Effect Of Diesel-Biodiesel (Microalgal, Apricot And Papaya) Blends Material On Performance And Emission Of Ci Engine

Sandeep Kumar Duran, Harminder Singh Saggu

Abstract: Biodiesel material has captivated the attention as renewable fuel and also endorses its outcome on the compression ignition (CI) engine emission. In this experimental work the diesel- biodiesel material blends (MB20, MB30, AB20, AB30, PB20 and PB30) has been selected as fuel for diesel engine. The effect of different biodiesel material on engine performance (brake thermal efficiency and brake specific fuel consumption) and emission parameters (CO, CO_2, UHC and NO_X) were evaluated and compared with diesel. The result showed that physiochemical properties are with biodiesel limit, as suitable for as fuel in diesel engine. AB30 showed highest BTE, which is about 3% more than diesel. Almost all blends showed lower value of CO and UHC emissions.

Keywords: Microalgal biodiesel; apricot biodiesel; papaya biodiesel; engine; performance and emission.

1. INTRODUCTION

THE compression ignition engines are more useful than spark ignition engines for agricultural sectors and heavy transportation due to higher thermal efficiency and durability. The modern society's life is based on high consumption of energy and goods. We are facing with two problems, first: Scarcity of resources and second: pollution, which is very serious and it threatens the air, soil and water. In recent years, several researchers had put serious efforts to use different sources of energy as fuel in existing diesel engine. Biofuels are becoming more interesting as an alternative to fossil fuels due to increasing population, depletion of fossil fuels and environmental degradation [1]. Biofuels made from agricultural materials, it reduces our dependency on fossil fuel. Many countries fulfill their energy requirements by importing the oil from other countries, biofuel will reduce that and support local agricultural industries and enhance farming income. The petroleum based fuels full field the 80.7% of world energy demand, which released large amount of greenhouse gas (GHG) emissions and global warming had direct relation with GHG emissions, the biodiesel is green fuel and produce less GHG emissions as compared to diesel fuel, with the help of transesterification technique vegetable oil can easily converted into biodiesel, because direct use of vegetable oil leads to high smoke, CO (carbon monoxide) and UHC (unburned hydrocarbon) emission and side by side lower brake thermal efficiency as compared to diesel fuel. Biodiesel has better emission profile, such as lower particulate matter, CO and UHC emissions due to high flash point and good lubrication properties [2], so biodiesel become popular as new alternative energy source. Biofuels are classified as first generation, second generation and third generation. First generation biofuel production will directly entrench upon the food chain because it derived from the edible materials such as edible oil, second generation biofuels derived from non-edible material such as non-edible oil, waste and dedicated lignocellulose and third generation biofuels are derived from the macro/microalgae materials [3]. In the study, the second generation (apricot and papaya seed biodiesel) and third generation (algal biodiesel) biofuels are selected to identify the effect of different diesel-biodiesel materials on engine performance (brake thermal efficiency and brake specific fuel consumption) and emissions parameters (CO, CO_2, UHC and NO_X).

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2. BIODIESEL MATERIAL DEVELOPMENT PROPERTIES ANALYSIS

2.1 Biodiesel production

The microalgae oil was purchased from the Soley Biotechnology Institute, Turkey. The apricot seed was purchased from the local market in Kullu, Himachal Pradesh and papaya seed was collected from the local fruit and juice stalls in Jalandhar, Punjab. Oil was extracted from the apricot and papaya seeds with the help of mechanical press.1:6 molar ratios (oil to methanol) with 1 % (w/w of oil) KOH as catalyst was taken for single step transesterification, which carried out in Radley rector (biodiesel preparation unit). The mixture was continuously heated at 65 °C for 2 h at 550 rpm and after than mixture was put for 24 h rest. Two layers was formed in the mixture; upper is the biodiesel and lower is glycerol. The glycerol was taking out and remained mixture was washed with hot water for two- three times till all the residue like catalyst, excess methanol and soap were removed, then for the removal of moisture content it was put in oven for 30 min at 100 °C, finally after that pure biodiesel was obtained.

2.2 Properties analysis

The blends of microalgae biodiesel (MB), apricot biodiesel (AB) and papaya biodiesel (PB) were prepared with base fuel as diesel. Different biodiesel material and diesel fuel were mixed at volumetric ratio of 20% and 30%, which named as MB20, MB30, AB20, AB30, PB20 and PB30. The important physico chemical properties of different fuel material were determined as per standards.

3. ENGINE TEST FACILITY AND EXPERIMENTAL PROCEDURE

3.1. Engine test facility

The experimental engine setup employed in this investigation consisted of single cylinder, 4-stroke, direct injection, water cooled with developing power output of 3.5 kW at unvarying speed of 1500 rpm. The diesel engine's technical specifications are given in Table 1.

Table 1

Test Engine Specifications

Kiloskar – TV1 series	
General information's	Four strokes, direct injection
Maximum power output	5.2 kW at 1500 RPM
Number of cylinders	1
Cooling system	Water cooled
Stroke	110 mm
Bore	87.5 mm
Compression ratio	18:1
Swept volume	661cc

The engine was loaded with eddy current dynamometer. Air flow was measured through orifice meter which connected to large tank and it further connected with engine. Crank angle position was identified with optical encoder. All recorded analogue signals which recorded from the test rig were further transmitted to computer for performance analysis by using 'Engine soft LV version 9.0 (Apex Innovation Pvt. Ltd)' software AVL DI 444 exhaust emission analyzer was used for measuring the CO, CO_2, UHC and NO_X emissions.

3.2. Experimental procedure

The engine run with diesel fuel initially and then followed by MB20, MB30, AB20, AB30, PB20 and PB30. All the measurements were taken, after thermal stability of the engine. For better accuracy all the tests were conducted for four times than the averaged data was considered for further investigation.

4. RESULT AND DISCUSSION

4.1. Fuel properties

A fuel property always affects the engine performance and emission parameters. The fuel properties of diesel, microalgae, apricot and papaya biodiesel were measured with European Biodiesel Standards (EN14214) and were given in Table 2. The measured properties of biodiesels are compared with diesel fuel. The fuel properties for all biodiesel and their blends like density and viscosity are higher than diesel fuel but did not exceed EN 14214, so they are suitable for as fuel in diesel engine.

Table 2

Comparison of Properties between Diesel and Biodiesel

Properties	Diesel	Microalgae biodiesel	Apricot biodiesel	Papaya biodiesel
Density at 25°C (g/cc)	0.833	0.887	0.884	0.840
Kinematic Viscosity (cSt)	2.37	4.30	4.21	3.53
Calorific Value (MJ/kg)	44.8	22.82	39.64	38.97
Cloud point (°C)	-15	-13	-4	-5
Flash point (°C)	58.5	>160	111	116

4.2 Engine performance

4.2.1 Effect on brake thermal efficiency (BTE)

Fig.1 shows variation of brake thermal efficiency for diesel MB20, MB30, AB20, AB30, PB20 and PB30 according to engine load conditions. BTE was found 14.39% for AB30 at full load which is higher than diesel fuel. BTE values increase about 2.3% and 3.15% for AB20 and AB30 in comparison to fossil fuel and for remaining biodiesel blends it is lower than diesel fuel.

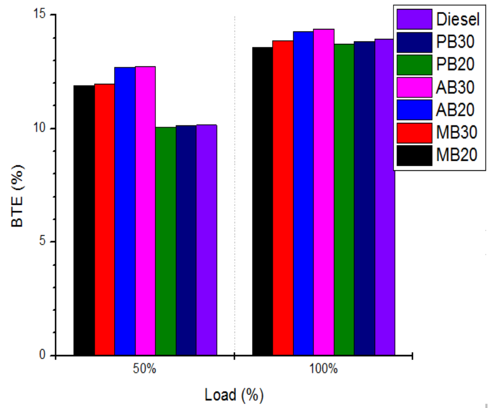

Fig. 1 *The relationship between engine load and BTE*

4.2.2. Effect on brake specific fuel consumption (BSFC)

The variation of BSFC with engine load for diesel MB20, MB30, AB20, AB30, PB20 and PB30 was shown in Fig. 2. The highest value of BSFC was for PB20 and lowest was for AB30 obtained from engine at 50% loading conditions. At full load BSFC changes about 1.6%, 2.99%, -0.16%, 0.47%, 4.2% and 4.34% for MB20, MB30, AB20, AB30, PB20 and PB30 was obtained with respect to diesel. The higher values of BSFC recorded for almost all biodiesel blends due to the lower calorific value [4].

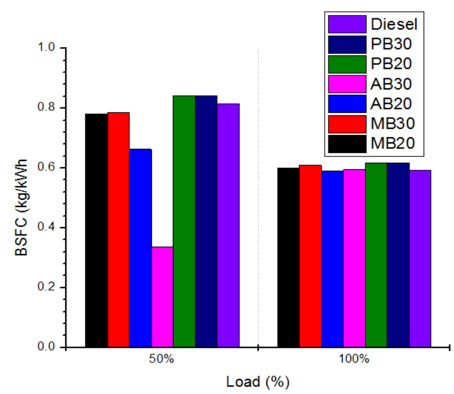

Fig. 2 *The relationship between engine load and BSFC*

4.3. Engine emission

4.2.1 Effect on carbon monoxide (CO)

Reduction in CO emission occurs with biodiesel than diesel fuel due to additional oxygen, which enhances the combustion efficiency.

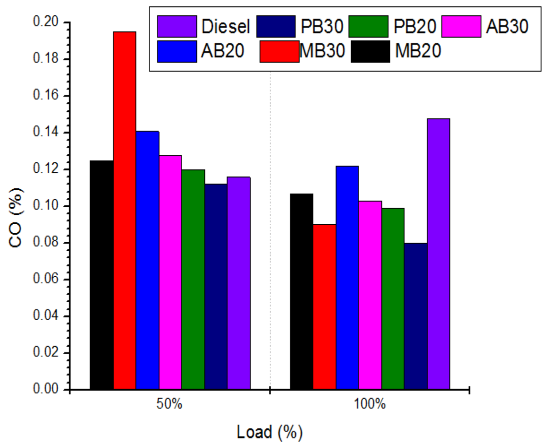

Fig. 3 *The relationship between engine load and CO emission*

Fig. 3 shown the CO emissions for all blends are lower than fossil fuel. The reason for this pattern is lower in-cylinder temperature as compared to higher engine load. The high in-cylinder temperature promotes the CO oxidation and it will be converted into CO_2. Biodiesel has 10% more oxygen content, which play positive role and was helpful for reduction trend of CO emission [5].

4.3.2. Effect on carbon dioxide (CO_2)

At higher loading conditions engine produced high amount of CO2, because of higher in-cylinder temperature as shown in Fig. 4. The higher oxygen content in biodiesel with lower carbon content promotes the high carbon dioxide, which is indication of complete combustion and finally more CO will be converted into CO_2. The higher combustion efficiency always promotes higher CO_2 emission, thus in literature rarely any one considered CO_2 emission as harmful emission [6].

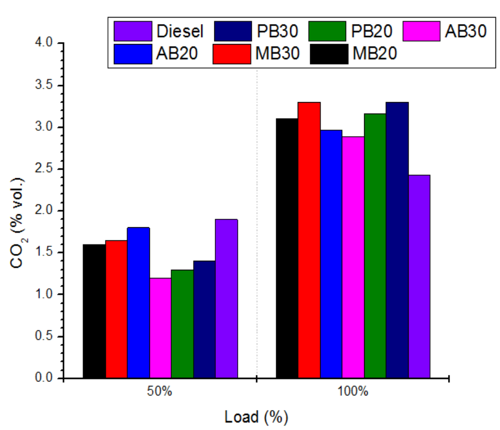

Fig. 4 *The relationship between engine load and CO_2 emission*

4.3.3. Effect on unburned hydrocarbon (UHC)

Unburned hydrocarbon emission reduced with higher cetane number and higher quantity of oxygen. Fig. 5 shows the variation of HC emission profile for algae biodiesel and its blends in comparison to diesel fuel for different engine loading conditions. The higher cetane number for biodiesel leads to reduce the ignition delay and higher oxygen contents in biodiesel promotes the complete combustion which at-last promotes reduction in unburned hydrocarbon emission in comparison to diesel fuel [7].

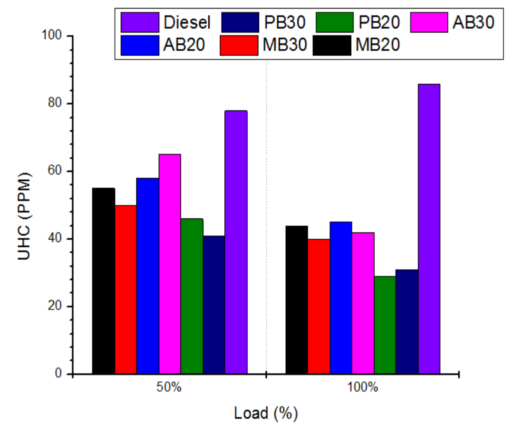

Fig. 5 *The relationship between engine load and UHC*

4.3.4. Effect on NO_X

The variations of NOx emission for all tested fuel are shown Fig. 6 at different loading condition. Nitrogen oxides emissions are in the most toxic pollutants category. NOx emissions are formed due to high flame temperature and oxygen content of fuel. It can be observed form the Fig. 6, the NOx increases as the engine load increase, because rises of combustion temperature at high engine loading condition [8]. The higher NOx emission for algal biodiesel blends in comparison to diesel fuel is attributed to high oxygen content, density and viscosity.

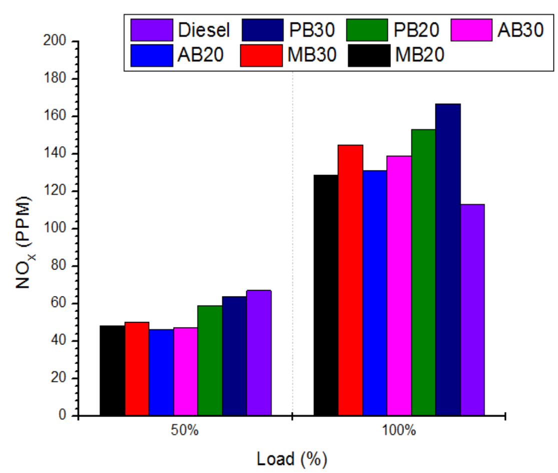

Fig. 6 The *relationship between engine load and NO_X*

5. CONCLUSIONS

Engine performance and emission experiments were conducted for diesel MB20, MB30, AB20, AB30, PB20 and PB30 on 4-stroke, single cylinder, DI diesel engine. The major conclusions were summarized as follows:-

- The physicochemical properties of microalgal, apricot and papaya biodiesels are within biodiesel standards.
- The engine performance results showed that; the only AB30 showed higher than diesel rest all having lower BTE in comparison to diesel fuel.
- The exhaust emission tests showed that CO and UHC emissions decreased for biodiesel blend.

REFERENCES

[1] S. A. Scott et al., “Biodiesel from algae: Challenges and prospects,” Curr. Opin. Biotechnol., vol. 21, no. 3, pp. 277–286, 2010.
[2] M. Y. Noraini, H. C. Ong, M. J. Badrul, and W. T. Chong, “A review on potential enzymatic reaction for biofuel production from algae,” Renew. Sustain. Energy Rev., vol. 39, pp. 24–34, 2014.
[3] S. K. Duran, P. Kumar, and S. S. Sandhu, “Prospect of Algal Biodiesel as a Fuel in Engine,” Int. J. Eng. Adv. Technol., vol. 8, no. 6, pp. 2739–2744, 2019.
[4] S. K. Duran, P. Kumar, and S. S. Sandhu, “A review on microalgae strains, cultivation, harvesting, biodiesel conversion and engine implementation,” Biofuels, vol. 7269, pp. 1–12, 2018.
[5] S. H. Al-lwayzy and T. Yusaf, “Diesel engine performance and exhaust gas emissions using Microalgae Chlorella protothecoides biodiesel,” Renew. Energy, vol. 101, pp. 690–701, 2017.
[6] U. Rajak, P. Nashine, and T. N. Verma, “Assessment of diesel engine performance using spirulina microalgae biodiesel,” Energy, 2018.
[7] G. Tüccar and K. Aydın, “Evaluation of methyl ester of microalgae oil as fuel in a diesel engine,” Fuel, vol. 112, pp. 203–207, 2013.
[8] G. Tüccar and K. Aydın, “Evaluation of methyl ester of microalgae oil as fuel in a diesel engine,” Fuel, vol. 112, pp. 203–207, 2013