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Impact of Injection Timing on CI Engine using Biodiesel

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Abstract*: Now a days Compression ignition (CI) engines show a significant part in industrial, transportation, power generation, construction equipment and marine propulsion sectors. Due to this the fossil fuel utilization is being increased rapidly in day to day life. In this view there is an urgency to search for alternative sources as a substitute to fossil fuels. The alternative fuels are vegetable oils, natural gas, hydrogen etc. The heat content value of these alternate fuels is inferior to diesel fuel. Hence in this work an attempt is made to use black sesame methyl ester as a substitute to diesel. Further the experiments are performed on single cylinder four stroke water cooled direct injection (DI) diesel engine with different injection timings. The injection timings considered are 23°, 25°, 27° & 29° Before Top Dead Centre(BTDC) using Black sesame methyl ester (BSME) as a substitute fuel. The performance characteristics such as Brake Thermal Efficiency (BTE), Mechanical Efficiency and Specific consumption of fuel are analyzed. The emission characteristics viz., Carbon dioxide (CO), Hydrocarbon (HC) and oxides of nitrogen (NOx) are evaluated.

Index Terms*: Bio-Diesels, Black Seasame Methyl Ester Compression Ignition Engine, injection timing.

I. INTRODUCTION

In global across the world 5 million ha. of sesame was growing, where 65% is intended for extracting oil and remaining 35% is utilized as foodstuff [15]. Sesame seeds were small, smooth, and elliptical by a wacky flavor and weak by means of nearly imperceptible munch. They fluctuate in dimension from small range to large range and approach in a swarm of various colors, such as white, brown, grey, red and black. In India black colored seeds were available in the region of north east and the seeds obtained from Easter regions were in black to brown. Whereas the seeds from southern region were in reddish color [19]. The black and white colored seeds have oil percentage ranging from 44 percentages to 56 percentages respectively [20]. The anti-oxidant property of black and white sesame was substantial [18, 19]. The energy utilization in the world was increasing with increase of population [10]. The rapid extraction of crude oils result in extermination of petroleum products in near future. Further the pollutants form diesel engines create severe environmental pollution leading to global warming [1]. To overcome the above said problems, there was a need to use suitable biodiesel in place of petro diesel [3]. The main advantage of biofuel was that this fuel can be utilized in diesel engines without any alterations. Biodiesel was prepared from renewable sources like vegetable oil, waste cooking oil and animal fats [5, 7].

The vegetable oils contain high viscosity mainly due to presence of free fatty acids. These oils contain triglycerides, these esters were produced from the reaction of 3 free fatty acids (FFA) & trihydric alcohol and the glycerol. Tran's esterification method was used to prepare biodiesel. In Tran's esterification technique vegetable oils converted into glycerin and FFA alkyl esters. A strong catalyst like KOH or Sodium hydroxide and heat was required to complete the reaction [4]. The properties of biodiesels prepared from jatropha oil, rice bran oil, sesame oil and waste frying oil etc. were closer to properties of diesel fuel. These fuels were recommended to use as fuels in diesel engines [6]. The tests conducted on a direct injection diesel engine by using oil prepared from waste plastic with varied injection timings (23^{o},20^{o},17^{o} and 14^{o} BTDC) reveals that there was a decrease in oxides of nitrogen, unburned hydrocarbon and carbon monoxide at 14^{o} BTDC. But the Brake Thermal Efficiency (BTE), smoke and carbon dioxide (CO) were improved at all operating conditions [17].

The effect on performance, combustion and pollutant parameters of CI engine by using Dairy scum oil methyl ester blends (DSOME) and injection timings were evaluated. In first stage the engine runs DSOME blends identify the best blend that was DSOME20. The experiments were carried out on the test engine by varying the injection timings (20° bTDC to 29° bTDC) for DSOME 20. Results revealed that 26° bTDC injection timing for DSOME20 experiments shown better performance, emission and Combustion characteristics compare to other injection timings [2]. The experiments were conducted on diesel engine with different injection timings varies from 17° to 28° bTDC using Palm Methyl Ester blend20 (PME20). Results showed that the NOx pollutants were reduced; UBHC, CO increased, but advanced injection timing reverse the effect. The optimum injection timing for PME 20 is 21°bTDC, where thermal efficiency was high and BSFC, NO_x emissions were reduced [13].The combined effect of compression ratio, injection timing and injection pressure was studied. The brake thermal efficiency was increased and the brake specific fuel consumption was reduced. The emission parameters observed were lower for Pungam methyl ester (PME20). The hydrocarbon (HC), carbon dioxide (CO) pollutants were decreased for pungam methyl ester compared to standard diesel fuel. At 240 bar pressure, 27^{o}BTDC and 19:1 compression ratio brake thermal efficiency obtained was maximum and was about 30%.

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From the results it was concluded that at 240 bar injector opening pressure and at 27^o BTDC advanced injection timing, the pollutant and performance characteristics were optimum [16].

The experiments were conducted on compression ignition (CI) engine with different injection timing from 23^o BTDC to 28^o BTDC with Honne oil methyl ester (HOME). From the investigations it was revealed that the combustion parameters were improved with HOME by advancing injection timing. The emissions parameters like HC, CO, smoke opacity and NO_x were decreased with HOME compared to neat diesel by varying injection timing form 23^o to 28^o BTDC. From the experiments it was suggested that HOME can be used as a substitute fuel in place of neat diesel fuel [14].

Experiment focused on performance, combustion and pollutant parameters of engine at constant engine speed 2000rpm, 20% by volume canola oil blended with diesel and varying of injection timing. Results proved that combustion pressure, BSFC, Pmax change, slightly at advanced injection time. CO and PM were decreases with delaying of injection timing of BTDC, but NOx increases slightly IMEP was decreased slightly with increasing of EGR. PM and BSFC increases slightly but NOx was decreased at the same condition [11].

The Effect on combustion, pollutant and performance parameters of direct injection engine was run by using Ethyl Ester of Fish Oil (EEFO) by different injection timings 21^0, 24^0 and 27^0bTDC. Results revealed that the pollutant and performance examination on biodiesel and diesel (ethyl ester of fish oil) decreases ecological ruin by dropping noxious emissions [9]. An analysis was conducted to study the impact of injector opening pressure, injector nozzle geometry and injection timing on the combustion, emission and performance parameters using HOME, COME & HONE in modified CI engine. Form the results it was revealed that reduced injection timing with increased injector opening pressure gave increased BTE and better engine performance with and reduced carbon monoxide, hydrocarbon and smoke [12].

II. MATERIALS & METHODOLOGY

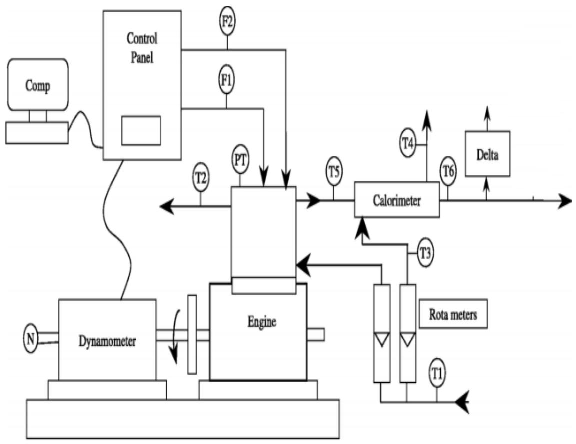

Fig. 1: Layout of the engine setup

The layout of the engine setup is shown in Figure 1. The test engine is set through proportions of the entire working parameters. Experiments are conducted on compression ignition engine with pure Black Seasame oil Methyl Ester (BSME), various injection timings (23^0, 25^0, 27^0 and 29^0 bTDC) with variation of load to estimate the pollutant and performance parameters. The experimental results are correlated against the standard results of base engine for different injection timings. The parameters of BSME are shown in Table 1 and the test engine specifications are shown in Table 2.

Fig. 2: Engine Setup

Table 1: Properties of BSME

S.No.	Property	ASTM Standard	BSME	Biodiesel limit (ASTMD6751)
1	Kinematic Viscosity @ 40^0C in CSt	ASTM D 445	2.49	1.9 to 6.0
2	Density @30^0C (gm/ml)	ASTM D 1298	0.894	0.85 to0.89
3	Specific Gravity @ 15^0C	ASTM D 1298	0.915	0.88
4	Flash Point in ^{0}C	ASTM D 92	164	100 to 180
5	Fire Point in ^{0}C	ASTM D 92	180	
6	Boiling Point in ^{0}C	ASTM D 1120	300	
7	Pour Point in ^{0}C	ASTM D 97	-21	-5 to 10
8	Cloud Point in ^{0}C	ASTM D 2500	-6	-3 to -12
9	Free Fatty Acids (%)	ASTM D 5555	0	
10	Acid Value (mg KOH/ kg)	ASTM D 664	0259	0.8 max
11	Calorific Value (MJ/kg)	ASTM D 5865	39.15	Min 35
12	Cetane Number	ASTM D 613	46	44 to 49
13	Moisture content	ASTM D 1744	0.2036	0.5% max
14	Carbon Residue	ASTM D 189	0.011	

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Table 2: Engine Specification

S.No.	Parameter	Specification
1	Make	Apex innovations Ltd.
2	No. of cylinders	1
3	No of strokes	4
4	Cylinder bore	87.5mm
5	Stroke length	110mm
6	Connecting rod length	234mm
7	Orifice diameter	20mm
8	Compression ratio	12:1 – 17.5:1
9	Power	5.2kw
10	Speed	1500 rpm
11	Fuel	Diesel
12	Injection pressure	180bar
13	Injection point variation	0 to30^0 BTDC
14	Dynamo meter type	Eddy current
15	Dynamo meter arm length	185mm

III. RESULTS & DISCUSSION

The investigations are carried out on single cylinder four stroke diesel engine with varying injection timing. The engine performance parameters determined are Mechanical Efficiency, Brake Thermal Efficiency(BTE), and specific consumption of fuel. The pollutant parameters computed are carbon dioxide, carbon monoxide, hydrocarbon and oxides of nitrogen.

A. Brake Thermal Efficiency (BTE)

The figure 3 indicates the correlation between brake powers with brake thermal efficiency. From the figure it is noticed that the brake thermal efficiency increases from zero load to maximum load condition. The BTE observed to be higher and is about 31% for 27° BTDC BSME at rated load. The lowest brake thermal efficiency recorded for 23°BTDC BSME and is about 28%.

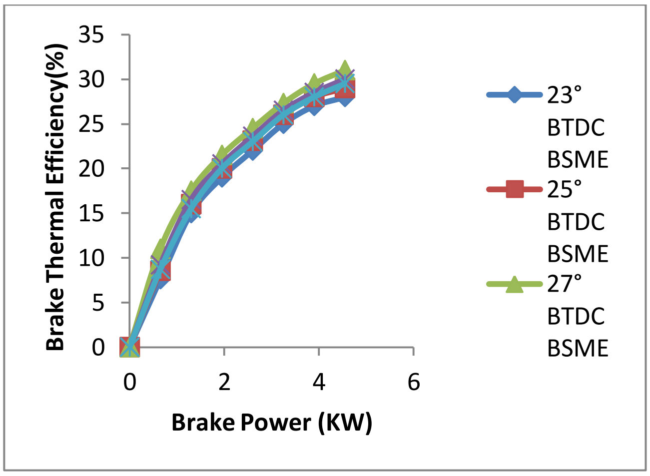

Fig. 3: Brake power Vs Brake thermal efficiency

B. Mechanical Efficiency (ME)

The comparison of Brake Power and Mechanical Efficiency is indicated in fig.4. From the figure it is noticed that Mechanical Efficiency increases from low load to partial load condition. The highest values of ME are found for 27°BTDC BSME and are about 81%. Mechanical efficiency is always directly proportional to Brake thermal efficiency.

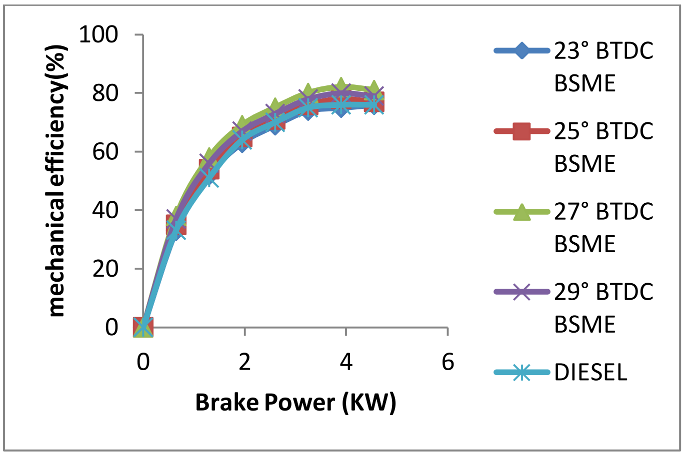

Fig. 4:Brake power Vs Mechanical efficiency

C. Specific Fuel Consumption(SFC)

Graph is plotted for Brake output power vs consumption of fuel per unit brake power is shown in fig 5. It is noticed that the SFC is high at initital condition and drastical reduced upto partial load condition. The lowest specific fuel consumption is 0.29 for 27°BTDC BSME at partial load condition. By advancing the injection timing the heat transfer losses are decreased.

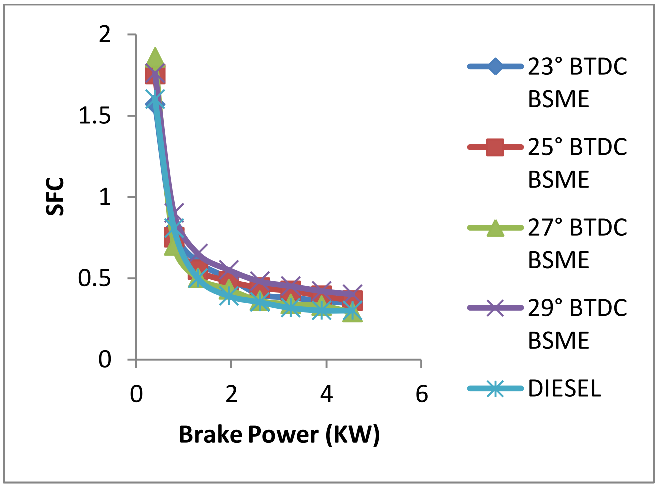

Fig. 5:Brake power Vs Specific fuel consumption

D. CO Pollutants

A plot is drawn between brake power and CO pollutants in fig.6. From the plot it is revealed that there is an increase in CO upto 75% load. After that the emissions are increased drastically. From the experimental results it is found that the minimum CO is obtained 1.3% for 27° BTDC BSME compared to other injection timings. The CO emissions are dangerous to human health therefore it has to be minimized. The carbon monoxideemissions are mainly due to incompleter combustion of the fuel.

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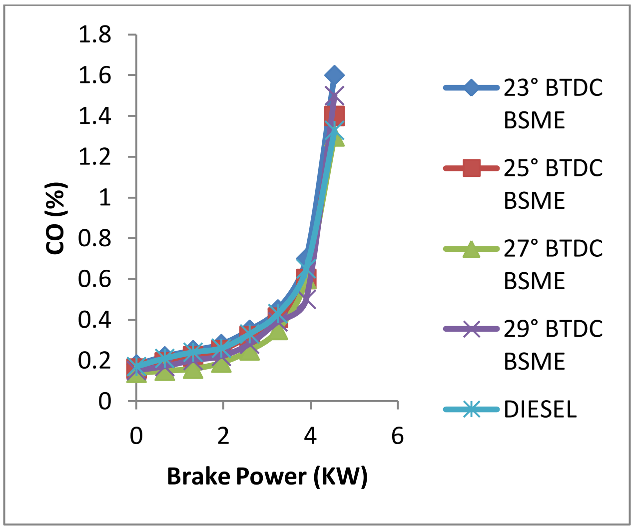

Fig. 6:Brake power Vs CO pollutant

E. CO_2 Pollutants

The fig.7. shows the brake power vs carbondioxide emissions. It is revealed that carbondioxide(CO_2) pollutants are increases from no load condition to maximum load condition for all injection timings. From the figure it is concluded that the CO_2 emissions of 27°BTDC BSME are more or less equal to base diesel. The CO2 emissions are increased for other advancing the injection timing with BSME.

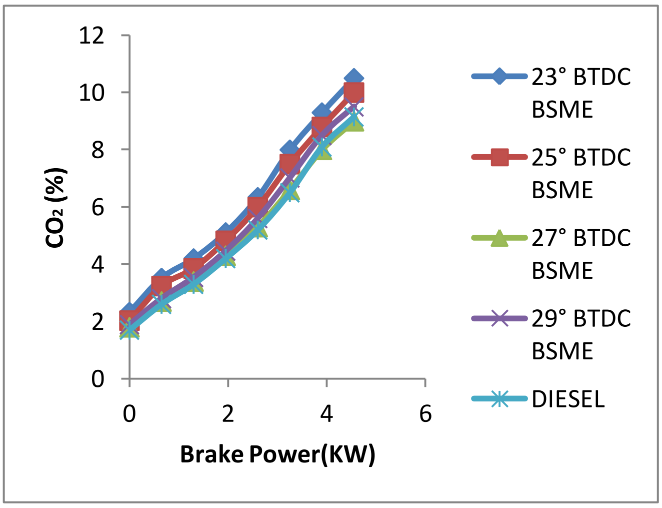

Fig.7:Brake power Vs CO_2 pollutants

F. NO_x Pollutants

The variation between brake power and nitrogen oxide emissions are shown in fig 8. The NO_x emission levels are increased from initial load to final load condition for all injection timings with BSME. Compare to all injection timings 27°BTDC BSME is less NO_x emission levels. The oxides of nitrogen emissions for 27° BTDC BSME is more about 2.4% compared to base diesel. The oxides of nitrogen (NO_x) are the main dangerous pollutants from diesel engine. It consists of nitric oxide and nitrogen dioxide. The percentage of NOx pollutant is increased with advanced injection timing.

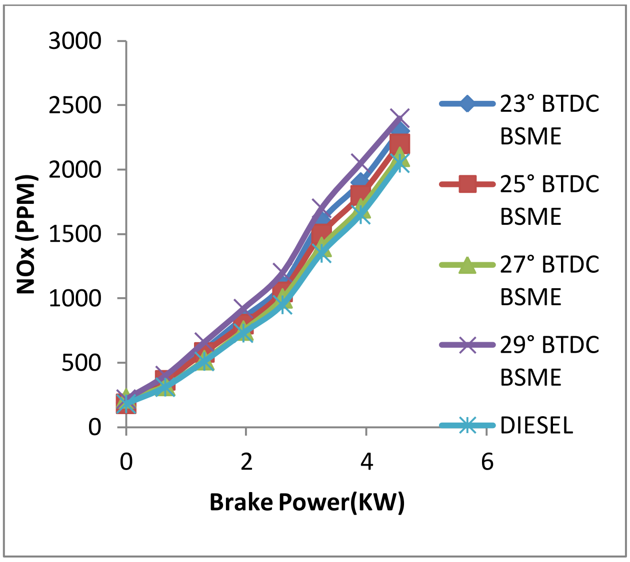

Fig. 8:Brake power Vs NOx pollutants

G. HC Pollutants

The fig.9. indicates the correlation between brake output power vs unburnt hydrocarbon pollutants. Form the graph it is noticed that the HC pollutants are increasing from low load operation to maximum load condition. The HC emission levels of 27° BTDC BSME is closer to diesel fuel. The emission of HC is mostly caused by the unburned fuel and incomplete combustion. By the amount of premixed combustion increases, the temperature and pressure inside the engine cylinder increases. Therefore the oxidation process of hydrocarbon fuels is accelerated. Thus the production of HC decreases with the injection timing advanced.

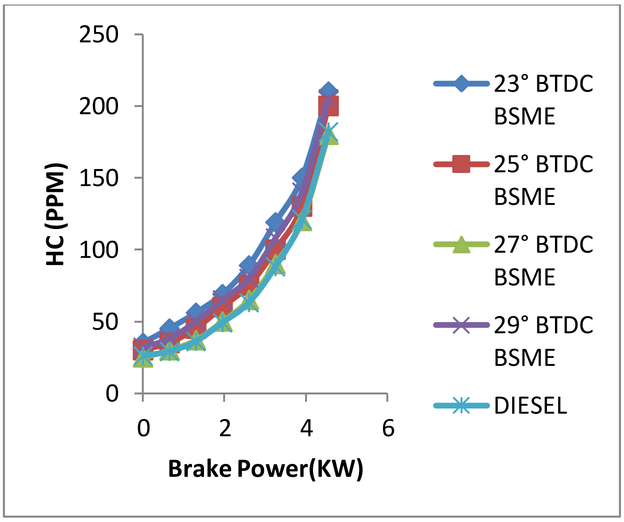

Fig. 9:BrakepowerVs HC pollutants

IV. CONCLUSION

Following are the main conclusions made from the present study

- The Brake Thermal Efficiency (BTE) of 27° BTDC BSME is higher about 5.08% compared to standard diesel. This is due to effective combustion in the cylinder.
- The mechanical efficiency obtained is high for 27° BTDC BSME and is about 6.57% compared to base engine. The reason is high cylinder temperature and pressure.
- The specific fuel consumption is decreased about 3.6% for 27° BTDC BSME compared to standard diesel. This is due to reduction of incylinder heat transfer loss at optimum injection timing.
- The CO emissions are for 27° BTDC BSME of 2.2% low compared to standard engine. This is occurred due to high flame speed propagation.
- The CO_2 emissions of 27° BTDC BSME are more or less equal to conventional. This is due to improved combustion process, where the presence oxygen content in the BSME.
- The oxides of nitrogen emissions for 27° BTDC BSME is more about 2.4% compared to base diesel. The highest temperature and pressure in the cylinder is the reason for more nitrogen oxide emissions.

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