Comparative Investigations on Mahua Biodiesel-Diesel -Alcohol Low Percentage Blends with a VCR Diesel Engine

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Abstract. In this analysis mahua oil biodiesel is selected as one of the best alternative fuel to diesel. Transesterification process is used for biodiesel production. Serious concern on the emissions, in particular the nitrogen oxides (NO_x), PM (particulate matters) and carbon dioxide (CO₂) led to think about additives to improve the overall performance. In this investigation additives are used to improve the performance, combustion and emission characteristics of Mahua biodiesel (B) and Diesel (D) blends. B20 blend is used as basic blend to compare the performance. Ethanol (E) and Propanol (P) used as additives in diesel-biodiesel blend with 5%, 10% and 15% and tested in VCR diesel engine. Ethanol shown better performance in particular as compare to Propanol. The reduction of NO_x, CO, CO₂, HC emission in diesel engine and also increase performance in addition of 10% ethanol. From this conclude the result ethanol is alternative to improve efficiency of diesel engine by using the blended biodiesel.

1 Introduction

The diesel fuel is commercial and transportation fuel. The rapid increment in the demand of fossil fuel such as a diesel has a great impact on economy of countries. The transportation sector is identified as major polluting sector. The crude oil prices are fluctuating in the global market. Biodiesel has a capacity to cut down the lump sum of expenditure on fuel. Biodiesel is important alternative to fossil fuels. Different types of biodiesel are largely studied in the past. Different alcohols in different percentage in biodiesel can change the emissions of engine significantly. Mahua oil biodiesel is ecofriendly better performing biodiesel. Biggest problems with the use of biodiesel are decrement in performance, Increase in the emissions and incomplete combustion. Additives are added to increase the performance of biodiesel in diesel engine. These additives are environment friendly and useful for the growth of farmers. Second generation ethanol and propanol are used as additives.

2 Literature Review

Additives such as ethanol and 1-propanol added into diesel blends. By adding them decrease in NO_x and soot emission is found. At the same time CO emissions are increased [1]. Alcohols such as methanol, ethanol, propanol, butanol and all having 5% oxygen content are tested with waste cooking oil diesel blends. It leads to reduction in emission of HC, NO_x, CO, CO₂ [2]. By using additives increase in oxidation stability and 4–5 °C

change in cold flow properties achieved [3]. Additives used in diesel-biodiesel blends are Propanol, n-butanol and 1-pentanol. Higher brake specific fuel consumption of D40B40Pro20 than ternary blends of D40B40nB20 and D40B40Pn20 at all engine loads [4]. D40B40Pro20, D40B40nB20 and D40B40Pn20 have the exhaust gas temperatures higher than that of the diesel-biodiesel blend [4]. Different oxygenates are considered for study. By adding 2-propanol in pseudo binary and ternary biodiesel density is measured at different temperatures. Excess molar value shows positive and negative effects on Performance. In this investigation Methanol (M) and Ethanol (E) used as additives. Reduction in emissions of NO_x, CO, CO₂ HC takes place on addition of methanol in 10% and 15% [6]. Biodiesel (20%) added with 5% and 10% additives shows better performance in emission reduction. Fuel properties are found to be similar to conventional fuel. [7,8]. NO_x and PM emission are reduced. Operating conditions and biofuel concentration are important parameters in reducing emissions. [9]. B20D80 blend shows better performance than other blends [10,11]. Mahua oil biodiesel blended with octanol reduces emissions by significant amount significant results are found [12,13]. diesel-biodiesel-ethanol and bioethanol ternary blends are tested ternary blends shows better reduction in particulate matter other parameters are nearly same as like diesel [14,15]. Mahua oil biodiesel shows better performance below 25% diesel blends. Less brake specific fuel consumption than the diesel. It has been proved by the results [16]. At the end Mahua oil biodiesel 20 % blend is significant and less

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studied. Hence mahua oil biodiesel is selected for study to improve the performance of engine by using additives. Propanol and ethanol in low percentage are selected as additives.

3 Material and method

The Mahua oil feedstock is collected from Indian biodiesel corporation Baramati. Mahua oil initially with free fatty acids having density 910 gm/cc which are need to be removed. This feed stock is then undergoes esterification and transesterification process. Under esterification 0.4% H₂SO₄ ACID catalyst by volume and 10% methanol as a solvent were added. Mixture then heated at 55-60 °C and agitated at 550-600 rpm for 30 minutes. At the end of esterification fatty acid count reduced to the 5-6 mg from 17-18 mg of KOH. Density and viscosity of mahua oil then reduced by significant amount. Under transesterification esterified mahua oil mixed with 0.4% NaOH AND 10% methanol and agitated at 550rpm at 60 °C for 75 minutes. Settling of mixture for 8 to 10 hrs resulted into 20% glycerol and 80% biodiesel. After purification and demulsification at 110 °C for 20 minutes pure mahua oil biodiesel B100 obtained. Ethanol (E) and propanol (P) were added in 5%, 10%, 15% in B20 biodiesel blend. Diesel with 20% Mahua oil biodiesel used as base fuel with best performance. Different blends to be tested of list is given in Table 1.

Table 1. List of blends to be tested

Blends	Diesel	Biodiesel	Propanol	Ethanol
Diesel	100%	-	-	-
D80B20	80%	20%	-	-
D75B20E5	75%	20%	-	5%
D70B20E10	70%	20%	-	10%
D65B20E15	65%	20%	-	15%
D75B20P5	75%	20%	5%	-
D70B20P10	70%	20%	10%	-
D65B20P15	65%	20%	15%	-

4 Experimental setup and methodology

The experimental setup consists of Kirloskar Computerized VCR engine of specification and details are given in Table 2 and Figure 1. Eddy current

dynamometer is used to change the load from 0 to 16. Compression ratio kept constant at 18. Engine and dynamometer are water cooled there flow rate is measured by rotameter and calorimeter. Piezo sensor, load cell and temperature sensors are used for performance measurement. Exhaust gas analyzer is connected to measure emissions of NO_x, CO, CO₂, HC. Data acquisition is done by computer connected to the system.

The Diesel and blends D80B20, D75B20E5, D70B20E10 D65B20E15, D75B20P5, D70B20P10, D65B20P15 are tested respectively. During testing readings are taken when engine became totally steady. Loads are varied from 0 to 16. While compression ratio kept constant. Computerized system generated results for various blends.

Table 2. Diesel engine specification and details

Engine specification	Details
Type	1 cylinder 4 stroke
Bore dia x stroke length	87.5 x 110 mm
Cubic capacity	661 cc
Compression ratio	17.5
Piezo sensor Range	5000PSI, with low noise cable
Maximum speed	2000 rpm
Rotameter	40-400 LPH
Connecting rod length	234 mm
Over dimensions	W2000 x D2500 x H 1500 mm
Data acquisition device	Ni USB-5210, 16 bit ,250KS/s

Fig. 1. Computerized VCR engine setup

5 Result and discussion

5.1 Performance

5.1.1 Brake power

Fig.2. Shows graph of Break power with Load. At low load condition nearly all blends shows same break power variation. As we know that the engine efficiency is depends upon the brake power and it is directly proportional to the brake power. From the graph we can concluded that the by using blends we can slight increase the efficiency of the engine. The power output is 2% increases for ethanol concentration blend and maximum for D70B20E10 and D65B20E15 Due to the complete combustion occur in Diesel engine.

5.1.2 Brake thermal efficiency

Fig.3. Shows graph of Break thermal efficiency with Load. At low load condition nearly all blends shows same break power variation. At higher load little change in result takes place. Brake thermal efficiency increases with increase in BMEP up to 2.92 bars beyond that small increases or decrease for various blends This result is beacase of additional lubricity and oxygen content in oxygenates additives , which results into the reduction in heat loss and active combustion process. Average 2% increment for D70 B20E10 as compare to diesel is seen as the load increases. D70B20E10 and D65B20E15 are coming out as best out of all blends as they are showing nearly 2% increment in the brake thermal efficiency.

5.1.3 Indicated thermal efficiency

Fig.4. Shows graph of Indicated thermal efficiency with Load. The indicated thermal efficiency increases with addition of oxygenates both ethanol and propanol than pure diesel. The ethanol concentration blend is effective than the propanol concentration blend due to maximum oxygen content in ethanol concentration blend. Total increment in indicated thermal efficiency is about 3% for various loads. It is highest for the blend D70B20E10 and blend D65 B20E15.

5.1.4 Brake specific fuel consumption

Fig.5. shows graph of Specific fuel consumption vs load condition. It is about 5% for various loads. Brake specific fuel consumption decreases with increase in load of the engine. The brake specific fuel consumption is lower for ethanol concentration blend due to lower viscosity than proanol, Hence the ethanol concentration blend consume less fuel than ethanol concentration blends. Brake specific fuel consumption is lower for the blend D70B20E10 AND D75B20E5. D70B20E10 shows

less fuel consumption for all loads specially at higher loads. The Difference in specific fuel consumption is nearly about 1- 2%.

Fig. 2. Variation of Brake power with BMEP

Fig. 3. Variation of brake thermal efficiency with BMEP

Fig. 4. Variation of indicated thermal efficiency with BMEP

Fig. 5. Variation of Brake Specific fuel consumption with BMEP

5.2 Emmisions

Gas analyzer gives the results of emissions of CO, CO₂, HC and NO_x are plotted on the graph.

5.2.1 Carbon monoxide (CO) emission

Fig.6. shows graph of carbon monoxide vs. changing load condition. CO is prodiced due to the incomplete combustion, which is formed due to scarcity of air or due to low gas temperature. CO emission decreases in addition of oxygenates in diesel. At higher load, the combustion of blends is almost complete due to the presence of oxygen which reduces the incomplete combustion of fuel in the region, results into to lesser CO emission. By more oxidation of CO, smallest possible emission of D70B20E10 is observed at higher loading condition. Average 3% decrement in CO emission is found for D70B20E10 which is highest as compare to other blends.

5.2.2 Carbon dioxide (CO₂) emission

Fig.7. shows graph of carbon dioxide vs. changing load condition. Fuel blend with ethanol and propanol has less CO₂ emission as compare to diesel fuel. It is observed that the emission of CO₂ increases with respective increase in load of the engine. Increasing percentage of ethanol in blend, decrease in CO₂ emission is observed because of higher oxygen content and higher carbon in mahua biodiesel. Decrement of CO₂ emission is 3% for all load conditions for the blend D70B20E10.

5.2.3 Hydrocarbon (HC) emission

Fig.8. shows graph of Hydrocarbon vs. changing load condition. Diesel and D75B20P5 have minimum HC emission at low load conditions. At higher loads D750B20P5 and ethanol blends have low HC emission. Overall less emission of HC is shown by D75B20P5 and D70B20E10. Reduction in emission of

D70B20E10 is 3% as compare to B20D80. HC emission increases with addition of oxygenates than diesel at various loading condition. The result revealed that the HC emission for propanol concentration blends are less than ethanol concentration blends. HC emissions are found lowest for diesel due to less carbon and oxygen percentage as compared to various blends. The blends D70B20E10 and other shows contradictory results as compare to diesel.

5.2.4 Nitrous oxide (NO_x) emission

Fig.9. shows graph of Nitrogen oxides vs. changing load condition. NO_x emission decrease with increasing percentage of ethanol in the blend, this is due to the characteristic that lower heating value and latent heat of vaporization of ethanol as there is lesser peak temperature in the cylinder. In addition, this is due to the percentage of nitrogen in chemical composition of biodiesel and alcohol is less as compare to diesel. The NO_x emission is decreases due to oxygenates added in biodiesel and diesel blend. The blend D70B20E10 and D65B20P15 shows minimum NO_x emission as compare to other blends. It is nearly 5% decrement in NO_x emission.

Fig. 6. Variation of CO with BMEP

Fig. 7. Variation of CO₂ with BMEP

Fig. 8. Variation of HC with BMEP

Fig. 9. Variation of NOx with BMEP

Conclusions

The experimental investigation concludes as given below

- 1 In performance the brake thermal efficiency for additives as a oxygenates is increased as compared to diesel. It is found maximum for the ethanol oxygenate blend (D70B20E10).
- 2 The brake specific fuel consumption is comparatively less as that of diesel fuel for D70B20E10 blend. It is 1-2% less for D70B20E10 blend.
- 3 The emission of CO is reduced by 2 % on addition of ethanol in diesel and biodiesel. It is lowest for D70B20E10 blend.
- 4 The emission of NOx is reduced by 5 % on addition of ethanol in diesel and biodiesel. It is lowest for D70B20E10 blend.
- 5 The emission of HC increases than diesel for both oxygenates and maximum for ethanol concentration blends.
- 6 From the experimental investigation, it can be concluded ethanol is found best oxygenate additives than that of propanol.
- 7 The effective blend found amongst the tested blend is D70B20E10.

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