

## Comparative Analysis of Jatropha-Methanol Mixture and Diesel on Direct Injection Diesel Engine

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### Abstract

Impact of increasing trend in the production of automobile focuses on the control of greenhouse gases. This should be within the limits of different norms of emission. Alternative fuels are better than the conventional fuel in those aspects. In this work, an attempt was made using blends of Jatropha and methanol to run the single cylinder diesel engine and their performance and emission were compared with the diesel. It has yielded better results on the emission of HC, CO and CO<sub>2</sub> and oxides of nitrogen and the data acquired by electronic system exhibit better performance results for jatropha methanol blend<sup>1</sup>. Diesel fuel is considered as base reading for comparing performance and emission characteristics of

blend1 (the mixture of Jatropha 75% methanol 25%) and blend2 of (jatropha 80% methanol 20%) approximately. The result shows that jatropha methanol mixture gives better performance in high load rather than less than half load operations.

**Key Words:** Transesterification, diesel engine, diesel, jatropha oil, methanol, performance and emissions, blends.

## 1. Introduction

Nowadays usage of the automotive vehicle and need of electric power increases due to the increase in population and want of luxurious lifestyle. This leads to increase in fuel consumption and fuel demand. Due to depletion of fossil fuel, there is a necessity to find out the alternative source for fuel. There are many authors investigated the usage of vegetable oil (edible and non-edible oil) or animal fats mixed with diesel as fuel and revealed that the performance and emission characteristics are approximately equal to the diesel fuel. Jatropha oil has the property of higher density, higher moisture content, and higher acidic value so we cannot use this fuel directly in our engine or without any modifications to the engine. So in order to convert this fuel into a usable form, some catalysts are added. There is limited research focusing on the usage of jatropha alone as fuel and also at high concentration ratio. Senthil Kumar et al experimentally studied the usage of methanol in different methods as blending, transesterification and dual fuel operation in single cylinder four stroke diesel engines at constant speed of 1500 rpm and compression ratio of 15:1 and the fuel injection timing of  $27^\circ$  before top dead center for diesel and  $29^\circ$  before top dead center for jatropha oil and the ester. The result revealed that NO, CO and HC emissions for this mixtures are less than diesel at different brake power. He also found that there is more ignition delay, combustion duration and exhaust gas temperature than diesel [1]. Gaurav Paula et al experimented that the addition of jatropha biodiesel in mineral diesel and studied the performance, combustion and emission characteristics experimentally and numerically using diesel R-K software at pure diesel (B0) and pure jatropha biodiesel (JB100) as fuel and found that brake specific fuel consumption increases and brake thermal efficiency decreases for jatropha biodiesel, maximum efficiency of 29.6% and 21.2% for pure diesel and pure jatropha biodiesel. The emission result shows that NO<sub>x</sub> emission increases with the load as well as an increase of biodiesel than diesel due to increase in oxygen content [2]. Syarifah Yunusa et al experimented that the jatropha-palm blended fuel in four strokes single cylinder vertical diesel engine at various load conditions. The result revealed that CO, CO<sub>2</sub>, and NO<sub>x</sub> produced from all biodiesel are higher than diesel. This is due to higher oxygen content and higher exhaust temperature during combustion. [3]. Bobade et al studied that the preparation of jatropha biodiesel by transesterification process from jatropha oil, the methyl ester produced by this method gives good result i.e. 83% of methyl ester and 17% glycerol using molar ratio of 6:1 (methyl alcohol to oil) [4]. Antony Raja et al studied about the production and characteristics of jatropha methyl ester from jatropha oil by transesterification process and the result shows the density, flash point, kinematic viscosity, cloud point and pour point values are approximately equal to diesel[5]. Senthil Kumar et al studied the comparison of different methods of using jatropha oil as fuel in diesel engine and concluded that dual fuel operation with methanol, orange oil, and hydrogen can be a good method to use jatropha oil efficiently in the engine that operates at high loads. The jatropha oil methyl ester gives good results at part load and acceptable in full load. The results also shows that blends of orange oil,

methanol, diethyl ether and dimethyl carbonate with jatropha gives acceptable results [6]. Senthil Kumar et al studied compressed ignition engine fueled with vegetable oil of dual fuel in the engine. It is concluded that usage of jatropha oil and the methyl ester of jatropha oil as pilot fuels and orange oil as the induced fuel will lead to reduced smoke level and improved thermal efficiency but HC, CO emissions were higher [7].

Main aim of the experimental work is to analyze the performance and emission characteristics of compressed ignition engine when diesel alone as directly injected as fuel, jatropha and methanol mixture at various blends as fuel. In this 0kg, 5kg, 10kg considered as no load, half load and the full load applied to the engine.

## **2. Production of Bio Diesel and Engine Details**

In order to describe the quality of fuel, some basic test were carried out in order to find iodine value, moisture content, density, viscosity, flash point, fire point, calorific value, kinematic viscosity, specific gravity and free fatty acid before and after production of jatropha biodiesel blend1 and blend2. The transesterification process was carried out in order to reduce the viscosity and fatty acid present in jatropha oil.

Materials used in transesterification process are the thermometer, retort stand, pipette, measuring cylinder, separating funnel, magnetic stirrer, oven, water bath, hydrometer, conical flask, digital weighing balance, stopwatch, hot plate, distilled water, methanol and jatropha oil.

Initially, Jatropha oil and methanol was heated to 50 degrees Celsius along with the 0.25g of sodium hydroxide pellet. This solution was stirred for 50 minutes using a magnetic stirrer and the mixture was kept to settle for 24 hours in a separating funnel.

Free fatty acid content in jatropha oil is 21.6% so in order to reduce it the concentrated  $H_2SO_4$  is added and heated to  $50^\circ C$  then the mixture was stirred for 1 hour and kept for 2 hours without any disturbance. In this process glycerin was obtained as the byproduct.

Before removing the glycerin the fuel was combusted in open environment and the observed that the fuel was burned very slowly along with that some bad smell and at last some foam like content is obtained. In order to overcome that, glycerin was removed by adding the heated water and kept for few hours for separation. Biodiesel yield is increasing with increase in the molar ratio of methanol to oil.

### **2.1. Properties of Jatropha-Methanol Mixture**

The properties of jatropha-methanol blends shown in below table1.

Table 1: Properties of Jatropha-Methanol Blends after Esterifications

Property	Jatropha-methanol blend1	Jatropha-methanol blend2
Refractive index	1.46	1.42
Iodine value	102	105
Flashpoint	50°C	55°C
Fire point	63°C	68°C
Calorific value KJ/KG	40622.46	39622
Specific gravity	0.912	0.912
PH	5.62	5.03
Free fatty acid	18.4	19.4
Saponification value (mg KOH/g)	190	210
Moisture content	0.20	0.28
Acid value %	38.1	40.3
Kinematic viscosity at 50°C	3.3cs	3.9cs

## 2.2. Engine Specifications

The details of constant speed compressed ignition engine used for our experimental work are shown in table 2.

Table 2: Details of Engine

Engine type	Computerized Kirloskar TV1 diesel engine
Stroke	4
Number of cylinder	Single
Type of injection	Direct injection
Method of cooling	Water cooled
Speed	1500 rpm
Power	3.50 KW
Cylinder bore	87.50 mm
Stroke length	110 mm
Connecting rod length	234 mm
Swept volume	661.45 cc
Fuel used	Diesel, jatropha Blend1 & Blend2
Measurement of readings	Data acquisition system
Smoke meter	AVL 437 C



Fig. 1: Photographic View of an Engine

### 3. Performance and Emissions Characteristics

#### 3.1. Torque

Load increases torque also increases for Jatropha methanol blend and diesel fuel. Torque is more for diesel than jatropha in no load and full load condition. At half load torque developed is slightly more for jatropha blend1 than diesel and jatropha blend2. So at half load jatropha blend1 gives more torque and another blend2 also approximately equal to diesel result.

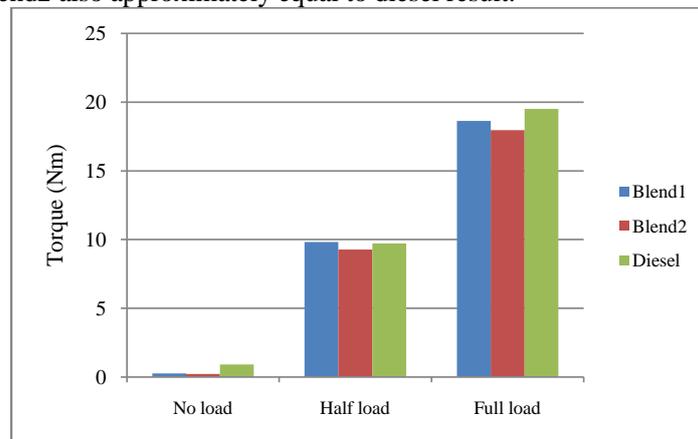


Fig. 2: Torque Versus Load

#### 3.2. Volumetric Efficiency

Load increases from low to high, volumetric efficiency decrease for all the three fuels used. Volumetric efficiency is more for diesel in all loads of operation than jatropha blend1 and jatropha blend2. But at no load and half load condition jatropha blend1, volumetric efficiency is more than jatropha blend2.

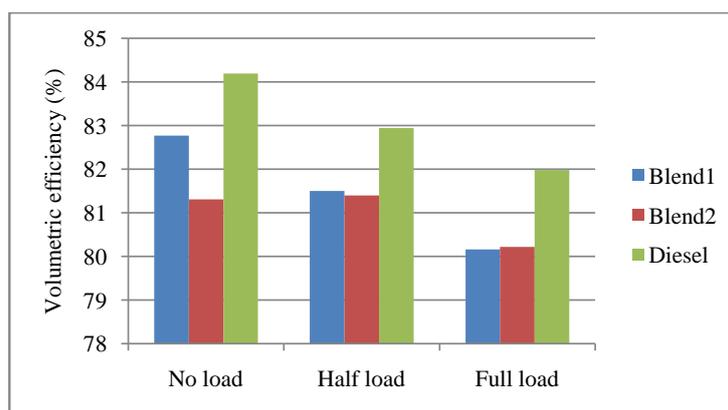


Fig. 3: Volumetric Efficiency Versus Load

### 3.3. Brake Thermal Efficiency

At no load, the brake thermal efficiency obtained in the order of high to low as diesel, jatropha blend1, and jatropha blend2. At half load in the order of high to low as jatropha blend1, diesel and jatropha blend2. At full load high to low order as jatropha blend1 and jatropha blend2 are approximately equal to diesel fuel. When the engine is run at full load the brake thermal efficiency of jatropha blend1 obtained (29.03%) is considerably more than that of diesel (20.87%) and jatropha blend2 (20.42%). In overall when the engine is run at half load and more than half load jatropha blend1 performance is higher than diesel, and the jatropha blend2 performance is approximately equal to diesel fuel performance.

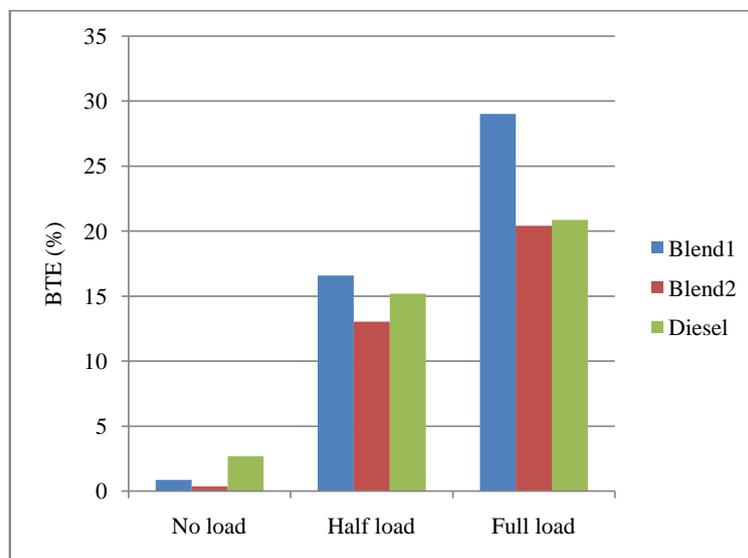


Fig. 4: Brake Thermal Efficiency Versus Load

### 3.4. Indicated Thermal Efficiency

In full load indicated thermal efficiency obtained for jatropha blend1, jatropha blend2 and diesel are 62.52%, 44.92%, and 45.47% respectively. At half load indicated thermal efficiency is 54.03%, 53.04% and 44.36% respectively for jatropha blend1, diesel and jatropha blend2. At no load indicated thermal efficiency obtained are 56.92%, 15.02% and 60.67% for jatropha blend1, jatropha blend2 and diesel respectively.

So in overall load increases indicated thermal efficiency of jatropha blends increases but for diesel load increases indicated thermal efficiency decreases. At half and full load operations jatropha blends gives better result than diesel fuel. Due to high density, high duration of low burning ability and higher delay of combustion it performs well in full load than no-load operations.

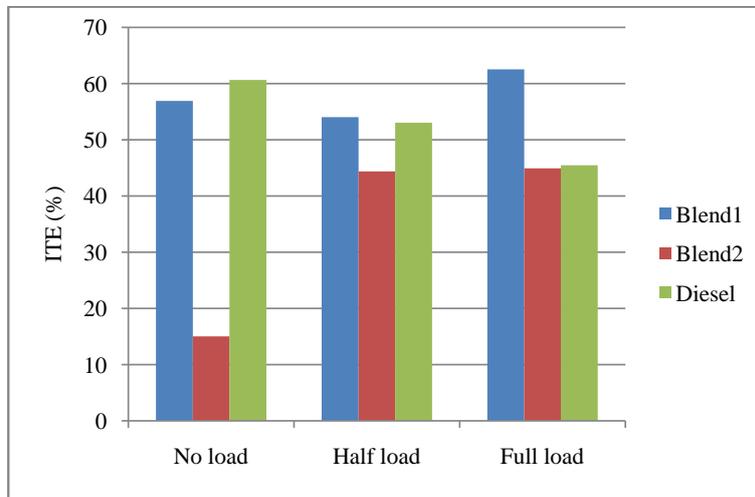


Fig. 5: Indicated Thermal Efficiency Versus Load

### 3.5. Mechanical Efficiency

When the load increases mechanical efficiency also increases for all the fuels used. At half load, mechanical efficiency of jatropha blends results obtained is more than diesel fuel. At full load jatropha blend1, mechanical efficiency is considerably higher than diesel and jatropha blend2. Notably at the half and full load engine operations jatropha blend1 mechanical efficiency is more than diesel and jatropha blend2. Due to higher viscosity and better lubricating capacity jatropha blends gives a better result than diesel, so we can save the material damage considerably due to friction and also it acts as a lubricant. Due to higher density straightaway use this jatropha oil as a good lubricant

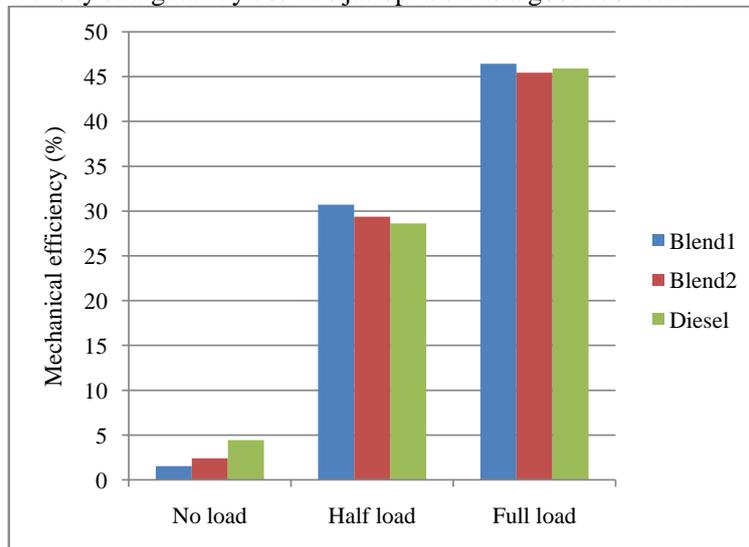


Fig. 6: Mechanical Efficiency Versus Load

### 3.6. Specific Fuel Consumption

Load increases specific fuel consumption decreases for all fuels of diesel, jatropha blend1, and jatropha blend2. At no load, specific fuel consumption is 25.17kg/kw-hr for jatropha blend2, 10.42kg/kw-hr for jatropha blend1 and 3.05kg/kw-hr for diesel. At half load, specific fuel consumption is 0.55, 0.7 and 0.54kg/kw-hr for jatropha blend1, jatropha blend2 and diesel respectively. At full load 0.31, 0.44, 0.39kg/kw-hr for jatropha blend1, jatropha blend2 and diesel respectively. At half load, specific fuel consumption of jatropha blends and diesel are approximately equal. At full load, specific fuel consumption of jatropha blend1 is lower than jatropha blend2 and diesel as fuel.

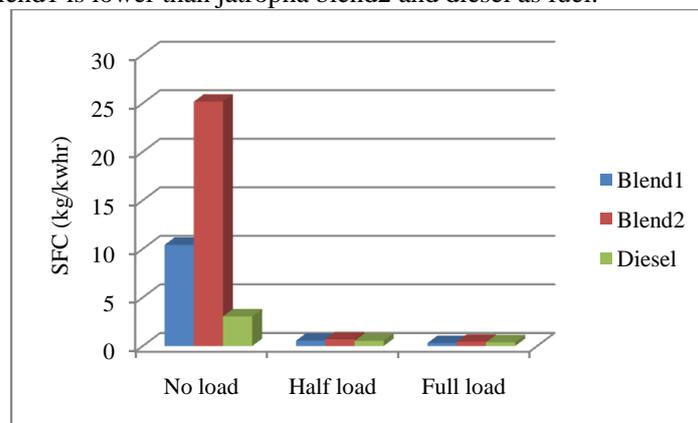


Fig. 7: Specific Fuel Consumption Versus Load

### 3.7. Brake Power

Load increases brake power also increases for jatropha methanol blends as well as the diesel fuel. At full load brake power of Jatropha methanol blends are less than diesel but at half loads, brake power obtained is approximately equal to diesel.

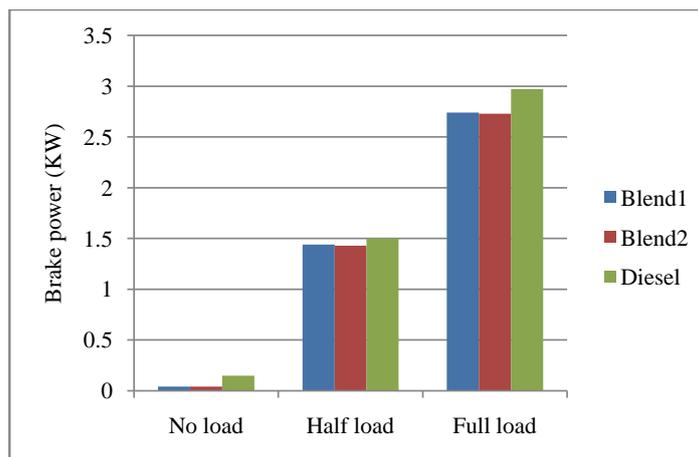


Fig. 8: Brake Power Versus Load

### 3.8. Frictional Power

Load increases the frictional power of the engine also increases for all type of fuels. In no load, half load, full load operations frictional power obtained is high for diesel than Jatropa-methanol blended fuel. This is due to the lower density and lubricating capacity of the diesel than Jatropa fuel.

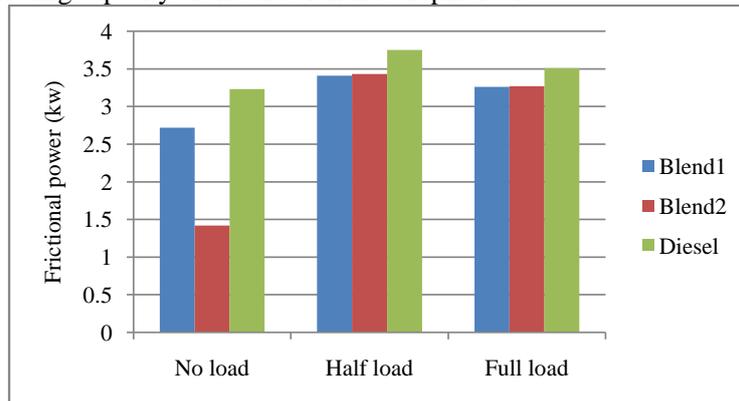


Fig. 9: Frictional Power Versus Load

### 3.9. Hydrocarbon

Load increases hydrocarbon also increases when the engine is fueled with Jatropa-methanol blends and diesel. At no load, hydrocarbon emission is more for jatropa methanol blends than diesel fuel. At half and full loads compared to diesel, hydrocarbon emission is high for jatropa blend2 and low for jatropa blend1. In jatropa blends, hydrocarbon emission is more for jatropa blend2 than jatropa blend1. So in order to reduce environmental pollution and conserve the fuels, it is better to use jatropa methanol blend1 as an alternative fuel for diesel. At full load, hydrocarbon emissions are 217, 250 and 381 ppm for jatropa blend1, diesel and jatropa blend2 respectively.

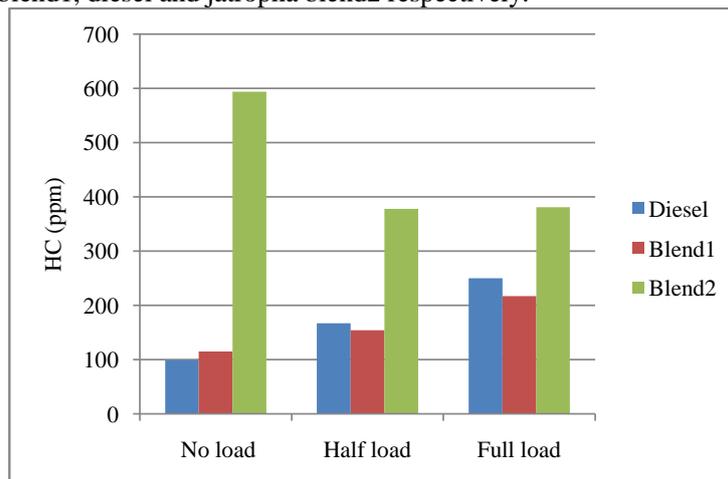


Fig. 10: Hydrocarbon Versus Load

### 3.10. Nitric Oxide

Load increases NO emission also increases due to increase in combustion temperature. At half load and full load jatropa blend1 and jatropa, blend2 emits low oxides of nitrogen than diesel as fuel. At no load, nitrogen oxide emission is 17, 38 and 32 ppm for diesel, jatropa blend1, and jatropa blend2. At half and full load diesel, jatropa blend1, jatropa blend2 emits 1117, 918, 317 and 1486, 1108, 831 ppm respectively. The reason for reduced nitrogen oxide emission is the rate of slow burning characteristics of jatropa blended fuel.

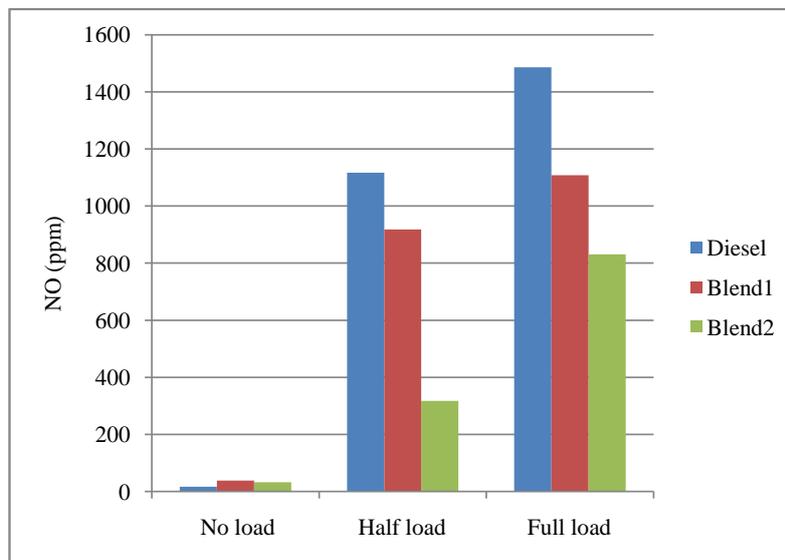


Fig. 11: Nitric Oxide Versus Load

### 3.11. Carbon Monoxide

Load increases carbon monoxide emission decreases for all the fuels. At all loads of engine operations, diesel fuel emits lower carbon monoxide than jatropa methanol mixture as fuel.

At all loads, carbon monoxide emission is more for jatropa blend2 than jatropa blend1 and diesel but at full load jatropa blend1 and diesel emissions are approximately equal. When the engine is operated at full load carbon monoxide emissions are 0.11%, 0.14%, and 0.32% respectively for diesel, jatropa methanol blend1, and jatropa methanol blend2.

The reason for increased carbon monoxide emission is improper mixing of air and jatropa fuel due to high density, low volatile, shorter duration of stay in the engine cylinder and unavailability of required oxygen leads to incomplete combustion.

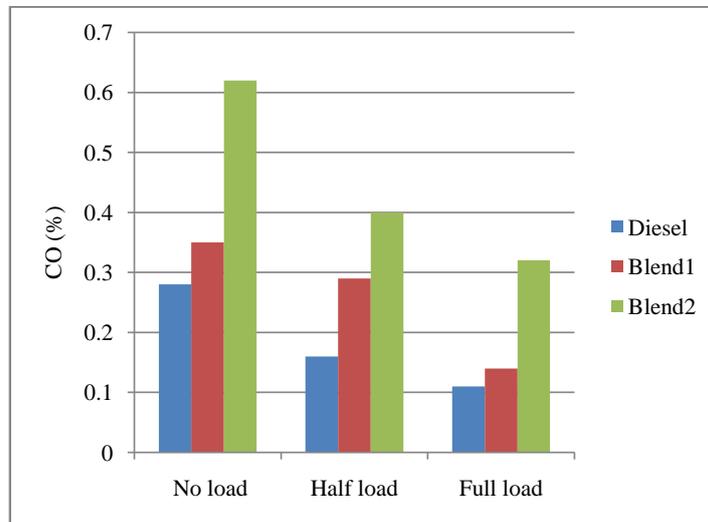


Fig. 12: Carbon Monoxide Versus Load

### 3.12. Carbon Dioxide

Load increases carbon dioxide emission also increases for diesel and jatropa as fuels due to more consumption of fuel. In all load conditions, carbon dioxide emission is more for diesel due to complete combustion than jatropa blends due to incomplete combustion. Due to slow burning characteristics of jatropa fuel, not all molecules are completely burned that is carbon is converted into carbon dioxide, so emissions are decreases which lead to reduced global warming.

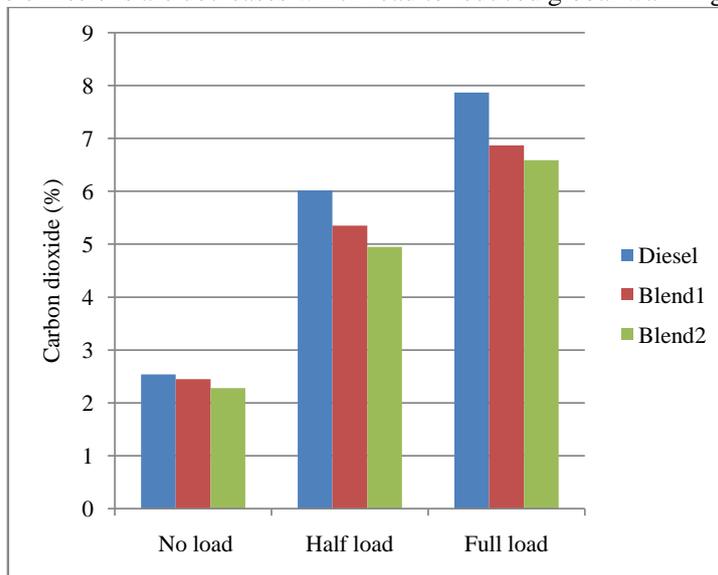


Fig. 13: Carbon Dioxide Versus Load

## 4. Conclusion

Jatropha-methanol mixture and diesel fuels are supplied one by one in single cylinder four stroke direct injection water cooled constant speed diesel engine then the following observations were made.

- When the engine is operated at half load and more than half load Jatropha-methanol mixture gives better performance and emission result than diesel fuel.
- In performance point of view Jatropha-methanol mixture, blend1 gives higher brake thermal efficiency, Indicated thermal efficiency, mechanical efficiency, specific fuel consumption, volumetric efficiency and torque than jatropha methanol blend2. So jatropha blend1 is an optimized blend.
- In emission point of view, the load increases hydrocarbon emission increases for diesel and jatropha blend1 but for jatropha blend2 reverse trend was seen. Considerably jatropha blend1 emission is lower than jatropha blend2 and diesel at the half and full load operation but for no load, it is approximately equal to diesel.
- Nitrogen oxide and carbon dioxide emission are low for jatropha methanol blends than diesel due to the lower release of heat. This is because of higher density and moisture present in the fuel and improper mixing of atomized fuel and air.
- When the fuel is combusted the moisture present in the fuel vaporizes by absorbing part of heat that is generated. So the nitrogen oxide emission is lower for jatropha blends than diesel. This is an added advantage if you consider in global warming point of view.
- Jatropha methanol mixture has the tendency to replace the diesel fuel in future because of its excellent performance and emission characteristics. In addition, specific fuel consumption of jatropha blend1 is considerably less than diesel fuel at full load.
- In economy, global warming and alternative source of fuel point of view jatropha methanol blend1 is directly usable in the diesel engine without any modifications, if it is operated at the half and full load of operation rather than no-load operation.

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