EFFECT OF INJECTION PARAMETERS ON ENGINE PERFORMANCES AND EMISSIONS USING COTTON SEED BIO DIESEL AS FUEL

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ABSTRACT

India is one of the world's largest producer of cotton, increasing price of fossil fuels, environmental concern are the various reason for exploring cotton seed oil as an alternative for diesel oil and shows some attractive environmental benefits such as lower emission of CO and un burnt hydrocarbons**.** Straight vegetable oil cannot be used directly in CI engine due to high viscosity, to reduce this viscosity it under goes a chemical process called transesterfication. In this study, the fuel properties of biodiesel from cotton seed oil are determined; their performance and emission characteristics are studied on four stroke, single cylinder diesel engine with variable injection pressure and injection timing to ensure the suitability of biodiesel produced from cotton seed oil as compression ignition engine fuel. The results showed a better performance and emission with injection pressure of 200 bar and injection timing 30^0 of bTDC.

Key words: Diesel Engine, Cotton Seed oil Bio Diesel, Injection Pressure, Injection Timing, Performance and Emission Appraisal.

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INTRODUCTION

Energy is considered as very important factor for life quality, social development as well as economic growth of people. Fossil fuels have been an important conventional energy source for many years. Energy demand around the world is increasing at a faster rate as a result of on-going trends in industrialization and modernization. Most of the developing countries import fossil fuels for satisfying their energy demand. Consequently, these countries have to spend their export income to buy petroleum products. The climate changes occurring due to increased carbon dioxide (CO_2), emissions and global warming, increasing air pollution and depletion of fossil fuels are the major problems in the present century. The present researchers have been focused on the biofuels as environment friendly energy source to reduce dependence on fossil fuels and to reduce air pollution. The biofuels can play an important role towards the transition to a lower carbon economy and also combine the benefits of low greenhouse emissions with the reduction of oil import. Biofuels are drawing increasing attention worldwide as substitutes for petroleum-derived transportation fuels to overcome energy cost, energy security and global warming concerns associated with liquid fossil fuels. The term biofuel is used here to mean any liquid fuel made from plant material or animal fat that can be used as a substitute for petroleum-derived fuel. Some of the vegetable oils from farm and forest origin have been identified. The most predominantly sunflower, soybean, cotton seed, honge, jatropha, peanut oil etc., have been report as appropriate substitute of petroleum based fuels. The vegetables oils can be used in diesel engines by various techniques such as fuel modification by transesterification, diesel vegetable blends, vegetable oil heating etc [1, 2 and 3].

MATERIALS AND METHODS

The raw cotton seed oil was obtained from a local vegetable oil vendor which had small traces of organic matter and other impurities. Transesterfication is a most common and well established chemical reaction in which alcohol reacts with triglycerides of fatty acids (vegetable oil) in presence of catalyst to form glycerol and esters. Transesterification is otherwise known as alcoholysis. It is the reaction of fat or oil with an alcohol to form esters and glycerin. A catalyst is used to improve the reaction rate and yield. Among the alcohols, methanol and ethanol are used commercially because of their low cost and their physical and chemical advantages. They quickly react with tri-glycerides and NaOH and are easily dissolved in them. To complete a transesterificaton process, 3:1 molar ratio of alcohol is needed. Enzymes, alkalis or acids can catalyze the reaction, i.e. lipases, NaOH and sulphuric acid, respectively. Among these, alkali tranesterification is faster and hence it is used commercially. A mixture of vegetable oil and sodium hydroxide (used as catalyst) are heated and maintained at 65^0C for 1 hour, while the solution is continuously stirred. Two distinct layers are formed, the lower layer is glycerin and the upper layer is ester. The upper layer (ester) is separated and moisture is removed from the ester by using calcium chloride [4, 5 and 6]

FUEL PROPERTIES

The basic composition of vegetable oils is triglycerides which are esters of three acids and one glycerol. The properties COME and diesel are presented in Table 1[7 and 8].

Table 1. Properties of Fuels used in Diesel Engine.

Fuel	Specific Gravity	Kinematic Viscosity at 40^0C (mm^2/s)	Cetane Index	Flash point (^{0}C)	Calorific Value (MJ/kg)
Diesel	0.838	4	47	44	43.92
Raw Cotton seed oil	0.912	50	48.1	220	39.60
Cotton seed oil BD	0.850	4.2	51.2	142	41.68

EXPERIMENTAL SET UP

The Fig1 shows the experimental setup and its components necessary to carry out engine test for performance characteristics at different injection pressure and injection timings using cottonseed oil biodiesel blend with diesel (20% Cottonseed oil biodiesel and 80% diesel) as fuel. The engine used for this test is TV1, Kirloskar, Single cylinder, 4 stroke, water cooled diesel engine having a rated output of 5.2 kW at 1500 rpm for a compression ratio of 17.5:1 and the engine is coupled with eddy current dynamometer for different load measurements. The water flow measurement is carried out with rotometer and exhaust emission measurement with Indus model 5 gas analyzer (PEA 205).

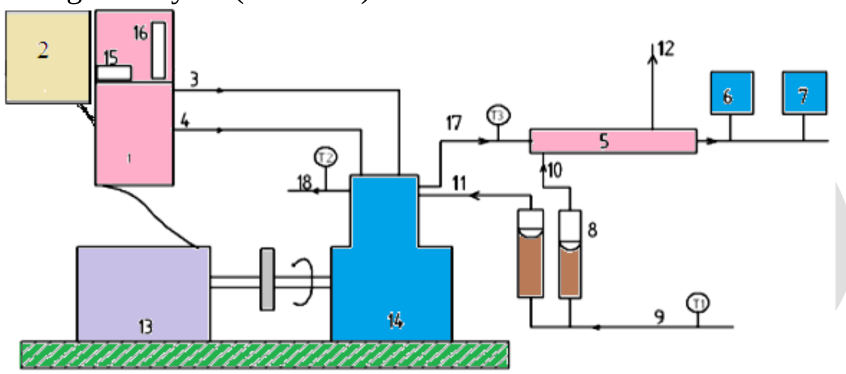
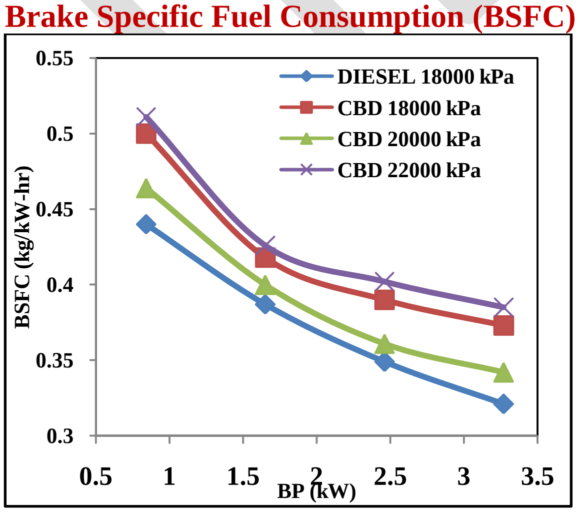


Fig 1: Schematic Diagram of the Experimental Set-up.

1 = Control Panel, 2 = Computer system, 3 = Diesel flow line, 4 = Air flow line, 5= Calorimeter, 6 = Exhaust gas analyzer, 7 = Smoke meter, 8 = Rota meter, 9= Inlet water temperature, 10= Calorimeter inlet water temp., 11= Inlet water to engine jacket, 12 =Calorimeter outlet water temp., 13 = Dynamometer, 14 = CI Engine, 15 = Speed measurement, 16 = Burette for fuel measurement, 17 = Exhaust gas outlet, 18 = Outlet water from engine jacket, T1= Inlet water temperature, T2 = Outlet water temperature, T3 = Exhaust gas temperature.

RESULT AND DISCUSTION

i) Brake Specific Fuel Consumption (BSFC)



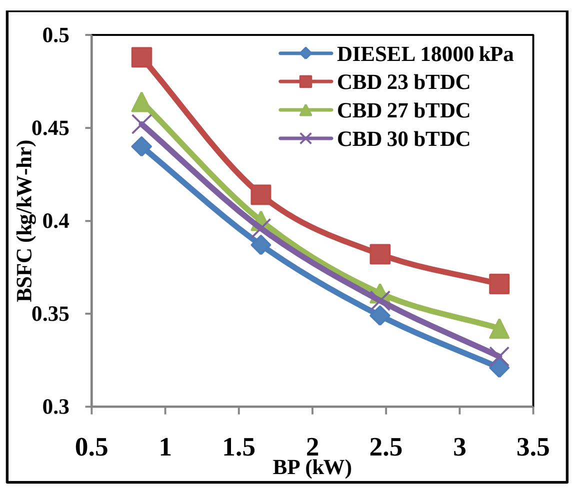


Fig 2: BSFC v/s BP at IT of 27^0 bTDC **Fig 3: BSFC v/s BP at IP of 20000 kPa.**

From Fig 2 and 3, variations of BSFC for different injection pressures (IP) and injection timings (IT) can be observed. Fig 2 shows that, BSFC decreases with the increase of brake power (BP) and minimum BSFC can be observed for diesel compared to COME at IP of 20000 kPa, 18000 kPa and 22000 kPa, this is because of lower calorific value and viscosity of the biodiesel. At optimum pressure, fuel air mixing and spray atomization will be improved thereby decreasing BSFC. So in this case IP of 20000 kPa. The Fig 2 shows minimum BSFC of 0.342 kg/kW-hr for COME at IP of 20000 kPa. From Fig 3, the variations of BSFC for different IT at optimum IP of 20000 kPa are shown and the BSFC for COME at IT of 30^0 bTDC is less compared to IT of 23^0 bTDC and 30^0 bTDC and little higher than diesel can be observed. This is because of optimum delay period and smaller amount of fuel supplied during burning.

ii) Brake Thermal efficiency (BTE)

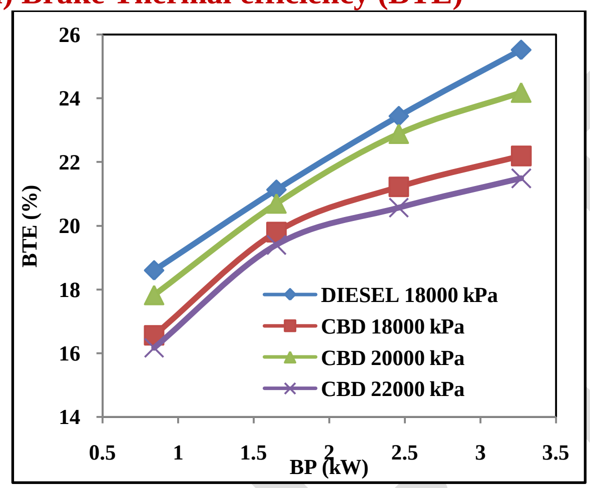


Fig 4: BTE v/s BP at IP of 27^0 bTDC

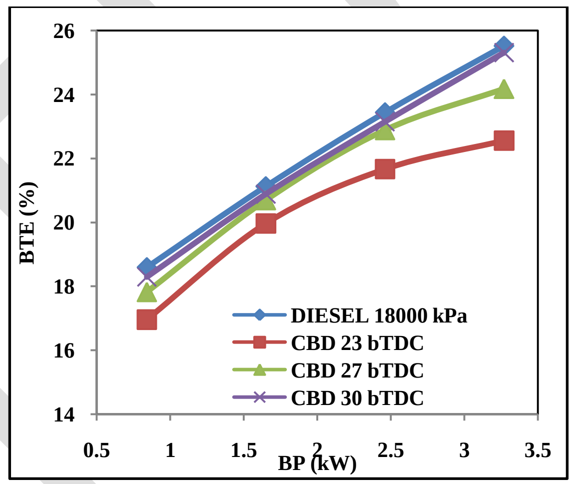


Fig 5: BTE v/s BP at IP of 20000 kPa

The variation of BTE for different IP and IT can be observed from Fig 4 to 5. In the Fig 4, BTE for diesel at IP 18000 kPa is maximum compared to COME of IP 18000 kPa, 20000 kPa and 22000 kPa and increase of BTE with the increase of BP can be observed, this is due to lower calorific value and higher viscosity of biodiesels than diesel. For optimum IP the value of BTE will be high as their will be improvement in the fuel air mixing and spray atomization and for further increase in IP above optimum value the BTE will going to decrease. The maximum BTE of 25.52% and 24.18 can be seen for diesel at 18000 kPa and COME at 20000 kPa which is shown in Fig 4 and from Fig 5, the variations of BTE for different IT at optimum IP of 20000 kPa can be observed.

iii) Unburnt Hydrocarbons (UBHC)

The variation of UBHC emission for different IP and IT is shown in the Fig 6 and 7. It is observed that emission of unburnt hydrocarbon is more in case of diesel compared to biodiesel i.e., combustion of diesel in CI engine produces more unburnt hydrocarbons emission than biodiesel. Since biodiesel has more oxygen content in it than diesel, the chances of combustion of hydrocarbons is more in case of biodiesel. Fig 6 also indicates that minimum emission of unburnt hydrocarbons can be obtained for optimum IP. The Fig 7 shows the minimum emission of unburnt hydrocarbon of 48 ppm is obtained for COME of IP 20000 kPa and IT 30^0 bTDC.

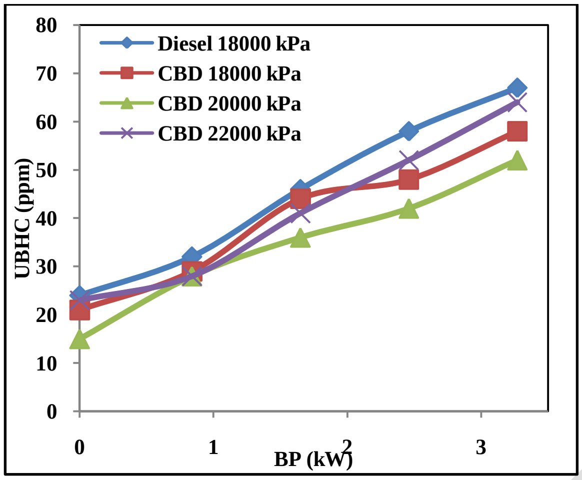


Fig 6: UBHC v/s BP at IT of 27^0 bTDC

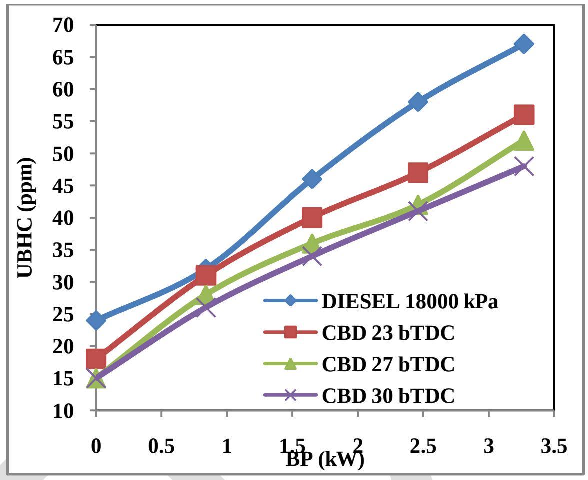


Fig 7: UBHC v/s BP at IP of 20000 kPa.

iv) Carbon Monoxide (CO)

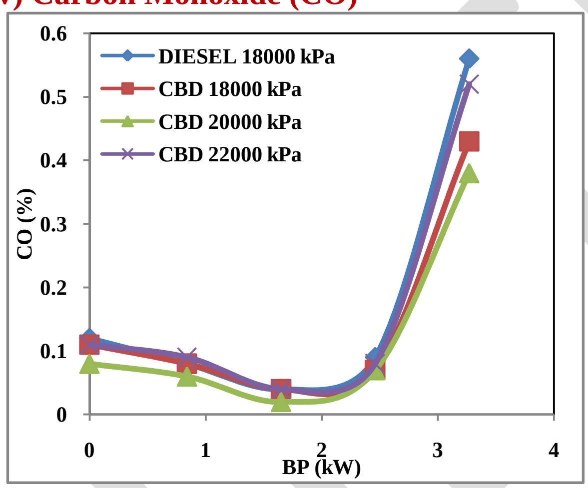


Fig 8: CO v/s BP at IT of 27^0 bTDC

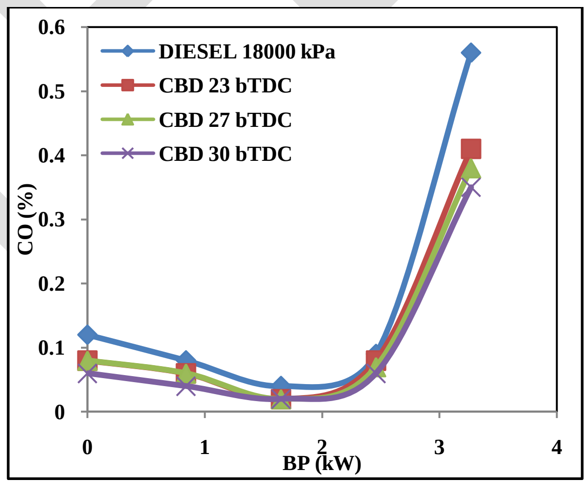


Fig 9: CO v/s BP at IP of 20000 kPa.

From Fig 8 and 9, the variation of CO for different IP and IT can be observed. The Fig 8 shows the variation of CO for different IP and it is observed that maximum CO emission will be in case of diesel compared to biodiesel. The CO emission will be less for optimum IP and it is noted that minimum CO emission of 0.38% for IP 20000 kPa from Fig 8. The variation of CO emissions for different IT can be observed in the Fig 9 and it also indicates with the increase of IT CO emission will going to reduce. From Fig 9, minimum CO emission of 0.35% is noted for COME at IT 30^0 bTDC.

v) Nitrogen Oxides (NO_X)

The variation of NOx with BP for different IP and IT is shown in Fig 10 and 11. From Fig 10 it is observed that NO_X emission higher for COME at IP of 22000 kPa compared to COME at IP of 18000 kPa, 20000 kPa and diesel. This is because engine working at higher

IP results in higher temperature, as a result NO_X emission increases. The formation nitrogen oxides will be more at higher temperatures. The Fig 10 shows the minimum value of NO_X emission is 1112 ppm for COME at IP 20000 kPa. The variation of NOx at different IT can be observed in the Fig 11, it shows NO_X emission will be minimum for diesel also shows that NO_X emission increases with the increase of it, this is due to high temperature working.

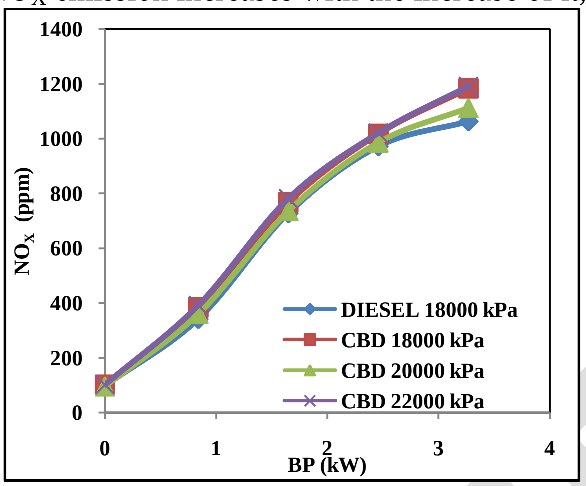


Fig 10: NOx v/s BP at IT of 27^0 bTDC

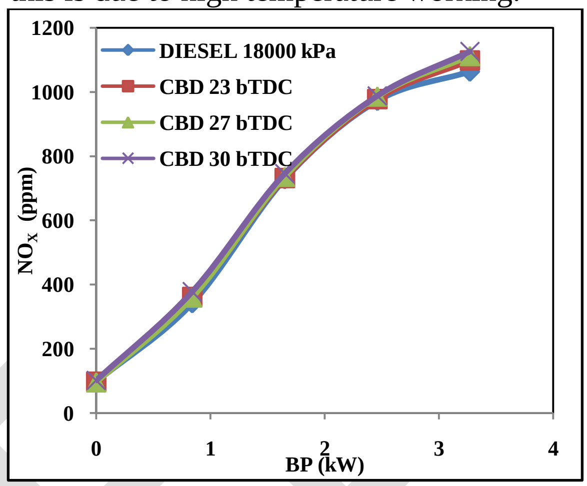


Fig 11: NOx v/s BP at IP of 20000 kPa.

CONCLUSION

- The BTE is improved with increase in BP; this was due to reduction in heat loss and increase in power with increase in load.
- BSFC for methyl esters of cottonseed oil fuel are 0.342 kg/kW-hr at 20000 kPa. It is noticed that, with increase in injection pressure from 18000 to 22000 kPa the BSFC for methyl esters of cotton seed oil fuel is increased to 0.385 kg/kW-hr, where as diesel fuel 0.321 kg/kW-hr.
- The UBHC is increased with increase in BP of cotton seed oil fuel. The UBHC emission of methyl esters at full load is approximately 23% lower than the diesel value.
- It is observed that the CO emissions for cotton seed oil fuel used are lower than the diesel fuel. The CO emission for cotton seed oil fuel used at full BP is approximately 33% lower than the corresponding value for diesel.
- It is also observed that the average NOx emission in the case of conditioned bio fuels is 1112 ppm which is slightly higher than the diesel fuel (1063ppm).
- Increasing the injector opening pressure from the rated value for diesel (18000 kPa) to 20000 kPa resulted in a significant improvement in performance and emissions with conditioned oils (methyl esters) due to better spray formation.

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