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Performance and Emission Characteristics of CI Diesel Engine Using Neem Biodiesel with Assorted Operating Parameters

Shaik Hussain, Dr. B Sudheer Prem Kumar, Dr. B Durga Prasad[3]
[1]*Research Scholar, Department Of Mechanical Engineering, JNTUA, Ananthapuramu*
[2]*Professor, Department Of Mechanical Engineering, JNTUH College of Engineering, Hyderabad*
[3]*Professor, Department Of Mechanical Engineering, JNTUA College of Engineering, Ananthapuramu*

Abstract: One of the significant problem for the global environment due to increase in demand of fossile fuel with population growth causes increase in air pollution. The depletion of fossil fuels and its emissions promoted the researchers to search for alternative fuels. The major source of energy comes from fossil fuels. The fossil fuels using today are oil, coal, and natural gas. Among these fossil fuels, oil is the most consumed for energy conversion. To overcome these problems there is a need to search for an alternative fuel. The successful alternative fuels full fills energy and environmental security needs without sacrificing operating performance parameters. Biodiesel is considered as one of the prominent alternative resources. In this work, an attempt is made to use Neem biodiesel as an alternative fuel in CI diesel engine. The performance and emission characteristics are studied on water cooled naturally aspirated CI diesel engine varying assorted operating parameters with Neem biodiesel. The experiments are carried at different injection pressure such as 180, 200, 220 and 240bar and advancing injection timing(AIT) viz., 1^o and 3^o on CI diesel engine. The performance parameters are observed such as brake thermal efficiency(BTE), brake specific fuel consumption (Bsfc) and Mechanical efficiency. The Emission parameters are recorded such as NOx, CO, CO_2 , O_2 and HC emissions at different conditions.
Key words: Neem biodiesel; Performance; Emissions; Fuel injection pressure; Injection timing.

1. Introduction

For many years, IC engine research was aimed at improving thermal efficiency and reducing noise and vibration. There has been continuous research for the most efficient diesel engine which will cause less harm to the environment right from its invention. Increasing concern about the impact of the IC engine on the environment has led to the various researches on control pollution from engine exhaust emissions. Currently, emission control requirements are one of the major factors in the design and operation of IC engine. The increasing motorization of the world has led to a steep rise in demand of petroleum products. But petroleum products are finite, highly concentrated in certain region of the word and source of environmental pollution. The transportation sector consumes 65 percent of the total petroleum products supplied. In Indian transportation contributes about 1/3rd of CO_2emissions, 1/3rd of NOx emissions, nearly 77 percent of CO emission and around 45 percent of Particulate matter.

The advanced injection timing results in increase in-cylinder pressure, temperature, heat release rate, cumulative heat release and NOx emissions (6.88%) and retarded injection timing results in reverse trend (NOx emission 6.85%). In case of advanced injection timing the soot emissions show increasing trend up to certain crank angle then reverse trend whereas in case of retarded injection timing soot emissions show the reverse trend. The supercharged with inter-cooled cases show lower peak heat release rate and maximum cumulative heat release, shorter ignition delay, higher NOx (15.03% and 58.69% at 1.21 bar and 1.71 bar respectively) and lower soot emissions (8.82% and 51.47% at 1.21 bar and 1.71 bar respectively). The optimum injection timing (start of injection) is 12 bTDC. The intake pressure boosting up to 1.21 bar is the best option[1].

The demand for non-edible oil sources is expected to increase sharply in the near future. Some of non-edible feedstocks for biodiesel production include Jatropha curcas, Pongamia pinnata, Rubber seed, Madhuca indica, Calophyllum inaphyllum, Sterculia feotida, etc. However, it must be pointed out that global biodiesel feedstocks should not rely on certain sources as it could bring harmful influence in the long run. The worlds' dependence on fossil fuels is a perfect example. Therefore, biodiesel feedstock should be as diversified as possible, depending on geographical locations in the world[2]

Using ethanol as a fuel additive to unleaded gasoline causes an improvement in engine performance and exhaust emissions. Ethanol addition results in an improvement in brake power, brake thermal efficiency,

volumetric efficiency and fuel consumption, however the brake specific fuel consumption and equivalence air–fuel ratio decrease because of lower calorific value of the gasohol. Using an ethanol–unleaded gasoline blend leads to a significant reduction in exhaust emissions of CO and HC for all engine speeds. On the other hand, CO2 emissions increase marginally. Ethanol diesel blends up to 20% can very well be used in present day constant speed CI engines without any hardware modification. Exhaust gas temperatures and lubricating oil temperatures were lower for ethanol diesel blends than mineral diesel. The engine could be started normally both hot and cold. Significant reduction in CO and NOx emission was observed while using ethanol diesel blends [3].

The reduction of NOx emissions by air humidity does not totally depend on the lower in-cylinder mean temperature. However, the in-cylinder temperature has direct effect on O formation, which has significant effect on the NOx emission. Air humidity inhibits OH radicals and reduces the oxygen content due to dilution of air by water, which is adverse to soot oxidation. With increasing humidity, the oxygen-rich area decreases and the pyrolysis fuel is reduced, resulting in the reduction of soot emissions. However, at the same time, the soot oxidation amount decreases as a result of the decrease in the oxygen content and the combustion temperature. In all, humidity has a dual effect on soot formation[4].

2. Preparation of neem biodiesel

Measure 2L of neem crude oil and pour it in three mouth flask. Three mouth flasks should be provided with cooling system to circulate ethanol. By using electric heater, heat crude oil upto 70°C and stir it continuously using magnetic stirrer. Prepare a solution of 400ml of ethanol and NaOH crystals. When temperature of three mouth flask reaches 70°C, slowly add above prepared solution into the flask. Continue heating till one to two hours, make sure that temperature remains constant. After that Pour the content of flask into separation funnel and keep it for at least 6 hours which permits glycerine to settle down. Hence it is being denser than biodiesel. Remove the glycerine from the separating funnel. Now wash the biodiesel obtained with water so as to remove the chemicals. Heat the biodiesel to remove any traces of water to obtain pure biodiesel. Obtained pure neem biodiesel which is free from all chemicals and water. This biodiesel is used to carried out the experiments.

Fuel properties	**Neem biodiesel**
Density(gm/cc)	0.940
Viscosity(cSt) @40^o Celsius	8.5
Calorific value(MJ/kg)	35.5
Flash point(^{o})	39
Fire point(^{o})	45

Fig. 2.1 Properties of neem biodiesel

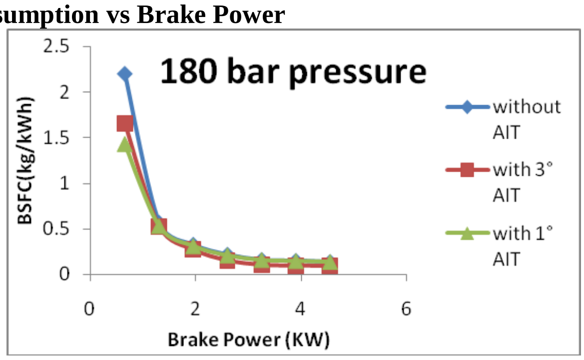
3. Experimental Procedure

All tests are conducted on single cylinder four stroke water cooled direct injection diesel engine at the rated speed of 1500 rpm, where eddy current dynamometer is used to vary the load. The tests are conducted on diesel engine using neem biodiesel (B100) with varied load conditions. All observations are recorded only after the engine attaining the stable condition. All instruments are periodically calibrated. At each load, performance parameters, air flow rate, fuel flow rate, exhaust gas temperature and the exhaust emissions are noted.

4. Results and Discussion:

The main performance characteristics considered in this project are Brake Specific Fuel consumption, Brake Thermal Efficiency, Mechanical Efficiency.

4.1 Brake Specific fuel consumption vs Brake Power



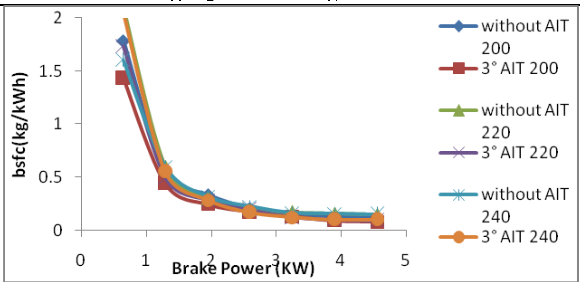


Fig 4.1 Bsfc vs BP

From the above fig.4.1 Brake specific fuel consumption decreased with increasing brake power. Initially the bsfc is high compared to advanced injection timing at same pressure by installing shims at fuel pump of engine. Bsfc slightly decreased with increasing of injection pressure and timing. Less bsfc occurred at 200 bar with advanced injection time by 3°. At initial load condition and 180 bar pressure bsfc consumption is 8 kg/hr more than 20°bTDC and 10 kg/hr than 22°bTDC injection times.

4.2 Brake Thermal Efficiency vs Brake power

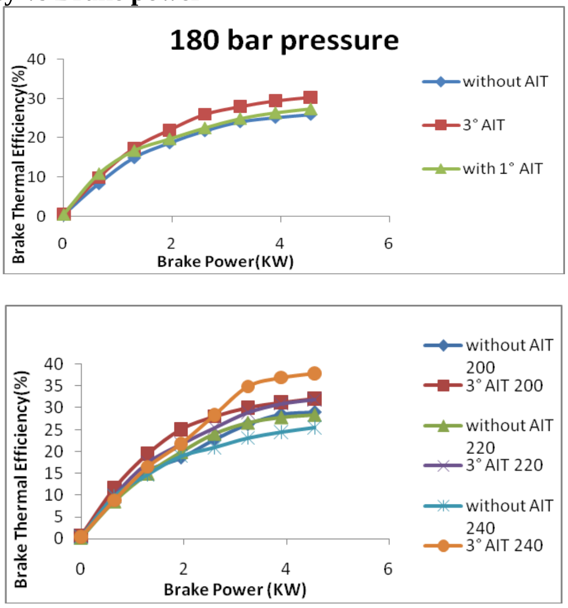
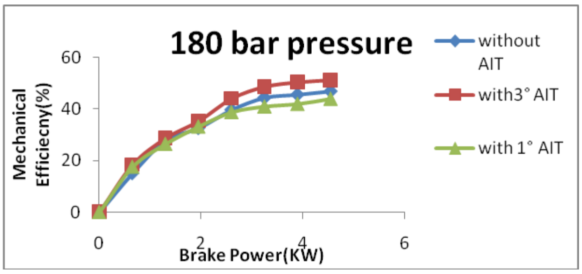


Fig 4.2 BTE vs BP

The brake thermal efficiency increased with increasing brake power. From the graph 4.2 it is observed that brake thermal efficiency of an engine slightly increased with advanced injection timing. Maximum brake thermal efficiency occurred at 240 bar pressure with advanced injection time by 3°.

4.3 Mechanical Efficiency vs Brake Power



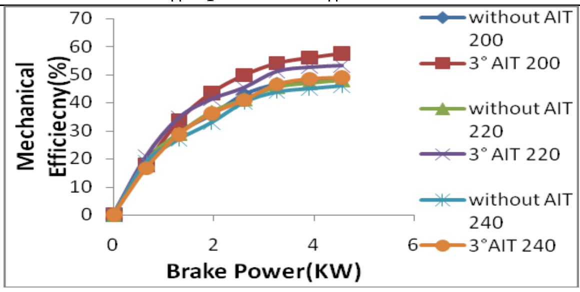


Fig 4.3 ME vs BP

From the fig.4.3 the mechanical efficiency of an engine increased with increasing brake power. Maximum efficiency of an engine occurred at 200 bar pressure with advanced injection time by 3^{o}.

Emission Characteristics:

Exhaust gas or flue gas is emitted as a result of the combustion of fuels such as natural gas, gasoline, petrol, biodiesel blends, diesel fuel, fuel oil, or coal. The amount of emission from engines depends upon their design, operating conditions, and the characteristics of fuel. The vehicles primarily emit the harmful gases (pollutants) like CO, unburned HCs, and NOx. In addition the diesel vehicles also emit smoke and particulate matter (PM).

4.4 Oxides of Nitrogen (NOx)

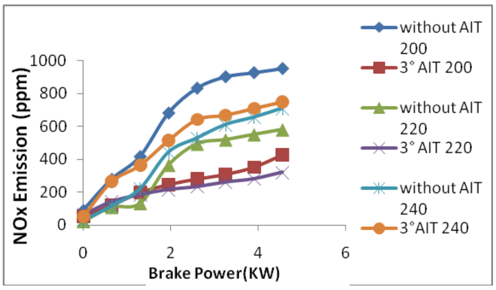


Fig 4.4 NOx vs BP

NO_x emissions increase with biodiesel operation due to the reactive nature of biodiesel molecule at higher temperature and oxygen present in its structure. From the fig.4.4 it is observed that formation of NOx increased with increasing brake power. At 200 bar and without shims NOx formation is higher than with 200 bar and advanced injection timing (3^{o}). This is due to high temperature formation inside the cylinder.

4.5 Carbon Monoxide (CO)

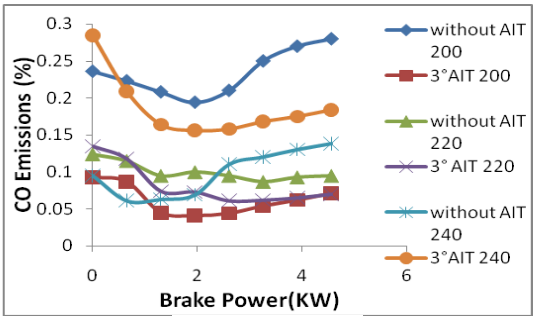


Fig 4.5 CO vs BP

CO is an intermediate combustion product and is predominantly formed due to the lack of oxygen and incomplete combustion. If combustion is complete CO will be converted to CO_2.

4.6 Carbon Dioxide (CO_2)

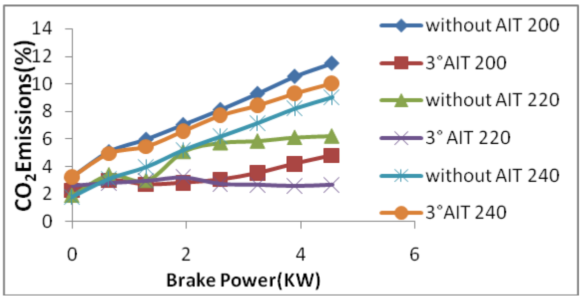


Fig 4.6 CO_2 vs BP

Due to the decrease in brake thermal efficiency energy release rate is less in turn there is a reduction in CO_2. If combustion is complete CO_2 emission is more because CO will be converted to CO_2. From fig 4.6 it is concluded that CO_2 emission is less 220 bar and advanced injection timing (3^o) compare to other injection pressures.

4.7 Unburned Hydrocarbon (HC)

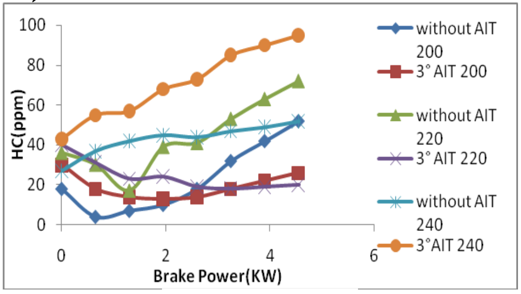


Fig 4.7 HC vs BP

Hydrocarbon emissions are produced due to some of hydrocarbon present in the fuels does not participate in combustion. From fig.4.7 it is found that HC emissions are less for 220 bar and injection time is advance by 3^o compared to other pressures.

5. Conclusions

In this work, the experiments are carried out on performance and emission characteristics of CI diesel engine using Neem biodiesel (B100) with varying assorted parameters. The following conclusions are drawn.

- The Specific fuel consumption is decreased about 18.85% using 3^o advanced injection timing at 200 bar compared to standard injection timing at 200 bar. This is due to smaller ignition delay.
- The test result shows that break thermal efficiency of 3^o advanced injection timing at 240 bar is increased about 12.06% compared to standard injection timing at 240 bar. Since the engine operates under injection advance the smaller ignition delay leads to initiation of combustion much before TDC.
- The mechanical efficiency increased about 17.34 % applying 3^o advanced injection timing at 200 bar compared to standard injection timing at 200 bar due to early start of combustion.
- The NO_X emissions are decreased about 14.28% applying 3^o advanced injection timing at 240 bar compared to standard injection timing at 200 bar.
- The CO, CO_2 and HC emissions are lower for 3^o advanced injection timing at 220 bar compared to standard injection timing at 220 bar pressure.

The optimum condition for performance parameters is 200 bar pressure with 3^o advanced injection time because good atomization of fuel and early start of combustion. The optimum condition for emission parameters is 220 bar pressure with 3^o advanced injection time.

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