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Performance, Combustion and Emission Characteristics of Direct Injection Diesel Engine Fueled With Castor Oil Methyl Esters and Ethanol Blends Equipped With 6 Hole Nozzle

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Abstract: ***Depletion of fossil fuel reserves and stringent pollution norms has created a need for search alternate source that can fuel internal combustion engine. The fuels obtained from green matter has got great potential to replace conventional fossil fuels to power internal combustion engine (ICE). But the performance of the ICE are influenced by many parameters such as injector opening pressure, injection timing, and combustion chamber profile. Current work deals with evaluation of engine performance, combustion characteristics of direction injection diesel engine fitted with re-entrant toroidal (RET) combustion chamber equipped with six hole nozzle fueled with castor oil methyl esters (CAOME) and ethanol blends. The peak value of break thermal efficiency (BTE) is found to be 26.34% at 75% load for a blend 80D+5B+15E with minimum emissions and with combustion duration and ignition delay in comparison with diesel.***

Keywords: Injector opening pressure, Injection timing, reentrant toroidal, Nozzle.

I. INTRODUCTION

With industrialization and rapid growth in vehicle density in 21st century the fossil fuel usage is having uptrend. This scenario resulted in search for alternate sources that are renewable in nature, yield best performance with minimum emissions and low processing cost. Enormous research has previously materialized to fuel engine with different edible and non-edible oils produced from green matter but research towards enhancing efficiency and minimizing emissions of engine with the same is minimum.

The fuels produced from green matter are categorized as first and second generation fuels. Ethanol produced by fermentation from sugar based green matter is considered as First generation fuels, this resulted in contradiction as it influenced the food chain. Since first generation fuels has great impact on food chain, later research was focused on producing oils from non-edible seeds which are considered as second generation fuels. Among the available second generation fuels CAOME has a potential to suit as fuel for IC engines. [2]

Engine performance is influenced by various factors namely compression ratio (CR), injector opening pressure (IOP), injection timing (IT), combustion chamber geometry, number holes in nozzle and many more. The optimum compression ratio was reported to be 17 to 18 for diesel engines fueled with biofuels and 17.5 CR [4] has produced best performance as reported by numerous researchers. With increase in IOP the BTE increases from 200 bar to 240 bar and further rise results in ignition delay thereby efficiency follows downtrend. [1]

II. MATERIALS AND METHODS

The materials used in the present work is CAOME synthesized from raw castor oil and performance evaluation is done on four stroke direct injection Kirloskar make diesel engine. The experiment is carried out at optimized injection timing and injector opening pressure fitted with 6 hole nozzle. Castor seeds from infections are selected, moisture content is removed by heating in hot air oven and oil is extracted by regular extraction method. The impurities are removed and free fatty acids are removed by using Transesterification, to convert it to biodiesel and the properties are evaluated as per ASTM standards.

2.1 Materials used

The castor oil is synthesized from castor beans and properties mentioned in table 1.

Table 1 Properties of Raw Castor Oil

Sl. No.	Properties	Castor oil Methyl esters
1	Flash point	320°C
2	Fire point	345°C
3	Kinematic viscosity	52cSt
4	Density	956 kg/m^3

The biodiesel is obtained by transesterification, process from raw castor. The characterization of Castor oil biofuel is estimated as per ASTM standards.

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F_1	Fuel flow rate sensor	T_3	Temperature of the calorimeter water inlet
F_2	Air flow rate measuring sensor	T_4	Temperature of calorimeter outlet
F_3	Flow rate to the jacket water measurement	T_5	Temperature of exhaust gas before calorimeter
F_4	Water flow inlet to the calorimeter	T_6	Temperature of exhaust gas after calorimeter
T_1	Water jacket inlet temperature	PT	Pressure sensor at combustion chamber
T_2	Water jacket outlet temperature	Wt	Weight

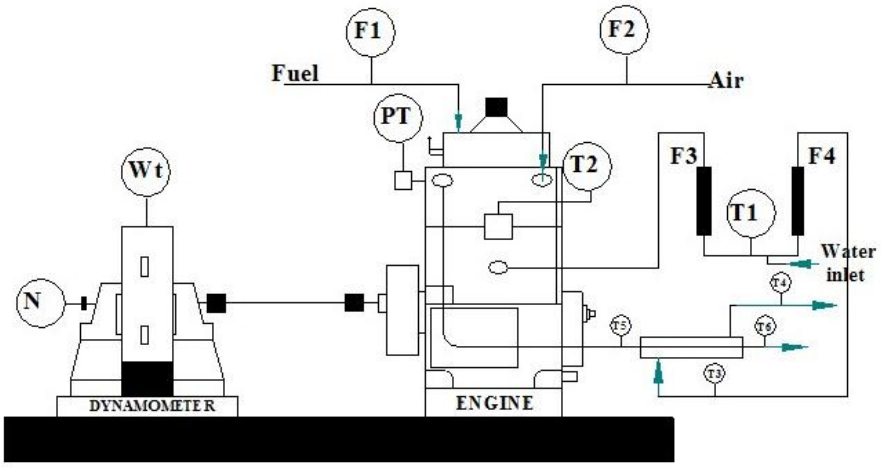

Figure 1 Test Rig

Table 2 Engine specifications of tested engine

Parameters	Specifications
Engine type	TV1 (Kirloskar make)
Software used	Engine soft
Injector operating pressure	210 to 260 bar
Static injection time	17° to 31°B TDC
Governor type	Centrifugal type
No of cylinders	Single cylinder
No of strokes	4 stroke
Fuel oil	High Speed Diesel
Rated power	5.2 kW at 1500 rpm
Cylinder diameter (Bore)	0.0875 m
Stroke length	0.11 m
Ratio of compression	17.5:1

Table 3 Biodiesel Properties

SL. No.	Diesel (%)	Biodiesel (%) COME	Density (kg/m^3)	Viscosity (cSt)	CV (kJ/kg)	Specific gravity	Flash point (^{0}C)
1	100	-	834	2.38	42250	0.834	60
2	-	100	927	5.57	37730	0.927	189

III. EXPERIMENTAL RESULTS AND DISCUSSION

Effect Of Caome+Ethanol+Diesel Blends:

In the present research, experiments are conducted for optimum IOP of 240 bar, optimum IT of 27°BTDC [3], [1] for RET Combustion chamber using a nozzle with 6 holes.

Performance Evaluation

Break Thermal Efficiency

The calorific value of CAOME is less and is viscous in nature in comparison with diesel hence it poor performance. But the increase in addition of ethanol and diesel percentage have shown the rise in calorific value and drop in viscosity [4] and have resulted in best performance.

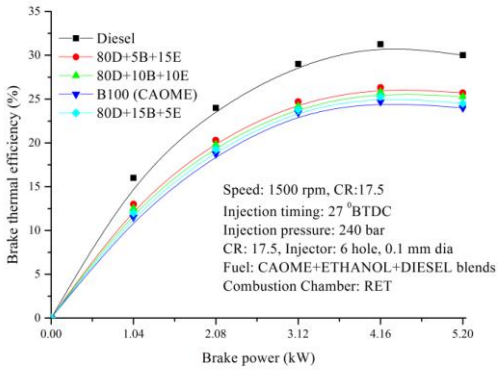

Figure 2 BTE vs BP

Smoke Emissions

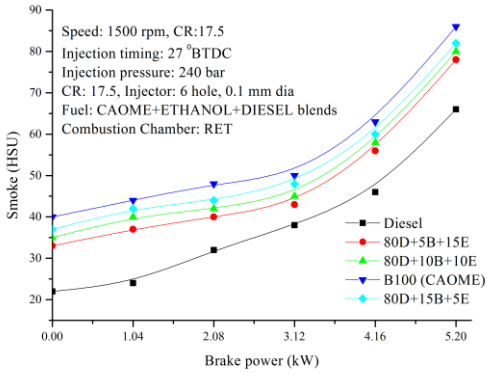

Figure 3 Smoke opacity vs BP

FFA are present in biodiesel which leads to formation of poor air fuel mixture and results in incomplete combustion as a result of that smoke emissions are more for pure CAOME but the same has found to be decreasing gradually with the increase in percentage of diesel and ethanol.

HC Emissions

Higher viscosity of CAOME result in poorer atomization in comparison with diesel which in turn result in poor combustion as a result results in higher UHC emissions but same tend has decreased with addition of increase in percentage of diesel and ethanol .[1]

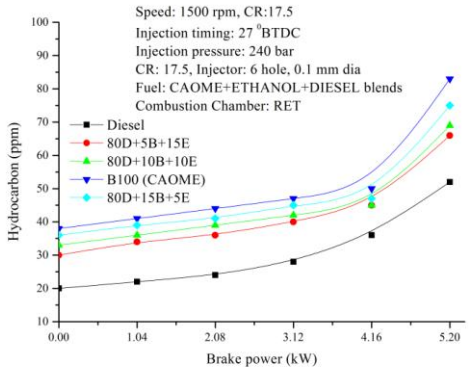

Figure 4 UBC vs BP

CO Emissions

Results shows that CO emissions of blends decrease with increase in percentage of ethanol and diesel are higher due to lower volatility and also due to lower BTE obtained with CAOME.

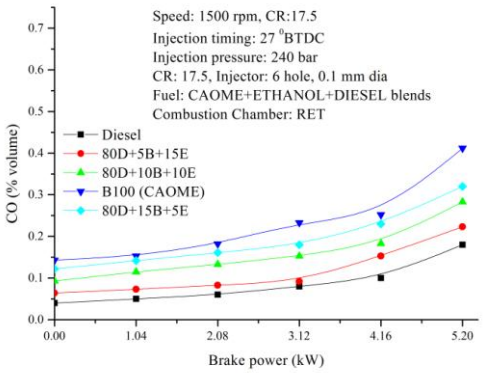

Figure 5 CO vs BP

NOx Emissions

NOx emissions of CAOME and its blends are quite low because the peak cylinder temperature for diesel is more compared to CAOME and its blends. Low cetane number of CAOME attributes for less peak in cylinder temperature.

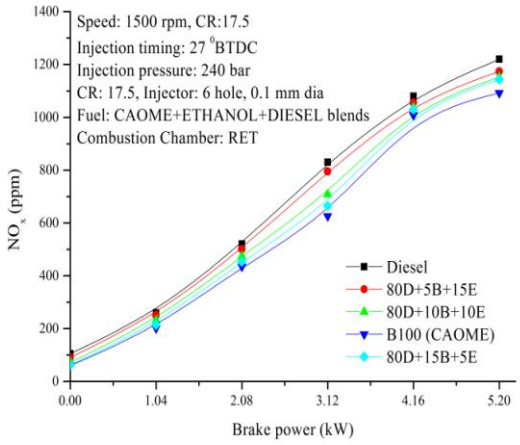

Figure 6 NOx vs BP

Ignition Delay

Ignition delay for different blends of CAOME tend to decrease with percentage increase in Diesel and Ethanol as it enhances fuel atomization and results in complete combustion. [1]

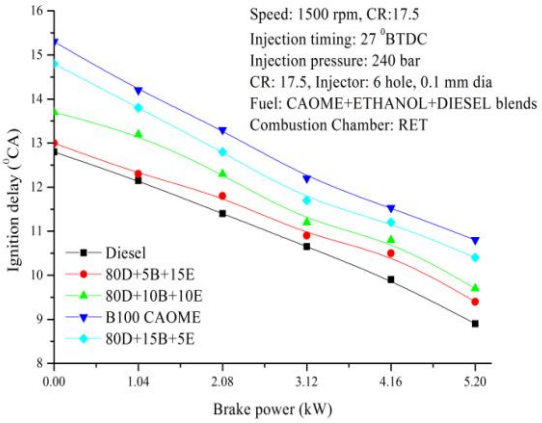

Figure 7 Ignition delay vs BP

Combustion Duration

Combustion duration for different blends of CAOME tend to decrease with percentage increase in Diesel and Ethanol and the same is reflected in the plot shown below.

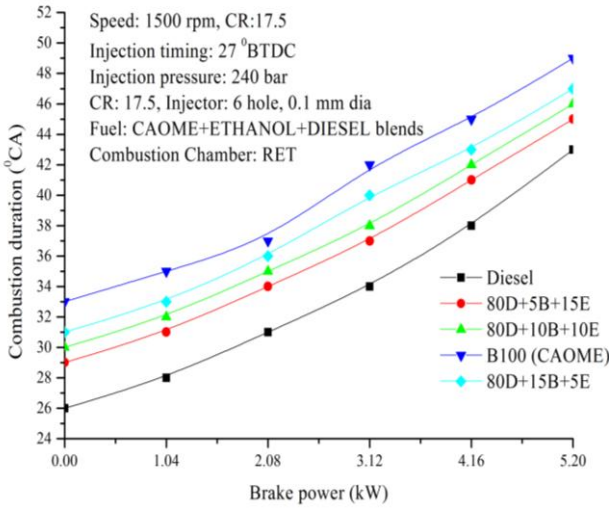

Figure 8 Combustion duration vs BP

IV. CONCLUSION

The best results in terms of higher performance and lesser emissions ate obtained for six-hole nozzle at 240 bar IOP and IT of 27°BTDC for RET Combustion chamber and has produced higher thermal efficiency (26.34%) for blend 80D+5B+15E at 75% load. Drop in CO, UBC, Smoke levels and NOx emissions are reported with percentage increase in diesel and ethanol in the blends. Higher calorific value of ethanol compared to CAOME results in better combustion and results inn lesser combustion duration and ignition delay.

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