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Effect of injection timing on emission analysis of a constant speed diesel engine running on biodiesel fuelled with pure diesel fuel.

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ABSTRACT

In the development of alternative, biodegradable, and renewable fuels used for internal combustion (IC) engines to obtain the power. Therefore, in this present study, influence of fuel injection timing on the exhaust emission of a single cylinder, four stroke, and direct injection(DI) diesel engine was considered. It has been experimentally investigated using rubber seed and jatropha seed oil blended diesel fuel from 20%(B20)to 40%(B40) with an increment of 10%. The engine was tested at different loads from no load to full load conditions with diesel fuel at normal injection pressure of 220 bar and fuel injection timing of 24^{0}CA BTDC. The experimental tests were performed at 21^{0}CA BTDC injection timings by changing the thickness of advance shim. The experimental results obtained show that CO and UHC emissions were decreasedfor the proportion of B20,NOx and exhaust gas temperatureincreased with increasing amount of biodiesel concentration in the fuel mixture.

Keywords: *Performance, Biodiesel, Injection Timing, Diesel fuel, Emission, Diesel engine.*

1. INTRODUCTION

Most of the power producing machine use petroleum fuels which are limited and estimated to be exhausted in future years. The best alternative solution is a natural source of straight pure vegetable oils can be used as substitute fuels in diesel engines which run to produce powerbecause of their muchclosed cycle of physical and chemical properties. They are also eco-friendly, non-toxic, safe in storage and easy totransportation. Higherthermal efficiency and lower fuel costs makes diesel engines clear choice in applications requiring relatively large amounts of power such as in ships, heavy earth movers and power generation sectors. In general, compression ignitions (CI) have higher thermal efficiencies and formation of nitrogen oxides (NO) emission due to higher compression ratios.R. Adnan [1] was studied the engine performance increased whenwater injected from 20 BTDC to 200 ATDC with injection duration of 20^0 CA and 40^{0}CA.It also obtained that water injection timing of 20^0 ATDC and duration of 20^0 CA has shown better engine efficiency due to increased gross indicated work and indicated thermal efficiencywith lowest NO concentrations. Likos[2] examined the emission characteristics of DI diesel engine when using 10%, 20%, 30% ethanol blended pure diesel fuel. The test result was effective power and NO emissions increased and CO and UHC emissions decreased with the increasing of ethanol concentrationamount in the fuel mixture. However, in this work, performance of engine has not been considered. Can et al. [3] studied the effect of ethanol blended with diesel fuel by volume basis on the performance and emissions of a turbocharged indirect injection compression ignition (CI) engine and found exhaust emissions CO and SO_2 reducedand it caused an increase in NO emissions and power reductions. Many types of alternative fuels have some other disadvantages such as higher viscosity with lower volatility and lower heating value when compared to pure diesel. This can lead to the low atomization and mixture concentrations with air that result in slower combustion, lower thermal efficiency and higher emissions [4-5]. Natural gas contains large amount of methane with less percentages ethane, propane, and butane. However, biogas consists ofmethane and CO_2 (about 60% methane and 40% carbon dioxide) and has lower calorific value than natural gas. Methane in biogas mixes readily with air and has high octane number with high heating valves, making it a suitable fuel for spark ignition (SI) engines. The heat energy utilization of biogas is maximized when it is converted into electric power, biogas generator and a less capacity gas engine at a farm, which makes the process less air pollution and energy efficient[6]. Two different type of engine technologies were used to analyze the limited operation range and lack of direct control on fuel injection timing.[7]The injector nozzledesign with narrow spray cone angle for diesel engine combustion by varying the spray cone angle and advanced injection timing. It is found that a carbon monoxide (CO) and NO_X emission rises dramatically and combustion efficiency drops significantly and improves the performance of the diesel engine [7].CenkSayin [8] studied about ethanol blended with diesel fuel from 0% to 15% in a single cylinder diesel engine at engine load from 15 to 30 Nm. The experimental tests were conducted at five different injection timings such as 21^0,24^0,27^0,30^0 and 33^0 CA BTDCwith help of change in advance shim. The retarded injection timings (21^0 and 24^0 CA BTDC) at the all test conditionsthe UHC and CO emissions were decreased and BTE improved. In terms of injection timingadvanced as compared to the original injection timing in the all fuel blends gave negative results for all test engine conditions.Ruijun Zhu[9] three diesel-dimethoxymethane (DMM) blends with 15%, 30% and 50% volume fraction with tested at diff erent engine loads and engine speeds. The test resultwas found that using diesel-DMM blends can improve thermal efficiency and reduction in smoke,CO emissions, and slightly increased NO_x emission. The fuel injection timing advanced to improve the fuel efficiency and thermal efficiency. Increasing fuel injection timing reduces exhaust smoke and nano particles number at the cost of increased NO_x emission characteristics. The test was found that early fuel injection timing can either increase or decrease nanoparticles in exhaust gas. When advancing fuel injection timing from 20^0 to 23^0 CA BTDC, the number of nanoparticles is minimized. The further increasing fuel injection timing from 23^0 to 26^0 CA BTDC produces more nano particles. Therefore, in this present study, the effects of injection timing and jatropha and rubber seed oil blended with diesel fuel on the engine exhaust temperatures and exhaust emissions were experimentally investigated using a single cylinder constant speed direct injection(DI) diesel engine.

Table 1.1: Properties of the fuels used in the tests

Property	Diesel	Rubber seed oil	Jatropha oil	Biodiesel
Sp. Gravity	0.74	0.82	0.96	0.90
Viscosity at 40^0C(mm^2/s)	4.15	6.2	4.4	4.2
Calorific Value (KJ/kg)	42000	37700	38500	39500

2.Experimental setup and test procedure

A single cylinder constant speed DI engine was used to evaluate the engine performance and emission characteristics of biodiesel. The diesel engine runs under different load conditions at a constant speed of 1500 rpm with the different biodiesel proportions. The diesel engine (Kirloskar made) was directly attached with an eddy current dynamometer for varying the loads. Some of measuring devices were attached in the test engine such as orifice meter with U tube manometer for measuring air consumption, the one liter burette for fuel consumption and the Separate biofuel fuel tank. An AVL415 smoke meter was provided for measuring the smoke opacity and exhaust temperatures. The test rig was installed with AVL software to obtain various curves and results during testing operation. A five gas analyzer was used to measure the emission characteristics such as CO, UHC, NO_x and exhaust gas temperaturesvalues from the exhaust gas. The specifications of the test engine are described in table 1.2.

Table 1.2: The specifications of the test engine

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	24^0 BTDC
Pressure	220 bar
No. of strokes	4stroke

3. RESULTS AND DISCUSSIONS

3.1. Carbon monoxide (CO)

CO emission results are presented in Fig.1for five different engine loads with injection timings.CO exhaust emission of all the test biofuels decreases with increasing engine load except full load condition. The reduction in CO emission of biodiesel is mainly due to the large amount of oxygen content of biodiesel which results in complete combustion in the combustion chamber. From Figure 1. 1, it can be declared that the CO emission for diesel fuel was higher than that of biodiesel at the proportion of B20 and lower than that of pure diesel at all injection pressures and timing.

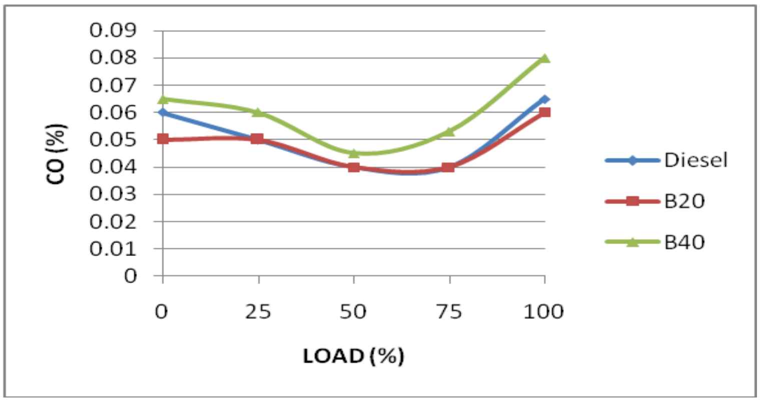

Figure 1.1.Variation of carbon monoxide with engine load

If the pure diesel is directly supplied inside the engine, the CO emission reduced from no load condition to 75% of load. Further increaseat 100% load, the CO increased up to0.065% forB20 biodiesel supplied,the CO varied from no load from 0.05%to full load condition 0.06%. The biodiesel concentration increased to B40 and the CO increased from no load condition as 0.065% to full load condition as 0.08%. Form the result,it was found that B20 gives the positive results compared to other fuels.

3.2. Unburnt Hydrocarbon (UHC)

The variation of unburnt hydrocarbon (UHC) emission for biodiesel fuel compared to the diesel fuel for varying injection timingis given in Fig. 2. High cetane number and oxygen content available in biodiesel which is lowest UHC exhaust gas emission was observed. UHC emission of biodiesel fuel was slightly lower than that that of diesel and biodiesel but it does not depend on the injection parameters such as injection pressure and timing. Minimum UHC emission of 11 ppm was observed with biodiesel fuel at an injection timing of 21° BTDC in75% load condition, which was 3ppm higher than that of pure diesel and 2.3 ppm higher than that of B40 blended biodiesel. The biodiesel concentration increased in diesel fuel is due to the lower cetane number present. The lower cetane value reduces the combustion efficiency of biodiesel and increases the exhaust emissions. The compression ratio might be increased and preheating of biofuel causes the complete combustion to take place. The result was found that the B20 and B40 given best result compared to the pure diesel.

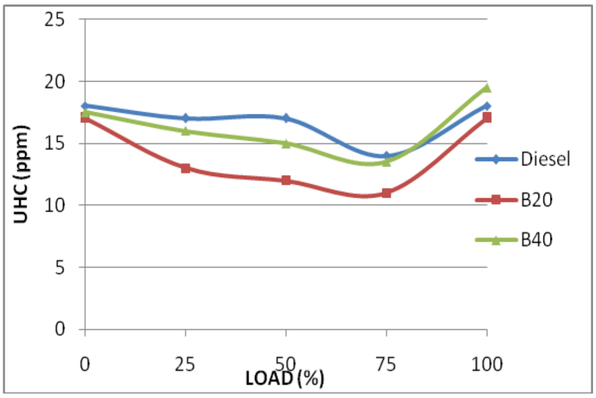

Figure 1. 2. Variation of Unburned Hydrocarbon with engine load

3.3. Nitrogen oxides (NO_x) emissions

Figure 1. 3 shows the comparison of NO_x emissions for variation of loads from the test engine. One of the most critical exhaust emissions from diesel engines is NO_x emissions.

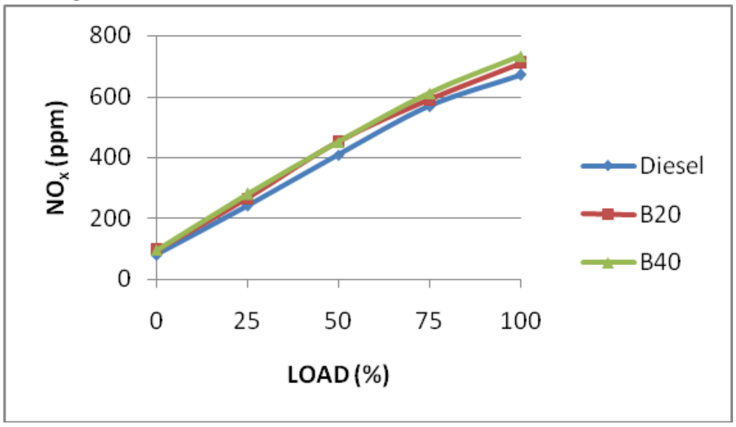

Fig 3. Variation of Nitrogen oxides with engine load

The formation of NOxis highly dependent on the inside cylinder temperature, low oxygen concentration and ignition delay for the reaction to take place [11-12]. NO_x concentration generally increased with engine load in all biofuels. The test results indicated that NO_x values of diesel was lower than the others. Maximum valves of NO_x were observed as 432 ppm with B40 and 708 ppm with B20 at 100% of engine load. For the pure diesel, the NO_x emission was lower from 79 ppm at no load and 671 ppm at full load conditions. It is very clear from the Fig. 3, the cetane number and oxygen content are more effectivelyincreased in biofuels due to the reduction of NO_x and increasing peak pressure in the cylinder. Therefore, the concentration of NOx emission increased for the different engine loads.

3.4. Exhaust Gas Temperature

The variations of Exhaust Gas Temperature(EGT) with respect to various engine loads are presented in Fig. 4. The EGT is increased with increase in and decreased with increase in compression ratio and injection timing for all the test fuels. The maximum heat energy is utilized to produce the large amount of brake power and minimum of brake specific fuel consumption. It is observed from the resultsthatthe exhaust gas temperature varies from 175^0C at no load to 420^0Cat full load for retarded injectiontiming for pure diesel fuel. For the blended fuels such as B20 and B40 at no load to 75% of load,the EGT was almost closer to thediesel. For the load varied at 100% of full load condition the exhaust gas temperature was increased up to 450^0C.Theinjection timing was retarded at 21^0BTDC; the exhaust gas temperature is less compared to the designed injection timing.

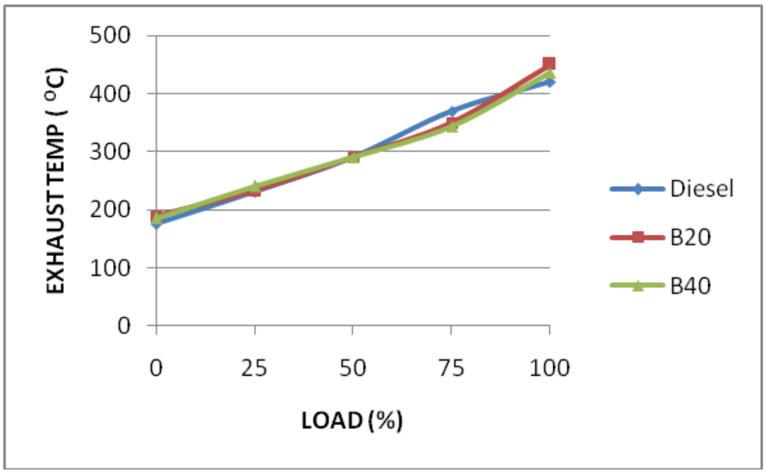

Fig 4. Variation of Exhaust temperature with engine load

4. CONCLUSIONS

Experimental investigations have been carried out to determine the emission characteristics of DI engine. Between the jatropha and rubber seed oils, there were few differences in the results from the engine tests Compared to fossil diesel fuel, however, there were a limited significant differences when using the plant oils, Conclusions drawn from this study are as follows.

(a) In CO emission test, the load is increased from no load to at 75% of load condition the B20 of experimental valves was deduced. It was very closer to the pure diesel fuel valves. The CO of blended fuel at B20 gives the better performance compared to the B40.

(b) Very low amount of UHC was achievedfor B20 from no load to full load condition. It was varied from 16 ppm to full load 18 ppm. Another blended fuel of B40 also reduces the UHC emission as compared to the pure diesel fuel in all test conditions.

(c). The NO_x and exhaust gas temperatures were increased from no load to full load condition in all test fuels. The blended fuels B20 and B40 were very closer to the pure diesel. It also concluded that if the fuel injection timingdecreases, the emission characteristics such as CO, UHC were reduced.

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