INFLUENCE OF INJECTION TIMING (IT) ON THE PERFORMANCE AND EMISSION CHARACTERISTICS OF A DIESEL ENGINE OPERATED ON DUAL-FUEL MODE

Abstract

In present scenario fossil fuels are getting depleted, in addition to this dependency and price are increasing. A time may come in future there might have no fossil fuel left. Hence we need to make use of alternate fuels, in order to make a better future. Therefore renewable fuels can be predominantly used as fuel for transportation and power generation applications. In view of this background, effect of injection timing (IT) on the performance, combustion and emission characteristics have been investigated in a single cylinder, four stroke water cooled direct injection (DI) compression ignition (CI) engine operated on dual fuel mode using Neem Oil methyl ester (NeOME) and producer gas induction. In the present experimental investigation, an effort has been made to enhance the performance of a dual fuel engine utilizing different IT (19^o to 31^o in step of 4^o) was optimized. Results of investigation on NeOME-producer gas operation showed increased brake thermal efficiency with reduced emission levels at 27^O before top dead center (bTDC).

Keywords: Neem Oil Methyl Ester (NOME), Injection, power generation, Dual fuel engine.

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I. INTRODUCTION

The fuels are used in several sectors like Automobiles, Industries, Power plants, Power generation engines (generator) to produce a power for further application. Beside these problems the researchers are found that during next 30 to 40 years there will complete depletion of fossils fuels and no fuel left to run vehicles or machines and now at present conditions are showing that there is continuously increasing of fossil fuel price and also usage parallel [1,2,3,4].

In the rural areas farmers use fuels in power generation purpose which produces gases like CO, NO_x, sulphur oxides, particulate matters etc., which are harmful for the environment, animal life and human life. The use of biofuel as alternative fuel has a more advantages. The biofuels may be alcohol, vegetable oil etc.,[5,6,11]

The using of biofuels reduces the environment pollution and dependence on fuels. The CO_2 produced from burning of bio fuel does not much affect the environment. The CO_2 produced from burning of biofuels forms the complete cycle of CO_2 .Hence we can use alternate fuels like neem oil, rice bran oil, methane etc. in dual combustion engine to generate electricity using producer gas produced from agricultural wastes and bio wastes.[7]

In the present work neem oil as bio fuel which is produced by transesterification process, and biogas is produced by gasification method using wood, to conduct experiment on duel fuel engine. Duel fuel engine is a engine that uses a two fuels for the production of power. Neem oil is used as a primary fuel and producer gas as a secondary fuel to get a high efficiency from engine[12]. As neem trees are abundantly available and it is highly growing plantation in our country. As per the present calculation the growth is higher, which we get 60% of dry fruit of which constitutes 40%, kernel 17%of seed. It is said that there will be no diseases where there are more neem trees. [8,9,10]

II. MATERIALS AND METHODS

In the present work NeOME and Producer gas derived from neem biomass (PG-NeOEM) have been used as injected and inducted fuels respectively. Properties of NeOME and PG-NeOEM are presented in Table 1.

Table 1: Properties of fuels used

Sl. No	Properties	Diesel	Neem oil	NeOME	Property	Neem wood
1	Kinematic Viscosity @ 40 0C, cSt	3.6	24.8	4.8	Moisture content, % w/w	10.38
2	Flash point, 0C	56	34	163	Ash content, %, w/w	0.56
3	Calorific Value, kJ / kg	44500	38580	41450	Volatile matter, %w/w	79
4	Specific gravity	0.840	0.910	0.860	Fixed carbon, %w/w	8.38
5	Density, kg / m3	840	910	860	Sulphur, %w/w	0.036
8	Type of oil	----	Non edible	Non edible	Nitrogen, % w/w	0.16
---	---	---	---	---	Calorific value, kcal/g	5600
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III. EXPERIMENTAL SET-UP AND METHODOLOGY

Diesel engine was coupled to the down draft gasifier and was operated on dual-fuel mode under various engine loads at 1500 rpm. Diesel engine mainly involves, downdraft gasifier; cooling-cleaning system, flow meters and other accessories as shown in Figure 1.

The engine has eddy current dynamometer used for engine loading. The complete specification of both diesel engine and gasifier is presented in Table 2 and 3.During experimentation; data generated are recorded in the data acquisition system. Calibrated venturimeter was used to measure PG flow rate, (digital). Similarly, burette and single tube manometers are used to measure air and pilot fuel flow rate. Piezoelectric transducer was used to measure in-cylinder pressure, and mounted to the cylinder head. In-cylinder pressure was recorded for every crank angle and stored in a data acquisition system. Diesel engine had a conventional mechanical fuel injection (CMFI) system. It has 3 holes, and each hole has 0.3 mm diameter. Injector for the NeOME–PG operations, Manufacturer specified static IT and IOPas 23^{o}bTDC and 205 bar respectively.

IT was varied from 19^{o}bTDC to 31^{o}bTDC in steps of 3^{o}. Exhaust gas emissions were recorded with Hartridge smoke meter and five-gas analyzer after periodic calibration and steady state conditions.

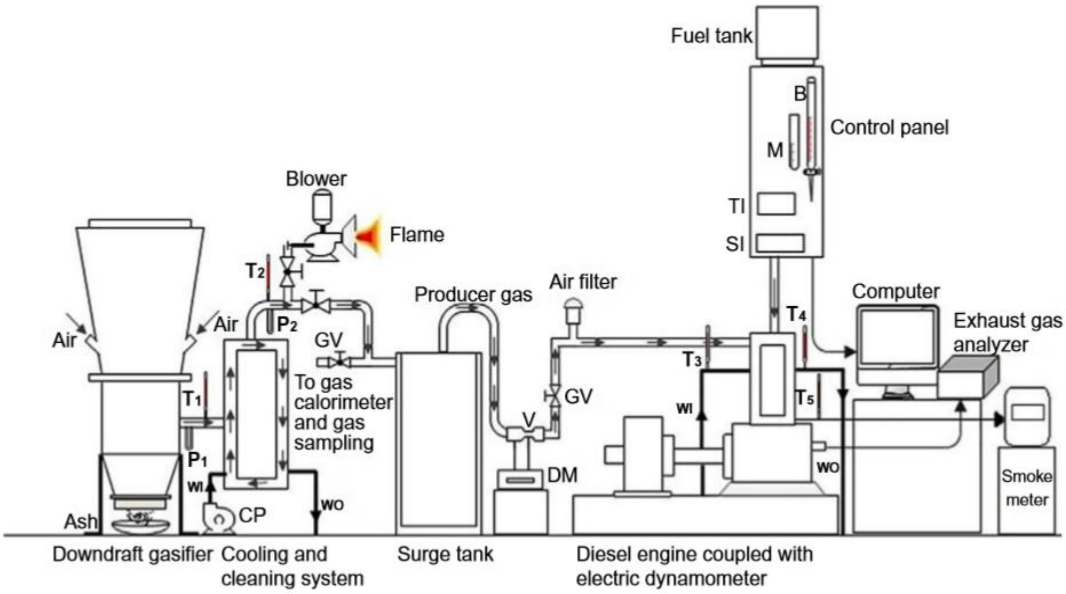

Figure 1: Experimental Test Rig

Table 2: Specifications of engine

Sl No	Parameters	Specification
1	Machine Supplier	Apex Innovations Pvt Ltd, Sangli. Maharastra State.
2	Engine Type	Single cylinder four stroke water cooled direct injection TV1 CI engine with a displacement volume of 661 cc, compression ratio of 17.5:1, developing 3.7 kW at 1500 rev/min (Kirolsker make)
3	Software used	Engine Soft
4	Nozzle opening pressure	200 – 225 bar (20 -22.5 MPa)
5	Governor type	Mechanical centrifugal type
6	Cylinder diameter (Bore)	0.0875 m
7	Stroke length	0.11 m
8	Piston bowl dimension	52 mm diameter,
9	Clearance/length	40.1 cc at CR 17.5.
10	Connecting rod length	234 mm
11	Combustion camber	Open Chamber (Direct Injection) with hemispherical cavity
12	Eddy current dynamometer:	Model :AG – 10, 7.5 KW at 1500 to 3000 RPM and Water flows through dynamometer during the use

Table 3: Specification of the downdraft gasifier

Type	Down draft gasifier
Rated capacity	15000kcal/hr
Rated gas flow	$15Nm^3/hr$
Average gas calorific value	$1000kcal/m^3$
Rated woody biomass consumption	5-6kg/hr
Hopper storage capacity	40kg
Biomass size	10- 50 mm
Moisture content (DB)	5 to 20%
Typical conversion efficiency	70-75%

3.1 Uncertainty analysis

During experiment while measuring parameter the uncertainties are most common due to random and systematic errors. Table 4 Gives list of uncertainties in the calculated parameters.

Table 4: The uncertainties in the calculated parameters

Measured variable	**Accuracy (%)**
Load (N)	0.1
Engine speed (rpm)	1
Fuel consumption (g)	0.1
Measured variable	**Uncertainty (%)**
HC	‡1.2
CO	‡2.5
NOx	‡2.3
Smoke opacity	‡2.0
Calculated parameters	**Uncertainty (%)**
BTE (%)	‡ 1.2
HRR ($J/^0CA$)	‡ 1.3

IV. RESULTS AND DISCUSSIONS

During experimentation, IT has been optimized in terms of enhanced performance, combustion emission characteristics while PG flow rate and engine speed were maintained constant. A suitable carburetor was used to ensure air–gas mixture at stoichiometric ratio.

1. **Effect of Injection Timing:** For a single cylinder diesel engine fuelled with producer gas and neem oil methyl ester. The basic emission characteristics and performance is tested with varied injection timing (19°,23^o and 27^o bTDC). Variable load test was conducted at rated speed of 1500 rpm and with selected compression ratio of 17.5 and an injector opening pressure of 205bar for each load air flow rate, fuel flow rate, exhaust gas temperature, HC, CO, smoke, and NOx emissions are recorded. A 3-hole injector of 0.3

mm diameter orifice are selected for studies. Based on results optimum injection timing was determined for selected fuel combination.

2. **Effect of Injection Timing on Brake Thermal Efficiency:** From fig. 2 brake thermal efficiency values of NeOME along with producer gas as dual fuel is lower compared to diesel tested for 3 injection timings. For the same output power, the fuel consumption is high and low energy is attributed due to which there is decrease in brake thermal efficiency. The viscosity of NeOME is high but formation of mixture is poor compared to diesel. The brake thermal efficiency of NeOME and diesel are 16.5 % and 18 % at 27^o bTDC. By advancing the injection timing by 4 o there is increase in brake thermal efficiency. Therefore, for NeOME the observed brake thermal efficiency values were 15.5% and 16 % at 19^o bTDC and 23^o bTDC. The brake thermal efficiency values of optimum injection timing for NeOME were 27^o bTDC.

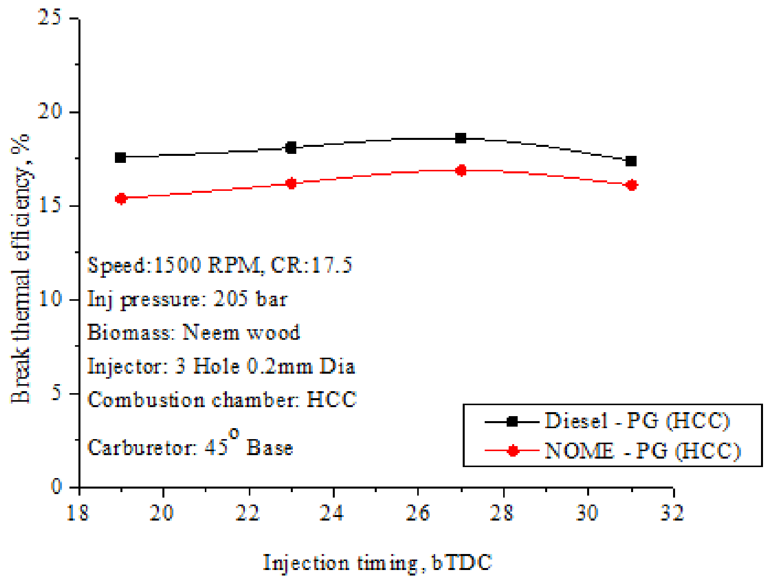

Figure 2: IT vs. Break Thermal Efficiency

3. **Effect of Injection Timing on Smoke Capacity:** From fig. 3 smoke emission for both fuel decreases with advanced Injection timing. Improper Air-fuel ratio and improper mixing, the combustion is incomplete when injection timing is advanced to 27^o bDTC from 19^o bTDC, the fuel injection occurs at low temperature and pressure in cylinder due to this the smoke level falls. This results in increase of Injection delay and lower smoke The smoke emission with NeOME is found to be minimum for 27^o bTDC for advanced injection timing. NeOME smoke emissions were 68HSU,65,60 with injection timings 19^o,23^o and 27^o bTDC at 80% load.

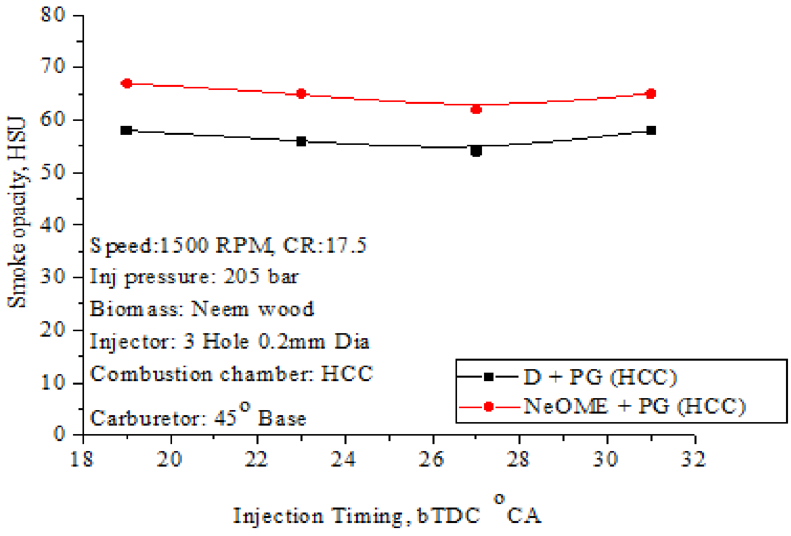

Figure 3: IT vs. Smoke Opacity

4. **Effect of Injection Timing on HC and CO Emissions:** The lean mixture during delay period and under mixing of fuel coming out of fuel injector nozzle at low velocity is the reason for hydrocarbon emissions in diesel engines. For 19°, 23° and 27° bTDC injection timings the hydrocarbon emission values of NeOME at 80% load were 68ppm, 65ppm and 62ppm. One of the toxic by-product with incomplete combustion is carbon monoxide. For all injection timings the CO is increased at higher loads and decreased at part loads. At 19°, 23° and 27° bTDC injection timings the amount of CO is 0.52%, 0.48% and 0.45% for NeOME at 80% load. As compared to other injection timings of 19° and 23° bTDC lowest CO levels were found at the optimum injection timing 27° bTDC. Fig (11 & 12) shows that effect of injection timing on HC and CO emissions.

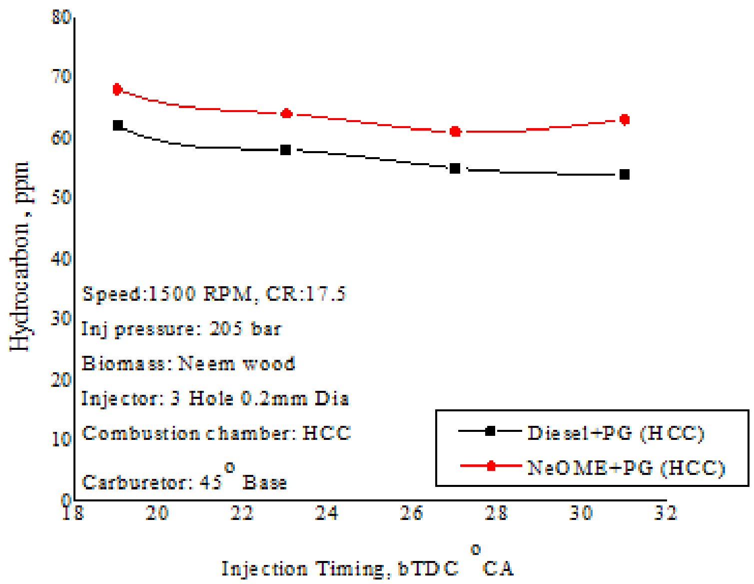

Figure 4: IT vs. HC emissions

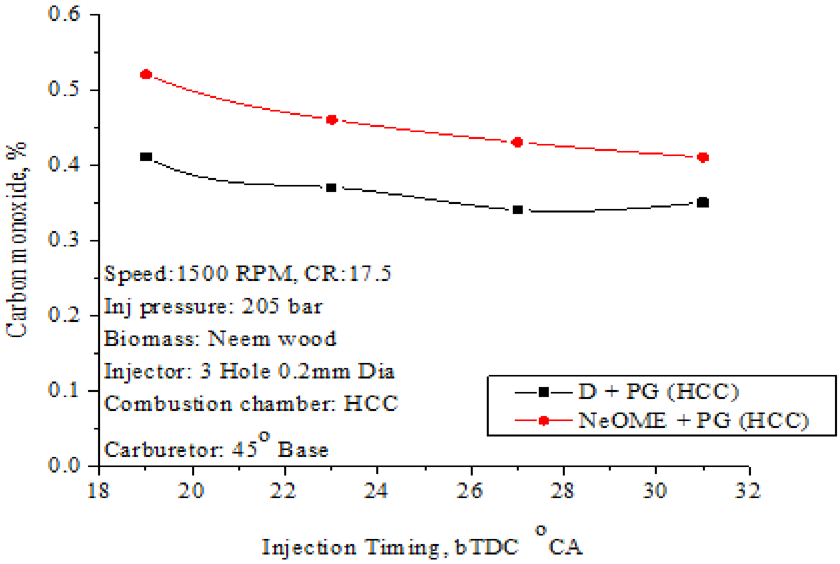

Figure 5: IT vs. CO emissions

5. **Effect of Injection Timing on NOx Emission:** In general, there is substantial reduction in NOx emissions for retarded injection timings. The combustion process is retards as Injection timing retards. The Concentration levels of NOx were found to be lower at lower peak temperatures. For Injection timings of 23°,27° bTDC NOx levels were higher and also due to higher ignition delay leads to sharp premixed heat release. With operation of NeOME, NOx emissions were higher at injection timing of 31° bTDC compared to 19°, 23 ° and 27° bTDC. It is concluded that 19° bTDC injection timing is optimum for home based on the results. Fig (13) shows the effect of Injection timing of NOx emissions.

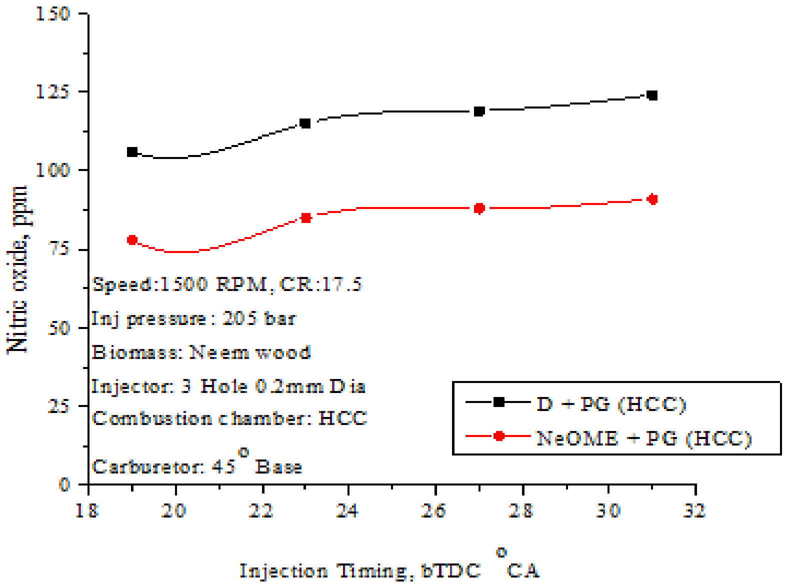

Figure 6: IT vs. NOx emissions

V. CONCLUSION

From the experimental observation the combustion efficiency is found to be less compared to the diesel fuel but by advancing the Injection timing the performance is improved. Favourable results are found by varying Injection timing from 19^o to 31^o bTDC. Hence for diesel engines NeOME can be used as an alternate fuel.

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