Emission characteristics of biodiesel blends

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Abstract

In Current study, the impact of biodiesel percentage and engine load on the emission characteristics of 4 stroke diesel engine with one cylinder has been investigated. Argemone Mexicans and Mahua based dual blend biodiesel were used for current study. The carbon monoxide (CO) and hydrocarbons (HC) emissions reduced for the biodiesel blend, while Nox emission was higher as compared to diesel.

Keywords: Dual biodiesel, Diesel engine, Argemone mexicana, Mahua, CO, CO_2, NOx

1. Introduction

The consumption of petrol is increasing in these days due to which its prices are surging and fossil fuels are continuously dwindling. Therefore, there is a need to switch to renewable resources of energy. In addition, fossil fuel burning leads to greenhouse gases which harms our environment and biodiesel has been observed as a good substitute. From many years, researches have been testing the engine with different biodiesels, they observed that engine gives very less exhaust emissions as compared to diesel fuels. Biodiesel can be extracted from various vegetables like jatropha, sunflower etc. The biodiesel is non-toxic, biodegradable, give less exhaust emission and lower sulphur content. The use of biodiesel in direct form lead to many issues owing to its high viscosity. Moreover, biodiesel is expensive which is a big hurdle for commercialise use.

Edible and non-edible plant could be used to produce biodiesel. The plant is selected on the basis of FFA content present in it. However, the utilisation of edible oil for biodiesel can lead to food scarcity. Therefore, it is necessary to search for non-conventional feedstock to reduce the cost of biodiesel.

2. Literature Review

Bing et al.[1] ten major trees were taken which could be used as potential raw material for biodiesel .The relation between the fatty acid composition of vegetable oils and fuel properties of biodiesel were analyzed. Only fully matured seeds were used because immature seeds had not reached the final fatty acid composition. ***Wang et al.***[2] siberian apricot seed were used for production of biodiesel. The fully matured siberian apricot fruit were used. The siberian apricot had excellent value of cold filter plugging point. The cetane number observed was 48.8 which satisfied the standard value, but it had poor oxidation stability. The flash observed was also high which was173˚C. It had low acid value and water content. The cold flow properties of the fuel were excellent. On the other hand cetane number and oxidative stability can be improved using additives and antioxidants. ***Liaquat et al.***[3] the emission characteristics was tested with the coconut biodiesel blended fuels and diesel fuel without any modification in engine. The engine was tested with three fuel samples. The samples were 100% diesel fuel, 5% coconut biodiesel and 95% diesel fuel, and 15% coconut biodiesel and 85% diesel fuel respectively were used. It had been observed that engine performance was tested at 100% load, kept throttle 100% wide open with variable speeds of 1500 to 2400 r.p.m and the emission characteristics were tested at 2200 r.p.m at 100% and 80% throttle position. ***Nalgundwar et al.***[4] studied emission characteristics. The biodiesel blends were used for testing. The change in properties was observed when mixed in different ratio with blends of palm and jatropha. There was increase in brake thermal efficiency as increase the ratio of biodiesel blends to the mixture. The temperature of gas for the biodiesel blend was less than diesel owing to lower heating value and higher content of oxygen. The combustion reaction was not complete in diesel fuel due to which formation of carbon monoxide occur while in case of biodiesel the complete reaction takes. ***Zhiaho et al.***[5] studied the emission characteristics.The acid present in the fatty acid of pistacia chinesis bunge seed were palmitic, olein and linoleic and the content of these acid were 45.45%, 28.91% and 21.37%. The test was conducted at different speed of 1500r.p.m and 2400r.p.m with the different loaded conditions of 25%, 50%, 75%, 90% and 100%. It had been observed the HC emission decreased as biodiesel proportion increased in the biodiesel blends. As the biodiesel ratio increased the content of sulphur and aromatic hydrocarbons reduced. The fatty acid methyl ester had higher oxygen content, which result in the complete burning and reduced hydrocarbons. But at high load the former CO emission was more that of later blend due to existence of oxygen. The NO_x emission for lower blends like B10 and B20 was less than that of diesel. But almost same for B30 and diesel. It had been observed that exhaust smoke decreased as we increased the biodiesel. ***S.Jindal*** [6] the effect of engine parameters on the NO_x emission had been investigated using jatropha biodiesel. It had been observed in many researches that biodiesel upto 20% might be used without any modification in engine. It was concluded that using biodiesel as fuel in the diesel engine without any modification reduced the higher emission of NO_x. Firstly the engine was tested using diesel fuel at standard parameters and then with 100% biodiesel under different value of compression, injection pressure, engine speed, injection time and emission were recorded. ***Chavan et al.***[7] the emission of variable compression ratio engine were discussed using different blends of jatropha biodiesel. The blends prepared were JB100, JB10, JB20, JB30 at 40˚C.The experiment was performed at compression ratio of 14-18 for each blend at different load of 0, 3, 6, 9, 12kg. It had been observed that density, flash point, fire point were increased as the biodiesel blends increased. The blend JB100 had showed least CO emission at CR of 14, 15, 16.The better results were found with blend JB30 which reduced HC and CO emission upto 43% and 50% respectively. ***Dharmadhikari et al.***[8] the emission of C.I engine. It was observed the BTE of diesel and blends of biodiesel were increased with increasing load but tend to decrease with further increase in load. The NO_x was 5 to 10% higher for the biodiesel blends. ***channapattana et al.***[9] the emission characteristics of ci direct injection VCR engine had been investigated using hone oil methyl ester as biodiesel. The various blends prepared were B20, B40, B60, B80 and pure diesel. The test was performed with varying load. The BSFC for the B20 blend was comparable with diesel and it was maximum for B100. The BTE of B20 was almost comparable to diesel at less load. The average reduction of BTE for B20 was 3% and 11% for B100. The EGT was increased by 2% for the B20 and 5% for the B100. It was observed that as the load increased for constant speed, the CO_2 emission also increase. The CO_2 was increased by 3% for B20 and 14% for B100 as compared to diesel. It was observed that CO emission decreased by 10% for B20 and 54% for B100. The HC emission also decreases. The NO_x was increased for the biodiesel. It was increased by 13% for B20. ***Kumar et al.***[10] emission of DI diesel engine using biodiesel B50 was analyzed at cr of 14, 16 and 18. The biodiesel prepared was jatropha biodiesel. The brake power was higher for the B50 fuel. The maximum BTE was observed at compression ratio of 18, which was due to better intermixing of fuel. It was observed that BSFC was more for the B50. The CO emission was decreased as the compression ratio increases. The O_2 emission was higher for the B50, the reason behind that was biodiesel contains nearly 10% inbuilt oxygen. ***Dawody et al.***[11] the experimental investigation had been made on the single cylinder fuelled by soybean methyl ester. The experiment was performed at different compression ratios of 15, 16, 17.5 and 19. There was a slight reduction in BTE for the B20. It was observed that HC emission decreased as the percentage of SME increases, which was due to complete combustion. The CO emission were also decreased for the biodiesel. The NO_x emission increases with compression ratio and concentration SME in the blend. It was concluded that B20% has better results as compared to others blends.

3. Scope of the Study

Biodiesel made from the non-edible plants of argemone mexicana and mahua are reported to be a possible choices for countries like India, where cost and consumption of the edible oil is very large. The selection of economical and existing feedstock for production of biodiesel inside the country is major concern. Before presenting the biodiesel in our country, the following points have to be considered:

- The NOx emission was found to be increased for the dual biodiesel blend. Therefore the further study can be done to reduce the NOx emission.

4. Experimental setup

4.1 Biodiesel setup

The transesterification was performed in a redley reactor with biodiesel. It is fitted with a magnetic stirrer, thermometer & reflux condenser. It consists of heater and external jackets to maintain the temperature constant throughout the process. The supplementary impeller was provided for the proper mixing. The condenser was used to condense the methanol escaping out from the reactor.

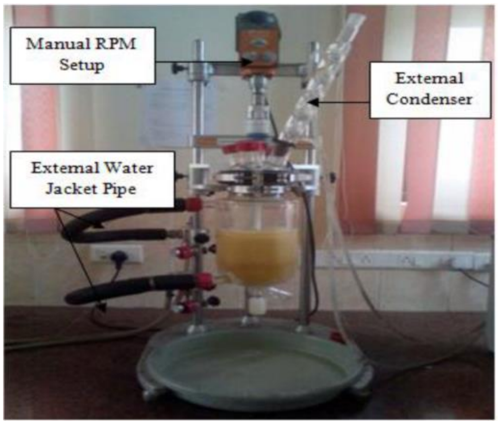

Figure 1: Biodiesel setup

4.2 Engine setup

After the production of biodiesel blends were prepared and were fuelled in engine. The engine was running at a constant speed of 1500rpm. The experiment was performed using diesel and biodiesel blends of biodiesel. The specification of the engine are given below:

S.No	Chemicals	Proportion
1	Argemone oil	1500ml
2	Catalyst Na (metal)	10gm
3	Methanol	375ml

Engine	**Kirloskar engine setup**
Cylinder	Single cylinder
Strokes	4 strokes
Power rating	3.5KW
Engine Speed	1500RPM
Cylinder bore	87.50mm
Stroke length	110mm
Connecting rod length	234mm
Orifice diameter	20mm
Dynamometer arm length	185mm
Cooled type	Water cooled
Compression ratio	17.5
Dynamometer	Type eddy current, water cooled
Load indicator	Digital, supply 230AC
Software	"EnginesoftLV"

Table 1: Specification of the engine

5. Experimental work

In this experiment firstly biodiesel is generated from the non-edibles of argemone mexicana and mahua. After the generation of biodiesel, blends with diesel were made then fuelled in a diesel engine. The detailed experimental work is discussed below:

5.1 Production of biodiesel

As the viscosity of argemone oil and mahua oil are very high as compared to diesel, therefore, they could not directly use in the diesel engine as they can lead to many engine life problems Therefore, it is necessary approach to reduce oil's viscosity to use them in the unmodified engine. There are various methods for the reduction of viscosity. The method used in this experiment is transesterification. The following steps were used for the transesterification process.

- Methanol and Na were mixed in measured quantity.
- Methanol and Na were mixed with argemone oil at constant temperature of 70◦C.
- Argemone methyl ester and glycerine were separated out after interval of 24hours.
- The argemone methyl ester was washed with the water for 10 to 12 times.

The argemone seeds were purchased from the market and then processed to extract the oil from them. The seeds were black in colour. The oil yield in seeds was 35%. The colour of the oil was pale yellow. Table below presents the proportion of methanol, catalyst and the oil utilized for biodiesel generation from the Argemone mexicana.

Table 2: Composition of Argemone Biodiesel

PROPERTY	UNIT	ARGEMONE OIL	ARGEMONE BIODIESEL	DIESEL
Density at 15°C	Kg/m^3	932	886	850
Viscosity at 40°C	mm^2/s	35	5.07	2.60
Flash pt.	°C	220	130	68
Pour point	°C	-	-	-20
Content of Water	%	0.7	0.2	0.02
Content	%			0.01

of Ash				
Carbon residue	%	0.61	0.02	0.17
Acid value	Mg KO H/g	4.7	0.34	0.35
Calorific value	MJ/k g	36.72	39.41	42

Table 3: Properties of Argemone Mexicana

The same method is used for mahua. The mahua seeds contain 50-55% of oil. It was greenish yellow in colour. The catalyst used was sodium hydroxide (NaOH). Table below presents the proportion of methanol, catalyst and the oil used for the production of biodiesel

- Methanol and Na were mixed in measured quantity.
- Raw mahua had been heated to 70 degree.
- Methanol and sodium were mixed with argemone oil at constant 70◦C.
- Mahua methyl ester and glycerine were separated out after interval of 24hours.
- The mahua methyl ester was washed with the water for 10 to 12 times.
- Methyl ester was collected in a flask.

S.No	Chemicals	Proportion
1	Mahua oil	1500ml
2	Catalyst NaOH	10gm
3	Methanol	375ml

Table 4: Composition of Mahua Biodiesel

5.2 Separation

After the stirring, settlement of mixture was permitted for two days. The 2 layers with the lower is glycerine and above layer is biodiesel. The glycerine is much denser than the Biodiesel. The glycerine can be further used in for various purposes like in medicines and cosmetics creams. The biodiesel was separated in a separating funnel and the glycerine was separated out. After separating the glycerine from the methyl ester, the product was washed with hot water from 10 to 12 times to remove the soap from it. The product formed was pure biodiesel. The biodiesel obtained was 1 litre. After separating out the biodiesel was allowed for the drying. The blends were prepared on the volumetric basis, simply by mixing of biodiesel and diesel.

Figure 2: Separation

5.3 Blend Preparation

After the preparation of biodiesel the blends are prepared. The four blends prepared were B10, B20, B30 and B40.

The below sample is pure diesel. It was purchased from the local petrol pump

Figure 3: Pure Diesel

The sample below is pure biodiesel that is B100. It was produced from the argemone mexicana oil. In this process, 1.5 litre of oil is heated at 70◦C. After that mixture of 375 ml methanol and the 10gm sodium metal is poured into the oil. The oil was heated continuously at 70◦C. The reaction was continuously stirred with blender for 2 hours. The mixture is then permitted to settle for a day. The glycerol is separated out in a separate funnel. The pure methyl ester was washed with the hot water from 8 to 10 times.

Figure 4: B100 (Argemone)

The below sample is pure biodiesel produced from the mahua oil. The process used for the production of the biodiesel was same as for the mexicana argemone oil. The catalyst used was NaOH. The 1.5 lite of oil heated at constant at constant temperatue of 70○C. After that mixture of 375ml methanol and the 10gm sodium hydroxide (NaOH) is poured into the oil. The reaction was continuously stirred with blender for 2 hours. The reaction was continuously stirred with blender for 2 hours. The mixture is then permitted to stabalise for a day. Glycerol is separated out in a separating funnel. The pure methyl ester was washed with the hot water from 8 to 10 times.

Figure 5: B100 (Mahua)

The Sample in the below figure is B10.The sample is mixture of diesel and the biodiesel. In the mixture there is 5% mahua biodiesel , 5% mexicana argemone and 90% diesel.

Figure 6: B10

The below sample is B20 is that mixture of 10% mexicana argemone biodiesel, 10% mahua biodiesel and the 80% diesel.

Figure 7: B20

The below sample is B30 is that mixture of 15% Mexicana argemone biodiesel, 15% Mahua biodiesel and 70% diesel.

Figure 8: B30

The below sample is B40 is that mixture of 20% Mexicana argemone biodiesel, 20% Mahua biodiesel and 60% diesel

Figure 9: B40

5.4 Engine Testing

The experiment was performed on 4 stroke, and variable loading engine. The engine was connected to the dynamometer to provide load. The engine ran over the various loads of 0kg, 3kg, 6kg, 9kg, 12kg and 15kg. The circulation of water was provided for the cooling of engine with pump. The inside pressure and the net release of heat were seen at the full load of 15kg. The test was conducted with the various blends of Mexicana argemone and mahua prepared by volume basis i.e A5M5D90 (B10), A10M10D80 (B20), A15M15D30 (B30) and A15M15D70 (B40). The performance parameters and combustion characteristics were evaluated at different loads.

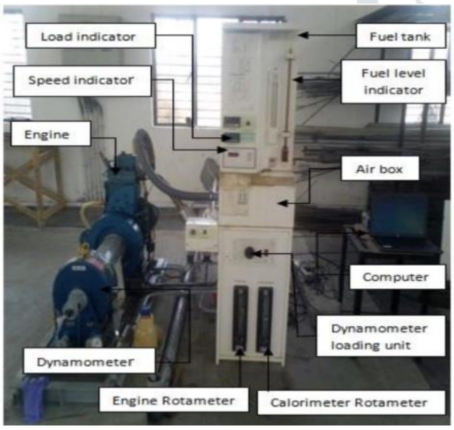

Figure 10: Testing engine setup

6. Results

In this study, the emission characteristics were obtained using two field biodiesel blends. The results obtained were compared with the diesel.

6.1 Emission characteristics

The emission characteristics like carbon monoxide, carbon dioxide, oxides of nitrogen and unburnt hydrocarbons were observed for diesel and its biodiesel blends. The biodiesel blends showed reduction in the CO, CO_2 and HC, but increase in NOx due to inherent oxygen in biodiesel.

6.1.1 CO Emission

Diesel fuel does not contain any inherent oxygen, therefore combustion does not take place completely. The CO reduces with biodiesel concentration upto B20, but CO starts increasing with further increase in the concentration of biodiesel. Higher density of the biodiesel leads to incomplete combustion. Therefore B30 and B40 shows the higher carbon monoxide emission as compared to diesel and biodiesel blends.

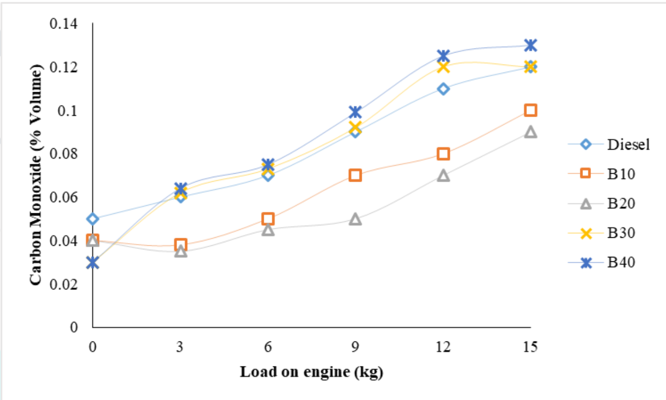

Figure 11: CO variance with load

6.1.2 HC Emission

Incomplete combustion culminates to the unburnt hydrocarbons. Unburnt HC plummet using biodiesel blends. Unburnt hydrocarbons surge with load and reduces with biodiesel concentration in blend. Complete combustion occurs results in diminishing of UHC owing to rich oxygenated fuel. The unburnt hydrocarbons decreases with increase in concentration of biodiesel upto B20, but hydrocarbon emission starts growing with biodiesel concentration.

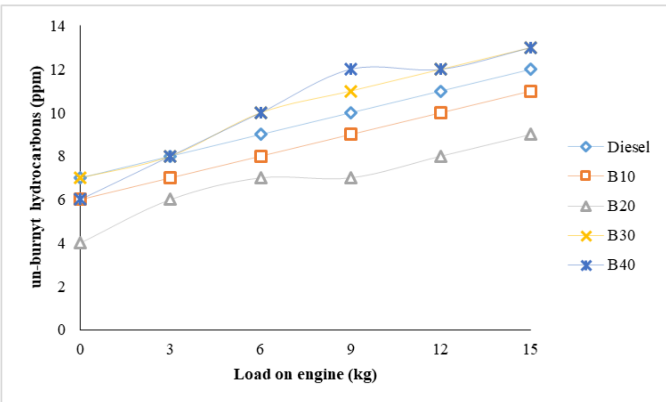

Figure 12: unburnt hydrocarbons variance with load

6.1.3 Oxides of nitrogen

Higher peak cylinder pressure culminates to NOx. The biodiesel blends showed higher oxides of nitrogen emission as compared to the diesel, which was owing to more full combustion of biodiesel due to presence of rmore oxygen content. The NOx emission surges with load. NOx was high for the diesel at lower loads contrary to blends, but NOx was more for blends at more load. The increase in Higher chamber temperature led to increase in NOx for blends.

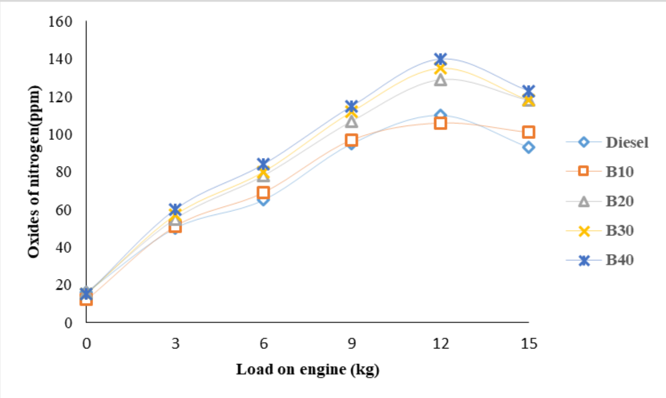

Figure 13: NO_x variance with load

6.1.4 CO_2 Emission

The CO_2 formation is result of complete combustion. The more the CO_2 lesser will be the carbon monoxide. The Blend B10 shows highest CO_2 emission contrary to other biodiesel blends and diesel. All the blends of biodiesel show higher CO_2 emission. This is due fact that, biodiesel contains inherent oxygen. The CO_2 formation decreases with biodiesel concentration, which was due to its higher density. Higher density of biodiesel results in incomplete combustion of fuel. Therefore CO_2 formation was found maximum for the lower blends of biodiesel. Blends B20 and B10 shows higher carbon dioxide formation due to better combustion characteristics as compared to other blends.

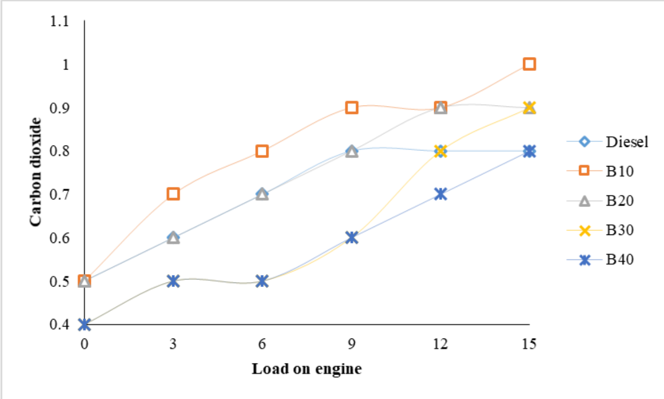

Figure 14: CO_2 variance with load

7. Conclusion

In this study, dual blends of argemone mexicana and mahua were utilized for experimental results characterization inquiry. The engine used for the experimental study was 4 stroke. First the engine was made to run on the dual biodiesel blends of biodiesel. The blends prepared were A5M5D90 (B10), A10M10D80 (B20), A15M15D70 (B30), and A20M20D60 (B40). The obtained results were compared to normal diesel. The following conclusion were made after the experimental study:

- CO and HC were reduced with biodiesel blends.
- At more loads, NOx was more for blends contrary to diesel.

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