Performance and emission characteristics of a CI engine fuelled with waste cooking methyl ester and it's respective blends with diesel fuel

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Abstract— The main aim of this paper is to study the optimization, performance and emission characteristics of WCOME. The Transesterification of WCO with methanol has been studied in the presence of various catalyst i.e. sodium hydroxide and potassium hydroxide. The optimization of experimental parameters was established to gain 95% WCOME. The final properties of WCOME like density, viscosity, pour point, cloud point, flash point, fire point and C.V. were evaluated by ASTM standards and were found to be comparable to ASTM standards for diesel. The most recommended WCME blended ratio 5 to 20% for better engine performance and emission characteristics were used. The performance and emission indicators such as brake power, BTE, EGT ,BSFC ,NOx ,CO,CO2HC and smoke opacity have been estimated for 5%,10% and 20% blend are compared to diesel fuel. The results of experiment show that BSFC increases with use of biodiesel however BSEC decreases with increase in blend percentage. CO and HC emissions were reduced for biodiesel. But NOX emission increases at B20 blend by50% from (B5, B10 and B20). This work discovered that waste cooking methyl esters can be used in CI engine as a replacement of diesel fuel

Key words: Transesterification; Waste cooking oil methyl ester, Performance; Exhaust emission

NOMENCLATURE

WCOME- Waste cooking oil methyl esters
DI- Diesel engine
CN- Cetane number
BP- Brake power
CV- Calorific value
CO- Carbon monoxide
NOx-Oxides of nitrogen
HC- Hydrocarbons
CO2- Carbon di-oxide
BSFC- Brake specific fuel consumption
BSEC- Brake specific energy consumption
EGT- Exhaust gas temperature
BTE- Brake thermal efficiency
PM- Particulate matter

I. INTRODUCTION

Now a day's world increase in the consumption of petroleum products has caused economic and environmental problem. In order to reduce faith of petroleum oil, development of renewable fuel such as biodiesel is very important. The significance of biodiesel fuel likes renewability, High biodegradability, high flash point and low emission of pollution. Biodiesel formation is from various edible and non edible vegetable oil like rapeseed, soybean, sunflowers, palm, rocket seed and waste cooking oil. The Transesterification of WCO with methanol has been studied by using KOH catalyst [6]. The various studies are reviewed to understand the information related with conversion of Waste Cooking Oil into biodiesel which blends with Diesel and the performance testing adapted on C.I engine. Following are the various Researchers are present their views related with the same. Dr,Kolhe K.P.et al [1,2,3,4&5] has studied out Testing of Tractor Mounted and Self Propelled Coconut Climber for coconut harvestings This wcome was used in Tractor Mounted. and Self Propelled Coconut Climber. our methyl ester was used for agricultural purpose and this was used in this equipment for in regular use Dr. Ragit S.S. et al [7&8] has carried out an experiment to Comparative study of engine performance and exhaust emission characteristics of a single cylinder 4-stroke CI engine operated on the esters of hemp oil and neem oil The results showed a 45.07%reduction in NOx, 84.42% reduction in HC, 28.35% in smoke but brake thermal efficiency increased slightly (0.19%) at full load for hemp biodiesel, 6.06 % reduction in NOx, 2.59 % reduction in HC, 18.39% reduction in smoke at full load for neem biodiesel, respectively.

II. MATERIALS

The primary raw material for biodiesel preparation is waste cooking oil, which was collected from different sources such as JSPM college canteen and other material like methanol, silica gel and KOH (catalyst). Unnecessary impurities in the oil such as solid matter and food residues were removed using vacuum filtration.

III. METHODS

A. Transesterification Process:

This process was performed in our campus pharmacy lab in our college. this process consists of magnetic stirrer with hot plate, thermometer, beaker, magnetic bid, separating funnel and tripod stand. Transesterification process is also called as one-way process. In this method NAOH or KOH were used as catalyst. wco was heated upto60oc in a beaker for 20 mins.

Methanol: oil molar ratio	Catalyst type	Catalyst content (wt %)	Reaction temperature(°c)	Reaction time (hr)	Kinematic viscosity at40° c	Biodiesel yield (%)
7.5:1	KOH	0.5	60	0.5	4.3	94
6:1	NAOH	1	50	1.5	4.25	92
6:1	KOH	1	65	1	4.6	96

Table 1: Optimum condition for Biodiesel

Removing moisture content before reaction.(200ml) Methanol is dissolved in KOH 1 %(Catalyst)to form a potassium methoxide using continuous stirrer for half an

hour. This Potassium methoxide solution was put into one liter of waste cooking oil, the mixture was heated at 60ocand with continuous stirring for 60 min at650 rpm. The wcome solution was cooled at room temp. and settle down ,and ensuing in the separation of two phases. Upper phase contained biodiesel and lower phase contain glycerin as above product. which was separated by decantation method After separation of biodiesel was purified by using distilled water. This biodiesel was passed in silica gel to remove impurities. And lastly pure biodiesel was formed.

Fig. 1: Transesterification Process

IV. FUEL TESTING CHARACTERISTICS

Density

Density of biodiesel is measured by using ASTM standard D1298 .density of fuel was directly affected on engine performance characteristics. Density also influences the exhaust emission.

Viscosity

viscosity of an engine fuel plays leading role in the fuel spray, mixture, formation and combustion process. Kinematic viscosity was determined by using ASTM D445.density affects atomization quality, size and fuel drops. low viscosity causes fuel system while high viscosity causes poor flow. High viscosity also causes in cold weather for starting the engine.

Flash point

The flash point is defined as the temperature at which fuel starts burn when it comes to contact with fire. This property does not affect the combustion directly. Flash point was measured by using ASTM D93.

Cloud and Pour point

Pour point is defined as lowest temperature at which the fuel can still flow can be pumped, before it turns into a cloud of wax crystal when cooled. All biodiesel having higher cloud and pour point than diesel fuel. Waste cooking oil have low cloud and pour point. But this problem was overcome blended with diesel fuel.

Calorific value

Calorific value is defined as the amount of heat transferred into chamber of the chemical reaction during the combustion process. Higher CV is the higher yield of fuel because of high heat release rate. Calorific value is measured by using bomb calorimeter. CV of biodiesel is in between (39-41MJ/KG)

Name of fuel property	Diesel	wcome5	wcome10	wcome20	WCOME100
Density, Kg/m3	827.1	832	835.4	840.1	862
Viscosity, Cst	5.1	4.25	4.34	4.81	4.9
Flash point	72	76	79	84	152
Pour point	-18	-24	-18	-17	-5
Cetane number	50.95	51.68	52.51	53.10	43.21

Table 2: Properties of fuel.

V. ENGINE TESTING CHARACTERISTICS

A. Performance Characteristics:

Torque

This is due to low calorific values of biodiesel and blended fuels. high viscosity affects engine power and torque.

BSFC

Biodiesel blends could be higher bsfc than diesel fuel due to the lower calorific value. This is mainly due to advance fuel injection timing. Biodiesel creates extra lean mixture in combustion chamber also increases bsfc.

BTE

It is a factor to represent the how much amount of chemical energy converted into the useful work. It is the ratio of brake power in the output shaft to the energy delivered to the system the reason of increasing bte is due to additional lubricity provided by biodiesel.

EGT

Biodiesel fuel and it's blends gives better exhaust temperature(EGT) than diesel fuel.EGT

B. Emission Characteristics:

NOx

NOx formation is totally dependent on volumetric efficiency, combustion timing and temperature rising due to chemical reaction involved. Exhaust gas temperature increased also increases

NOx percentages. Increase in NOx is proportional to the amount of biodiesel. Biodiesel contains oxygen content reacts with nitrogen resulting into the NOx formation.

CO

This may aspect to higher viscosity of biodiesel. Decrease of CO may be due to oxygen content in the biodiesel.

CO2

Biodiesel gave more complete combustion and hence more conversion of COtoCO2.

HC

Decrease in combustion delay and higher cetane number causes in reduced in HC reduction.

Sr no	Items	Specification
1	diesel engine	Kirloskar AV1
2	Compression ratio	17.5:1
3	Method of starting	Hand operated
4	No .of cylinder	Single cylinder

5	Bore X stroke (mm)	87.5x110
6	Maximum power	5HP
7	Nominal speed	1500 rpm

Table 3: Engine specification

VI. EXPERIMENTAL PROCEDURE

Ensuring the sufficient fuel has available in fuel tank. Give 230 V AC supplies to the trainer by connecting the 3 pin top provided with the trainer to the distribution board in laboratory. Switch on the supply Provide cooling water to engine, Dynamometer and exhaust gas calorimeter. Open the fuel supply valve of engine.

Fig. 2: Schematic Diagram of Experimental Set Up

VII. RESULT AND DISCUSSIONS

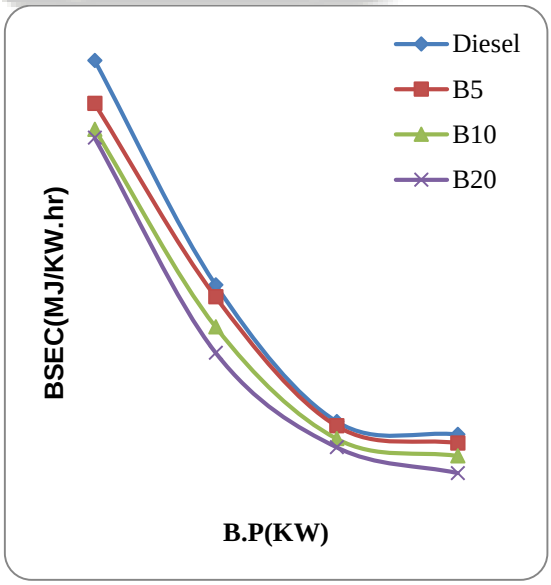

Fig. 3: Effect of B.P On Bsec

Fig. 3 indicates that BSEC decreases with increase in load .it also increases according to addition biodiesel content in blend. for B20 blend load bsec was reduced by 5.39%. at 1.5KW.

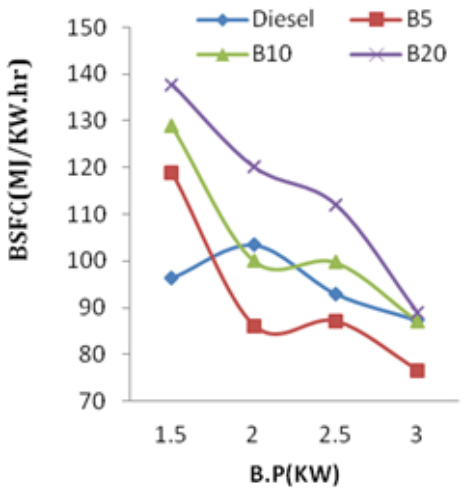

Fig. 4: Effect of B.P on BSFC

Fig. 4 shows the relation between BSFC and BP for different bio-fuel blends. For full load condition BSFC for B5 blend is lower than other blends and diesel fuel.

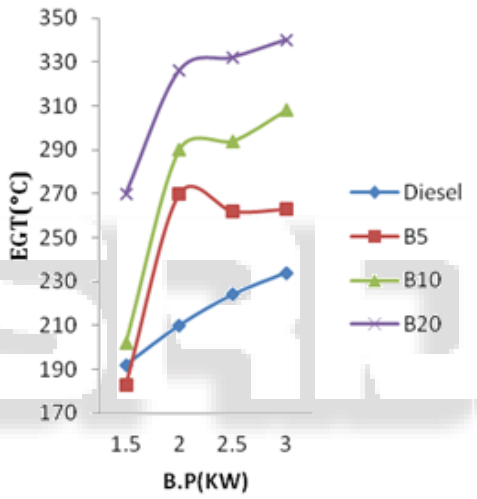

Fig. 5: Variation in Exhaust gas temperature with Brake Power

Fig. 5 shows the relation in between EGT and BP for different bio-fuel blends. For full load condition, the highest temperature obtained is 3400C for B20, 234 0C for diesel, 308 0C for B10 and 270 0C for B5 at half load.

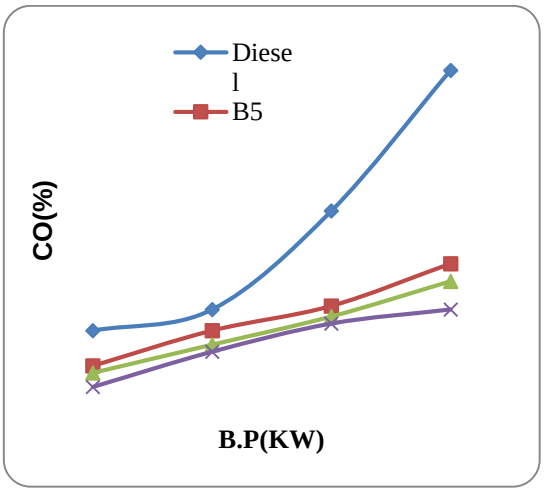

Fig. 6: Effect of B.P on Carbon monoxide

Fig. 6 depicts relation between B.P and carbon monoxide in which as B.P increases CO % increases for all the blends but maximum CO% observed 0.15 % for diesel and minimum 0.082% for B20 at the peak value of B.P 3KW.

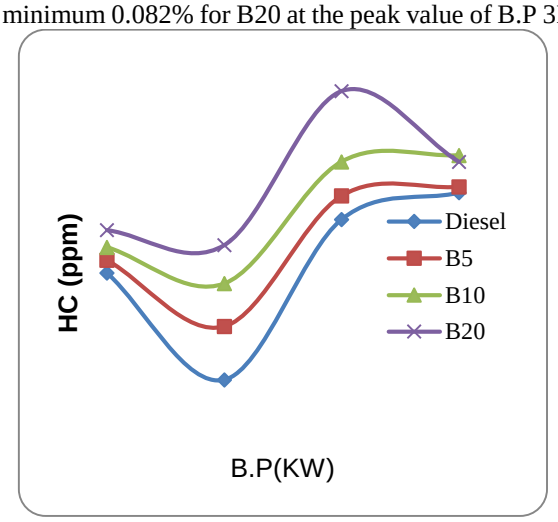

Fig. 7: Effect of brake power on hydrocarbon emission

Fig. 7 shows the relation in between HC and B.P. for different blend ratios .as the high B.P with increasing blending ratios maximum at B10 for 30.5 .At part load condition HC reduction increases26.3

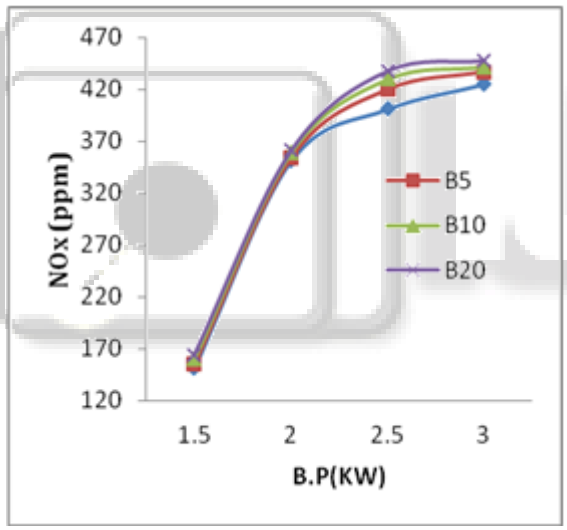

Fig. 8: Effect of B.P on NOX

Fig. 8 depicts the relation between B.P and NOX, in which linear relation observed for all the blends from 1.5 to 2KW B.P, Maximum value of NOx 448 ppm for B20 blend and Minimum value of 151ppm observed for diesel fuel at peak B.P 3KW.

VIII. Conclusion

1) Esterification process is done at methanol to oil ratio7.5:1 in the presence catalyst (KOH0.5%) at around60°c in time55 mins.94% yield was produced.
2) The BSFC is increased with increased of waste cooking oil methyl ester blending ratio in the blended fuels.
3) Lower percentage of blends (B 5, B 10, B 20) also reduces BSEC. While the best value of BSEC is at B 10 (where BSEC is reduced by 8% relative to that neat diesel fuel)
4) Lower percentage (10%) of blends (B5,B 10&B20) give a good improvement in the engine power.
5) The use of B 20 blend in C I engine found to be reduction in the CO, as it compared with standard diesel and B 5.
6) As blending ratios increases the percentage production of NOx also increases.
7) B20 blends are good for fuel economy.

IX. Future Scope

Biodiesel may be introduced as a diesel fuel extender or blends (B5, B10&B20) and not as a fully diesel engine fuel (B100).

1) The enhancement of performance and emission of the engine with the waste cooking oil biodiesel can be carried out by varying the injection Pressure.
2) 2.The performance and emission characteristics of the engine with variable of compression ratio of the engine can be studied for all blends. Test consequences with multi-cylinder engine fueled

By waste cooking oil biodiesel and its blends can be carried out and compared with that of single cylinder engine combustion, characteristics, performance

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