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Research Article

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Effect of injection timing on the performance and emissions of biodiesel fuelled diesel engine

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ABSTRACT

Continuous utilization of fossil fuels has been polluting our atmosphere with harmful exhaust emissions from the engines. Rapid increase in the cost of fossil fuels have also generated interest in search for the alternative fuels. One such alternative fuel for Compression Ignition (CI) engine applications is biodiesel. It is a renewable, biodegradable and clean burning fuel. In the present work, experiments have been carried out to study the performance and emission characteristics of a CI engine running on biodiesel. Injection timing was varied to obtain optimum performance and lowest emissions from CI engine. Comparisons were drawn with respect to standard diesel fuel performance and emissions. Results clearly indicated the optimum injection timing of 19° before top dead center (BTDC) for biodiesel. Also, the effects of injection timings on HC, CO and NOx emissions have been discussed.

Keywords: Bio-diesel, compression ignition (CI) engine, injection timing, emissions, engine performance.

INTRODUCTION

Renewable fuels have advantages in terms of energy, security, environmental concerns, foreign exchange savings and socio-economic issues, as compared to conventional fossil fuels. Therefore renewable fuels can be used predominantly as fuel for transportation and power generation. Recent reports have suggested that the share of renewable fuels in the Indian electricity generation sector is expected to rise to 15percent by 2030 [1].

Non-edible vegetable oils such as Honge (Karanja), Rice Bran, Jatrophacarcus, Mahua, Neem etc. are available abundantly in our country and can be used as renewable fuels. Investigators have reported that short-term engine tests using vegetable oils as fuels were promising but the long term test results showed higher carbon built up and lubricating oil contamination resulting in engine failure. They concluded that vegetable oils should be either chemically altered or blended with diesel to prevent engine failure [2].

Not many attempts have been made to use esters of non-edible vegetable oils as substitute for diesel [3,4]. Therefore in the present work, the esters of non-edible vegetable oils have been used to investigate their effects on emissions and performance of CI engines.

Biodiesel is made through a chemical process called transesterification whereby the glycerin is separated from the fat or vegetable oil. The process leaves behind two products namely methyl esters (the chemical name of biodiesel) and glycerin [5,6,7].

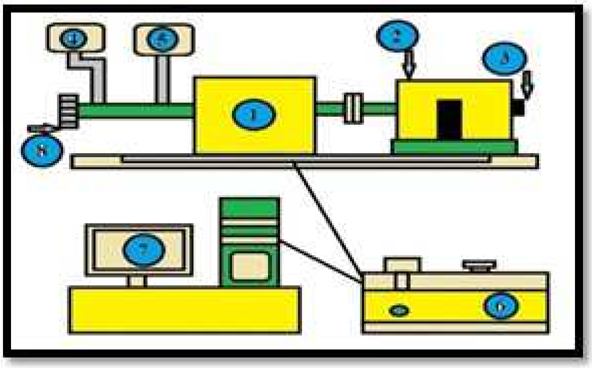
The major problems associated with the use of straight vegetable oils in CI engine are their high fuel viscosity and poor volatility. Transesterification of vegetable oils provides a significant reduction in viscosity, thereby enhancing their physical and chemical properties and improves engine performance [8].

EXPERIMENTAL SECTION

The schematic of the experimental test rig is shown in Fig. 1. Engine specifications are shown in Table 1. Exhaust gas analyzer was used to record the emissions from engine exhaust.

The experimental investigation involved the following steps:
1. The CI engine was operated with standard diesel and its performance measures such as brake thermal efficiency (BTE) and emissions characteristics were recorded.
2. Thereafter, the engine was run with the fuel, honge oil methyl ester (HOME). Injection timing parameter was varied and its effects on emissions and performance measures were observed.

All the obtained experimental results were analyzed and compared for deciding the optimum injection timing.



1. Engine; 2. Dynamometer; 3. Crank angle encoder; 4. Exhaust gas analyzer; 5. Smoke meter; 6. Control panel; 7.Computer; 8. Silencer.

Fig 1: Experimental Test Rig

Table 1. Engine specifications

Engine type	Four Stroke Direct Injection
Bore	0.0875m
Stroke	0.11m
Rated Power	3.7 kW(5 HP)@1500 rpm
Compression Ratio	17.5 : 1
Loading	Eddy Current Dynamometer, Water Cooling
Fuel Injection	23° BTDC
Nozzle Opening Pressure	200-225 bar

RESULTS AND DISCUSSION

3.1 Effect of varying injection timing on brake thermal efficiency

The engine performance with HOME oil was tested at injection timings of 19°, 23°, and 27°BTDC. For standard diesel, the engine was tested at the specified crank angle of 23°. Fig. 2 shows the effect of injection timing on BTE of CI engine operation with HOME at three injection timings. It can be seen that as the injection timing increases from 19° to 27°, BTE of the engine increases. However, at 23° BTDC, diesel performs much better than the HOME oil. In fact, the highest BTE was obtained with diesel at a static injection timing of 23° BTDC.

The lower BTE for HOME might be attributed to lower energy content of the fuel and higher fuel consumption for the same power output. Due to the high viscosity of HOME the formation of the mixture and subsequent combustion byproducts were poorer than diesel. Another inference is regarding the power output of 2.88 KW, which corresponds to maximum BTE regardless of the fuel used.

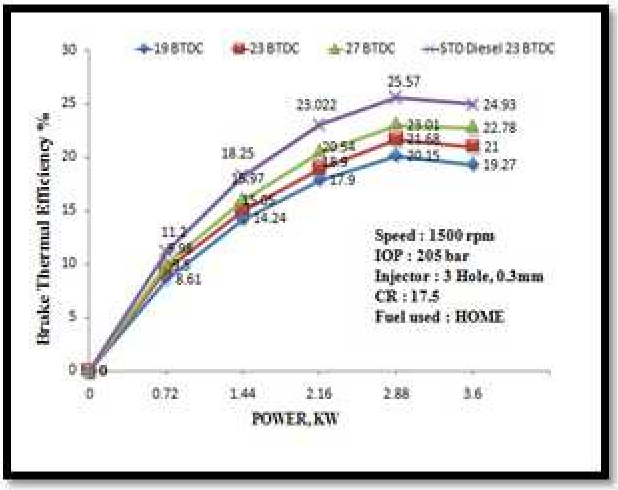


Fig 2: Variation of BTE on Injection Timing

3.2 Effect of Varying Injection Timing onHC, CO and NO_x Emissions:

Hydro Carbon (HC) emissions in the diesel engines are caused due to lean mixture during delay period and under mixing of fuel leaving fuel injector nozzle at lower velocity. Fig. 3 shows HC emission characteristics (in PPM) due to standard diesel and HOME at three injection timings. As expected, higher emissions are obtained for greater HOME injection timings. Diesel induced HC emissions were very low as compared to HOME generated HC emissions. This could be due to the poor spray characteristics of HOME oil resulting in poor mixing and consequently poor combustion.

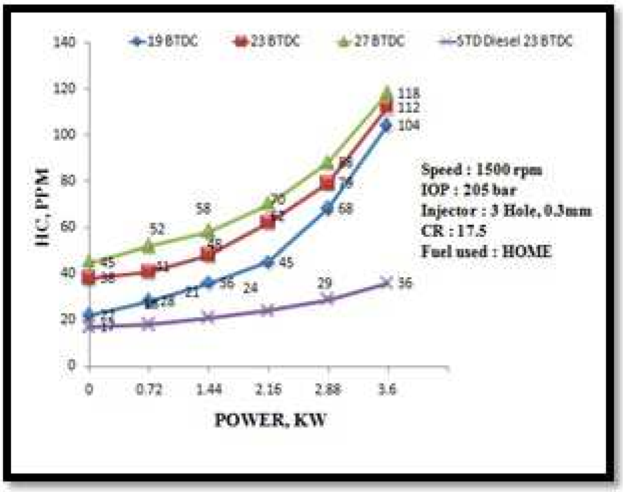


Fig 3: Variation of HC on Injection Timing

However, lowest HC emissions for HOME were obtained at 19° BTDC.

Fig 4 shows NOx emission characteristics for same conditions. Again, lowest emissions were obtained at 19° BTDC for HOME. In this case, diesel fuel generates highest PPM of NOx emissions. Lower NOx emissions from HOME oil could be due to retarded injections. As the injection timing was retarded, the combustion process too gets retarded. NO_x concentration levels were lower as peak temperature was lower. NO_xlevels were higher at the injection timings of 23° and 27° BTDC as they lead to a sharp premixed heat release due to higher ignition delay. With HOME oil operation, NO_x emissions were slightly higher at the injection timing of 27° BTDC than 19° and 23° respectively.

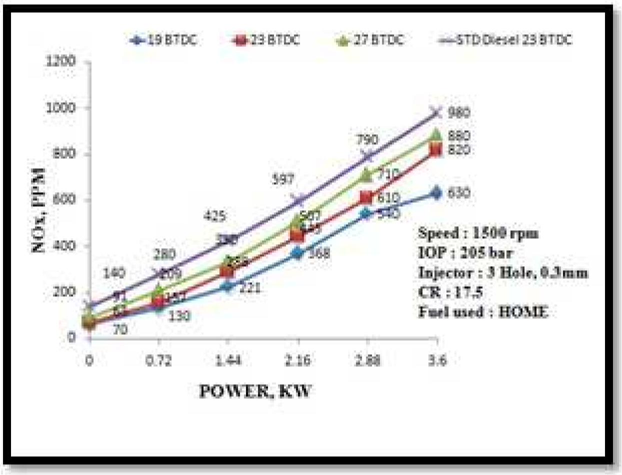


Fig 4: Variation of NO_x on Injection Timing

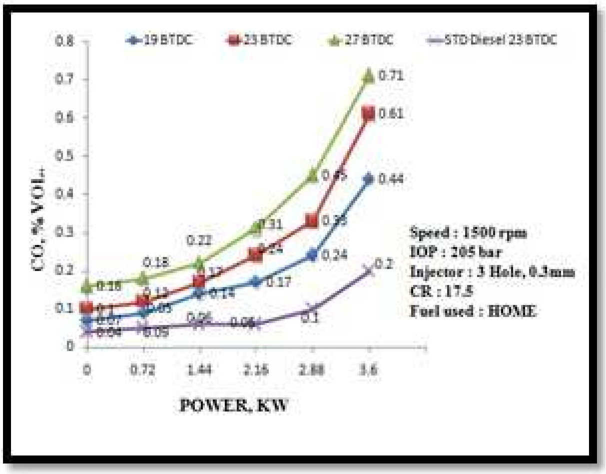


Fig 5: Variation of CO on Injection Timing

Fig. 5 shows variation of CO emissions with injection timings for HOME and standard diesel. CO emissions were a clear indication of incomplete combustion of pre-mixed mixture. The amount of CO was decreased at part loads and increased at higher loads at all injection timings. This may be concluded as proper combustion, increased cylinder pressure and temperature at 19° BTDC results in lowest un-burnt and in-complete combustions by-products such as HC and CO.

From all results, it was clear that the best injection timing for HOME oil was 19° BTDC, resulting in lowest exhaust gas emissions without compromising much on efficiency.

CONCLUSION

Based on the experimentation using HOME as fuel engine operation with optimized engine parameters that realized in better efficiency and acceptable levels were determined. The following conclusions were derived:

1. Retarding the injection timing improves the performance fuelled with HOME i.e. BTE increases while the emissions HC, CO, NO_x decrease.
2. Best results were recorded at 19° BTDC injection timing using HOME as fuel.
3. The bio-diesel used such as HOME can be used readily in CI engine without any major modifications in the engine.

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