emissions like hydrocarbon and oxides of nitrogen as compared to neat diesel for all load conditions [8]. 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. In this paper an analysis of four stroke TV single cylinder DI with different nozzle opening pressures of 230 bar and with different Static Injection Timings of 22^o, 23^o, 24^o bTDC at full load condition of the diesel engine with eddy current dynamometer using B0 and B100 as fuel is presented.

II. MATERIALS AND METHODS

Characterization of the oil

The properties of the oil were first measured to determine if pretreatment is necessary or not before alkaline transesterification. It was found that the free fatty acid value of the oil is 0.23% by 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^{o} C and held constant for 30 minutes to allow some of the water to evaporate.

Transesterification Procedure

Generally, vegetable oils contain fatty acids (palmitic, stearic, olenic, linoleic, lingoceric, eicosenoic, arachidic and behenic). Of these, cotton seed oil contains the saturated fatty acids palmitic (hexadecanoic acid) and stearic (octadecanoic acid) and the unsaturated acids oleic (octadec-9-enoic acid) and linoleic (9, 12-octadecadienoic acid). The cotton seed oil is commercially available in the local market and is used as the raw material. Transesterification 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 transesterification process are methanol, ethanol, proponol 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 catalyst to yield biodiesel (Cotton Seed Oil Methyl Ester).

III. EXPERIMENTAL SETUP AND PROCEDURE

Experiments have been conducted on a 4 stroke kirloskar Tangentially Vertical single cylinder (TV1) direct injection (DI) diesel engine developing power output of 5.2 KW at 1500 rpm connected with water cooled eddy current dynamometer.

IV. RESULTS AND DISCUSSION

Oxygen Concentration:

The variation in emission characteristics for O_2 in % by volume for both B0 and B100 for different Static Injection Timing is shown in Figure 1. From this figure, it is seen that both B0 and B100 gives lowest emissions of O_2 in % by volume of 9.84 and 10.06 respectively for Static Injection Timing of 22^{o} bTDC under steady state condition. However, for Static Injection Timing of 23^{o} bTDC, the emission of O_2 for both B0 and B100 is comparatively higher and produce 11.24 and 10.76 % by volume respectively. The same trend is observed for Static Injection Timing of 24^{o} bTDC for B0 and B100 which produces 11.22 and 10.71 % of O_2 by volume respectively.

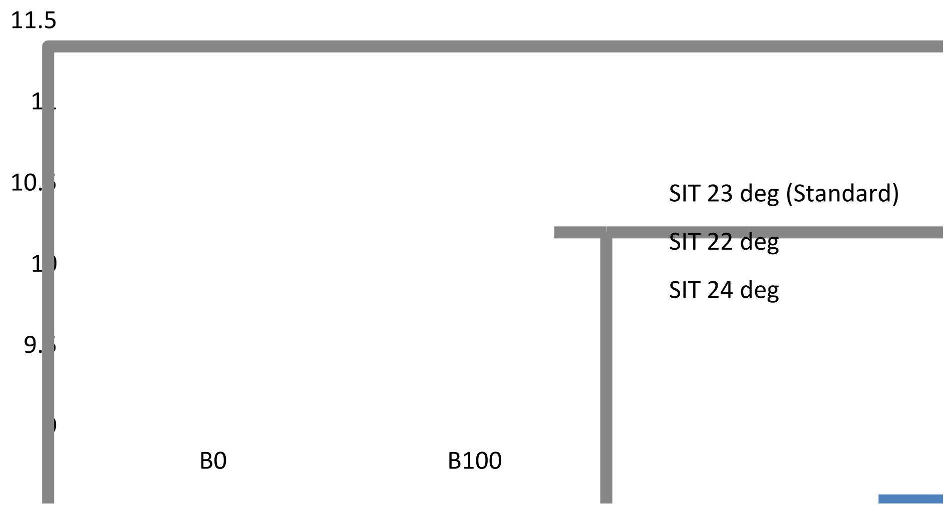

Figure 1: Oxygen Concentration vs Blend Ratio

Carbon monoxide:

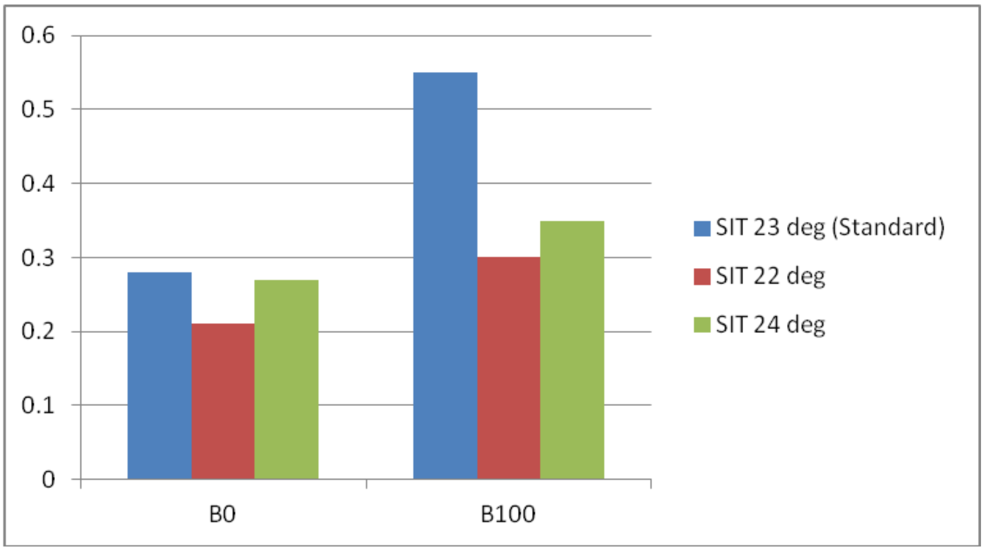

Figure 2: Carbon monoxide vs Blend Ratio

Figure 2 shows variation of CO emission characteristics. As it can be seen, both B0 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 B0 and B100 produce less CO emissions 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:

The variation for emission characteristics of CO_2 for both B0 and B100 is shown. CO_2 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 B100 fuels respectively. At Static Injection Timing of 23° and 24° bTDC, the CO_2 emissions are 7.6% and 7.9% for B0 respectively and 7.2% and 7.7% respectively.

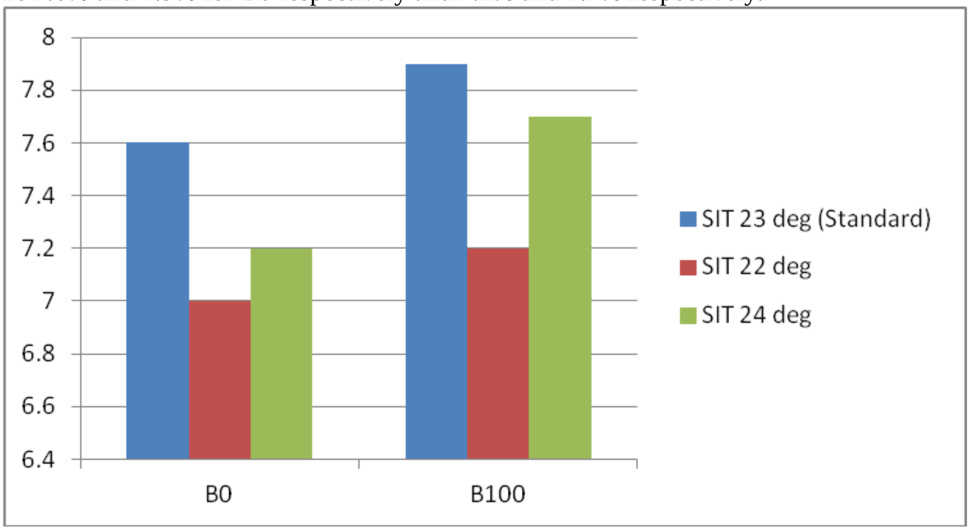

Figure 3: Caron-di-oxide vs Blend Ratio

Smoke Density:

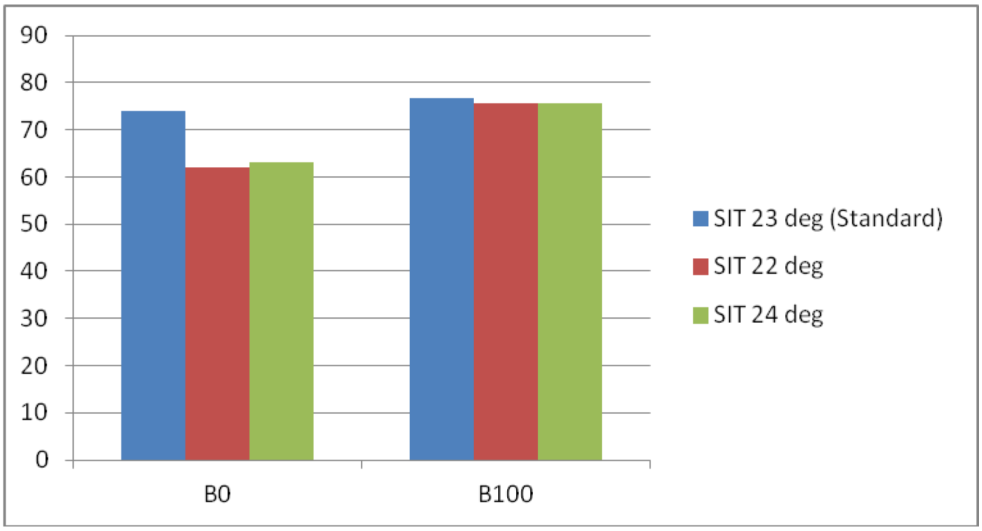

Figure 4: Smoke Density vs Blend Ratio

Figure 4 shows variation of Smoke Density over different Static Injection Timing of B0 and B100 fuels. It is observed that the Smoke Density remains almost the same for B100 fuel with 76.8 HSU, 75.5 HSU, and 75.6 HSU for Static Injection Timing of 23^o, 22^o and 24^o bTDC respectively. Whereas the Smoke Density reduces in case of B0 from 73.9 HSU at Static Injection Timing of 23^o bTDC to 62 HSU at Static Injection Timing of 22^o bTDC and 63 HSU at Static Injection Timing of 24^o 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 the Smoke Density. It is interesting to note that B0 emits lower smoke compared to B100 at Static Injection Timing of 22^o bTDC.

Hydrocarbon:

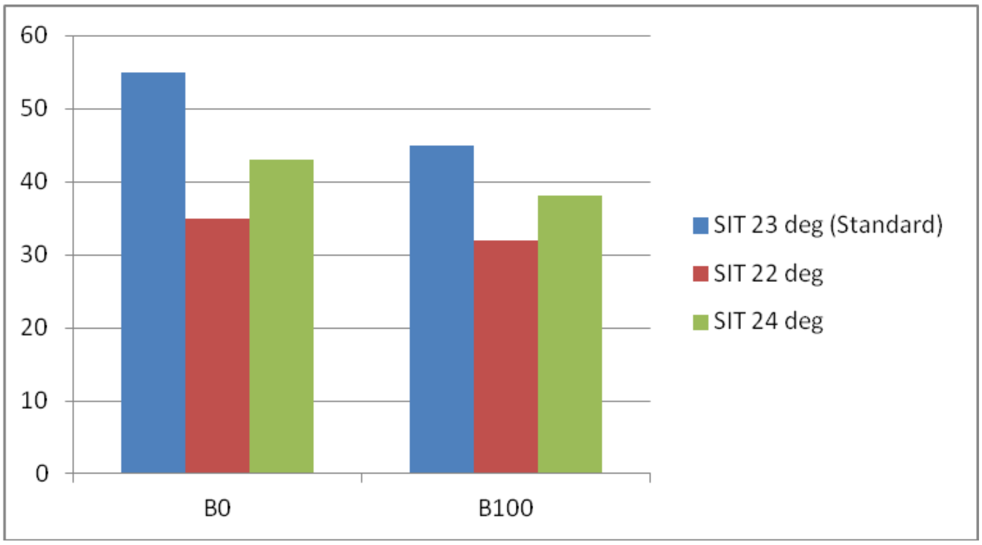

Figure 5: Hydrocarbon vs Blend Ratio

The variation of HC for B0 and B100 is shown for different Static Injection Timing in Figure 5. It is evident that the maximum HC is 55 ppm and 45 ppm for B0 and B100 fuels respectively at Static Injection Timing of 23^o bTDC. Static Injection Timing of 22^o bTDC has reduced HC figures as compared to other two Static Injection Timings of 23^o bTDC and 24^o bTDC.

Oxides of Nitrogen:

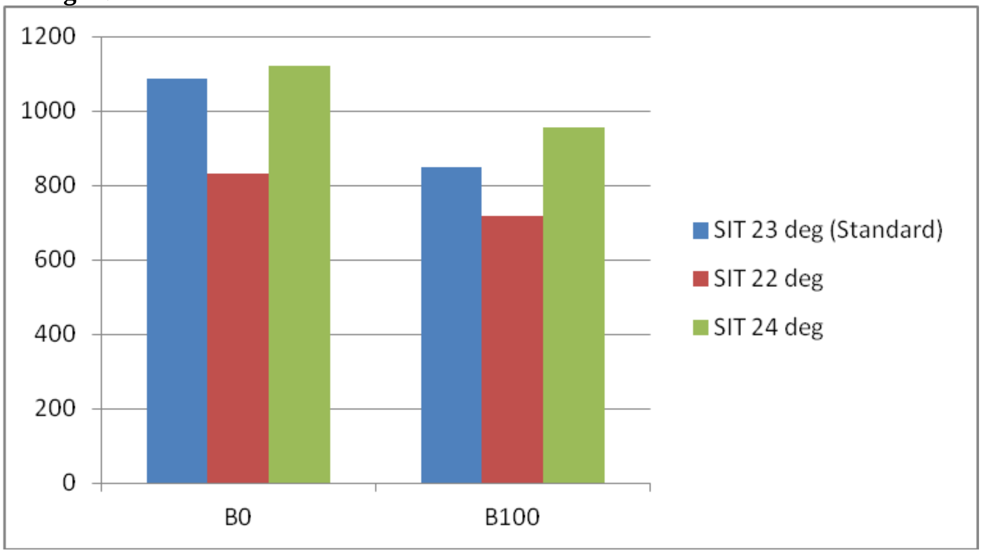

Figure 6: Oxides of Nitrogen variation

Figure 6 shows the variation in NO_x for both B0 and B100 fuels. From the figure, it is again evident that Static Injection Timing of 22^o bTDC has lower NO_x emissions for both B0 and B100 fuels with 830 ppm and 718 ppm respectively. The variation of NO_x is higher for Static Injection Timing of 24^o bTDC as compared to other timings. There is a greater % reduction in NO_x for Static Injection Timing of 22^o bTDC in both B0 and B100 cases.

V. CONCLUSIONS AND RECOMMENDATIONS

From this study, it could be concluded that Static Injection Timing of 22^o 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.

REFERENCES

[1] K Dilip Kumar and P. Ravindra Kumar, Experimental Investigation of Cotton Seed Oil and Neem Methyl Esters as Biodiesel on CI Engine, *International Journal of Modern Engineering Research, 2(4),* 2012, 1741-1746.

[2] Hanbey Hazar, and Huseyin Aydin, Performance and emission evaluation of a CI engine fuelled with preheated raw rapeseed oil (RRO) – Diesel blends. *Applied Energy 87,* 2010, 786-790.

[3] Deepak Agarwal, and Avinash Kumar Agarwal, Performance and emissions characteristic of Jatropha oil (preheated and blends) in a direct injection compression ignition engine. *Applied Thermal Engineering, 27,* 2007, 2314- 2323.

[4] Syed Ameer Basha, K. Raja Gopal, and S. Jebaraj, A review on biodiesel production, combustion, emissions and performance. *Renewable and Sustainable Energy* Reviews *13,* 2009, 1628-1634.

[5] C Sundarraj, S. Arul, S. Sendilvelan, and C.G Saravanan, Performance analysis of 1,4 dioxine-ethanol-diesel blends on diesel engines with and without thermal barrier coating, *Thermal Science, 14,* 2010, 979-988.

[6] N Saravanan, G. Nagarajan, S. Puhan, Experimental investigation on a DI diesel engine fuelled with Madhuca Indica ester and diesel blend, B*iomass and Bioenergy, 34,* 2010, 838-843.

[7] S Puhan, N. Vedaraman, G. Sankaranarayanan, V. Boppana and B. Ram, Performance and emission study of Mahua oil (madhuca indica oil) ethyl ester in a 4-S natural aspirated direct injection diesel engine, *Renewable Energy, 30,* 2005, 1269-1278.

[8] R Karthikeyan, Dr. C. Solaimuthu, and N. Balakrishnan, A Study of Performance and Emissions of Diesel Engine fuelled with neat Diesel and neat Hydnocarpus Pentandra biodiesel, *IOSR Journal of Mechanical and Civil Engineering, 10(2),* 2013, 53-57.