Taylor & Francis
Taylor & Francis Group

International Journal of Ambient Energy

ISSN: 0143-0750 (Print) 2162-8246 (Online) Journal homepage: http://www.tandfonline.com/loi/taen20

Experimental Investigation of Injection Timing on the Performance and Exhaust Emissions of a Rubber Seed Oil Blend Fuel in Constant Speed Diesel Engine

N. Karthik, R. Rajasekar, R. Siva & G. Mathiselvan

Publisher: Taylor & Francis & Informa UK Limited, trading as Taylor & Francis Group

Journal: *International Journal of Ambient Energy*

DOI: 10.1080/01430750.2017.1392353

Experimental Investigation of Injection Timing on the Performance and Exhaust Emissions of a Rubber Seed Oil Blend Fuel in Constant Speed Diesel Engine

N. Karthik[1], R.Rajasekar[2], R.Siva[3], G.Mathiselvan[4]

[1, 2, 3,4]Assistant Professor, School of Mechanical Engineering,
Sathyabama University, Chennai, India.
nkarthikme@gmail.com

Abstract

An experimental study is conducted to evaluate the use of rubber seed oil with diesel at proportion of 20% by volume (RSO20) in a constant speed (1500 rpm) direct injected four stroke air cooled single cylinder CI engine at different injection timing (24°,27°,30°,33° bTDC) . The series of test were conducted at various engine load conditions at the rated power of 5.9 kW. The injection pressure maintained at 200bar. As a result of investigations, at full load condition, the brake thermal efficiency of RSO20 at 30° bTDC, is high compared with other injection timings and brake energy fuel consumption is increased when advancing injection timing. There is significant reduction in unburned hydro carbon emission (UHC) and Carbon monoxide emission (CO) and the Oxides of Nitrogen emission (NOx) is increased, when advancing the injection timing.

Keywords: Biodiesel, Rubber seed oil, Injection timing, Performance, Emission

Introduction

Vegetable oil esters are non–toxic, biodegradable, and renewable alternative diesel fuel. These esters are known as "biodiesel." Many researchers have reveals that the properties of biodiesel are very close to those of diesel fuel. Therefore, biodiesel can be used in diesel engines with or without engine modifications. It has higher cetane number than petroleum diesel fuel, no aromatics, and contains 10% to 11% oxygen by weight [3, 5]. Zhu et al (2012) found that, when the engine injection timing retarded NOx emission was reduced but other emissions like CO, THC, DME and CH_2O were increased.Cenk Sayin et al. (2010) changed the injection pressure and injection timing in the compression ignition engine. The experiment result showed that there were reductions in smoke opacity, CO, THC emissions while NO_x emissions were increased. Jaichandar.S et al (2012), conducted experiments in a single cylinder DI diesel engine using B20 blend (pongamia oil methyl ester) as fuel. The results showed that BTE increased by 5.64 % , BSFC decreased by 4.6%, Nox increased by 11% due to better air-fuel mixing and retarded injection timing. Cenk Sayin and Mustafa Canakci (2009) studied the influence of injection timings the performance and exhaust emissions of a single cylinder diesel engine at 21°, 24°, 27°, 30° and 33° bTDC on using Diesel,B10,B15. Ethanol was used as biofuel. When injection timing changed from 27° bTDC to 21°bTDC, UHC and CO emissions were increased. For 30°bTDC and 33°bTDC, the HC and CO emissions were decreased and NO_2 and CO_2 emissions were increased. Venkanna et al [10] investigated a diesel engine using rice bran oil/diesel fuel blend (B5, B20, B50, and B100 from 0% to 100% load conditions. When compared with diesel, the NOx emission was increased by 26.27% 35.27%, 43.42%and 45.62% respectively

Table 1.The test engine specifications

Bore	87.5mm
Stroke	110.0mm
Speed	1500(constant speed)
Compression ratio	17.5:1
Rated power	4.4 kW
Number of cylinders	One
Type of cooling	Air cooled - eddy Current dynamometer
Injector opening	21°BTDC
Pressure	220 bar
No. of stroke	4 stroke

Table 2 Properties of fuels used in the experiment

Property	Rubber seed oil
Sp. Gravity	0.82

Viscosity at $40^0C(mm^2/s)$	4.2
Calorific Value (KJ/kg)	37000
Carbon residues (%)	0.19

Experimental setup and test procedure

A single cylinder, four-stroke CI engine is selected to evaluate the performance and emission characteristics using Diesel and Biodiesel as fuel. The specifications of the engine are given in Table1.The properties of test fuels are given in Table 2. The experimental setup has been shown in Figure 1. Two separate tanks (one for biodiesel, one for diesel) were provided in order to supply fuels to the test engine. An electric dynamometer with capacity of 4.4kW is coupled with test engine. The fuel properties can be found in Table 2. The tests were conducted with the condition of 220 bar injection pressure and 21° BTDC ignition timing. To analyse the performance and emission characteristics, initially the test was conducted using Diesel to provide baseline data then the test was conducted using biodiesel. The performance test was carried out for 0%, 25%, 50%, 75% and 100% load condition. An AVL model gas analyzer was used to measure carbon dioxide (CO_2) and carbon monoxide (CO) in percentage volume (%vol) and Unburnt hydro carbon (UHC) and Nitric Oxide (NOx) in parts per million(ppm).

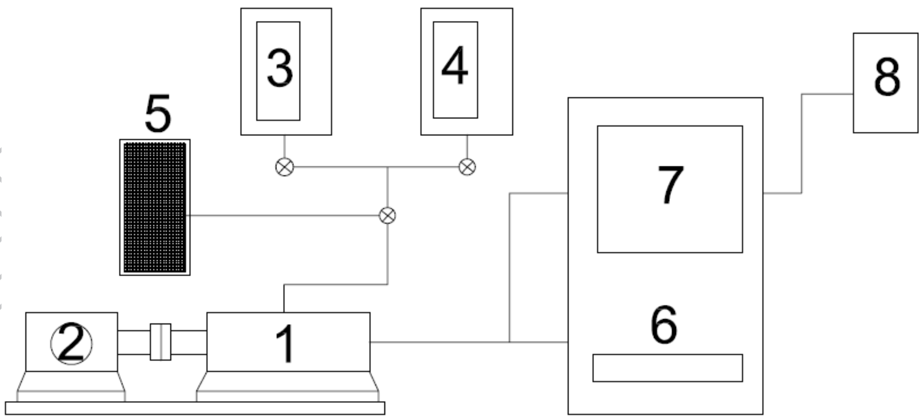

Figure: 1 Experimental setup

1. Engine 2.Alternator 3.Diesel Tank 4. Air inlet 5. Biodiesel tank 6. AVL meter 7.Display 8.Smoke Meter

Result and Discussion:

Brake thermal efficiency (BTE)

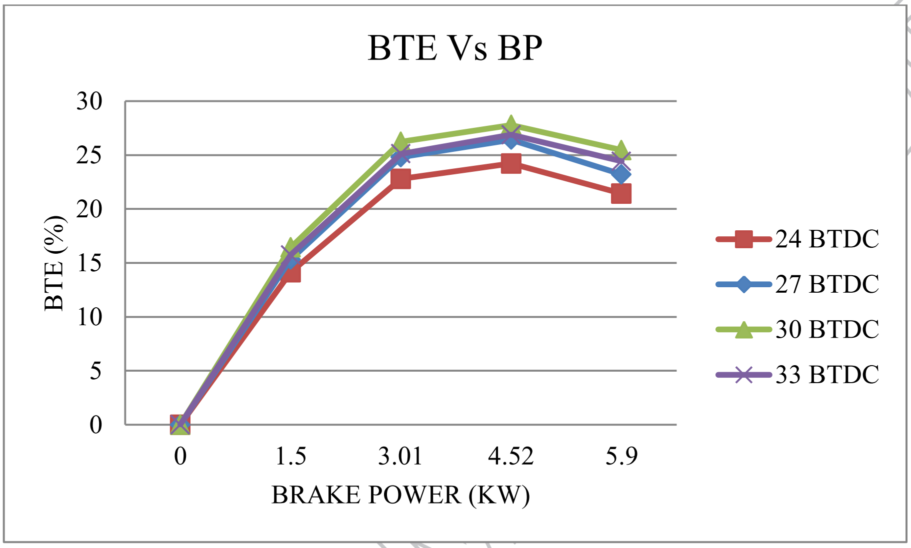

Figure: 2 Brake Thermal Efficiency of RSO20 blend at different injection timing with respect Brake power

Figure 2 shows that the advance injection timing increases the brake thermal efficiency of RSO20 blends when compared to standard injection timing (27° bTDC). When injection timing is retarded, the brake thermal efficiency decreases. For RSO20 blend at 24° bTDC, the brake thermal efficiency decreased by 2.07% when compared to RSO20 blend at 27° bTDC. This may be due to poor mixture formation which results in incomplete combustion. Injection timing advanced to 30° bTDC, the brake thermal efficiency of RSO20 blends increases by 1% when compared to standard injection timing at full load condition. For 33° bTDC injection timing, the brake thermal efficiency increases by 0.33% at full load condition when compared to standard injection timing at full load condition. For RSO20 blend at 30° bTDC, the maximum brake thermal efficiency was obtained when compared to other injection timing. This may be due to chemically correct fuel-air mixture which results in better combustion.

Brake specific energy consumption:

Figure 3 shows the variation of brake specific energy consumption with brake power for RSO20 at different load condition at various injection timing. The BSEC indicates the ability of the combustion system to accept the experimental fuel, and provides comparable means of assessing how efficiently the energy in the fuel was converted into mechanical output. For RSO20 blend, the BSEC decreases with increase in brake power. The BSEC for RSO20 at 33° bTDC is 14731kJ/kW-hr and at 30° bTDC is 14341kJ/kW-hr for 24° bTDC is 14127kJ/kW-hr. The increase in BSEC for RSO20 is due to lower calorific value of biodiesel.

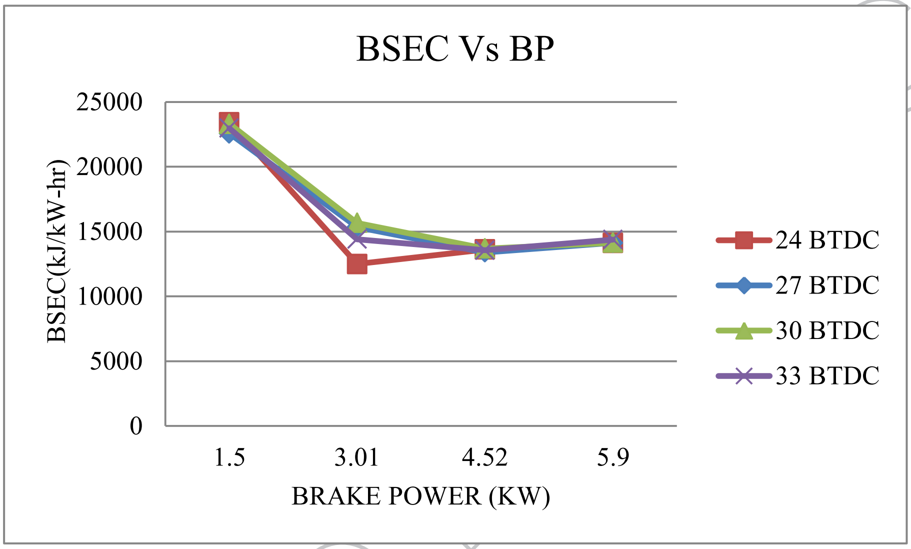

Figure: 3 Brake specific energy consumption of RSO20 blend at different injection timing with respect Brake power

Unburned Hydrocarbon Emission (UHC):

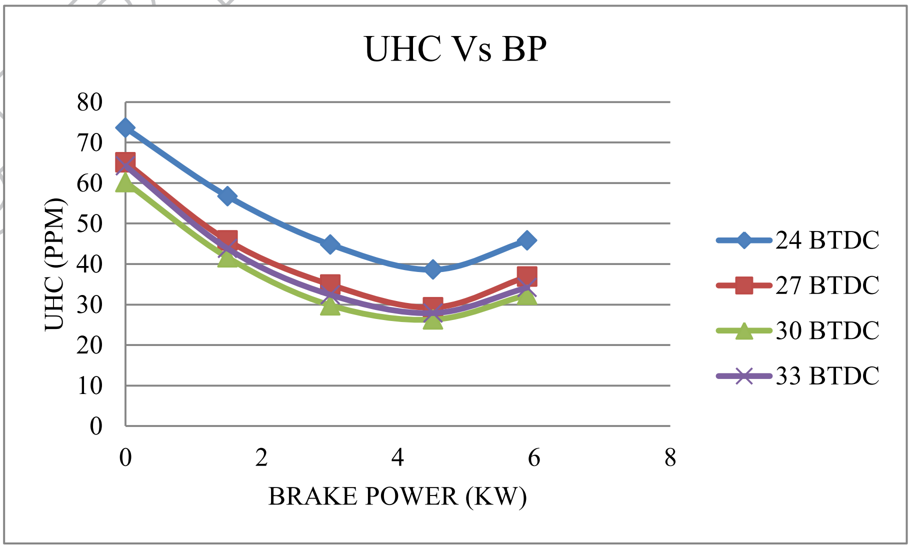

Figure: 4 Unburned Hydrocarbon emission of RSO20 blend at different injection timing with respect Brake power

Figure 4 shows the comparison of UHC emissions for RSO20 blend at different injection timings. The experimental result shows that the UHC emission increases when injection timing is retarded and decreases when injection timing is advanced. For RSO20 blend at 24° bTDC, the UHC emission increased by 11.25% compared to RSO20 blend at 27° bTDC. This may be due to under-mixing, some fuel particles in the fuel-rich zones never react due to lack of oxygen. The UHC emission decreases by 12.1% for RSO20 blend at 30° bTDC and 7.31% for RSO20 blend at 33° bTDC when compared with standard injection timing. This may be due to over-mixing of air fuel mixture formation which results in lean combustion.

Carbon monoxide emission (CO)

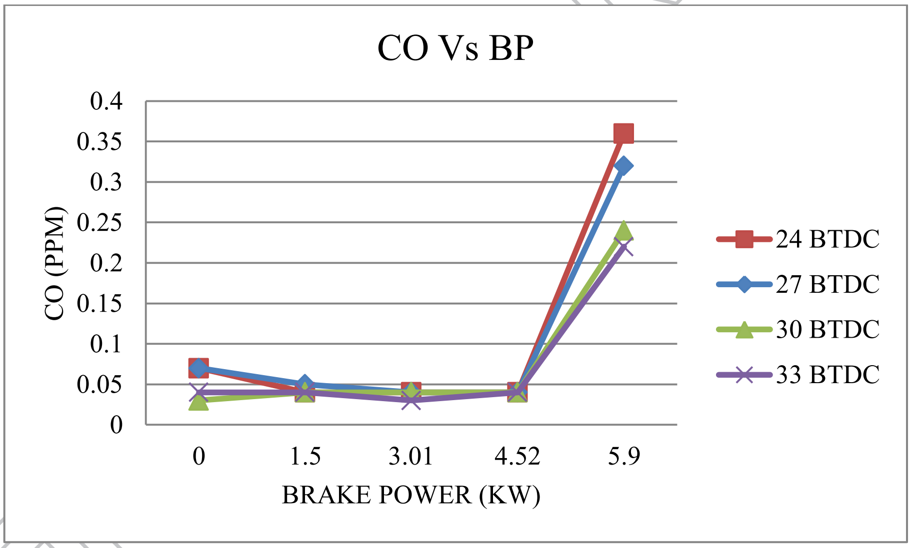

Figure: 5 Carbon monoxide emission of RSO20 blend at different injection timing with respect Brake power

Figure 5 shows the variation of carbon monoxide (CO) emission with brake power. The CO emission is maximum for 24° bTDC and minimum for 33° bTDC and optimum for 30° bTDC. This may be due to complete combustion takes place because of oxygen in the blend. When the injection timing is advanced leads to higher cylinder temperature and superior oxidation process between oxygen and carbon molecules which tend to decrease in CO emission. When the injection timing is re- tarded the amount of fuel burned is increased and decreased in consequent diffusion combustion phase and premixed combustion phase respectively. This leads to rich mix- ture environment and incomplete combustion resulted in CO emission enhancement.

Oxides of nitrogen emissions (NOx):

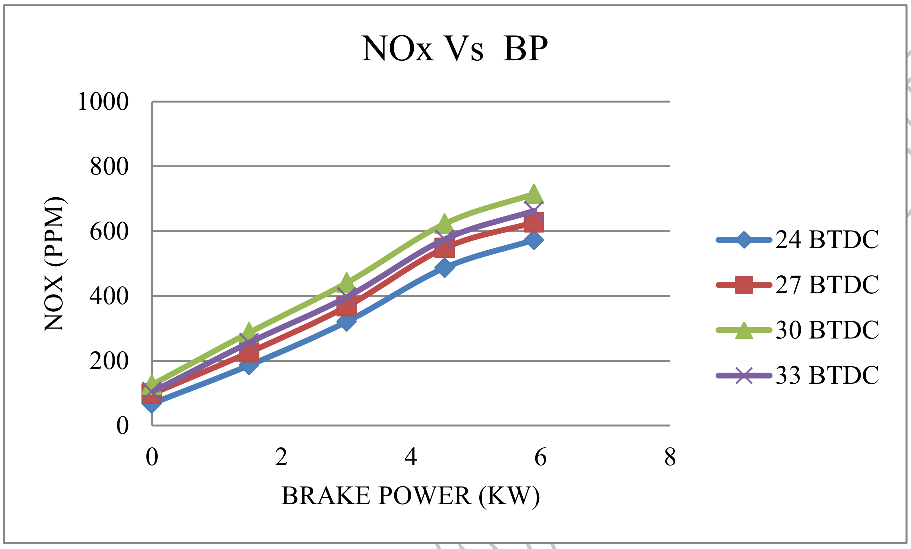

Figure: 6 Oxides of nitrogen emissions of RSO20 blend at different injection timing with respect Brake power

Figure 6 shows the comparison of NO_x emissions for RSO20 blend at different injection timings. The advancement of injection time enhances the NO_x emissions whereas retarding the injection help reduce the same. For RSO20 blend at 24° bTDC, the NO_x emission decreases by 8.93% when compared to RSO20 blend at 27° bTDC. This may be due to low flame temperature due to poor combustion. The NO_x emission increased by 14.03% for RSO20 blend at 30° bTDC and 5.74% for RSO20 blend at 33° bTDC, the maximum NO_x emission was obtained when compared to other injection timings. This may be due to the higher flame temperature due to stoichiometric fuel-air ratio. For RSO20 blend at 33° bTDC, the NO_x emission was decreased by 7.27% when compared to RSO20 blend at 30° bTDC. This may be due to rich fuel-air mixture formation which results in lower combustion.

Conclusion

The experimental investigations on the performance and emission characteristics of a constant speed(1500 rpm) direct injected four stroke air cooled single cylinder CI engine a diesel engine, fuelled with rubber seed oil biodiesel blend at proportions of 20% by volume (RSO20) at different injection timing(24°,27°,30°,33° bTDC). The following conclusions can be drawn from the analysis of the results obtained during the investigation.

- The use of rubber seed biodiesel in a conventional diesel engine increases its brake thermal efficiency when advancing the injection timing at full load condition.
- BSEC increases when advancing the injection timing
- While advancing the injection timing, CO and UHC emissions are decreased due to higher cylinder temperature and superior oxidation process between oxygen and carbon molecules.
- The advancement of injection time increases the NO_x emissions due to to the higher flame temperature due to stoichiometric fuel-air ratio, whereas retarding the injection help reduces NOx emission due to low flame temperature due to poor combustion.

References

1. Cenk Sayin, Ahmet Necati and Ozsezen Mustafa (2010), "The Influence of Operating Parameters on the Performance and Emissions of a DI Diesel Engine using Methanol-Blended-Diesel Fuel", Fuel, Vol.89, pp.1407-1414.
2. Cenk Sayin, and Mustafa Canakci (2009) "Effects of injection timing on the engine performance and exhaust emissions of a dual-fuel diesel engine", Energy Conversion and Management, Vol. 50, pp 203–213.
3. Graboski MS, McCormick RL., "Combustion of fat and vegetable-oil derived fuels in diesel engines". Progress in Energy and Combustion Science vol.24, pp.125-64, 1998.
4. Jaichandar.s., Senthil Kumar.P., and Annamalai.K. (2012) "Combined effect of injection timing and combustion chamber geometry on the performance of a biodiesel fueled diesel engine, Energy 47 388e394.
5. Mustafa C., Van Gerpen J. H., "Comparison of Engine Performance and Emissions for Petroleum Diesel Fuel, Yellow Grease Biodiesel, and Soybean Oil Biodiesel", Transactions of the ASAE, Vol. 46, pp. 937–944, 2003.
6. Venkanna.B.K, Reddy.C.V,2009,"Performance, emission and combustion characteristics of direct injection diesel engine running on rice bran oil/diesel fuel blend. Int J ChemBiomolEngg, Vol.2, pp.131–137.

7. Zhu Z., Li D.K., Liu J., Wei Y.J. and Liu S.H. (2012), "Investigation on the Regulated and Unregulated Emissions of a DME Engine under different Injection Timing", Applied Thermal Engineering Vol-35, pp. 9-14.