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Influence of N-Butanol additives with Terminalia Methyl Ester as a fuel on Engine Emission Characteristics

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Abstract

In the today's world increase of consumption of fossil fuels is on very large scale and resources are limitedhencethere must besome alternative source whichcould replace fossile fuels and alsogivedesired output as per given by fossil fuels. The presentresearch in thispaperreviews the various aspects of biodiesel fuel derievedfrom non edibleTerminaliaoilwhichisconverted to biodiesel by transesterification chemical process. The blend of biodiesel and diesel used where B00, D89B6NB5, D83B12NB5, D77B18NB5, D71B24NB5, D65B30NB5 and D59B36NB5. The Present performance test was conducted in a single cylinder, water cooled, four strokes, 3.5 KW at 1500 rpm, with VCR .The emission parameters such as CO, Nitrogen Oxide, HC and smoke opacity are discussed with different compression ratios of different blends at vary loads conditions. It was obtained that the Terminalia Oil with n-butanol additive blends with diesel are founding improved performance and emission characteristics outcome in a diesel engine with no any modification.

Keywords:*VCR, Terminalia oil, N-Butanol , transesterification, Brake power, Brake thermal efficiency.*

1. Introduction

It is a true fact that many countries around the world are still heavily dependent on fossil fuels for energy and basic needs. No doubt, these fuels are very effective when concerned the power production quality. when we think long run, they are not helpful. Fossil fuel is limited. They will undoubtedly finish one day. Therefore, before the critical phase comes up, Scientists and Engineers, around the world, are constantly functioning and researching in this regard and should attempt their level best to substitute fossils fuels with renewable energy sources. Choosing to utilize a renewable energy supply will not only convert into cost savings over the long-term but will also help keep the atmosphere from the risks of fossil fuel harmful emissions. Management of energy and utilizing renewable sources is the final goal of energy. Many vehicles run on gasoline (which is a fossil fuel). Gasoline will diminish one day and vehicle industry must alternative to some new class of energy. Thus, it is essential to substitute fossil diesel fuel by alternative fuel. In biofuels, the nation has a ray of expectation in providing energy security. The properties of biodiesel are very close and similar to the conventional fuels; therefore biodiesel becomes a very superior and little cost choice to the diesel fuel. Biodiesel is a biodegradable, harmless and renewable fuel which is produced from close by and locally accessible sources like vegetable oil and animal fats etc. the emission of unburned HC, CO, PM of biodiesel combustion is much lesser than conventional diesel fuel.

Murugesan et.al [3] reported that the very high flash point and high viscosity of vegetable oil are the major problems of the direct use of oil as fuel in compression ignition diesel engine. This problem is solved to convert into biodiesel by blending of vegetable oil with diesel fuel and transesterification chemical process.

Y.C. Sharma et.al [5] studied that general oil bearing plants and trees which are non-edible like Neem, Karanja, Mahua, jatropha, etc. These different species of forest-based seeds are reported as the possible resource of biodiesel feedstock in India. Heterogeneous catalysts such as calcium oxide, magnesium oxide and others are also being tried to decrease the catalyst amount and production cost of biodiesel.

The oil yields from this variety at current are unsatisfactory to meet the demand for raw material on great amount production of biodiesel. India is an agrarian nation and has rich plant biodiversity which can carry the growth of biodiesel. India has a huge geological area with farming lands and wastelands on which oil containing plants can be planted.

Maumita Chakraborty et.al [6] reported that Terminalia found locally obtainable raw materials could be right for biodiesel making in the north-eastern section of India and has the probable to suit an alternative for usual diesel.

K. Muralidharanet.al [7] evaluated the performance, combustion and exhaust emission levels of waste cooking oil biodiesel and diesel blends in a fully instrumented single cylinder, variable compression ratio multi fuel engine.

B. De et.al [9] evaluated that the effects of Jatropha oil combustion on the performance and pollutant emissions on VCR diesel engine. They demonstrated that increase in compression ratio improves the performance in terms brake thermal efficiency and the increase of Jatropha oil concentration in the blends increasing the exhaust gas temperature and emission parameters like NOx , CO and decreases the thermal efficiency of the engine.

GokhanTuccar et.al [11] reported that the power and torque output of engine reduced slightly when butanol was added to the microalgae biodiesel blends and CO, NOx emission and smoke opacity values improved with butanol addition.

Terminalia Oil preferred for the current work of investigational research of performance and emission characteristic of VCR diesel engine. From the literature examination, it found that a more of study work has been passed out on evaluating the performance and emission characteristics of dissimilar grades of vegetable oils and biodiesels at a compression ratio diesel engine but the very minute study has been done in evaluating the performance of Terminalia Oil with the n-butanol additive. The outcome of compression ratio has not been analysed for the Terminalia Oil - Diesel blends with the n-butanol additive. Hence, the research work of the individuality of Terminalia Oil on the diesel engine for variable compression ratio with vary loads is very essential. In the current study, an outcome of variable compression ratio with varies loads of Terminalia Oil – Diesel blended fuels with n-butanol additive on the performance and emission characteristic of fuel has been studied.

The dissimilar blends of Terminalia Oil with n-butanol additive and usual diesel fuel are prepared and the following studies are passed out. The performance of a variable compression ratio engine using dissimilar blends at different compression ratios like 16:1, 17:1, and 18:1 and vary load like 0,4 and 8 in kg. It is compared with the result of standard diesel fuel.

The emission parameters such as CO, Nitrogen oxide and HC are discussed with different compression ratios of different blends at vary loads conditions.

It was obtained that the Terminalia Oil with n-butanol additive blends with diesel are founding improved performance and emission characteristics outcome in a diesel engine with no any modification.

2. Material and Method

Biodiesel is prepared from terminalia seed oil using alkali-catalyzed transesterification. The fatty acid profile of Terminalia oil obtainable 39.5% of the oil is saturated whereas, 60.5% is unsaturated fatty acid. The methyl ester formed in two stages. The first stage (acid catalysed) of the process is to decrease the free fatty acids (FFA) content in Terminalia oil by etherification with methanol (99% pure) and acid catalyst sulphuric acid (98% pure) in one hour time at 57 ^{0}C in a 2000 ml three necked round –bottom flask was used as a reactor. The Terminalia oil is initially heated to 50 ^{0}C and 0.5% (by wt) sulphuric acid is to be mixed in oil then methyl alcohol about 10% (by wt) added. Methyl alcohol is a mixed in the extra amount to fast the reaction. This reaction was carried with stirring at 650 rpm and the temperature was maintained at 55-57 ^{0}C for 90 min with regular analysis of FFA every after 20-30 min. When the FFA is controlled up to 1%, the reaction is finished. The main difficulty to acid catalysed esterification for FFA is the water formation. After dewatering the esterified oil was ready to the transesterification process.

1000ml of Terminalia oil was calculated using the measuring cylinder, then poured into a 2000 ml three necked round bottom flask. This oil was heated up to 60 ^{0}C. Cao has used as a solid base ecofriendly heterogeneous catalyst. The reaction conditions taken were as10:1 (alcohol: oil) molar ratio of 3.00wt % of CaO catalyst at 65±0.5°C for 2 hr of reaction time. The solution(methanol+Cao) was correctly stirred and mixed into preheated oil then heated upto 60 ^{0}C. Finally, FFA was checked and the solution was permitted to settle for 24 hours in a separating funnel. By settling and separation method glycerol and soap were collected from the bottom of separating funnel. The extra alcohol was removed by distillation then hot water was used to clean it and then permitted it to remain in separating funnel until the plain water was seen below the biodiesel in the separating funnel. The seven fuel sample designation of different composition blends of diesel and Terminalia Methyl Ester were premixed on volume basis after production of ester which is shown in Table I.

Table I: Seven Fuel Sample Designation of Different Composition

Fuel Sample Designation	Composition (By Volume %)
B00	100% Diesel Fuel
D89B6NB5	89%Diesel+6% Terminalia methyl ester+5% n-butanol
D83B12NB5	83%Diesel+12% Terminalia methyl ester+5% n-butanol
D77B18NB5	77%Diesel+18% Terminalia methyl ester+5% n-butanol
D71B24NB5	71%Diesel+24% Terminalia methyl ester+5% n-butanol
D65B30NB5	65%Diesel+30% Terminalia methyl ester+5% n-butanol
D59B36NB5	59%Diesel+% 36Terminalia methyl ester+5% n-butanol

The parameter of diesel (B00) and dissimilar blends of diesel and TEME (B100) were determined as per ASTM D6751 which shown in Table II.

Table II: Properties of Diesel Fuel and Terminalia Oil

Parameter	Test Std.ASTM 6751	Reference		Diesel	Terminalia Biodiesel
		Unit	Limit	B00%	B100%
Density	D1448	gm/cc	0.800-0.900	0.830	0.875
Calorific value	D6751	MJ/kg	34-45	42.5	39.80
Cetane no.	D613	-	41-55	49	52
viscosity	D445	mm^2/sec	3-6	2.7	5.1
Flash point	D93	^{0}C	-	64	138

3. **Experimental Setup**

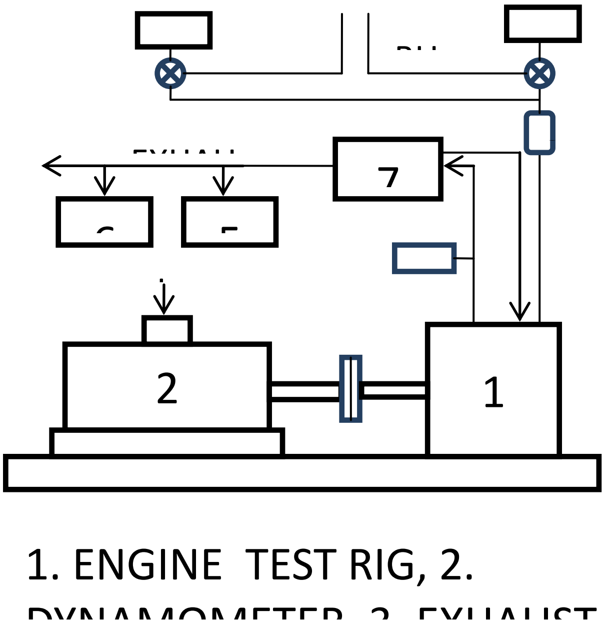

Fig.1 Experimental Setup

The setup used in this experiment as shown in Fig.1. The Present performance test was conducted in a single cylinder, water cooled, four strokes, 3.5 KW at 1500 rpm, with VCR shown in figure 1. Compression ratio was changed within the range of 12-18 and loading and unloading in KG with the help of loading unit manually. The different parameter measured with the help of various sensor which is mounted on the engine and then data stored using engine software. The detail specification of the engine is given in Table III. To obtain the baseline parameters, the engine was first operated on diesel fuel. Performance and emission tests are carried out on the diesel engine using Terminalia methyl ester, and its various blends.

Table III:Engine Specification

Sr.No.	Description	Specification
1.	Model and Make	Kirloskar and TV1
2.	No. of cylinder	Single
3.	Cycle	Four stroke
4.	Bore and stroke	87.5 mm and 110 mm
5.	Rated Power	3.5 kW at 1500 rpm
6.	Compression ratio	17.5, Modified to work in range of 12 to 18
7.	Dynamometer	Eddy current, water cooled, with loading unit
8.	Cubic capacity	0.661 liters
9.	Software	"EnginesoftLV"Engine performance analysis software

4. Result and Discussion:

Engine Performance

The performance parameters considered in the current work are BP and BTE. The different parameterwith respect to load of 0, 4 and 8 in kg andcompression ratio of16, 17, and 18 are presented respectively. the seven blends tested i.e.B00, D89B6NB5, D83B12NB5, D77B18NB5, D71B24NB5, D65B30NB5 and D59B36NB5.

Brake Power

It can be seen from fig.2a-c that BP graph lines of different blends came closer to each other as CR was increased from 16 to 18.It was found that when increase the blending of Terminalia biodiesel in diesel, slightly decrease or close in BP. As compression ratio increases from 16 to 18 and load increases 0 kg to 8 kg, the BP increases for all biodiesel blends. The maximum brake power obtained for D77B18NB5 and diesel at 8 kg load and CR18 are 2.42 kW and 2.41 kW respectively.

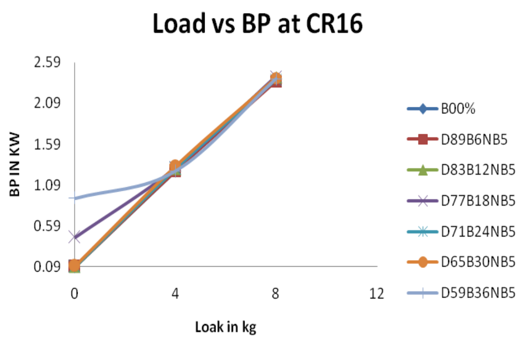

Fig. 2a Variation of load Vs BP at CR16

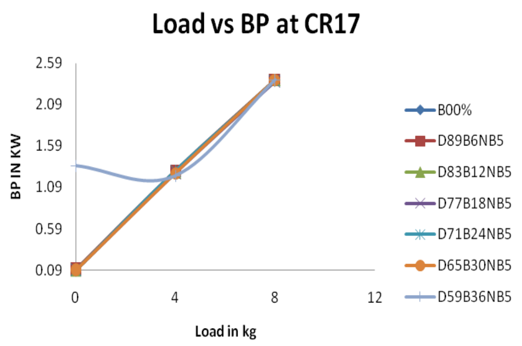

Fig. 2b Variation of load Vs BP at CR17

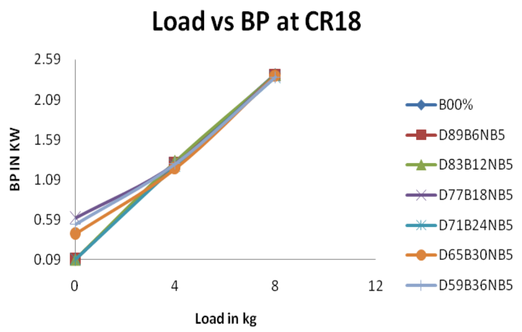

Fig. 2c Variation of load Vs BP at CR18

Brake Thermal Efficiency

It can be noted from Fig.3a-c that as the blend percentage increases the Brake thermal efficiency increases as compared to diesel. But it is found that the maximum BTE of D76B24NB5 is 27.01%. With the increase in CR from 16 to 18, the BTE increased for Terminalia bio diesel blends with respect to Diesel. The BTE increased for Terminalia biodiesel blends with the increasing load.

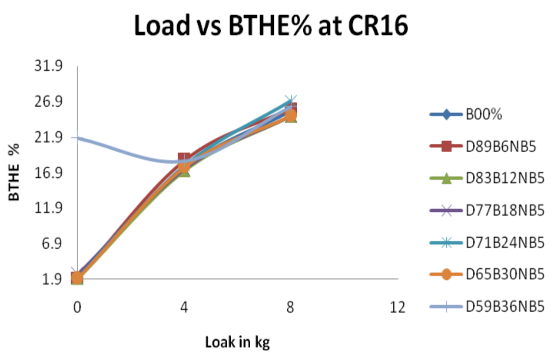

Fig. 3 a Variation of load Vs BHTE at CR16

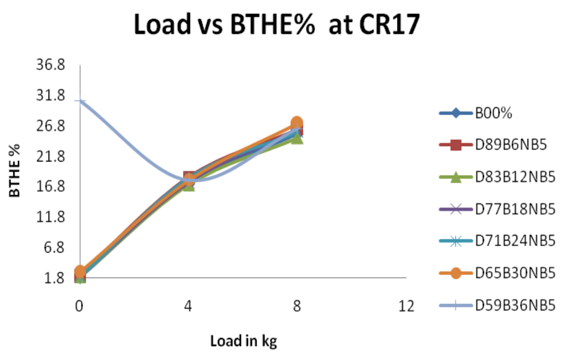

Fig. 3b Variation of load Vs BHTE at CR17

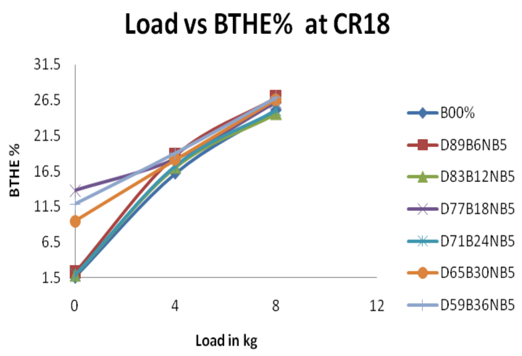

Fig. 3c Variation of load Vs BHTE at CR18

2. Emission Performance:

The variation of emission parameter with different compression ratio at 16,17 and 18 and increasing laod at 0 kg,4 kg and 8 kg considered are Carbon monoxide (CO), Unburned Hydrocarbon (HC) and Oxides of Nitrogen (NO).

Hydrocarbon Emission (HC) :

It is seen from the Fig.4a-c that HC emissions decrease with increase in CR from 16-18 for all the fuels tested which is due to complete combustion of fuel at higher CR as compared to diesel. It is also founded that HC decreases with the increase in blend percentage. This is due to better combustion of Terminalia biodiesel due to its oxygen content.

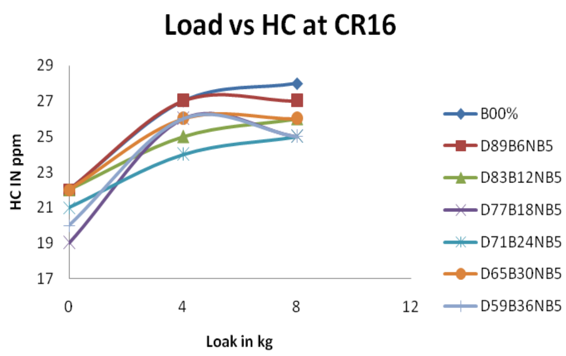

Fig. 4a Variation of load Vs HC at CR16

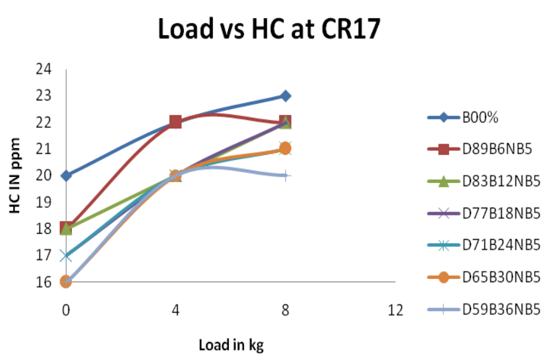

Fig.4b Variation of load Vs HC at CR17

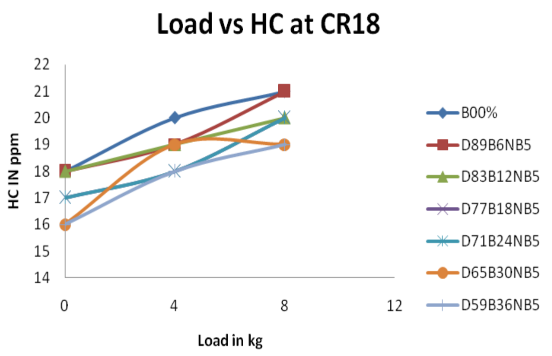

Fig. 4c Variation of load Vs HC at CR18

Carbon Monoxide Emission (CO):

It is seen from the Fig.5a-c that as the CR is increased, the CO emission is reduces for all Terminalia biodiesel blends. This is due to superior combustion of fuel at higher CR due to high air temperature in the combustion cylinder. It is observedthat the CO emission decreases with increasing load as compared to diesel fuel. This decrease is mainly due to the oxygen content of biodiesel which makes the entire combustion. This is held due to addition of n- butanol to Terminalia diesel blend.

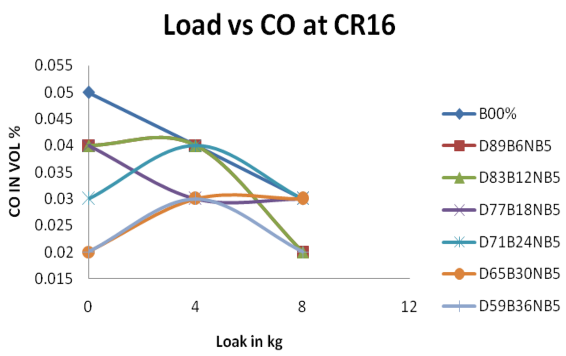

Fig. 5a Variation of load Vs CO at CR16

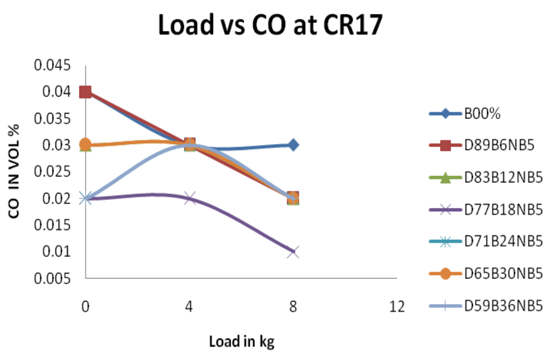

Fig. 5b Variation of load Vs CO at CR17

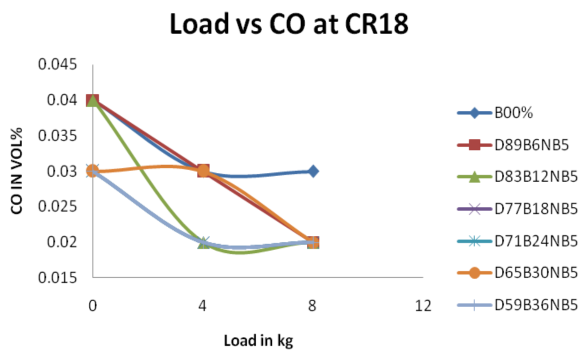

Fig. 5c Variation of load Vs CO at CR18

Nitrogen Oxide Emission (NO):

It is seen from the Fig.6a-c that as CR increases Nitrogen Oxides emissions increases for blends but it decreases for Diesel. At a CR of 16 and 17 and at load 8 Kg,it founded that the Nitrogen Oxides emissions for Diesel are higher as compared to Terminalia biodiesel. It is observedthat the Nitrogen Oxides emission decreases with increasing load as compared to diesel fuel at CR 16 and CR17.

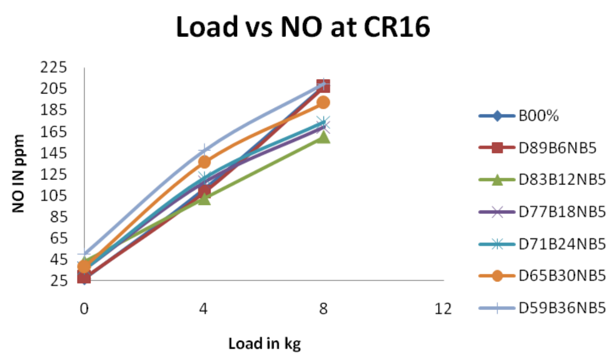

Fig. 6a Variation of load Vs NO at CR16

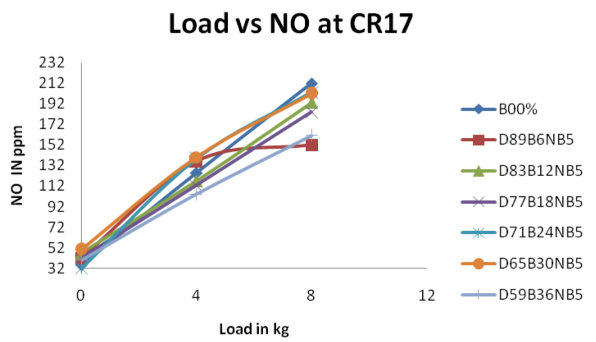

Fig. 6b Variation of load Vs NO at CR17

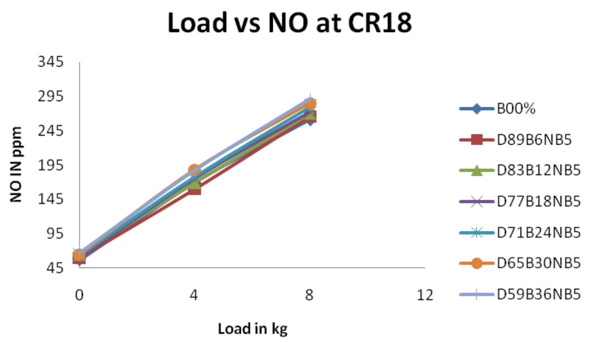

Fig. 6c Variation of load Vs NO at CR18

Conclusion:

Based on the performance and emission results, it is concluded that the brake power of biodiesel is close to standard diesel for all compression ratio in load operation. The Break Thermal Efficiency is increases with increasing load and compression ratios. At higher compression ratios (16 to 18), combustion of fuel is complete due to high temperature of compressed air. Due to which, the exhaust emissions are found to reduce at higher CRs. It is observedthat the CO emission decreases with increasing load and CRs as compared to diesel fuel. It is observedthat the Nitrogen Oxides emission decreases with increasing load as compared to diesel fuel at CR 16 and CR17.HC emission decreases with increasing CRs and Blend percentage. The exhaust emission tests revealed that CO and NOx emission values improved with butanol addition. CO and NOx emission values of biodiesel are decreased as compared to diesel fuel with addition of n-butanol in the blends because of n-butanol possesses higher heating value,highercetane number, lower vapor pressure and good atomization.

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