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Research Article

An experimental investigation of 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 ,NO_x ,CO,CO_2,HC and smoke opacity have been estimated for 5%,10% and 20% blend are compared to diesel fuel. The results of experiment shows that BSFC increases with use of biodiesel however BSEC decreases with increase in blend percentage. CO and HC emissions were reduced for biodiesel. But NO_X 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.

Keywords: *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
NO_x-Oxides of nitrogen
HC- Hydrocarbons
CO_2- Carbon di-oxide
BSFC- Brake specific fuel consumption
BSEC- Brake specific energy consumption
EGT- Exhaust gas temperature
BTE- Brake thermal efficiency
PM- Particulate matter

1. 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. The various studies were 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. Kalam M.A. *et al* has carried out an experiment to study the emission and performance characteristics of an indirect ignition diesel engine fuelled with 5% (palm) and 5%coconut oil with diesel fuel at constant 85% throttle position.

The result shows that there are reductions in both C5 and P5 reduce CO by7.3% and 21% respectively, and HC by 23% and 17% respectively. However C5 reduces 1% and P5 increases 2% NOx emission. It was observed that P5produces higher CO_2 than C5.Utlu Z. *et al* has investigated the effect of biodiesel from waste frying oil methyl ester in a diesel engine with a turbocharged four cylinder direct injection .From the investigation it was observed that the average emission reduction was 17.14% for CO, 1.45% for NOx and 8.05%for CO_2 Ozsezen *et al* has studied the performance and combustion characteristics of a DI diesel engine fuelled with Waste (frying) palm oil

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methyl ester (WPME). They observed that the unburned HC, CO emission and smoke opacity decreased by14.29%, 9.52%, and 86.89% with use of Waste (frying) palm oil methyl ester Lapuerta M. *et al* studied the effect of biodiesel fuel obtained from the waste cooking oil on 4-cylinder, WC,4-S,IC,TC,DI diesel engine emission. The main findings of this study show that the CO, HC, PM, PAHs Reduced and NOx low difference. Cheung C.S. *et al* studied the effect of waste cooking oil biodiesel on the emission of 4-cylinder naturally aspirated direct injection diesel engine with different blends of biodiesel (B10, B20, B30 and B100). They found that there is reduction in HC, CO, PM concentrations but increase in NOx. Murillo S *et al* evaluate the performance and exhaust emission in the use of biodiesel in outboard 1-cylinder, WC, 4-S, DI diesel engine operated at 1500-3500 rpm. It was observed that there is reduction in CO but increase NOx.

2. 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.

3. Methods

3.1Transesterification 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 upto60°c in a beaker for 20 mins.

Table.1 Optimum condition for Biodiesel

Methanol: oil molar ratio	Catalyst type	Catalyst content (wt %)	Reaction temperature(oc)	Reaction time(hr)	Kinematic viscosity at40oc	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

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 60°cand 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

3.2Fuel testing characteristics

3.2.1 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.

3.2.2. 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.

3.2.3. 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.

3.2.4. 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 were low cloud and pour point. But this problem was overcome blended with diesel fuel.

3.2.5. 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)

Table.2 Properties of fuel

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

4..2.1 Engine testing characteristics

4.2.1.1Performance 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 its blends give better exhaust temperature (EGT) than diesel fuel.

4.2.1.2Emission characteristics

NO_x:-NO_x formation was totally dependent on volumetric efficiency, combustion timing and temperature rising due to chemical reaction involved. Exhaust gas temperature increased also rises NO_x percentages. Increase in NO_x was proportional to the amount of biodiesel. Biodiesel contains oxygen content reacts with nitrogen resulting into the NO_x formation.

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

CO_2:-Biodiesel contributed more complete combustion and hence more conversion of COtoCO_2.

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

Table.3 Engine specification

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

4. 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.3 schematic diagram of experimental set up

5. Result and discussions

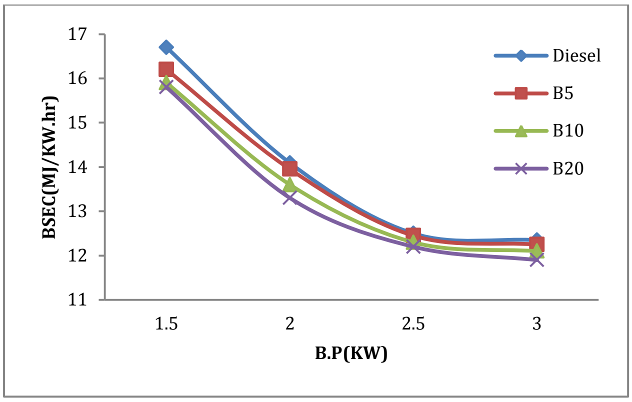

Fig.4 Effect of B.P on BSEC

Fig.4 Showed 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.

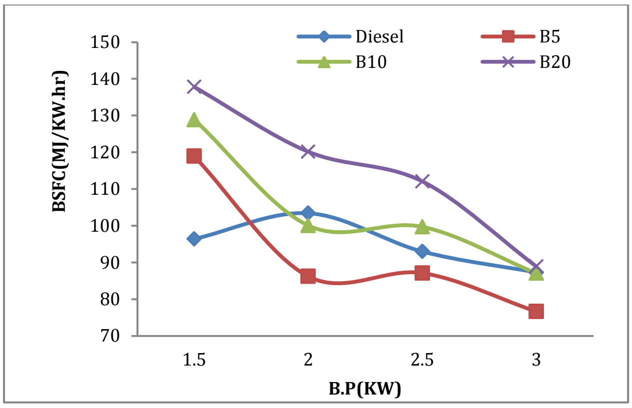

Fig.5 Effect of B.P on BSFC

Fig.5 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.

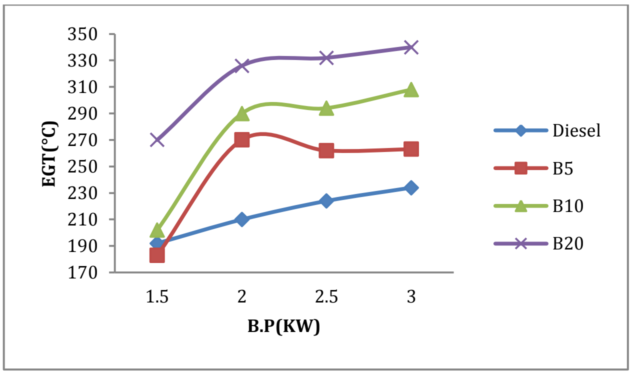

Fig.6 Variation in Exhaust gas temperature with Brake Power

Fig.6 shows the relation in between EGT and BP for different bio-fuel blends. For full load condition, the highest temperature obtained was 340^{0}C for B20, 234 ^{0}C for diesel, 308 ^{0}C for B10 and 270 ^{0}C for B5 at half load.

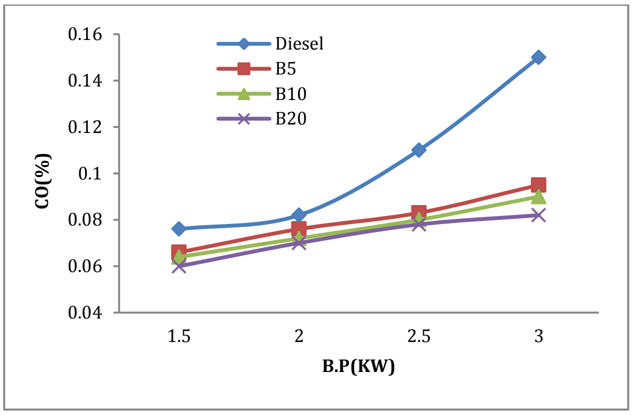

Fig.7 Effect of B.P on Carbon monoxide

Fig.7 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.

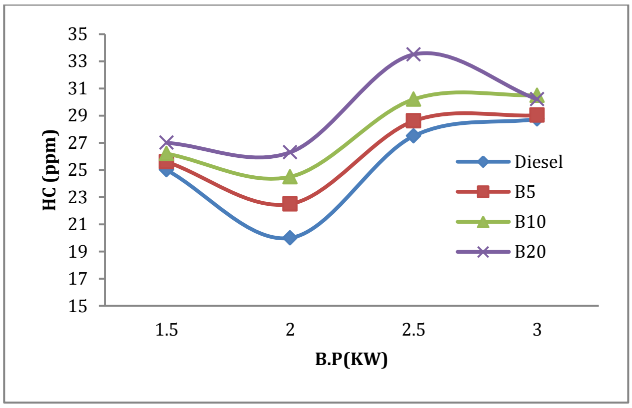

Fig 8, Effect of brake power on hydrocarbon emission

Fig.8 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 increases 26.3.

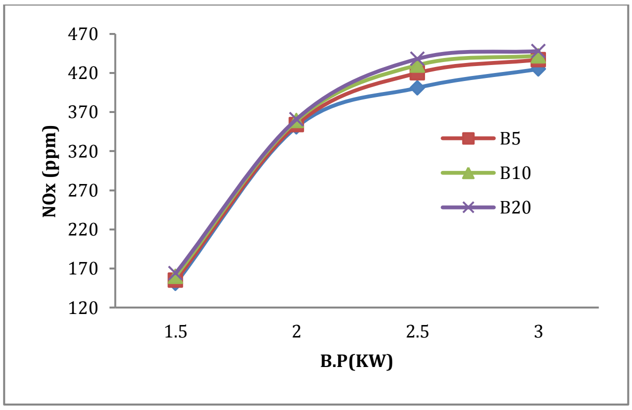

Fig.9 Effect of B.P on NO_X

Fig.9 depicts the relation between B.P and NO_X, in which linear relation observed for all the blends from 1.5 to 2KW B.P, Maximum value of NO_x 448 ppm for

B20 blend and Minimum value of 151ppm was observed for diesel fuel at peak B.P 3KW.

Conclusion

1) Esterification process was done at methanol to oil ratio7.5:1 in the presence catalyst (KOH0.5%) at around 60°c in time55 mins.94% yield was produced.
2) The BSFC was 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 reduced BSEC. While the best value of BSEC was at B 10 (where BSEC was 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 NO_x also increases.
7) B20 blends were good for fuel economy.

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 was be carried out by varying the injection Pressure.

2. The performance and emission characteristics of the engine with variable of compression ratio of the engine were be studied for all blends. Test consequences with multi-cylinder engine fueled

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

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