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Preparation of Biodiesel from Castor Oil and Performance Evaluation in VCR Engine

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Biodiesel can be used as Alternative fuel and acts as Renewable energy source. Rapid growth in industrialization of developing countries is resulting in increasing demand for new and eco-friendly energy sources. In this present research biodiesel was prepared from Castor oil by esterification and Transesterification process. The castor oil biodiesel produced was blended with diesel to obtain B10.Performance evaluation was carried out in VCR engine and emission testing was done by Gas analyzer to know the percentage of CO,HC, NO_X and comparison study was done with diesel and biodiesel blend. In this study it was found that NOx emission rate of biodiesel blend increases while percentage of CO, HC increases. Also various performance indicators such as break mean effective pressure, specific fuel consumption; break thermal efficiency was plotted with respect to variation of load by using VCR engine.

Keywords: Biodiesel; castor oil; transesterification.

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1. INTRODUCTION

Renewable energy becomes more attractive for reducing green house gases and due to deficiency of petroleum reserves. Biodiesel is an alternative form of diesel derived from either plants and plant product or animals. Vegetable oils are used as feedstock for production of biodiesel. Biodiesel has better property such as renewable, non-toxic, higher potential to reduce environment pollution. It can be used in any diesel engine without modification. It also reduces the carbon dioxide and provides an excellent quality of exhaust gas emission. Though higher emission of NO_x, lower emission of CO, CO2 and HC , biodiesel is receiving worldwide attention.

2. LITERATURE REVIEW

Deepanraj, B et al [1] had done studied for biodiesel blends (palm oil methyl ester) in a diesel engine. The emission test was done by gas analyzer and various performance parameters were evaluated it was observed that break thermal efficiency increased where fuel consumption and engine emissions also reduced. Arumugamurthy, S.S et al [2] had produced biodiesel by using catalyst brewer's spent yeast and the reaction rate was followed by pseudo first order reaction. Malhotra, R et al. [3] had prepared 5- Na/Zno loaded SBA-15 by one-pot method in atmospheric condition and the catalyst was characterized by using several techniques. Biodiesel was produced from virgin cotton seed in the presence of this catalyst by transesterification process. Soares, D et al. [4] had produced biodiesel from low value feedstock such as soybean feedstock oil by hydroesterification method. Baskar, G.et al. [5] had produced biodiesel from castor oil by using zinc oxide nano composite as catalyst. It was found iron doped in ZnO as promising nano catalyst for producing biodiesel. Wen, Z.et al. [6] had synthesized biodiesel from vegetable oil by using Li- doped MgO as catalyst within a calcination temperature. Tran, T.T.V. et al. [7] had produced biodiesel from waste cooking oil in presence of sulfonated carbon microsphere catalyst. Foroutan, R et al. [8] had studied different physical properties such as flash point, density, viscosity of blended biodiesel produced from different edible oils. Shriame, HY et al. [9] had studied that biodiesel can be used in engine without modification by blending with petrodiesel.It was studied that that emission rate reduced as well as both edible and non edible oil can be used. Sahoo P.K et al. [10] had done experiment on biodiesel produced from karanja, jatropa, polonga in diesel engine. The combustion test was carried out by varying different load by using biodiesel blends.

3. MATERIALS AND METHODS

3.1 Materials

Castor's reasonable advantages is that the growth period is much shorter than that of Mahua, Jatropha and Karanja and are not far mid mayors of experience and awareness of the farmers on their plows. The seeds contain between 40% and 60% of oil, which is rich in triglycerides, main ricinoleina. Son seminal of ricin toxin, which is also present in small concentrations along the plant. It will do in the winter neither cured or thin excessive heat cold, so even common used lubricant for cars and jet engines race.

3.2 Methods

The production of biodiesel from castor oil is basically done by transesterification process. This process can be done in three stages.

i. Pre-process (acid value calculation, heating of oil and esterification)

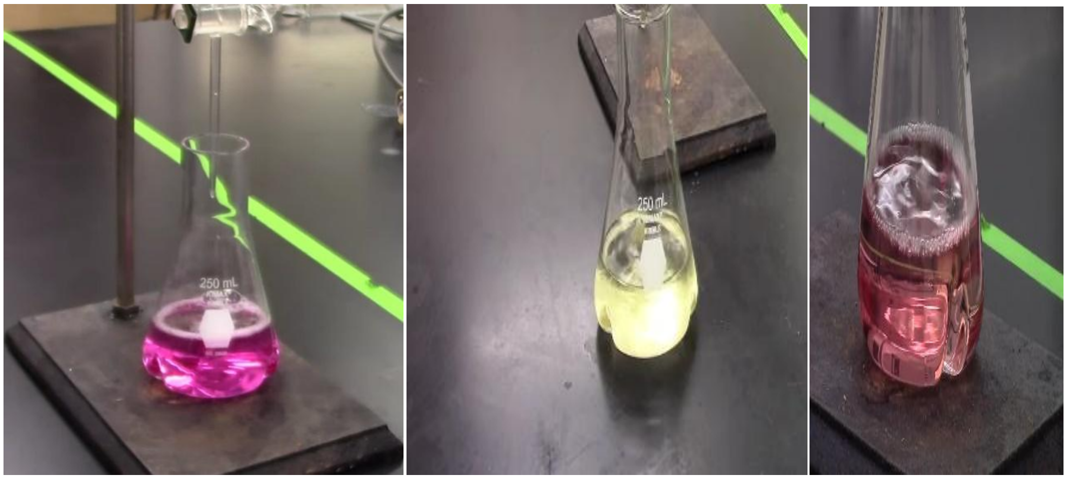
ii. Main process (transesterification)

iii. Post process (water wash)

3.2.1 Pre-process (acid value calculation and esterification)

3.2.1.1 Acid value calculation

First 10 grm of oil was weigh into 250 ml of conical flask then we add 50 ml of ethyl ester solution followed by 1ml of phenolphthalein indicator into the flask and was mixed well. Then the pH of the oil sample was found to be 6.48. We then prepared 0.1N KOH solution by mixing 5.8 grms in 1000 ml of distilled water. Then the burette was filled with the same 0.1KOH solution up to the zero mark. After noting the IBR reading the burette was opened drop wise and after the solution turns slightly pink the burette was closed and the final reading was noted. The same was process was repeated for four to five times for a concordant reading.



Before End point

Fig. 1. Acid value calculation

Table 1. Acid value titration reading

S.NO	Weight of oil taken(grams)	Initial Burette reading	Final Burette reading	Difference
1	10	0	37	37
2.	10	0	40	40
3.	10	0	40	40
4.	10	0	40	40
5.	10	0	40	40

Calculation

1ML of 0.1N KOH = 5.6mg of KOH

This means that

Acid value = 5.6 X vol of KOH used/weight of the sample

=>5.6 X 40/100

=> 2.4

3.2.2 Heating of oil and esterification

1 liter of castor oil was heated at 110^{0}C to remove moisture content .Then the oil was Cooled and 10 g of H_2SO_4 and 200 ml of methanol was added and mixed well. Then the Oil mixture was placed in the biodiesel reactor and heated for 3 hr maintaining thetemperature 60-64^{0}C. After 3 hr the sample was cooled and collected in a separating Funnel then on the next day the sample was filtered and the unreacted methanol was separated and the remaining product was transesterified. Esterification reaction is mostly used for reducing the FFA level of oil.

3.2.3 Main process (Transesterification)

The esterified sample was mixed with 10 g of KOH and 200 ml methanol solution. The mixture was then heated up to 3 hr at 70^{0}C in a biodiesel reactor with continuous stirring .Then the sample was cooled and kept in a separating funnel. Then on the next day we seen that two layers were formed and the upper layer which is the methyl ester was separated from the lower layer which is the glycerol. Transesterification reaction is used for converting fatty acid into fatty acid methyl esters. Transesterification can be carried out by either acid catalyst or alkali catalyst. The term transesterification refers to ester interchange reaction is conversion one ester to other. This includes all combinations of interaction between monohydroxy alcohol esters, mono and dieters of glycol mono di and triglycerides and the various esters of tetrahydroxy and higher alcohol are possible. The ester –ester interchanges of materials intended for non- edible industrial uses are undoubtedly becoming increasingly important when applied to fats and oils ester –ester interchange may improve physical properties because it changes acyl group arrangement within the components of the mixed triglycerides of fats and oils ester-ester interchanges may be affected without catalyst at high temperature at 150^0C and above. Ester-ester interchange occurs at rapid and at less temperature by use of either acid or alkaline catalyst. Ester interchanges proceed at random. This will result in compositional changes, the fatty acyl groups within triglyceride to all the possible combination.

Fig. 2. Pre-process

Fig. 3. Main process

Fig. 4. Post process

3.2.4 Post process (water wash)

The methyl ester which is obtained is then water washed to remove the remaining glycerol and impurities of solution. The methyl ester was mixed with water in 1:3 ratio and shaked well for 2 minute. Then it was kept for 15 minutes. After that water was comes down with impurities and the pure methyl ester was collected. This process was repeated for 5-6 times. The collected sample after water wash was heated at 110^0C for 40-50 minutes then the biodiesel was collected.

4. EXPERIMENTAL SET UP

A four- stroke single-cylindrical diesel engine (Figure no.) with eddy current dynamometer was used for this study. The specifications of the engine are shown in Table 2.

5. RESULT AND DISCUSSION

Short term engines tests were conducted using blends of diesel and castor biodiesel with diesel in order to study their effect on engine performance parameters at varying loads 2, 4, 6 and 8. The important performance parameters of the engine such as BP, SFC and BMEP obtained as a result of running the Variable compression Ratio Test rig engine with biodiesel are compared with that of using diesel fuel. The engine emissions are also measured by means of exhaust gas analyzer as shown in Fig 6. A comparative study is made on the composition of different gases such as CO, CO_2, NOx and HC with the results obtained by using diesel and castor biodiesel.

5.1 Emission with CO (Carbon Monoxide)

Analysis of Diesel and Castor diesel blend

By using gas analyser the emission testing of Biodiesel (Caster and diesel blend i.e. B10) was carried out.

The castor biodiesel blends is B10 i.e. 10% biodiesel in 90% diesel. Here the Co% of was Castor B10 and Castor Mix slightly changed with respect to the load value. When the load increases the Co% of Diesel, castor B10 mix is decreasing respectively.

5.2 Emission with CO2 (Carbon Dioxide)

Analysis of Diesel and Castor B10 Mix

The castor biodiesel blends is B10 i.e. 10% biodiesel in 90% diesel. Here the CO_2% of was Castor B10 Mix slightly changed with respect to the load value. When the load increases the CO_2% of Diesel, castor B10 mix is increasing respectively.

5.3 Emission with HC (Hydrocarbon)

The castor biodiesel blends are B10 i.e. 10% biodiesel in 90% diesel. Here the HC% of was Castor B10 Mix slightly changed with respect to the load value. When the load increases the HC of Diesel, castor B10 mix is increasing respectively.

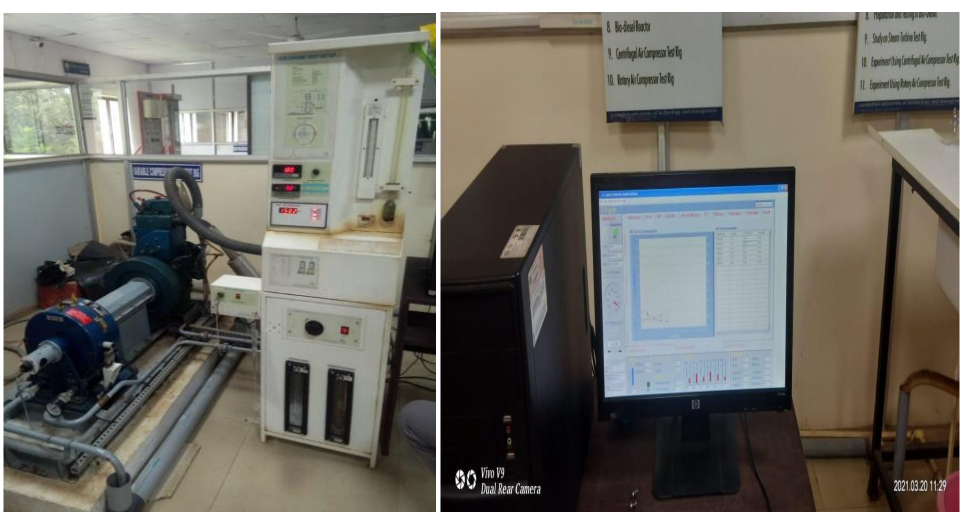


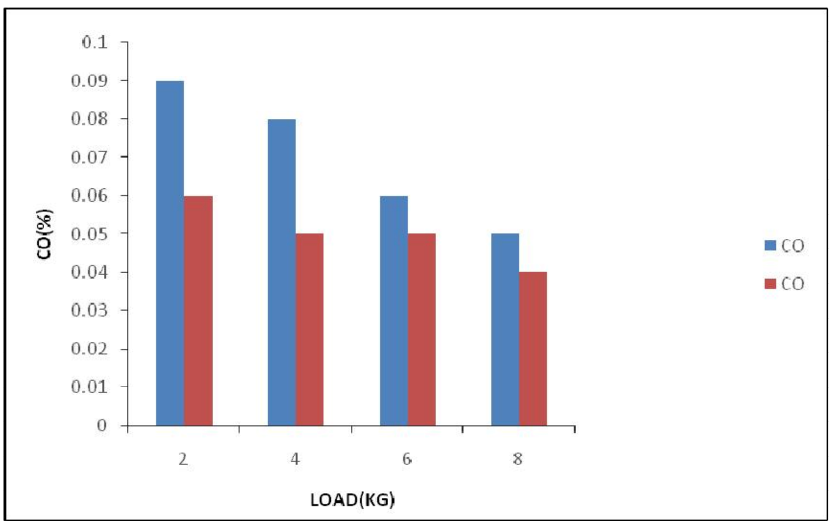
Fig. 5. Experimental setup of VCR engine test rig

Table 2. Engine specification of VCR engine

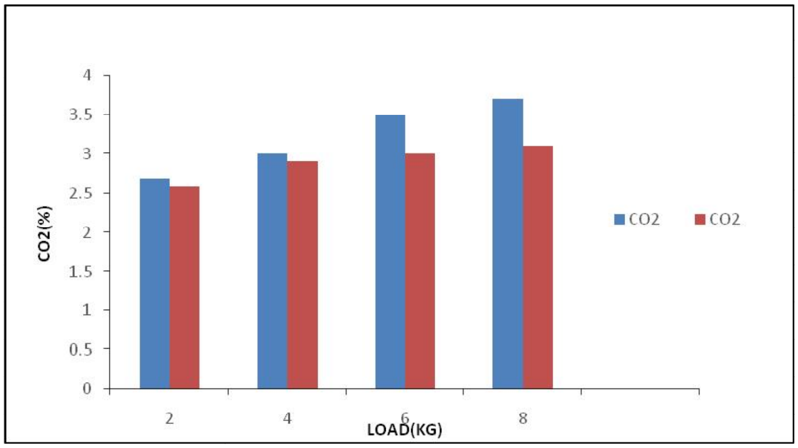
Engine specification of VCR Engine

Description	Value and unit
Break power	3.7285 kW
Speed	1500 rpm
Number of cylinders	One
Compression ratio	16.5:1
Bore	80mm
Stroke	110mm
Orifice Diameter	20mm
Type of ignition	Compression ignition
Method of loading	Eddy current dynamometer
Method of starting	Crank start

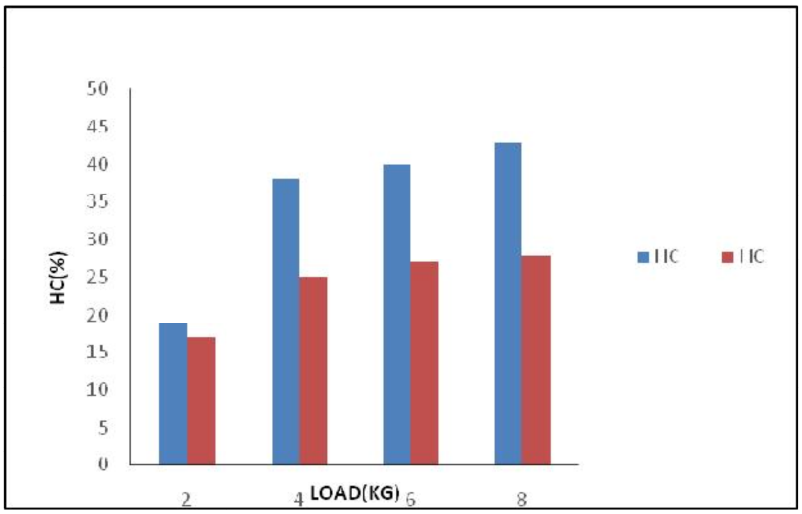
Fig. 6. AVL DIGAS 444N gas analyser



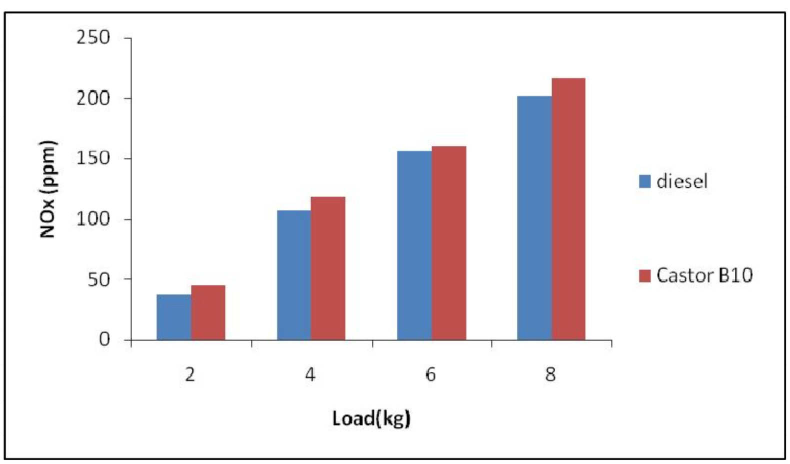
Graph 1. Graph represents the variation of the CO% with respect to the load of the diesel and castor blend



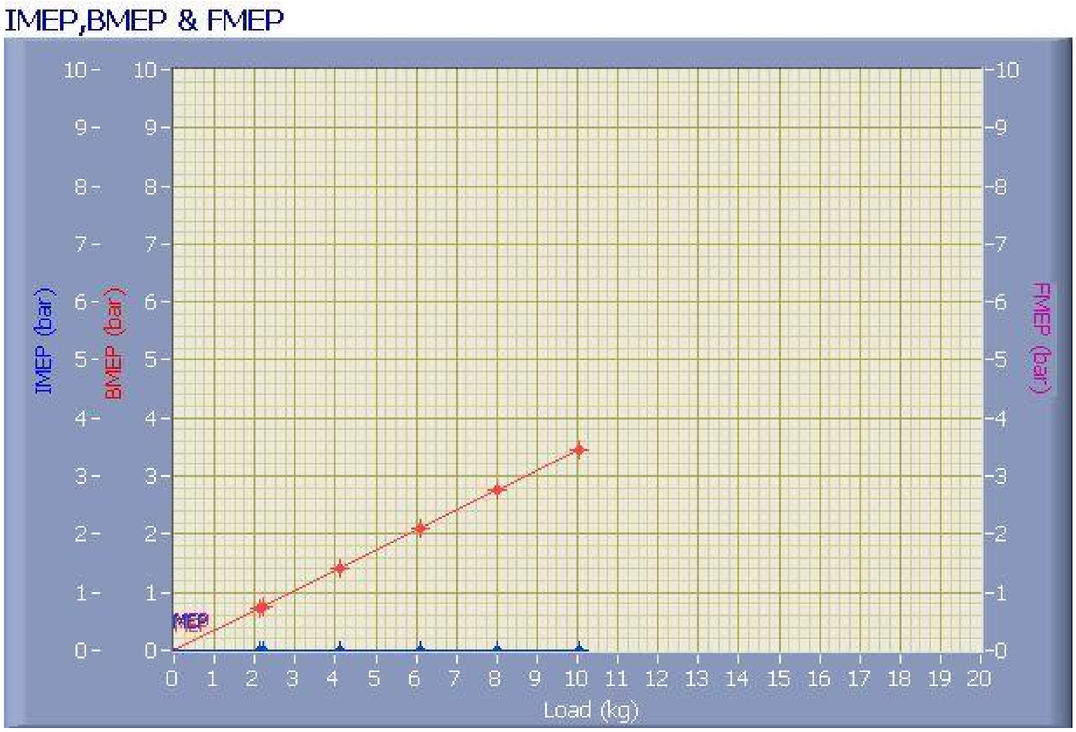
Graph 2. Graph represents the variation of the CO_2% with respect to the load of the diesel and castor blend



Graph 3. Graph represents the variation of the HC% with respect to the load of the diesel and castor mix

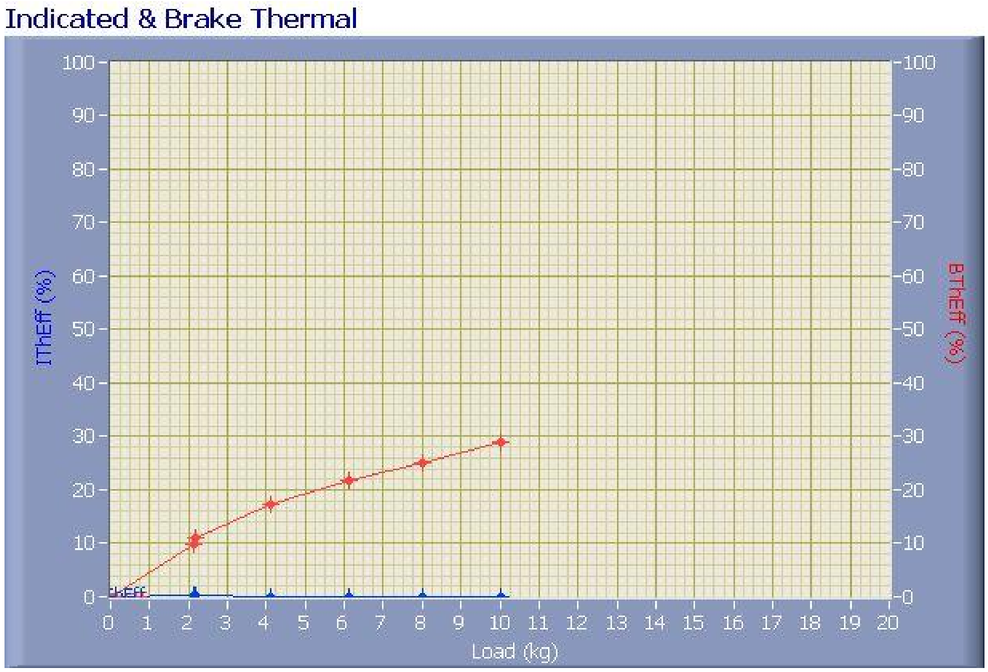


Graph 4. Graph represents the variation of the NO_X % with respect to the load



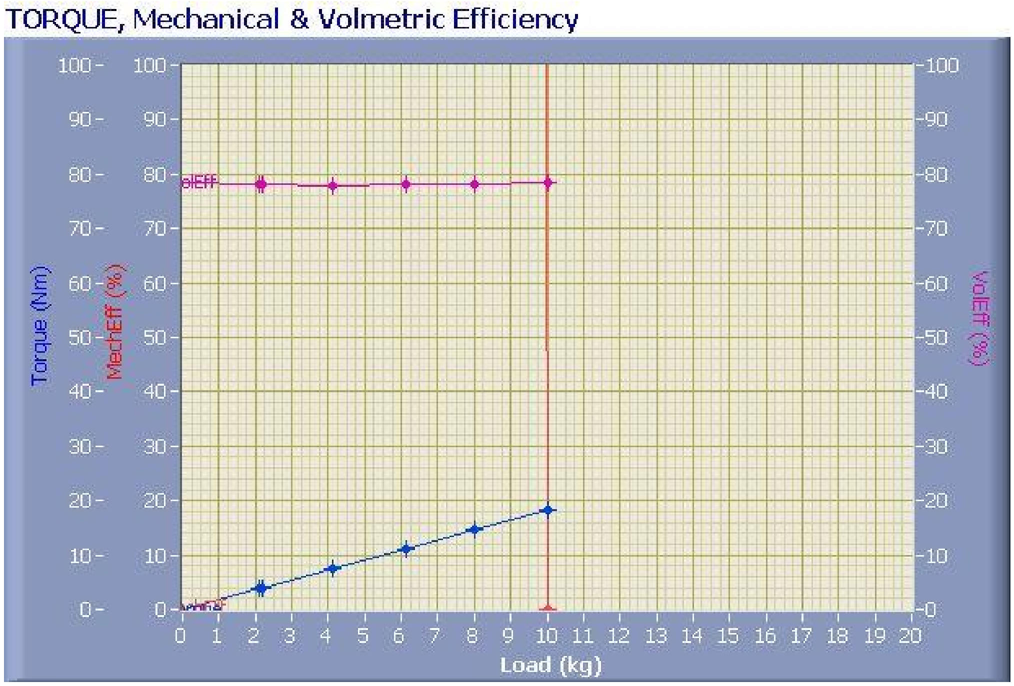
Graph 5. Graph represents the variation of the Break mean effective pressure (BMEP) with respect to the load of the Biodiesel blend (B10) in VCR Engine test rig. In the graph it has been shown that as load increases the mean effective pressure slightly increase

Graph 6. Graph represents the variation of the air and fuel flow with respect to the load of Biodiesel blend (B10) in VCR engine test rig



Graph 7. Graph represents the variation of the Indicated and Brake thermal efficiency with respect to the load of Biodiesel blend (B10) in VCR Engine test rig. From this graph it has been observed that as load increase, break thermal efficiency increases and indicated thermal efficiency remain unchanged

Graph 8. Graph represents the variation of SFC and Fuel Consumption with respect to the load of the Biodiesel blend (B10) in VCR Engine test rig. The specific fuel consumption and fuel consumption slightly increases with respect to increase of load



Graph 9. Graph represents the variation of torque, mechanical and volumetric efficiency with respect to the load of the Biodiesel blend (B10) in VCR engine test rig

5.4 Emission with NOx (Nitric Oxide)

The castor biodiesel blends is B10 i.e. 10% biodiesel in 90% diesel. Here NO_X % of was Castor B10 Mix slightly changed with respect to the load value. When the load increases the NO_X of Diesel, castor B10 mix is increasing respectively.

6. CONCLUSION

- From the experimental results obtained, compared to neat diesel operation, biodiesel of Castor oil and diesel mix results in comparable engine performance and slightly higher emissions. All the biodiesel and diesel tested result in a slightly lower thermal efficiency. The emission rate also reduces for biodiesel blend as compare to conventional fuel.
- The existing engine could be operated on the biodiesel and diesel blend tested without any modification.
- India being an agricultural country, the energy from bio sectors will be highly beneficial for both plantation as well as transportation. Thus Castor oil biodiesel blend will be a highly beneficial fuel in terms of both economy as well as fuel independence because this Castor oil will be easily available as long as air and water are available in the earth. The results show that, biodiesel will be a good substitute and it could replace diesel in future.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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