International Engineering Research Journal

Experimental Investigation of Performance and Emission Characteristics of Diesel Fuelled With Mexicana Methyl Ester

S. S. Yewale†, S. V. Channapattana‡

†PG student (Heat Power), JSPM'S Rajashri Shahu School of Engineering and Research, Narhe, Savitribai Phule Pune University,Pune, India.
‡Associate Professor, JSPM'S Rajashri Shahu College of Engineering, Tathawade, Savitribai Phule Pune University,Pune, India.

Abstract

The experimental work investigates the performance and emission parameters of single cylinder variable compression ratio (VCR) engine coupled to eddy current dynamometer fuelled with Mexicana biodiesel with addition of diethyl ether as additives and blend with diesel fuel under different load condition at compression ratio 16, 17 and 18.The blend of biodiesel and diesel used where D100, D90B5DEE5, D85B10DEE5, D80B15DEE5, D75B20DEE5, D70B25DEE5, D65B30DEE5.Use of diethyl ether as additives to improves the performance and emission parameters of the engine. All the Mexicana biodiesel blends shows that reduction in carbon monoxide, nitrogen oxide and hydrocarbon emission compare with diesel fuel and carbon dioxide emission is higher as compared to diesel fuel. The performance parameter like brake power and brake thermal efficiency close to diesel. There are slight increases in smoke opacity of Mexicana biodiesel higher than diesel fuel.

Keywords:*Mexicana biodiesel, additives- diethyl ether, engine performance, emission.*

1. Introduction

India's energy security would remain exposed until alternative fuels to substitute petro-based fuels produced renewable feedstock. Biodiesel is a renewable and eco-friendly alternative diesel fuel for diesel engine. The compression ignition engines are widely used due to its reliable operation and economy. Using optimized blend of biodiesel and diesel can help reduce some significant percentage of the world dependence on fossil fuels without modification of CI Engine, As the petroleum reserves are depleting at a faster rate due to the growth of population and the subsequent energy utilization, an urgent need for search for a renewable alternative fuel arise.
S.I mtenan et.al [3] described the emission and performance characteristics of the palm biodiesel with additives. The better blends contained 80% diesel, 15% palm biodiesel and 5% additive. Use of additives continuously improved brake power, reduced BSFC and improved BTE. Diethyl ether alternative potential additive can be formed from ethanol. It has got a very high oxygen content, high cetane number, low auto ignition temperature, high miscibility in diesel and broad flammability limits. NOx emission is increases by using a biodiesel blend, to overcome this problem to use of additives. Observed emission parameters additives showed relatively a good result of CO and NO emission.
Channapattana et.al [4] evaluated the emission and performance of nonedible honne oil is used on the DICI VCR engine. At 18 CR break thermal efficiency less than diesel and brake specific fuel consumption higher than that diesel fuel. Reduction in carbon monoxide and hydrocarbon as compare diesel fuel at compression ratio 18.Honne biodiesel at a CR18 results in lowest emissions but increases NOx emissions.
Panwar et.al [5] studied that the performance and emission parameters of castor methyl ester (CME) oil. Castor methyl ester (CME) blends showed performance characteristics close to diesel. The NOx emission of CME is similar to diesel fuel at lower loads and slightly higher at full loads.
As per literature survey, It is clear that much of the work has been done on the various biofuels such as Mahua biodiesel, Castor seed oil, Waste cooking oil methyl ester, Rapeseed plant oil, palm biodiesel, Calophyllum Inophyllum oil, Jatropha biodiesel, Palm Oil, Honne oil Methyl Ester, pinnai oil etc. In terms of finding various engine parameters like BP, ME, Brake thermal efficiency, Brake specific fuel consumption and its emissions. So, it has been found that less work has been carried out on the Mexicana biofuel, so it has been taken as an opportunity to explore its compatibility with diesel engine by undertaking experiments on various engine parameters.
India is an agrarian nation and has rich plant biodiversity which can carry the growth of biodiesel. These different species of forest-based seeds are reported as the possible resource of biodiesel feedstock in India. The current oil is unsatisfactory to meet the demand for raw material on great amount production of biodiesel. Mexicana Oil preferred for the current work of investigational research of performance and emission characteristic of VCR diesel engine. Mexicana oil is non-edible oil which is used for

the production of biodiesel. These found on the road side, waste land and field. Mexicana plant belongs to poppy family. It is commonly known as satyanashi and shialkanta in India.

In the present work investigate the performance and emission parameters of the Mexicana oil with using diethyl ether is additives. A diethyl ether additive is used to improve the performance of the biodiesel. Engine performance and emission analysis by using Mexicana biodiesel with CR 16, 17 and 18 with different load compare with diesel fuel.The fuel sample designation of different composition blends of diesel and Mexicana Methyl Ester with diethyl ether as an additive which is shown in Table I.

Table I: Fuel Sample Designation of Different Composition.

Fuel Sample Designation	Composition
D100	100% Diesel Fuel
D90B5DEE5	90%Diesel + 5% Mexicana methyl ester +5% diethyl ether
D85B10DEE5	85%Diesel + 10% Mexicana methyl ester +5% diethyl ether
D80B15DEE5	80%Diesel + 15% Mexicana methyl ester + 5% diethyl ether
D75B20DEE5	75%Diesel + 20% Mexicana methyl ester + 5% diethyl ether
D70B25DEE5	70%Diesel + 25% Mexicana methyl ester + 5% diethyl ether
D65B30DEE5	65%Diesel + 30% Mexicana methyl ester + 5% diethyl ether

2. Methodology

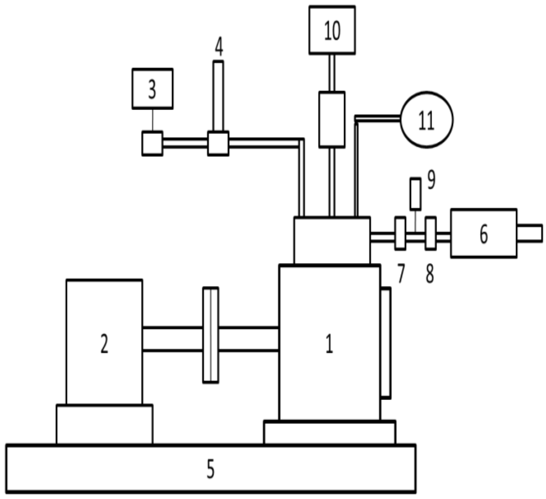
The Mexicana oil is first filtered to remove solid material then it is preheated at 110^{0}C for 30 min to remove moisture. The methyl ester is produced by chemically reacting Mexicana oil with an alcohol (methyl), in the presence of catalyst. A two stage process is used for the transesterification of Mexicana oil. The first stage (acid catalyzed) of the process is to reduce the free fatty acids (FFA) content in Mexicana oil by esterification with methanol (99% pure) and acid catalyst sulfuric acid (98% pure) in one hour time at 57^{0}C in a closed reactor vessel. The major obstacle to acid catalyzed esterification for FFA is the water formation. Water can prevent the conversion reaction of FFA to esters from going to completion. After dewatering the esterified oil was fed to the transesterification process. The catalyst used is typically sodium hydroxide (NaOH) with 0.5% of total quantity of oil mass. It is dissolved in the 10% of distilled methanol (CH3OH) using a standard agitator at 700 rpm speed for 20 minutes. When the methoxide was added to oil, the system was closed to prevent the loss of alcohol as well as to prevent the moisture. The temperature of reaction mix was maintained at 60 to 65^{0}C (that is near to the boiling point of methyl alcohol) to speed up the reaction. The recommended reaction time is 70 min. The stirring speed is maintained at 560-700rpm. Excess alcohol is normally used to ensure total conversion of the fat or oil to its esters. The reaction mixture was taken each after 20 min. for analysis of FFA. After the confirmation of completion of methyl ester formation, the heating was stopped and the products were cooled and transferred to separating funnel. Once the reaction is complete, it is allowed for settling for 8-10 hours in separating funnel. At this stage two major products obtained that are glycerin and biodiesel. Once the glycerin and biodiesel phases were been separated, the excess alcohol in each phase was removed by distillation. Once separated from the glycerin and alcohol removal, the crude biodiesel was purified by washing gently with warm water to remove residual catalyst or soaps. This is normally the end of the production process to remove water present in the biodiesel which results in a clear amber-yellow liquid with a viscosity similar to petro diesel. In some systems the biodiesel is distilled in an additional step to remove small amounts of color bodies to produce a colorless biodiesel. The properties of diesel and different Mexicana biodiesel blends were determined as per the ASTM6751 standards. The properties of Mexicana biodiesel and diesel are represented on table II.

Table II: Properties of Mexicana Biodiesel and Diesel

Sr. No.	properties	Ref. std. ASTM 6751	Reference Limit	Diesel D100 %	Mexicana Biodiesel B100%
1	Density gm/cc	D1448	0.800-0.900	0.830	0.876
2	Calorific value MJ/Kg	D6751	34-45	42.50	38.50
3	Cetane no.	D613	41-55	49.00	50.70
4	Viscosity mm2/sec	D445	3-6	2.700	5.2
5	Flash point ^{0}C	D93	_	64	149
6	Fire point ^{0}C	D93	_	71	158

3. Experimental Setup

The setup consists of single cylinder, four stroke, VCR (Variable Compression Ratio) Diesel engine connected to eddy current type dynamometer for loading. The compression ratio can be changed without stopping the engine and without altering the combustion chamber geometry by specially designed tilting cylinder block arrangement.



1. Test Engine, 2. Dynamometer, 3. Fuel Tank, 4. Fuel Burette, 5. Test Bed, 6. Silencer,
7. Smoke meter, 8. HC/CO/Nox/CO2/O2 Analyzer, 9. Exhaust Temperature sensor,
10. Air Flow Meter, 11. Stop Watch

Fig.1 Engine Setup

The detail specification of engine is given in above Table II. 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 Mexicana biodiesel using diethyl ether additives, and its various blends.

Table II: 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 and Emission

Performance parameters such as BP and BTHE and emission parameters such as HC, CO and NO has analysis by using Mexicana biodiesel with diethyl ether as additives with compression ratio 16, 17 and 18 with different load(0,4 and 8 kg) compare with diesel fuel.

1. Brake Power (BP)

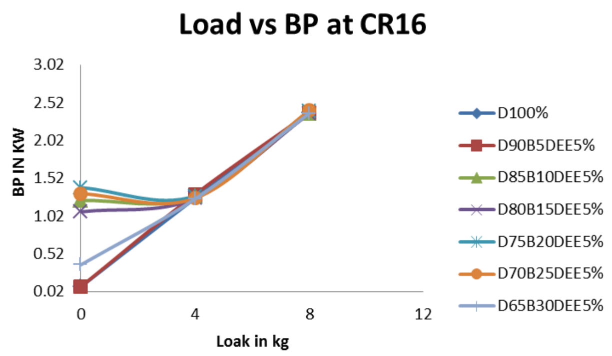


Fig 2: Variation of BP (KW) Vs. Load

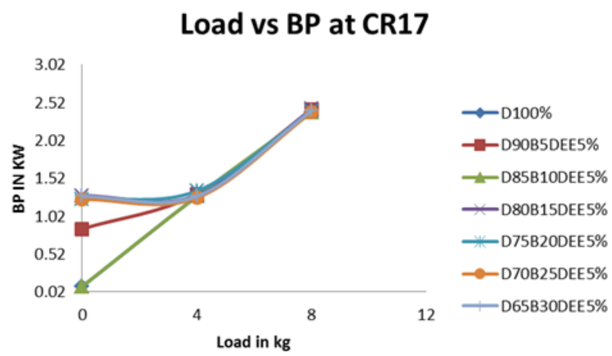


Fig 3: Variation of BP (KW) Vs. Load

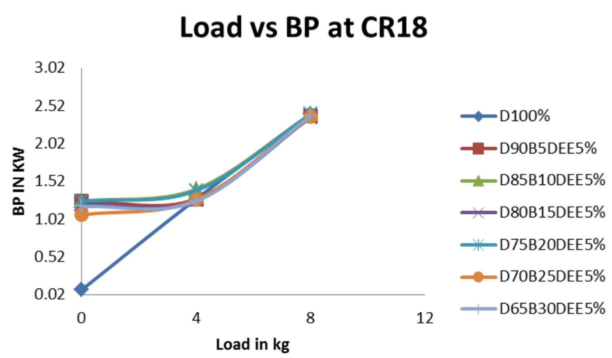


Fig 4: Variation of BP (KW) Vs. Load

Figure 2, 3 and 4 represent the variation of brake power versus load with compression ratio 16, 17 and 18 respectively.Brake power increases at increasing load with compression ratio 16, 17 and 18. Brake power of Mexicana biodiesel blend and diesel is close to each other due to enhanced combustion and high heat content in the biodiesel.

2. Brake Thermal Efficiency (BTHE):

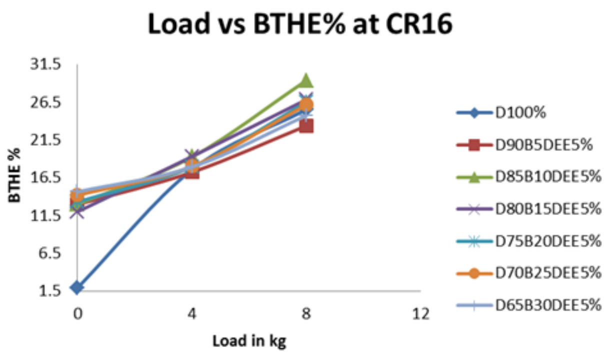


Fig 5: Variation of BTHE %Vs. Load

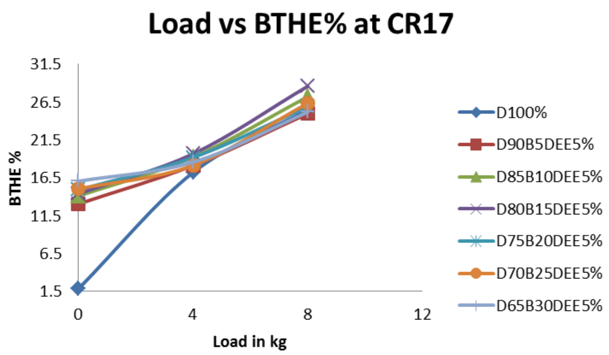


Fig 6: Variation of BTHE %vs. Load

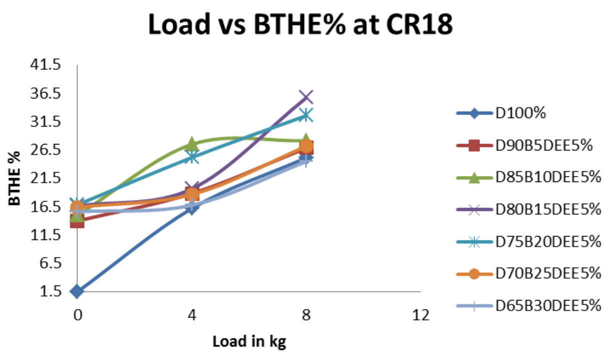


Fig 7: Variation of BTHE % vs. Load

From above figure 5,6 and 7 it is observed that Brake thermal efficiency of the biodiesel increases with increase in load. For compression ratio 16 and 17 brake thermal efficiency is close to diesel fuel, but compression ratio 18 brake thermal efficiency of biodiesel is high as compared to diesel fuel. Brake thermal efficiency of the blend D80 B15 DEE 5% and D75 B20 DEE 5% is high as compared to diesel with compression ratio 18.

3. Hydrocarbon Emission (HC) :

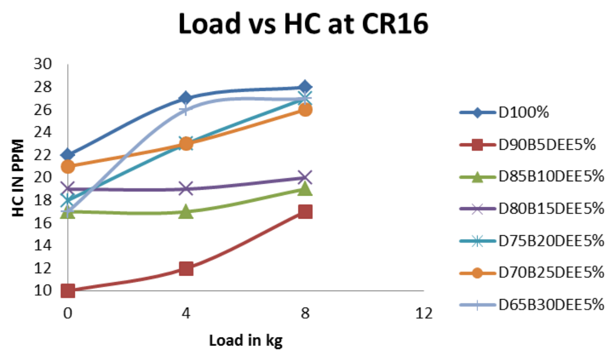


Fig 8: Variation of Hydrocarbon Emission Vs. Load

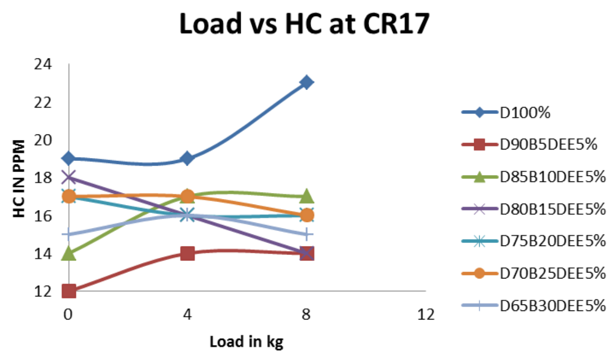


Fig 9: Variation of Hydrocarbon Emission Vs. Load

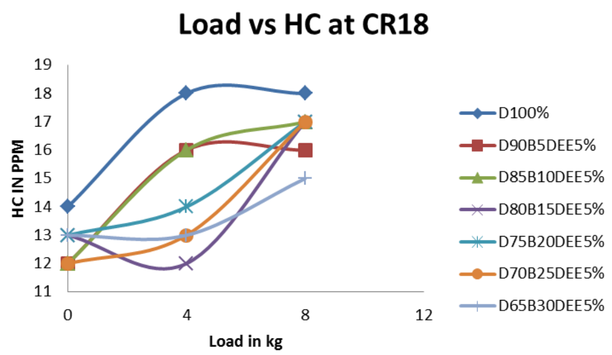


Fig 10: Variation of Hydrocarbon Emission Vs. Load

Above figure 8, 9 and 10 represents that the hydrocarbon emissions verses load with compression ratio16, 17 and 18. It is observed that hydrocarbon emissions of the all Mexicana blend with additives is decreases as compared to diesel fuel with compression ratio 16, 17 and 18. It is also seen that there is decrease in Hydrocarbon emission with increase in proportion of blend.

4. Carbon Monoxide Emission (CO) :

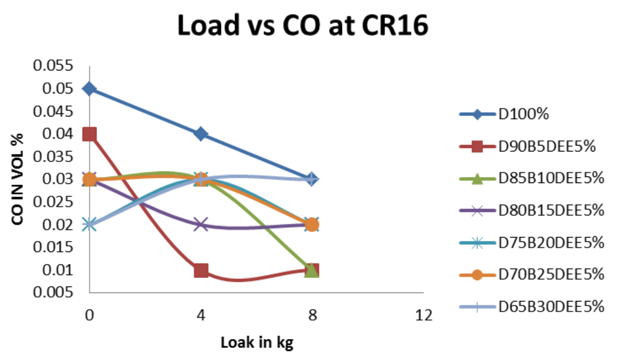


Fig 11: Variation of Carbon Monoxide Emission Vs. Load

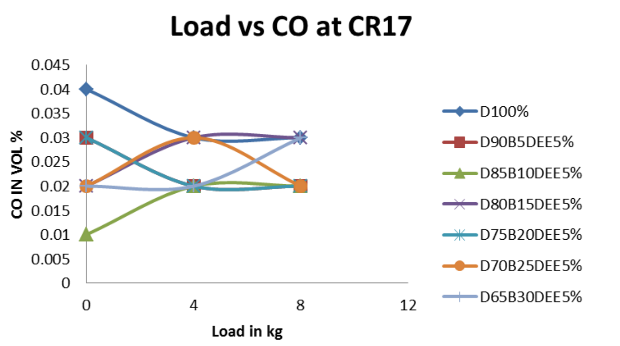


Fig 12: Variation of Carbon Monoxide Emission Vs. Load

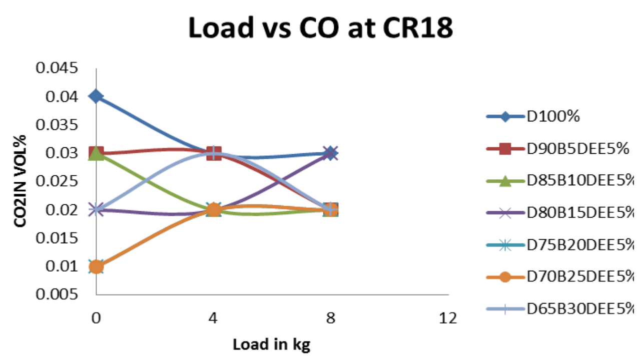


Fig 13: Variation of Carbon Monoxide Emission Vs. Load

From Figure 11, 12 and 13, it is observed that the carbon monoxide emission is decreasing with increase in compression ratio. This is due to the improved combustion rate at high air temperature in the cylinder. Carbon monoxide of blend D80 B15 DEE 5% and D75 B20 DEE 5% is close to diesel fuel.

5. Nitrogen Oxide Emission (NO):

From Figure 14, 15 and 16 represents the emission of nitrogen oxide versus load for different compression ratios. It is observed that nitrogen oxide emission of diesel fuel increases with increase in load, but all blend of the Mexicana oil is decreases as compared to diesel fuel.

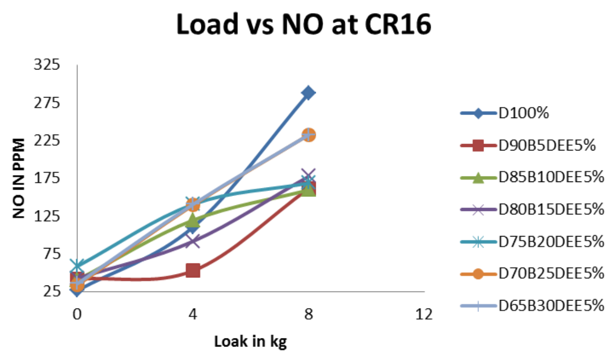


Fig 14: Variation of Nitrogen Oxide Emission Vs. Load

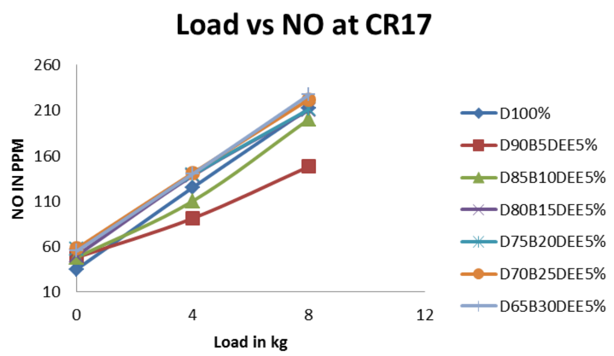


Fig 15: Variation of Nitrogen Oxide Emission Vs. Load

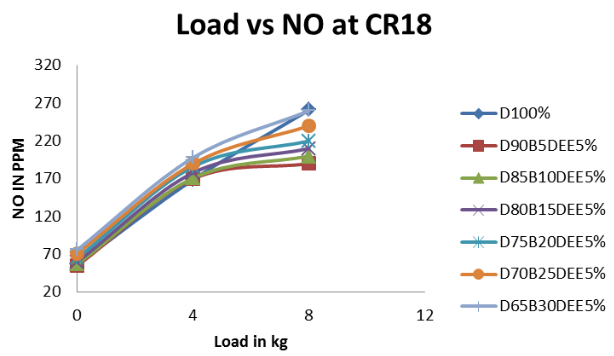


Fig 16: Variation of Nitrogen Oxide Emission Vs. Load

For the higher fuel bound oxygen in biodiesel nitrogen oxide emission is increases but addition of the diethyl ether which acquired high centane number, lowers auto ignition temperature and high oxygen content. Therefore it is observed that nitrogen oxide emission is decreases.

Conclusion:

From the above paper the following conclusions can be made in this work as:-

1. Brake power of Mexicana biodiesel blend and diesel is close to each other due to enhanced combustion and high heat content in the biodiesel.
2. Brake thermal efficiency of the blend D80 B15 DEE 5% and D75 B20 DEE 5% is high as compared to diesel with compression ratio 18.
3. It is observed that hydrocarbon emissions of the all Mexicana blend with additives is decreases as compared to diesel fuel with compression ratio 16, 17 and 18.

4. Carbon monoxide emission is decreasing with increase in compression ratio. This is due to the improved combustion rate at high air temperature in the cylinder.
5. Nitrogen oxide emission of diesel fuel increases with increase in load, but all blend of the Mexicana oil is decreases as compared to diesel fuel.

By addition of diethyl ether additives to improve the engine performance and emission characteristics of Mexicana oil because of by adding the diethyl ether in biodiesel which improved high centane number, lowers auto ignition temperature and high oxygen content.

I. References:

II.

1. Bobade S.N, Kumbhar R.R, Khyade V.B (2013) "Preperation of methyl ester (biodiesel) from Jatropha curcas linn oil" ISSN 2320-6063.
2. K. Muralidharan , D. Vasudevan , K.N. Sheeba , (2011)"Performance, emission and combustion characteristics of biodiesel fuelled variable compression ratio engine" Energy 36, 5385-5393.
3. S.Imtenan, H.H. Masjuki, M. Varman, M.I. Arbab, H. Sajjad, I.M. Rizwanul Fattah, M.J. Abedin, Abu Saeed Md. Hasib, (2014) "Emission and performance improvement analysis of biodiesel-diesel blends with additives" Procedia Engineering 90, 472 – 477.
4. S V Channapattana ,Kantharaj C,V S Shinde, Abhay A Pawar, Prashant G Kamble, (2015) "Emissions and Performance Evaluation of DI CI - VCR Engine Fuelled with Honne oil Methyl Ester / Diesel Blends", Energy Procedia 74, 281 – 288.
5. N.L. Panwar , Hemant Y. Shrirame , N.S. Rathore , Sudhakar Jindal , A.K. Kurchania, (2010), "Performance evaluation of a diesel engine fueled with methyl ester of castor seed oil" Applied Thermal Engineering 30, 245–249.
6. S. Imtenan , H.H. Masjuki, M. Varman, M.A. Kalam , M.I. Arbab, H. Sajjad, S.M. AshrafurRahman, (2014), "Impact of oxygenated additives to palm and jatropha biodiesel blends in the context of performance and emissions characteristics of a light-duty diesel engine", Energy Conversion and Management 83, 149–158.
7. Rupesh L. Raut1, Babaso N. Naik2, Shekhar D. Thakare3, Amol A. Gawali, (2014), " Emission Analysis Of Bio-Diesel Blends On Variable Compression Ratio Engine", International Journal of Research in Engineering and Technology, Volume: 03, eISSN: 2319-1163 | pISSN: 2321-7308.
8. Ajay V. Kolhe, R. E. Shelke, S. S. Khandare, (2014), "Performance, Emission and Combustion Characteristics of a Variable Compression Ratio Diesel Engine Fueled with Karanj Biodiesel and Its Blends", International Journal of Mechanical, Aerospace, Industrial and Mechatronics Engineering Vol:8, No:4.
9. Parmjit Singh, Sandeep Kumar Duran, Amanpreet Singh,(2015), " Optimization Of Biodiesel From Argemone Oil With Different Reaction Parameters And Performance Analysis In Ci Engine", International Journal of Research in Engineering and Technology, Volume: 04, eISSN: 2319-1163 | pISSN: 2321-7308.
10. H. Raheman , S.V. Ghadge ,(2008), "Performance of diesel engine with biodiesel at varying compression ratio and ignition timing" Fuel 87, 2659–2666.