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Experimental Investigation On Di Diesel Engine Powered With Raw Mango Seed Oil (MSO) And Mango Seed Bio Diesel (MSBD)

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Abstract

The objectives of the present work is on replacing the conventional diesel fuel with raw mango seed oil (MSO) and methyl ester of mango seed oil and compare the performance emission and combustion parameters on the use of Raw MSO and Mango seed bio diesel (MSBD). Mango seed oil was prepared from waste mango seeds which are collected from various places. The biodiesel of MSO was prepared by transesterification process. The experiment was conducted with different blends of raw MSO with diesel (B25, B50, B75 and B100) and MSBD with diesel (BD25, BD50, BD75, BD100). The performance emission and combustion tests were conducted with above blends on a single cylinder D.I diesel engine coupled with eddy current dynamometer. The regulated emission of NOx, HC and smoke density were measured with the help of exhaust gas analyzer. In addition, the combustion analyses were also made with the help of AVL combustion analyzer. The cylinder pressure and heat release rate were also analyzed for different cycles. The experimental results proved that SFC is less for MSBD than raw MSO and brake thermal efficiency is more for MSBD than raw MSO. In the emission test, it is found that the EGT and smoke density of MSO and MSBD are higher than that of sole diesel fuel but NOx level is less that of diesel. The NOx emission is decreased significantly about 200 ppm for B100 blend. The cylinder peak pressure and heat release rate for raw MSO and MSBD are always less than that of sole diesel fuel. The peak pressure for raw MSO is 5.4% less than that of diesel fuel but for MSBD its is 2.4% less.

At maximum load the NOx emission for MSBD is 15.70% higher than that of raw MSO.

Introduction

The major problem focused in the world is on the global fuel shortage and increasing fuel prices and that of environment pollution. These problems can be addressed by many researchers by the use of renewable fuels. Today we find that the combustion from diesel engines produce incomplete combustion products that emit more emission from the exhaust which causes environmental pollution in the form of regulated and unregulated emissions.

Investigations have been carried out globally to replace conventional fossil fuel with suitable alternate fuel which is renewable in nature and available throughout the world. The advantages of biofuel apart from the renewability are: High oxygen content, higher flash point and higher lubricity that produces complete combustion in comparison with conventional diesel fuel.[1] further, the environmental benefit is another investigation factor due to a lesser green house effect, less air pollution, less contamination for water and soil and reduced health risk.[2] Biofuel contains sulfur free, thus the issue of acid rain is therefore ameliorated. Several authors have studied the biodiesel and its blends in diesel engine regarding the emission performance characteristics. Jose M Desantes, et al.,[3] evaluated the rape seed oil methyl ester to improve the combustion process in a high-speed direct injection(HSDI) diesel engine equipped with high-pressure common-rail injection system. Generally, using biodiesel in diesel engine reduces the CO, HC emission and increases the NOx emission. This is due to increase in oxygen level during the combustion. D.C Rakopoulos, et al[4] studied the use of four straight vegetable oils like sunflower, cotton seed, olive and corn oils on mini-bus engine. It is reported that the olive oil has very high content of the unsaturated oleic acid(one double carbon bond) and very low content of the unsaturated linoleic acid (two double carbon bonds), in contrast with, the other three vegetable linoleic acids. Further, the cottonseed oil has the highest content of palmitic acid(saturated) . These may play some role in the soot formation and oxidation mechanism. The previous study has mentioned some of the disadvantages using vegetable oil with high viscosity, low volatility and high aromatic compared to diesel. The solution to the above problems has been approached in several ways: Preheating the oil, thermal cracking, using fuel additives, thermal barrier coating, high pressure injection and transesterification process. Many researches are focused on non edible oil which is not suitable for human consumption due to the presence of toxic components present in the oil. Further non edible oil crops grow in waste lands that are not suitable for use as food [5,6,7] . The cost of cultivation is much lower because these crops can still sustain reasonably oils that contain free fatty acids. Thus they may require multiple chemical steps or alternate approaches to produce biodiesel, which will increase the production cost, and may lower the ester yield of biodiesel below the standards [8]. The objective of the present work is the preparation of the biodiesel from mango seed oil a non edible oil and renewable nature [9,10,11]. Since conversion of Bio diesel from raw mango seed oil requires methanol & catalyst when costly, studies are performed for the use of raw mango seed oil directly in the diesel engine. The performance and emission characteristics of raw MSO blended with diesel(B25, B50, B75 and B100) and MSBD blended with diesel (BD25, BD50, BD75 and BD100)are analysed and compared. The physical, chemical properties of biodiesel and its blends were analyzed.

Preparation of Raw Mango Seed Oil & Mango Seed Bio Diesel

Raw waste mango seeds are collected from many places especially from mango juice centers and mango pickles industries. These seeds are dried at room temperature about 15 days. The outer cover from the seed was broken to get the kernel from the seed. The mango seed kernel is dried again at room temperature for 5 days. The kernel is broken into pieces and then subjected to crushing with the crusher machine. During crushing at one stage the oil was derived. The raw oil is then filtered for using is to the investigation.

Raw mango seed oil is slight yellowish in color, less volatile and having the combustible mixture of hydro carbons.

The raw MSO is converted to biodiesel by transesterification process. It is the process of reacting the oil with methanol in the presence of catalyst (KOH). During the process, the molecule of raw mango seed oil is chemically broken to form the ester and glycerol. Mango seed ester is filtered to separate from glycerol. The properties of diesel, raw MSO, MSBD and different blends with diesel are given in the table 1.

Property	Diesel	Raw MSO	MSBD BD100	Biodiesel BD50	Biodiesel BD75
Specific gravity	0.829 8	0.917 1	0.8796	0.8512	0.8646
Kinematic viscosity@ 40^0 C in CST	2.57	20.97	5.18	3.80	4.42
Flashpoint ^{0}C	37	298	166	82	102
FirePoint ^{0} C	40	315	179	92	113
Powpoint ^{0} C		+6C	+7C	-3C	+3C
Gross calorific valuein Kj/KG	44738	41803 .008	41924. 431	43230.77 5	42606.912
Cetane number	50	50.6	51.6	52.2	51.8

When comparing the properties, the specific gravity, viscosity, flash point, fire point of raw MSO and MSBD with different blends are more than diesel fuel. However its values are decreasing order when the diesel blend increases. But its calorific values are less than that of diesel fuel.

Experimental Setup

The experimental investigation was carried out in a single cylinder water cooled DI diesel engine with 87.5mm bore, 110mm stroke and 17.5:1 compression ratio. Test engine and experimental setting is shown in Fig 1. The test engine was coupled with eddy current dynameters to apply different engine loads. CO, HC and NOx are measured by AVL 444 digas analyzer which is connected with exhaust system. The exhaust smoke was measured by AVL smoke meter. The incylinder pressure was measured by AVL piezoelectric air cooled transducer.

First the engine was started with sole diesel fuel and allowed to run in steady state conditions while the engine cooling water temperature was maintained at 550 C. The fuel injection pressure was maintained at 205 bar throughout the experiment. Then the fuel consumption, exhaust gas temperature and exhaust emissions of NOx, CO, HC, smoke and combustion parameters were measured and recorded from different loads at each operating point and stored in the computer for post processing of the results.

Then the experiments were started with the raw mango seed oil, mango seed biodiesel and different blends of MSO and MSBD. For each fuel change. The fuel lines were cleaned and the engine was left to operate for about half an hour to stabilize at its new desired condition. The same procedure was repeated for every fuel change keeping the same operating condition. All the results constituting performance parameters emission parameters and combustion parameters were recorded and stored in the data acquisition system. The measurement system is shown in table.2

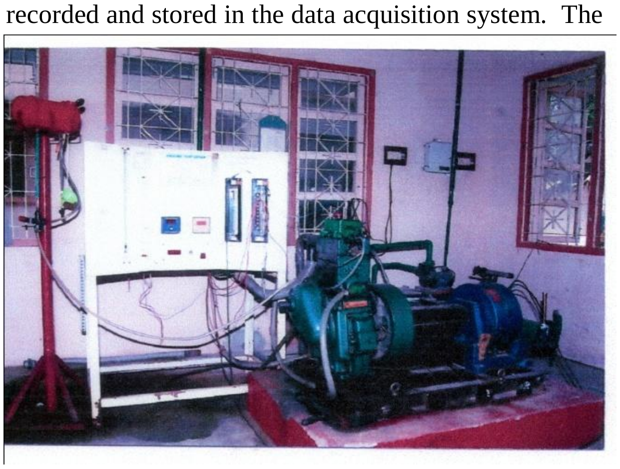


Fig1.Experimental setup

Fuel consumption	:Gravity type
Temperature	:Thermocouple
In-Cylinder pressure	:AVL piezoelectric transducer air cooled
CO,HC &NOx	:AVL 444 di-gas analyzer
Smoke	:AVL smoke meter

Table: 2 Measurement systems

Results and Discussion:-

Comparison of performance parameters of raw MSO and MSBD with different blends

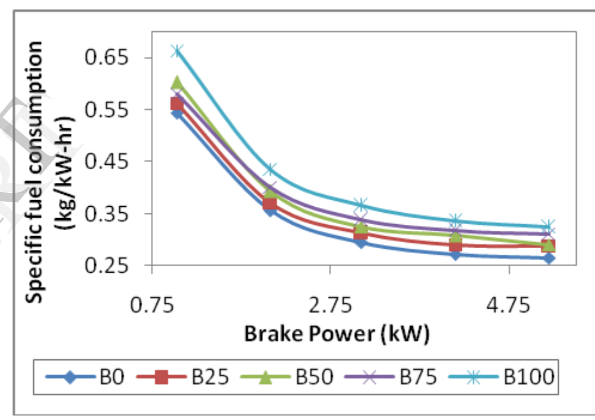


Fig 2.Specific Fuel Consumption of MSO

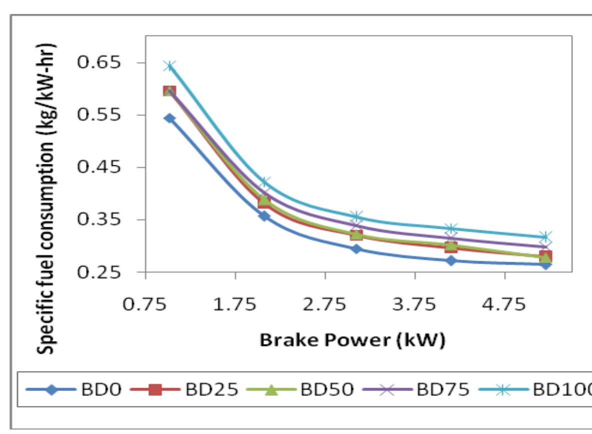


Fig 3.Specific Fuel Consumption of MSBD

Fig 2 and 3 shows the specific fuel consumption with brake power. It is seen that all the blends of raw MSO having high SFC than diesel. It is due to its high viscosity and poor volatility that results in poor atomization and mixture formation. SFC for MSBD when compared with raw MSO is less for all the blends. However BD25 and BD50 are having minimum SFC than other blends and almost close to diesel

Brake Thermal Efficiency against BP

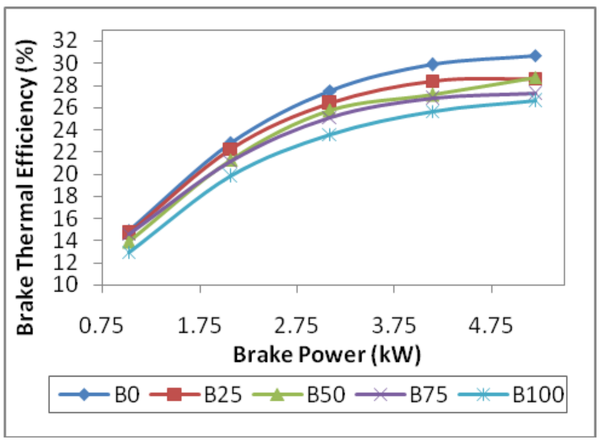


Fig 4. Brake Thermal Efficiency of MSO

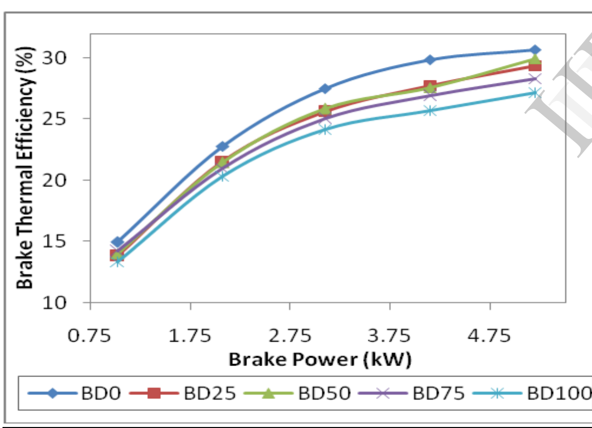


Fig 5. Brake Thermal Efficiency of MSBD

Fig 4 and 5 shows the variation of BTE with respect to BP for raw MSO and MSBD. It is seen that all blends of raw MSO shows less BTE than sole fuel. B25 and B50 blends of raw MSO gives 28% BTE at maximum brake power of the engine. But for MSBD having 29% BTE which is nearer to sole diesel fuel. It is due to high viscosity and low cross calorific value of the raw mango seed oil than MSBD. It is observed from the above two figures that BTE for raw MSO and MSBD are always less than that of sole diesel fuel for all blends.

Emission Parameters: 1.Exhaust Gas Temperature

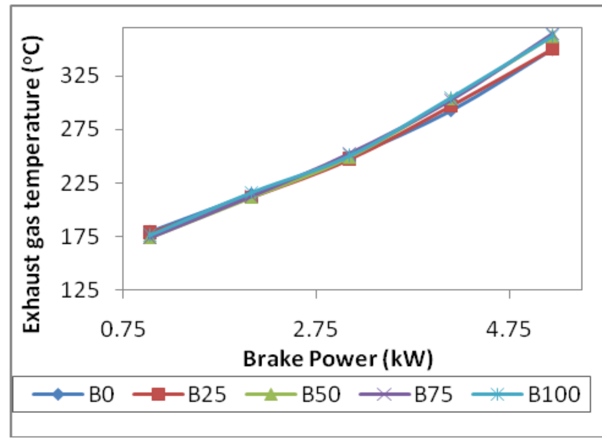


Fig 6. Exhaust Gas Temperature of MSO

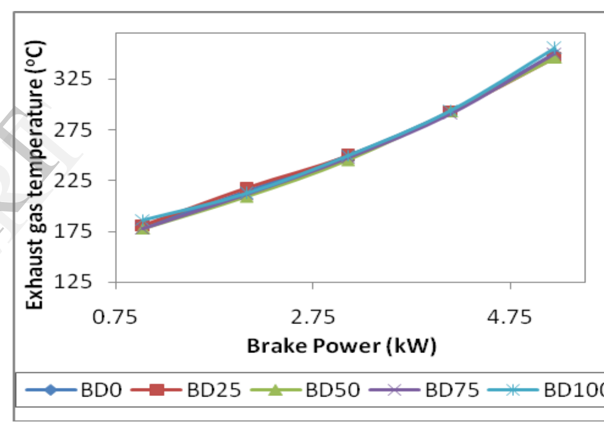


Fig 7. Exhaust Gas Temperature of MSBD

Fig 6 and 7 shows the variation of EGT against break power for different blends of raw MSO and MSBD. EGT for all the blends are almost near to the sole diesel fuel except B100 for raw MSO and MSBD at full load . EGT for raw MSO at full load is 367°C but for MSBD at full load is 352°C only. This is due to high viscosity and high flash and fire point of of raw MSO. At part load condition the exhaust gas temperature is almost same for all the blends of MSO, MSBD and diesel

2. Oxides Of Nitrogen

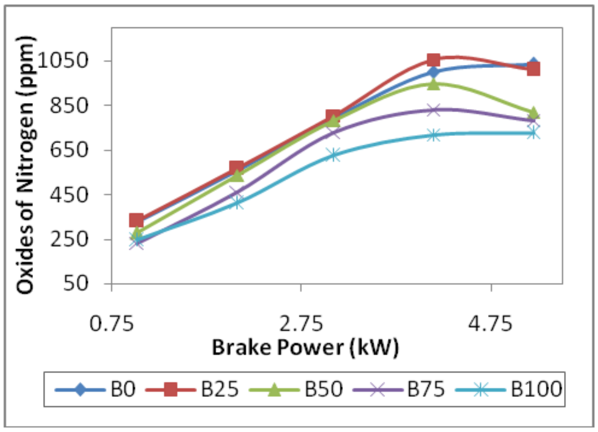


Fig 8. Oxides Of Nitrogen of MSO

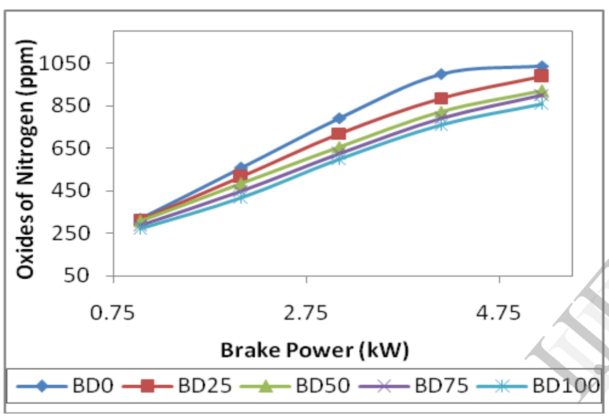


Fig 9. Oxides Of Nitrogen of MSBD

Fig 8 and 9 shows the variation of NOx emission for raw MSO and MSBD with different blends. The NOx emission formed due to high combustion temperature and unavailability of oxygen. It is seen that raw MSO and MSBD and its blends are emitting low NOx than sole fuel. The NOx emission for raw MSO(B100) at full load is 700ppm but for neat MSBD, the maximum NOx emission was 810 ppm at maximum load. The reduction in NOx emission with raw MSO is mainly associated with the reduced premixed burning rate followed by the delay period and less EGT.

3. Smoke Density

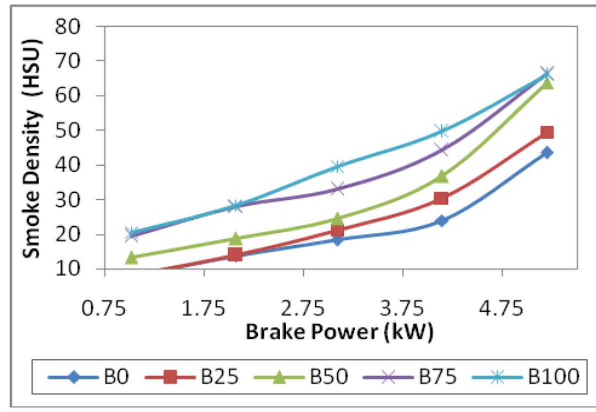


Fig 10. Smoke Density of MSO

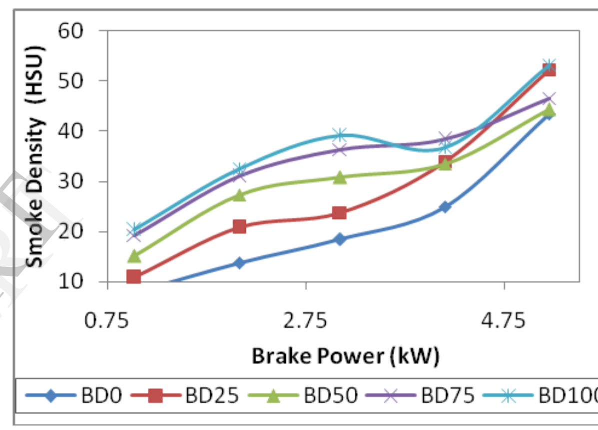


Fig 11. Smoke Density of MSBD

Fig 10 and 11 shows the variation of smoke density against BP for various blends of raw MSO and MSBD. Smoke density for raw MSO and MSBD in all the cases is found increased as compared to sole diesel fuel. For all the blends it, is higher than diesel fuel. Among all the blends B25 shows lowest smoke density in each cases and B100 shows highest smoke density. At full load the lowest smoke density for B25 for raw MSO is 45 HSU and for MSBD is 52 HSU. At full load the highest smoke density for B100 for raw MSO is 65 HSU but for MSBD is 53 HSU only. This is due to the high viscosity of raw MSO with incomplete combustion. The viscosity of raw MSO is 400% more than that of neat MSBD, which leads to incomplete combustion. The smoke density for diesel is 45HSU at maximum brake power of the engine

4. Combustion parameters

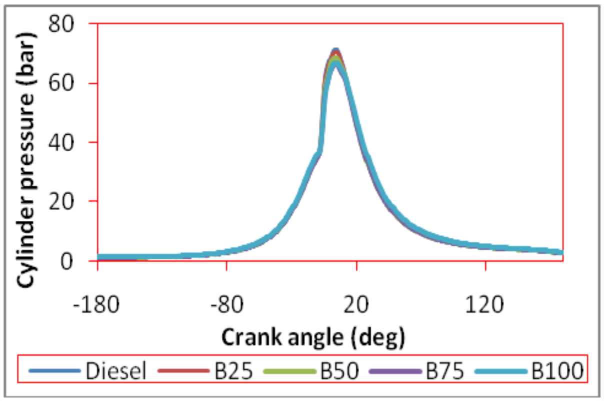


Fig 12.Cylinder pressure of MSO

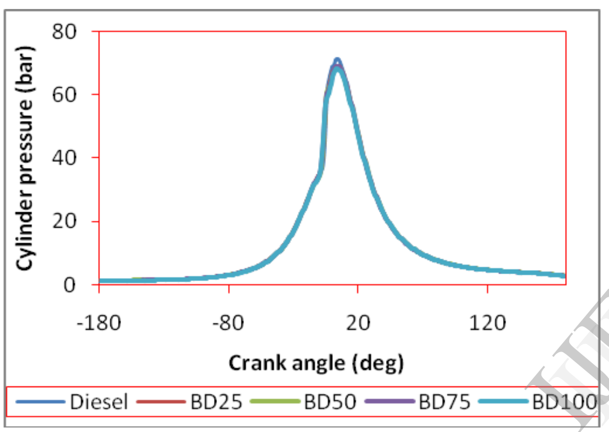


Fig 13.Cylinder pressure of MSBD

Fig 12 & 13 shows the variation of cylinder pressure with respect to crank angle for different blends of raw MSO and MSBD of the engine.From the above diagram it is clearly understood that the peak pressure for raw MSO and MSBD are lower than sole diesel fuel. In diesel engine, the cylinder pressure is depends up on the delay period and combustion rate. In the initial stage of combustion, the rate of combustion depends up on amount of fuel taking part in the uncontrolled combustion. The uncontrolled and the premixed combustion phase is governed by the delay period and the spray envelope of the injected fuel. The reason for low peak pressure is due to high viscosity and lower volatility of the raw MSO and MSBD. B25 blend for both cases is having cylinder pressure near to sole fuel. Peak pressure for raw MSO(B100) is 64 bar and peak pressure for MSBD(BD100) is 66 bar. This is due to high viscosity and low volatility of raw MSO than MSBD. The maximum cylinder pressure for sole diesel fuel is 67.69 bar. The variations of heat release rate against the different crank angle of raw MSO and MSBD with their different blends are shown in fig 14 and 15. It is noted that raw MSO and MSBD are having lower heat release rate than diesel fuel. However B25 gives more heat release rate than that the other blends. The MSBD releases heat earlier than raw MSO and the premixed combustion peak is much higher and sharper for the diesel fuel when compared to other biofuel blends.

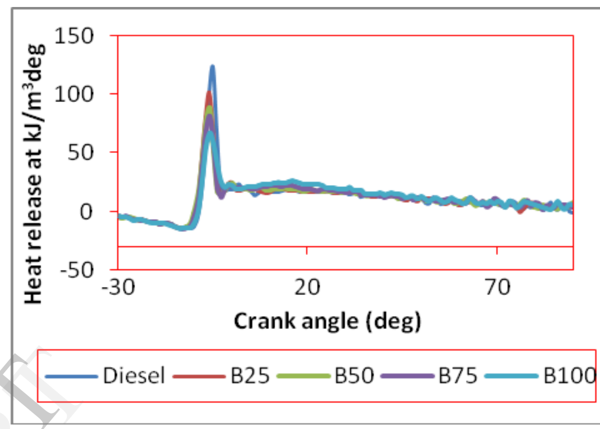


Fig 14.Heat Release Rate of MSO

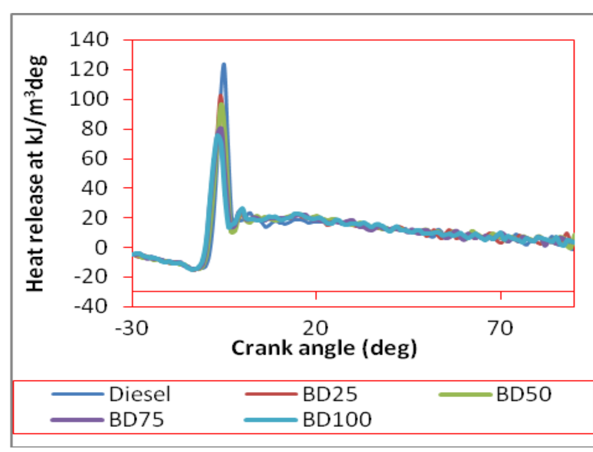
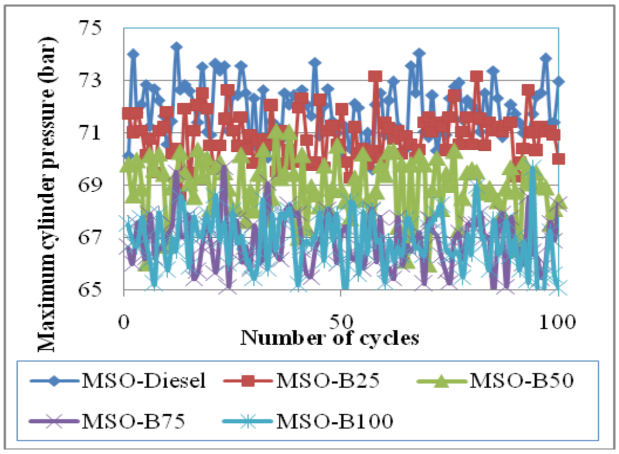


Fig 15.Heat Release Rate of MSBD

Fig 16 & 17 shows the variation maximum cylinder pressure against the number of cycles for raw MSO and MSBD with different blends. The maximum cylinder pressure for sole diesel fuel is higher than raw MSO and MSBD. The average cylinder pressure for raw MSO and MSBD are same for other blends. The MSBD oil blends relatively having low fluctuation in all the cycles.



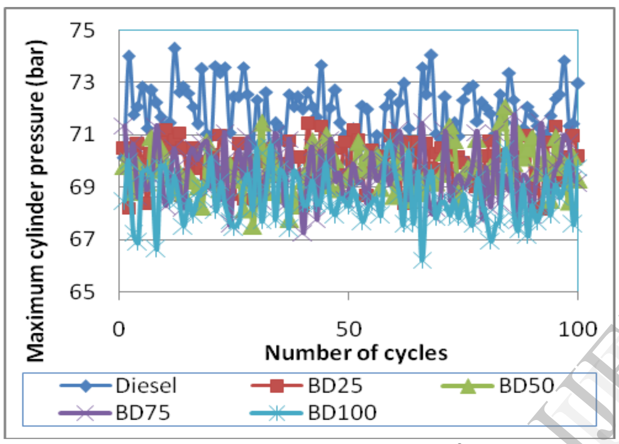


Fig 16.Maximum Cylinder Pressure of MSO

Fig 17. Maximum Cylinder pressure of MSBD

Conclusion

The experimental investigations were carried out in a single cylinder DI diesel engine with raw MSO and MSBD with different blends. The load test were carried out to find out the performance of the engine with different fuel for each load the fuel consumption, brake thermal efficiency, exhaust emission characteristic and combustion parameters were calculated with each of their properties.

The SFC for MSBD is less than that of raw MSO however BD25 and BD50 for MSBD are having minimum SFC than other blends and almost close to diesel fuel. The brake themal efficiency is more for MSBD than raw MSO and B25 shows the maximum BTE than other blends.

The EGT for raw MSO is more than that of MSBD at full load. At part load the EGT is same for all the cases NOx emission for the different blends of raw MSO and MSBD are less than that of sole diesel fuel. Smoke density of raw MSO is higher that that MSBD and sole fuel. At full load raw MSO having 44% higher smoke density than diesel fuel and MSBD is having 155% higher smoke density than that of sole diesel fuel. At maximum load NOx emission for MSBD is 15.71% higher than that of raw MSO. The cylinder peakpressure and heat release rate, for raw MSO and MSBD are always less than that of sole diesel fuel. Peak pressure for raw MSO is 5.4% less than that of diesel fuel but for MSBD it is 2.4 % less. However B-25 gives more heat release rate among other blends.

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