INFLUENCE OF COTTON SEED OIL OVER THE IGNITION DELAY, EMISSIONS AND PERFORMANCE OF A CI ENGINE

N. Srujana[1*], G. Bhanodaya Reddy[2], B. Narayana Reddy[3]

[1,2]Department of Mechanical Engineering, SV University College of Engineering, Tirupati

[3]Department of Mechanical Engineering, ChadalawadaRamanamma Engineering College, Tirupati

[1]saibhunnu@gmail.com, [2]bhanodayg@yahoo.com, [3]nari.biju@gmail.com

Abstract: *Rising petroleum derivative costs and ecological contamination with their utilization have brought expanded worldwide interest in biodiesel creation and use. The journey for bio-energy in this manner has been supported all through the world to care for the climate and substitute bio-diesel with petroleum products. The goal is to assess the seed oil of cotton and to utilize it as an elective fuel. Cottonseed oil has diesel-like fuel properties. Cottonseed oil is blended in with diesel in various extents viz 5%, 10%, 15%, 20%, and 25% experimented in a compression ignition engine. Bio-diesel is generated from cottonseed through a compound interaction called transesterification. With the petrol energizes right now known and their expanding interest for utilization, it is expected that they won't keep going long. By examination, the exhibition attributes give off an impression of being improved with the utilization of cottonseed oil for brake power, CO, HC, NO and NO_x emissions.*

Keywords: **Bio fuels, Cotton seed oil, Emission analysis, Injection events, Performance**

1. INTRODUCTION

As per Global Energy oil market report, IEA announced that, interest for the oil will increase almost by 1.3% in 2019 [1]. Oil based items will have higher in cost and contribute to the emission of harmful gases like CO, NO_x, CO_2 and HC. This inspires the specialists and researchers to search for an alternative source like biodiesel which plays a vital role for current and future generations. Biodiesel is the long chain fatty acid ester primarily obtained from vegetable oils. Biodiesel has similar characteristics to that of diesel. However, it can't be used in 100% quantities due to the presence of fatty substances so the transesterification process is needed to acquire biodiesel according to American Society for Testing and Materials (ASTM) principles. Biodiesel have some troublesome parameters like higher thickness, higher density and (Lower Heating Values) LHV. India has a potential and capacity to create sufficient vegetable oil not exclusively to meet its consumable oil prerequisites yet in addition for biodiesel creation. Yearly generation of cotton seed oil in India is 3 million tons [2]. A large portion of the environmental pollution is brought by the transportation sector and vigorously contributed by the diesel-based power systems. Such systems have an interesting issue, which contributes to the increased emission quantities, which is ignition delay [3]. Fuel should be quickly engulfed by the flame to deliver the ideal power. However, this isn't the situation with diesel motors. The fuel's sub-atomic properties should be evenly characterised to prevent any sort of undesired combustion characteristics particularly the knock and slow burning.

1.1 Objectives of the Research Work

An objective of the present research work is to identify the efforts of the author in outlining the emission characteristics of a stationary single compression ignition engine when blended with different proportions of diesel and cotton seed oil. The experiments were even carried out to identify the variations in engine performance for four different injection timings.

2. METHODOLOGY

Experimental methodology starts with the procurement of Cotton seed oil followed by measurement of its chemical properties, blending of process parameters (Cotton seed oil and Diesel), and ends with experimental investigation to determine Performance Parameters and emission characteristics.

2.1 Cotton seed oil

The processed cotton seed oil was considered and their Chemical properties were determined. The Cotton seed oil chemical properties are shown in the Table 1.

Table 1. Cotton seed oil properties [2]

Property	Value
Density (kg/m3)	909
Kinematic Viscosity at 40˚ (CST)	32.7
Calorific Value (MJ/kg)	40.3
Calculated Cetane number	42
Flash point (˚C)	234

2.2 Blending Process

The Table 2 shows the Diesel and cotton seed oil composition Blending percentages were orderly selected ranging from maximum diesel percentage and with uniform increment in mass of the cotton seed oil to observe the performance and polluting characteristics of the fuel. The sample concentrations are shown in the Table 2.

Table 2.Diesel and cotton seed oil composition

Sl.No.	Cotton Seed Oil (%)	Diesel (%)
1.	5	95
2.	10	90
3.	15	85
4.	20	80
5	25	75

2.3 Testing setup

The test arrangement utilized was a single cylinder compression ignition engine. The power unit was coupled to a eddy current dynamometer with a cantilever load cell. The experimenting setup was capable of variable injection timing and pressures. The injection pressures are of 180, 200 and 220 bar while the timings can be varied as 18˚, 22˚, 26˚and 30˚ BTDC. The testing experimental setup is shown in the Figure 1 and the Table 3 shows the Engine Specifications.

Figure 1. Experimental testing

Table 3. Engine Specifications

Make	Kirloskar Oil Engines Ltd.
Rated Power Output	7.5 kW @ 1500RPM, 10BHP
Stroke / Bore Ratio	116 mm / 102 mm
Stroke Volume :	948 CC
Compression Ratio	17.5:1
Loading	Eddy Current Dynamometer
Starting	By Hand Cracking

2.4 Emission gas detection

The gas measuring system was a QROTECH - 401 which can sense a total of five different gases (Figure 2. Gas Analyzer). They are CO, CO_2, HC, O_2 and NO_X. This sensing range of the equipment is 0-10% in volume of carbon dioxide and carbon monoxide, 0-9999 ppm of hydro-carbon, 0-22% in volume of oxygen and a maximum of 5000 ppm of nitrogen oxides.

Figure 2. Gas Analyser

3. EXPERIMENTATION

The fuel was mixed utilizing an Ana-lattice stirrer is shown in the Figure 3. Various blends were estimated in a beaker and the suitable rates were blended for 10 min at consistent speed [4]. The test was completed with five engine loads all with wide open throttle. The gas analyzing sensors were positioned at the exhaust manifold exit tip. The dynamometer load was adjusted according to the sample electrically once and the information was signed in the PC. In this manner all the samples were experimented on the motor.

Figure 3. Magnetic Stirrer

4. RESULTS AND DISCUSSION

The emission and thermal efficiency of the engine for different fuel samples are discussed in detail. The parameters are brake thermal efficiency, ignition delay, HC, NO_X,CO and CO_2.

4.1 Brake thermal efficiency

Brake Thermal Efficiency (BTE) is an immediate proportion of how well the fuel is delivering the energy and that even depends when it is delivering [5]. The accompanying figure 4 shows the efficiencies of all the five samples of test fuel and their efficiency characteristics at various injection timing of fuel. The highest and least efficiencies observed with these fuels are 36.5% being the highest while 15.2% was the least.

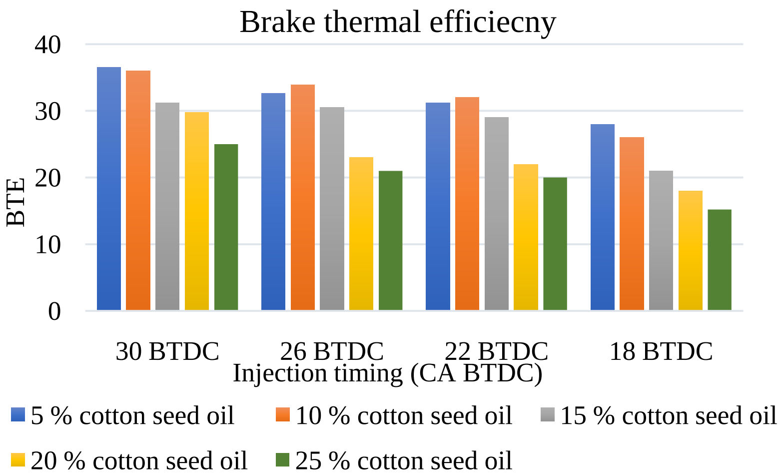

Figure 4. Brake thermal Efficiency

Though cotton seed oil thermal efficiency is comparably less than the standard diesel fuel, the difference was not significant enough to affect the performance (See the Figure 4). However, the blended fuels have higher emissions than that of diesel.

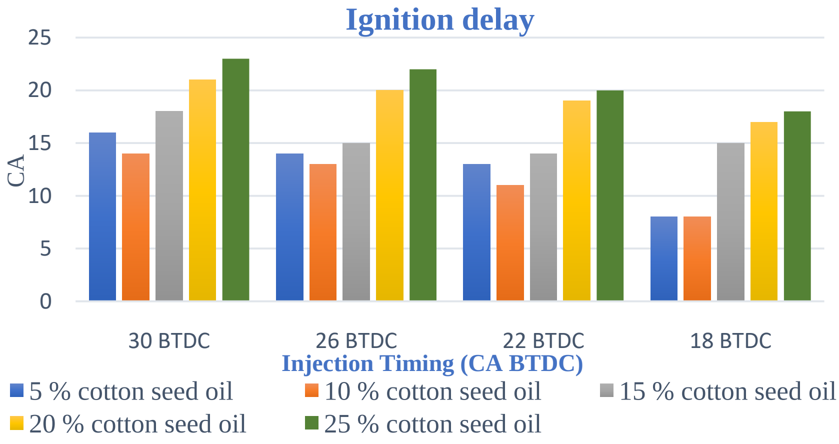

Figure 5. Ignition delay

As the cotton seed oil percentage becomes high in the fuel sample, the thermal efficiency reduces at injection timing of 26˚ and 22˚ BTDC, the fuel sample which has 10% cotton seed oil demonstrated better performance when compared to the 5% sample (Figure 5).

This is essentially in light of the fact that cotton seed oil in the sample helps in better combustion initiation of the fuel because of its calorific parameters being near to diesel fuel. Then again, the uniform mixing within the combustion chamber was fundamentally influenced by the cotton seed oil. Presence of cotton seed oil makes the atomisation difficult unlike diesel fuel. The brake thermal efficiency was significantly influenced by the ignition delay. As the injection timing was retarded the time available for proper atomisation and the charge distribution was affected. The injection event of 18˚ BTDC has least effectiveness contrasted with other sample runs. Contrastingly when the fuel was injected at much better advanced timings the thermal efficiencies showed an increasing trend, this is solely due to the atomisation and charge distribution time available. So, the injection timings whenever advanced have better performance parameters than the retarded timings.

4.2 NO_X Emissions:

From the Figure 6, Oxides of nitrogen are considered one of the most toxic emissions that come out a fossil fuel power unit. This is primarily because of its potential to cause acid rains when it reacts with ultraviolet rays. These are higher for retarded injection events than the advanced injection timing. The sample with the highest percentage of cotton seed oil emitted more NOX due to the availability of oxygen and this results in reaction with the nitrogen present in the combustion chamber [6]. This process is even accelerated by the exhaust gas temperature.

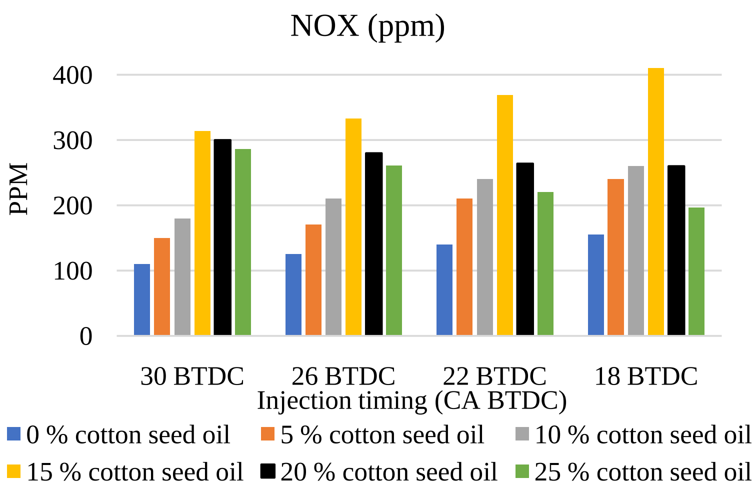

Figure 6.NO_X Emissions

4.3 HC Emissions

These emissions are due to the incomplete combustion of fuel. The left-over fuel particles that come out of the systems are known as hydro-carbon emissions.

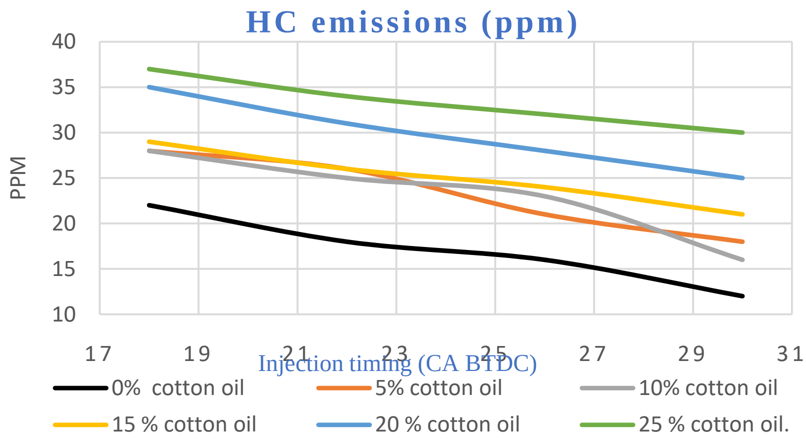

Figure 7. HC emissions

From the Figure 7, the main parameters that influence such emissions are the deficiency of oxygen in the combustion chamber, excessive amount of fuel sent into the system, improperly atomisation of fuel, cetane number of the blend. It can be observed from the graph that as the cotton seed oil percentage increased the emission also increased, this can be accounted for the effect of cetane number which is lower for the cotton seed oil. Samples with more than 10% have higher emission as the atomisation is severely affected by the presence of the cotton seed oil [7].

4.4 CO emissions

From the Figure 8, like the characteristics of hydrocarbon emissions carbon monoxide requires the accessibility of oxygen and deficient burning of fuel. In this manner, a comparative example can be set up between these two emissions. As the injection events are near to TDC it was evident from radical rise in carbon monoxide emissions, however increased cotton seed oil (15%, 20%, 25%) content increases the ignition delay period which later resulted in formation of carbon monoxide with the leftover oxygen which is primarily due to the increase in viscosity and density of cotton seed oil [8].

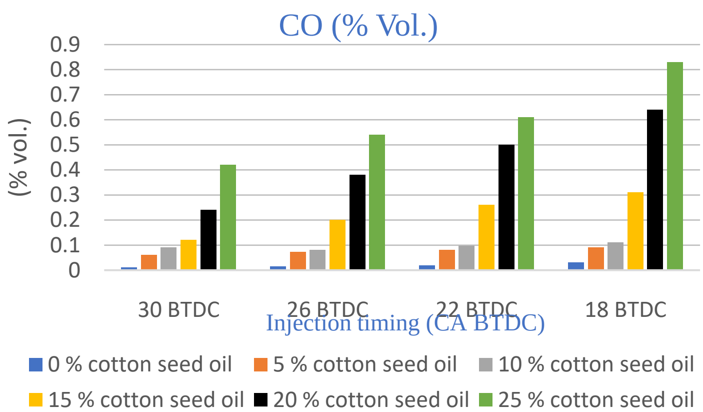

Figure 8. Carbon monoxide emissions

5. CONCLUSIONS

From the results it is apparent that brake thermal efficiency of the engine was not undermined by diluting the diesel with restricted amounts of cotton seed oil. Nonetheless, brake thermal efficiency is additionally profoundly impacted by the combustion delay. As the injection timings were advanced the emission quantities of various pollutants went down which can be noticed when comparing the injection events 30^o BTDC and 18^o BTDC. The non-uniform blending of fuel prompts inadequate burning and the generation of the toxic elements is initiated.

Acknowledgements

The authors would like to acknowledge the technical staff of Mechanical Engineering Department, S. V. College of Engineering, S V University, Tirupati for their help in this experimentation.

References

[1] *IEA, Oil Market Report – Topics – IEA,(2021), www.iea.org/oilmarketreport.*

[2] *M. Martin, V. Geo and B. Nagalingam, "Effect of fuel inlet temperature on cottonseed oil–diesel mixture composition and performance in a DI diesel engine", Journal of the Energy Institute, vol. 90(4), (2017), pp.563-573.*

[3] *M.Kaisan, F.Anafi,J.Nuszkowski,D. Kulla and S. Umaru, "Exhaust emissions of biodiesel binary and multi-blends from Cotton, Jatropha and Neem oil from stationary multi cylinder CI engine", Transportation Research Part D: Transport and Environment, vol. 53, (2017), pp.403-414.*

[4] *S.Kandasamy, A. Selvaraj and T.Rajagopal, "Experimental investigations of ethanol blended biodiesel fuel on automotive diesel engine performance, emission and durability characteristics". Renewable Energy, vol. 141, (2019), pp.411-419.*

[5] *S.Benjamin Franklin and R.Arul, "Experimental investigation on EGR technique and performance evaluation of diesel engine using diesel blend cotton seed oil as renewable fuel", Materials Today: Proceedings, (2020).*

[6] *V.Soloiu, J.Moncada, R.Gaubert, M.Muiños, S. Harp, M.Ilie, A.Zdanowicz and G. Molina, "LTC (low-temperature combustion) analysis of PCCI (premixed charge compression ignition) with n-butanol and cotton seed biodiesel versus combustion and emissions characteristics of their binary mixtures", Renewable Energy, vol. 123, (2018), pp.323-333.*

[7] *V.Mathan Raj, L.Ganapathy Subramanian and G.Manikandaraja, "Experimental study of effect of isobutanol in performance, combustion and emission characteristics of CI engine fuelled with cotton seed oil blended diesel", Alexandria Engineering Journal, vol. 57(3), (2018), pp. 1369-1378.*

[8] *K. Sundar and R. Udayakumar, "Comparative evaluation of the performance of rice bran and cotton seed biodiesel blends in VCR diesel engine", Energy Reports, vol. 6, (2020), pp. 795-801.*