Performance Combustion and Emission Characteristics of DI Diesel Engine Using Jojoba Oil

R.Sarsini[1], V. Vigneshwaran[1], K.Venkatachalam[1], R.Ashok Kumar[1]

[1] Department of Mechanical Engineering, SMK Fomra Institute of Technology, Chennai-603 103

Abstract

The higher cost of crude oil and its ability to produce a intended result in curbing the pollution of green house gases has made the scope for alternating fuel.Based on the availability the sources of the alternate fuels are categorized as mineral and biologicalfuels.This research work is the study of Jojoba oil (Simmondsiachinensis) had been used in diesel engine. The main aim of this research is to utilize the maximum proportion of jojoba oil and resulting diesel replacement in all modes of operation in C.I engine. Jojoba oil was used in CI engine as jojoba-diesel blends and the observations are studied for its performance, combustion and emission characteristics. From the experiments analysis, it was observed that the jojoba oil 30% by volume can be used to a maximum proportion in C.I engine. The jojoba-diesel blends more than 30% by volume had a poor performance and emitted unacceptable level of emissions.

Keywords: Jojobo oil, Heat Release Rate, Diesel engine, Emission,

1. Introduction

84% of the world's energy needs is arrived from crude oil. Due to cold war between the countries and unabundant availability of crude oil leads to find the alternate option for energy production. Nowadays the usage of fossil fuels and its requirements seems to be rising. At present, alternative fuel is a promising scope for automobile sectors and researchers are doing test very hard to find suitable oil for this issue. Many researchers are tirelessly working on this field and trying to find out a solution for this issue. But, still no fuel had been identified to replace diesel and gasoline completely from its application. This is mainly due to few of the unsuitable fuel properties and poor availability. Even though, the researchers are still having a greater hope on the plant oils. Plant oils are the best sources to replace diesel fuel completely from its application.

Jojoba plant is a perennial, evergreen, dioeciously; wind-pollinated shrub, reaching a height of 1-5 meters and having a long life span of 100 to 200 years. It is also known as goat nut, deer nut, pignut, wild hazel, quinine nut, coffee berry and gray box bush. The botanical name of

the Jojoba plant is “Simmondsiachinensis”. For the blends, there is slightly higher Brake Specific Fuel Consumptions and Brake Specific Energy Consumptions at low engine loads. Smoke emission is higher at low engine loads, but lower at high engine loads. Nitrogen Oxide emission is observed slightly lower at low engine loads and almost identical at high engine loads. Carbon Monoxide and Hydrocarbon emissions are higher under all range of engine loads for the blends.

The most important drawback of biodiesel fuel is cumbersome chemical reaction and manufacturing cost. By insisting their thought, the researchers are plan to apply biofuel into the diesel engine after suitable engine modifications. The engine that uses neat oil should have enough capability to combust heavier molecular structure without adverse loss of performance and emissions. Therefore, many modifications were suggested by the researchers while applying neat oil of higher Proportions in CI engine.

2. Experimental Setup

A single cylinder,direct injection, four stroke, water-cooled,3.8 kW, 2000 rpm, Kirloskar TV1C.I engine with eddy-current dynamometer was used as an engine test rig to conduct experimental investigation. The setup also consists of all kinds measuring facilities for measuring inputs and outputs. The inlet side of the engine consists of anti-pulsating drum, air temperature measuring device, air heater and an energy meter. Similarly, the outlet side of the engine consists of EGT indicator, gas analyzer and smoke meter. The fuel input was measured by burette and stop watch. The air consumption was measured by an anti-pulsating drum as well. The eddy-current dynamometer attached with the engine helps to measure and to vary the power output of the engine.

The setup also had a pressure pick-up and crank angle encoder to measure the combustion pressure at each degree of crank angle. The exhaust gas temperature and pollutant concentration were measured by EGT indicator and gas analyzer respectively. The smoke intensity was measured by an online smoke meter attached with the setup. The setup also had a computer system with DAQ facility to acquire cylinder pressure data. A Lab view based software called “engine soft” was used to acquire the cylinder pressure and crank angle data. This software was also used for calculating the heat release rate, rate of pressure rise and performance parameters. The specifications of the engine used for the experimental setup and its pictorial views are given in Table 1, Figure 1 and Figure 2 respectively.

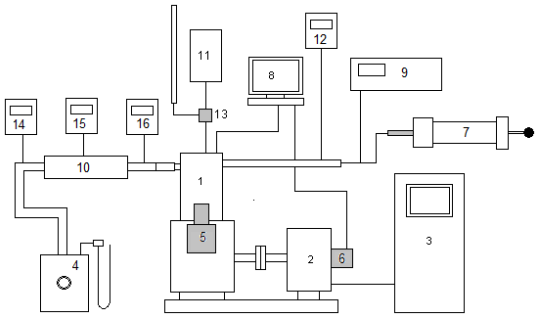

Figure No: 1 Schematic of the Experimental Setup

1 Diesel Engine, 2 Eddy current Dynamometer, 3 Dynamometer Control, 4 Anti-pulsating Drum, 5 Fuel Injection Pump, 6 Crank angle encoder, 7 Smoke sampler, 8 Computer with DAQ, 9 Gas Analyzer, 10 Air-preheater, 11 Diesel tank, 12 EGT indicator, 13 Two-way valve, 14 Air inlet temperature indicator, 15 Energy meter, 16 Air temperature indicator.

This work has used Jojoba oil as a test fuel. It has been used in neat and modified form to study the feasibility and performance of jojoba oil. The properties of such fuels are given below in Table 2.

Figure No: 2 Pictorial Views of the Experimental Setup

Table No: 1 Engine Specifications

Make and Model	Kirloskar TV1, Four stroke, compression ignition, constant speed, water cooled, direct injection
Number of cylinders	One
Bore	87.5 mm
Stroke	110 mm
Cubic capacity	661 cc
Compression ratio	17.5:1
Rated speed	1500 rpm
Rated output	4.4 KW
Fuel injection timing	23^0 BTDC
Injector opening pressure	180 bar

In this research 10, 20, 30 and 40% jojoba blends were admitted into the CI engine through regular fuel admission device of the CI engine. The engine used for this method has no special modifications. All blends were tested at all load conditions and its performance, combustion and emission parameters were observed at all load steps.

Table No: 2 Properties of Jojoba and Diesel

Properties	Diesel	Jojoba oil
Molecular Weight	200	606
Density (kg/m^3)	820	905
Specific Gravity	0.82	0.91
Boiling Point (^oC)	180-340	398
Viscosity(St)	4-5	22
Lower Heating Value (KJ/kg)	42,700	38,100

Flash Point(°C)	74	225
Flammability limit% Volume	1.0	1.0 – 5.2
Cetane Number	40-55	45-48

3.Results and Discussion

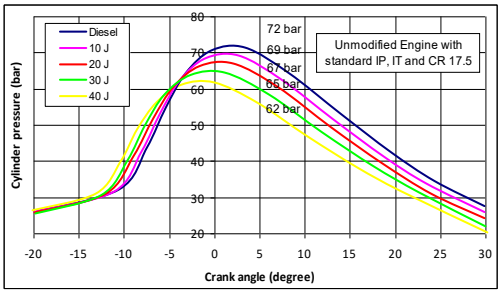

Figure No: 3 Variation of Cylinder Pressure with Crank Angle for Jojoba-Diesel Blends

Figure 3 clearly shows that 40J provides low cylinder pressure and it is 6.8bar and 9.5bar lower than 10J and neat diesel respectively. Likewise, 40J beginsexpansion at 11 degree BTDC, i.e. is 2and 4degrees before than 10J and diesel respectively. It is also noted that the peak pressure of all blends were lower than diesel fuel.

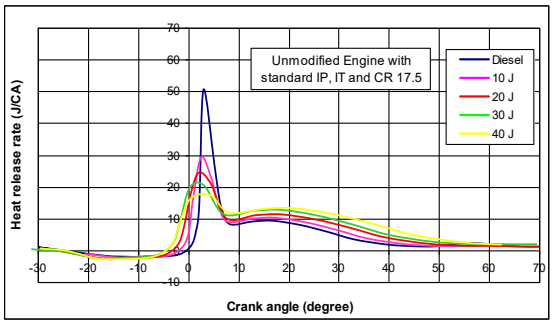

Figure No: 4 Variation of HRR with Crank Angle for Jojoba-Diesel Blends

The figure 4 clearly shows that 40J starts combustion at 10 degrees BTDC, which is 3 and 7 degrees earlier than 10J and diesel fuel respectively. It is also seen that the duration of combustion of 40J is longer than other blends and diesel fuel, which is 9 and 13 degrees longer than 10J and diesel fuel respectively.

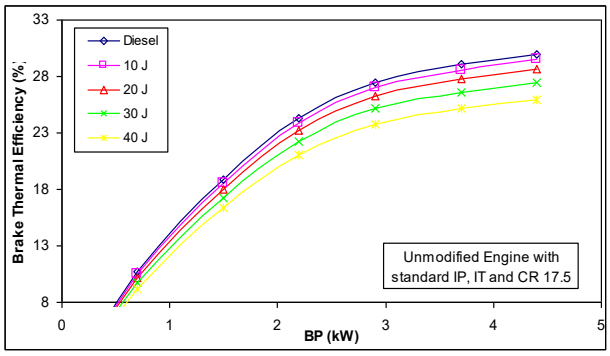

Figure No: 5 Variation of BTE with BP for Jojoba-Diesel Blends

Figure 5 shows the variation of Brake Thermal Efficiency with brake power for various proportions of jojoba-diesel blends. Generally, neat oils are heavier and viscous in nature and hence it requires longer time for completing its combustion. This particular behavior reduces the rate of heat release and consequently reduces BTE. However, this trend is indirectly proportional to the jojoba content of the blend. Hence, 40J offers lower BTE than other blends and diesel fuel. The higher viscosity of jojoba also influences the emission parameters and hence, the higher jojoba blends offer higher CO, HC and smoke emission. From the figure it is seen that 40J offers 26 % BTE at full load, which is 3 % and 4 % lower than 10J and diesel fuel respectively.

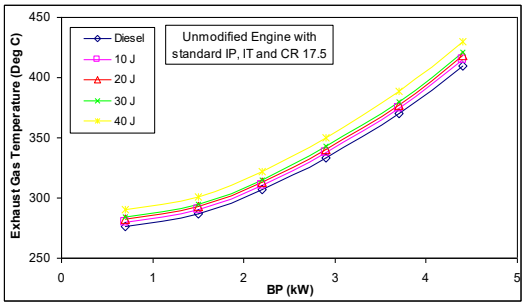

Figure No:6 Variation of EGT with BP for Jojoba-Diesel Blends

Figure 6 shows the variation of Exhaust Gas Temperature (EGT) with brake power for various proportions of jojoba-diesel blends.Generally, high viscous fuels affect spray parameters and reduce the rate of mixture preparation. This effect reduces the rate of heat release and extends the duration of combustion. Hence, the fuel blend that possess higher fraction of jojoba offers higher EGT. The secondary combustion occurs at the tail-end of the expansion was also one of the reasons for the higher EGT of higher jojoba blends. Figure shows that 40J offers 430^{0}C EGT, which is 15 and 20 degrees higher than 10J and diesel fuel respectively.

Figure 7 shows the variation of Carbon monoxide emission (CO emission) with brake power for various proportions of jojoba-diesel blends. From the figure it is seen that the CO emission is directly proportional to the jojoba content of the blender, higher jojoba blends emit more CO and lower blends emit less CO.

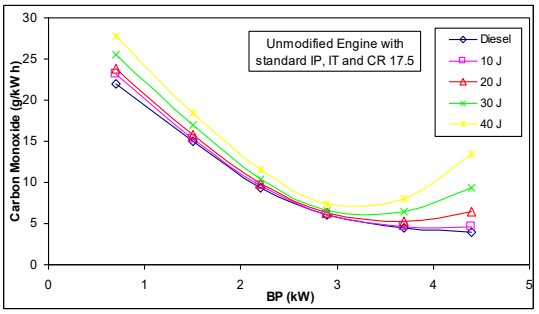

Figure No: 7 Variation of CO Emission with BP Jojoba-Diesel Blends

Figure 8 shows the variation of Hydrocarbon emission (HC emission) with brake power for various proportions of jojoba-diesel blends. From the figure it is seen that 40J emits 0.5g/kWh HC emission at full load and it is 42% and 38% higher than 10J and diesel fuel respectively.

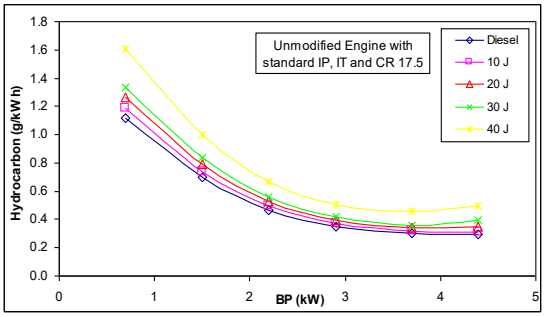

Figure No: 8 Variation of HC Emission with BP for Jojoba-Diesel Blends

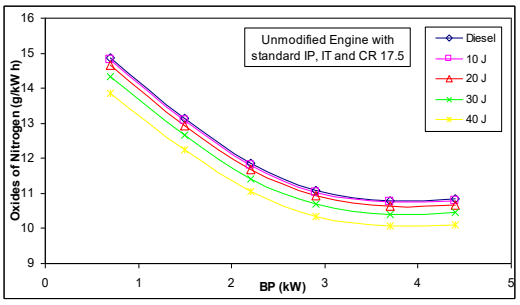

Figure No: 9 Variation of NO_x Emission with BP for Jojoba-Diesel Blends

Figure 9 shows the variation of Oxides of Nitrogen emission (NO_x emission) with brake power for various proportions of jojoba-diesel blends. From the figure it is found that the increase in jojoba proportion decreases NO_x emission. Generally, Nitrogen reacts after 1000C and produces oxides of nitrogen. The production of nitrogen oxides is directly proportional to the combustion temperature. Hence, the blend that offers higher combustion temperature produces higher NO_x emission. From the previous results it was found that the blend that carries lower proportion of jojoba offers higher combustion temperature than its counterpart. Hence, the blend that carries higher proportion of jojoba emits lower NO_x emission than lower jojoba blends.

4. Conclusion

As per the procedure the experiments were conducted and the following major conclusions are arrived. Based on the experimental results it is found that (jojoba –diesel blends) has permitted 30% jojoba oil through diesel fuel with 7% lower BTE, 96% higher CO, 45.5% higher HC, 4.6% lower NO_x and 22.4% higher Smoke than diesel fuel used in the normal engine. However, it is 3.5% higher BTE, 17% lower CO, 77.8 % lower HC and 12% higher NO_x Smoke than neat jojoba oil (100% jojoba oil) used in the normal engine.

From the above investigation, it was found that the blend 30J has performed well in normal CI engine in-terms of performance, combustion and emission characteristics. Hence, the blend 30J was fixed as the maximum blend and 30% neat jojoba oil can be applied in normal CI engine without adverse loss of performance and emission. The blend more than 30J was unable to perform well and emitted unacceptable level of smoke and other emissions.

5.References

1. Bohl, T, Tian, G, Zeng, W, He&Roskilly 2014, ‘Optical investigation on diesel engine fueled by vegetable oils’, Energy Procedia, vol.61, pp.670-674.
2. Chiariello, F, Allouis, C, Reale, F&Massoli, P 2014, ‘Gaseous and particulate emissions of a micro gas turbine fueled by straight vegetable oil – kerosene blends’, Experimental Thermal and Fluid Science, vol.56, pp.16-22.
3. Eliezer Ahmed Melo – Espinosa, Ramon Piloto – Rodriguez, Leonardo Goyos – perez, Roger Sierens& Sebastian Verhelst 2015, ‘Emulsification of animal fats and vegetable oils for their use as a diesel fuel: An overview’, Renewable and Sustainable Energy Review, vol.47, pp.623-633.
4. Gaurav Dwivedi&Sharma, MP 2014, ‘Potential and limitation of straight vegetable oils as engine fuel – An Indian perspective’, Renewable and Sustainable Energy Review, vol.33, pp.316-322.
5. Ghani, JA, Choudhury, IA & Hassan, HH 2004, ‘Application of Taguchi method in the optimization of end milling parameters’, Journal of Materials Processing Technology, vol. 145, pp. 84-92.
6. Gurrappa, I &Sambasiva A Rao 2006, ‘Thermal barrier coatings for enhanced efficiency of gas turbine engines’, Surface & Coatings Technology, vol.201, pp.3016-3029.
7. Hu Li, Patrick Biller, Seyed Ali Hadavi, Gordon E Andrews, Grezegorz Przybyla & Amanda Lea-Langton 2013, ‘Assessing

combustion and emission performance of direct use of SVO in a diesel engine by oxygen enrichment of intake air method', Biomass and Bioenergy, vol.51, pp.43-52.

8. Amir Khalid, NorrizalMustaffa, Manshoor, B, HanisZakaria, Ahmad JaisAlimin, Mutalib Leman &Sadikin, A 2014, 'The comparison of preheat fuel characteristics of biodiesel and straight vegetable oil', Applied Mechanics and Materials, vol.465-466, pp.161-166.
9. Antolin, G, Tinaut, FV, Briceno, Y, Perez, C & Ramirez, AI 2002, 'Optimisation of biodiesel production by sunflower oil transesterification', Bioresource Technology, vol. 83, pp. 111-114.