INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 4.295
(Volume 5, Issue 1)
Available online at: www.ijariit.com

Effect of various blends on diesel engine: A review

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ABSTRACT

Due to the increase in industrialization and urbanization, there is a rapid decrease in conventional fuels. The price of conventional fuels is going on increasing day to day and also increasing environmental pollution due to more usage. If this goes on there will be no longer the conventional fuels. There is a need to search for alternative fuels for automobile applications. Environmental degradations and depletion of oil reserves are matters of great concern around the globe. Developing countries like India depends heavily on crude oil import of aroud125 mt per annum. Diesel being the main transportation in India finding a suitable fuel alternative to diesel is an urgent need. The projects are aimed to investigate the performance and emission characteristics of the diesel engine at various loads fuelled with various blends. The experiments are conducted on the widely used diesel engine without the design modifications. The projects compare the performance characteristics such as Brake Thermal Efficiency (BTE), Mechanical Efficiency (ME) and emission characteristics such as CO_2, NO_X, HC, CO emissions of the blends to that

Keywords— *Blend, Brake Thermal Efficiency, Mechanical efficiency, Experimental setup, Engine performance, Engine emissions*

1. INTRODUCTION

All petrochemical fuels are extracted from the earth crust, in that diesel is the main constituent source for the transportation sector. As the population is getting escalated the usage of diesel engines for various purposes is getting enormous. Developing countries like India depends heavily on crude oil import of aroud125 Mt per annum. Diesel being the main transportation in India finding a suitable fuel alternative to diesel is an urgent need. The prices of the traditional fuels are growing day by day as such the costumers cannot afford any more. Quick exhaustion of fossil fuels has created a challenge for researchers to find an appropriate alternative for traditional fuels like diesel and petrol.

In the past few decades, fossil fuels mainly petroleum, natural gas, coal have been playing an important role as the major energy sources worldwide. However, these energy sources are non-renewable and are projected to be exhausted in near future. Internal Combustion engines operate mainly on petroleum based fuels. Diesel engines (C.I) are one among the leading machines in modern automobile industry because of its excellent drivability and thermal efficiencies. In the context of the fossil fuel crisis and increasing vehicle population, the search for Alternative fuel has become necessary for diesel engines due to increased environmental concerns, and socio-economic aspects. The other reasons are the high cost of petroleum products, emission problems and a large percentage of crude oil are imported from other countries which control the larger oil fields. Due to these reasons, scientists work on alternative fuel sources, so vegetable fuel studies become current among various investigations.

Researchers have done some experiments on alternative fuels and extracted results from that, some of them are emitting harmful gasses from exhaust which in turn leads to environmental pollution, the pollution that has been exhausted from automobile creating serious health issues for mankind, soil and crops are getting damaged due to these effects, efforts were made in this experimentation part to find an alternative source for diesel fuel and also to diminish the emission effects.

2. PAPER 1

B. L. N. Krishna Sai investigated the performance and emission characteristics of the VCR engine with used transformer oil as the blend with diesel. Therefore, in the work, the transformer oil which is obtained by the utilised transformer oil Is taken as a blend. In the first step, the test was conducted on four-stroke single cylinder diesel engine by using diesel and baseline was generated. Further, in the second step, experimental investigations were carried out on the same engine with same operating parameters by using utilised transformer blended with diesel in different proportions such as 15% and 20% of utilised transformer oil with diesel fuel to find out the performance parameters and emissions. It was observed that there are CO and HC emissions. NO_X and CO_2 emissions, when compared to diesel, were seen less. The brake thermal efficiency and mechanical efficiency of the blend 2 are more when compared to the diesel.

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Table 1: Comparison of fuel properties of diesel and transformer oil

Property	Diesel	Used transformer oil
Kinematic viscosity @40°c	4.2	10.1
Density @30°c (kg/m^3)	841	890
Flash point(°c)	90	140
Pour point (°c)	14	9

2.1 Experimental setup

The variable compression ratio (VCR) diesel engine used to conduct the experiments in a single cylinder, four strokes, water cooled, direct injection engine. Two main components from main parts of the test rig, welded steel base plate and Eddy Current Dynamometer provided with cooling water arrangement. Panelboard positioned over the base plate consists of a fuel system with flow measurement by burette, air flow measurement system, and temperature and speed indicator. The loading device used is an Eddy Current Dynamometer of matching capacity to load the engine up to HP at 1500 RPM. The following instrumentation is provided, U-tube manometer for air flow, Digital temperature indicator- multi-point indicator with thermocouples. The test rig is arranged for manual control with hand cranking start arrangement for engine starting. Fuel Measuring Arrangement consists of a fuel tank, burette and suitable stopwatch and supplied with fuel piping from the fuel tank to Engine. Heat carried away by cooling water consists of suitable inlet and outlet piping with a flow control valve. Rotameter is meant to measure the rate of flow of cooling water and thermocouples for measuring inlet and outlet water temperature. The equipment is instrumented so that the following experiments could be performed, Brake Thermal Efficiency, BHP Measurement, Fuel Consumption Measurement, Air Intake Measurement. The block diagram below represents the schematic representation of the experimental test setup.

Table 2: Engine specifications

Engine	Kirloskar diesel engine
Type	Water cooled
Injection	Direct injection
Maximum speed	Direct injection
Number of cylinders	One
Bore	80mm
Stroke	110mm
Compression ratio	16:5:1
Maximum HP	5 HP
Injection timing	27° before TDC
Injection pressure	190 bar
Swept volume	553cc

The experiments are conducted on a variable compression diesel engine. Diesel is blended with used transformer oil and the blending takes place at two different proportions for example BD1 (85% diesel, 15% used transformer oil) and BD2 (80% diesel, 20% used transformer oil), likewise the experiments were conducted at two different blends, and at different compression ratios 16 and 18.

2.2 Results and discussions

2.2.1 Load vs. Brake Power

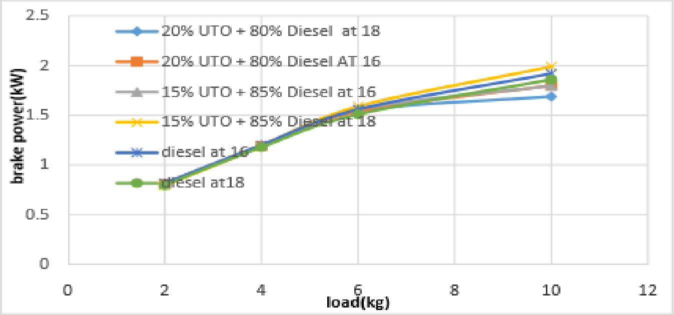

Fig. 1: Load vs. Brake Power

2.2.2 Load vs. Brake Thermal Efficiency

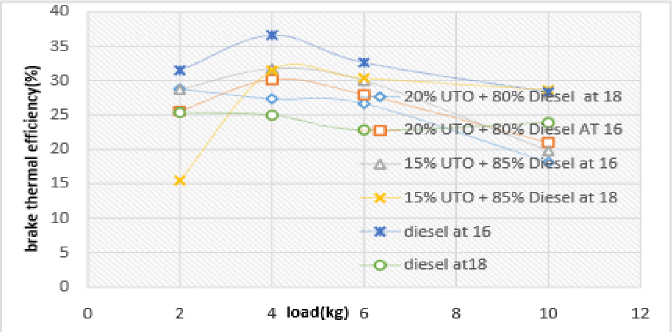

Fig. 2: Load vs. Brake Thermal Efficiency

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2.2.3 Load vs. Mechanical Efficiency

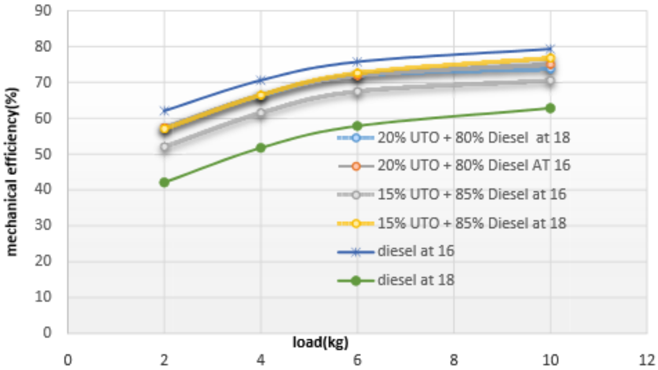

Fig. 3: Load vs. Mechanical Efficiency

2.2.4 Load vs. Carbon Monoxide Emission

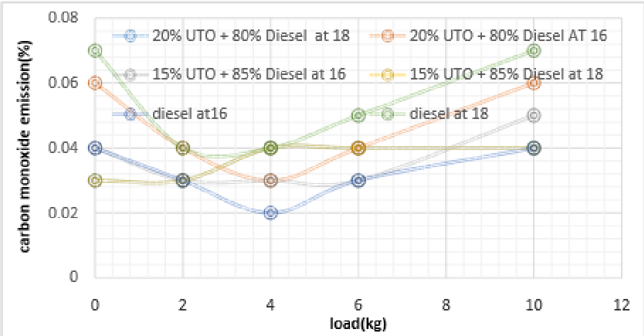

Fig. 4: Load vs. Carbon Monoxide Emission

2.2.5 Load vs Carbon Dioxide Emission

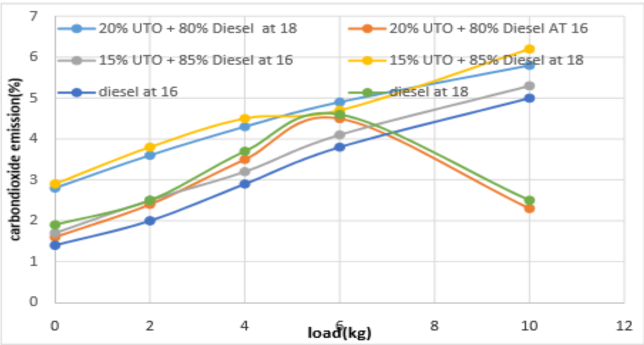

Fig. 5: Load vs. Carbon Dioxide Emission

2.2.6 Load vs. HC Emission

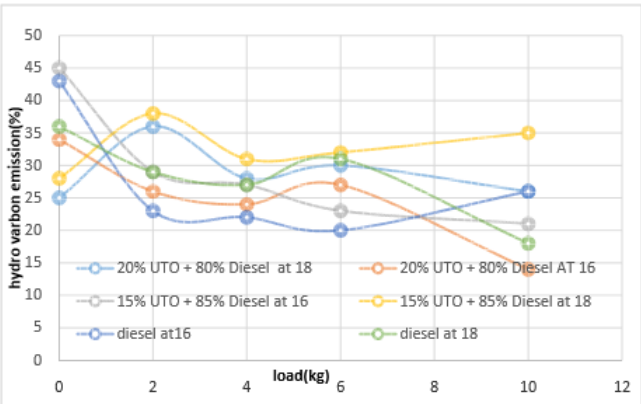

Fig. 6: Load vs. HC Emission

2.3 Conclusion

- It can be concluded that the brake power increased with increasing load.
- Brake thermal efficiency increased with an increase in load and decreased gradually.
- The amount of CO also decreased with the increase in load.
- CO_2 emissions have a greater impact on all the emissions since the emissions of CO_2 is more with a gradual increase in load.

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3. PAPER 2

A.V. Krishna Chaitanya investigated the performance and emission characteristics of VCR diesel engine in which diethyl ether was added with diesel. This paper results the investigation carried out on the performance of biodiesel obtained from mahua oil and its blends with diesel. An additive named diethyl ether was added to the blends and were tested at different proportions and at various compression ratios like 14:1, 16:1, 18:1 and 20:1. Experimental results evidence that by using BD1 as fuel and at 16 CR slight increase in brake thermal efficiency and reduction in specific fuel consumption at 14 CR for BD1 compared to that of diesel. The expense of trans-esterified mahua oil is low contrasted with the expense of diesel. Henceforth, mahua oil blends with diesel are more economical. However, this is a partial solution to the growing diesel scarcity in developing nations.

Table 3: Comparison of properties of diesel and Mahua oil

Property	Diesel	Mahua Oil
Kinematic viscosity @400 °c	4.2	38.2
Density @ 300°c	841	913
Flash Point (°c)	49	185
Pour Point (°c)	14	10
Net Calorific Value kJ/kg	43800	38073
Acidity (mg KOH/gram)	0.21	29
Carbon Residue (%)	0.31	0.45
Moisture (%)	-	0.08
Colour	Light Brown	Slightly Yellowish Green

3.1 Experimental setup

Experiments were carried out on variable compression ratio diesel engine with constant speed, water cooled, direct injection of diesel. The engine was coupled with eddy current dynamometer for loading. The flow rate of intake air was measured by an orifice meter connected to a manometer. A surge tank was utilised to damp the vibrations that are produced by the engine to ensure that a steady flow of air is maintained through the intake manifold. The fuel consumption was examined by a glass burette and stop watch. The speed of the engine was calculated by a digital tachometer and the readings are displayed on the engine console. The exhaust gas temperatures are measured by the k-type thermocouple.

Table 4: Engine specifications

S. No.	Features	Specifications
1	Make	Kirloskar Diesel Engine
2	Type	4 Stroke, Water cooled
3	No. of cylinders	One
4	Combustion Principle	Compression Ignition
5	Max Speed	1500
6	Compression Ratio	12-20
7	Loading	Eddy Current Dynamometer
8	Max Power	3.75 kW

Blends used are:

- BD1: 75%DIESEL & 20% MAHUA OIL & 5% DIETHYLETHER
- BD2: 70%DIESEL & 20% MAHUA OIL & 10% DIETHYLETHER

3.2 Results and discussions

3.2.1 Load vs. specific fuel consumption

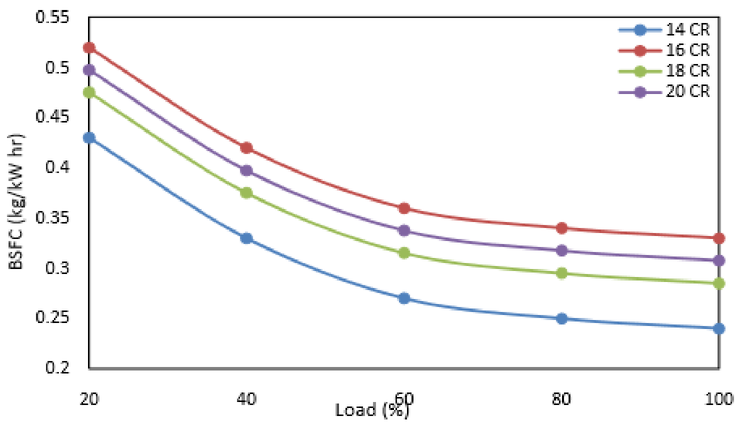

Fig. 8: Load vs. brake specific fuel consumption for diesel

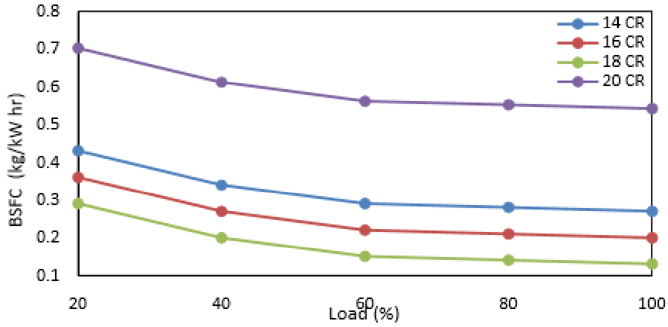

Fig. 9: Load vs. Brake specific fuel consumption for BD1

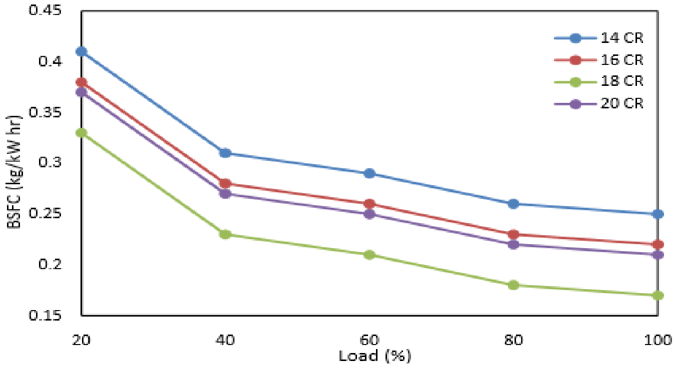

Fig. 10: Load vs. brake specific fuel consumption for BD2

3.2.2 Load vs. Brake Thermal Efficiency

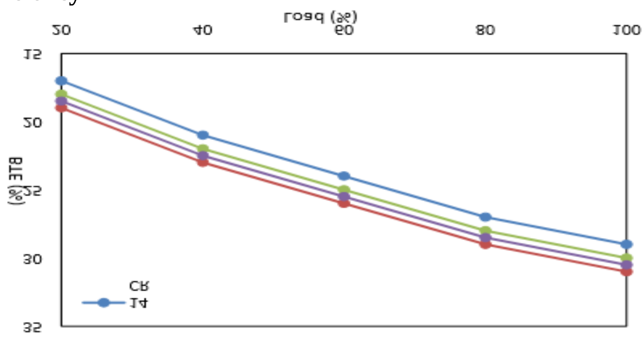

Fig. 11: Brake Thermal Efficiency vs. Load for Diesel

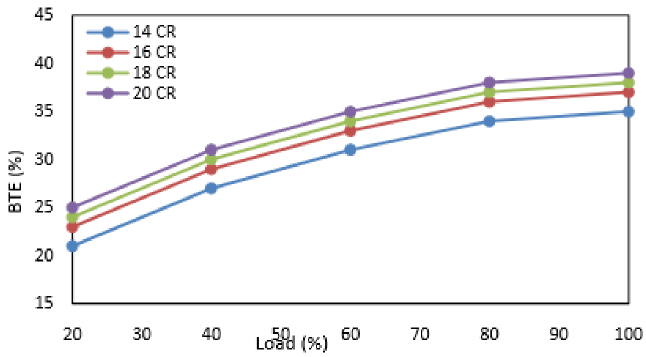

Fig. 12: Brake Thermal Efficiency vs. Load for BD1

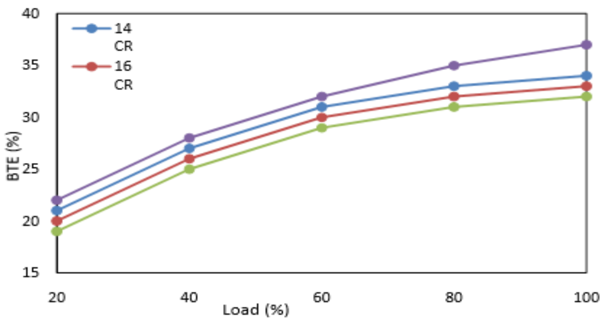

Fig. 13: Brake Thermal Efficiency vs. Load for BD2

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3.2.3 Load vs. Nitric Oxide Emission

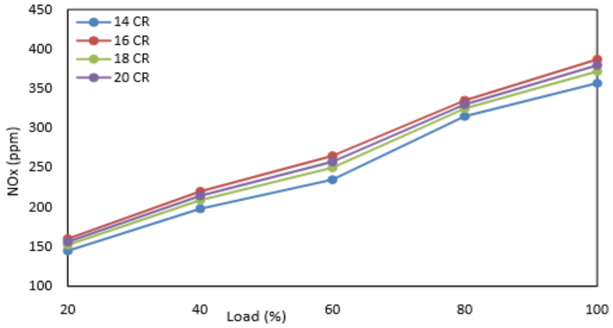

Fig. 14: Load vs. NOx Emission for Diesel

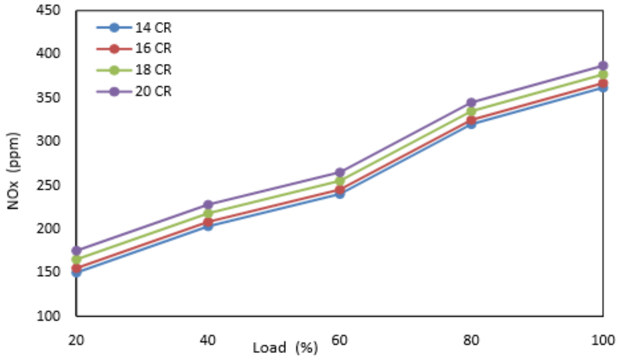

Fig. 15: Load vs. NOx Emission for BD1

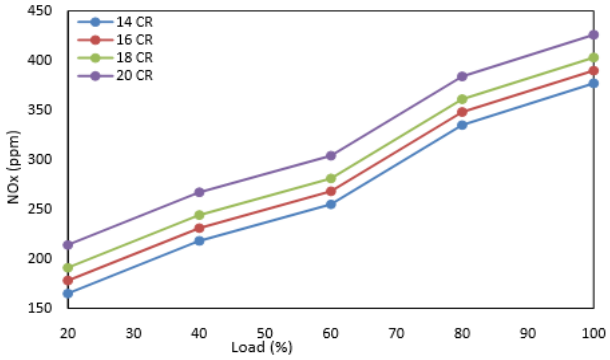

Fig. 16: Load vs. NOx Emission for BD2

3.2.4 Load vs. Hydrocarbon Emission

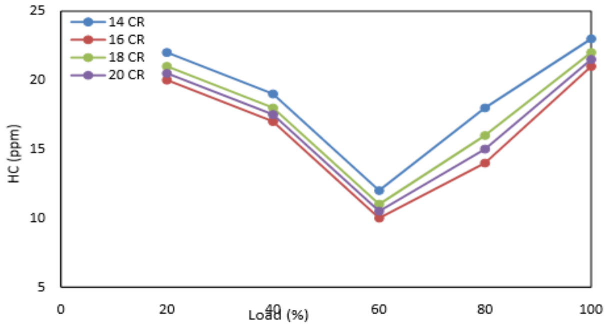

Fig. 17: Load vs. HC Emissions for Diesel

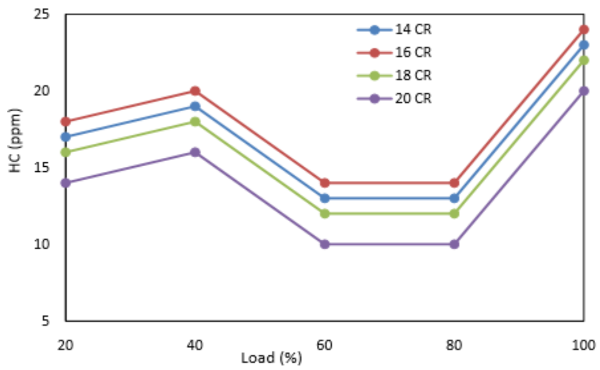

Fig. 18: Load vs. HC Emission for BD1

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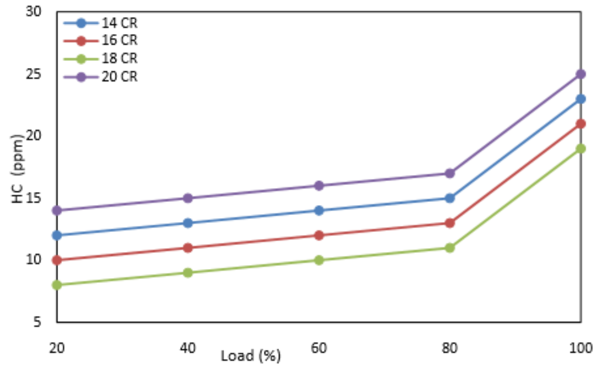

Fig. 19: Load vs. HC Emission for BD2

3.2.5 Load vs. Carbon Monoxide Emission

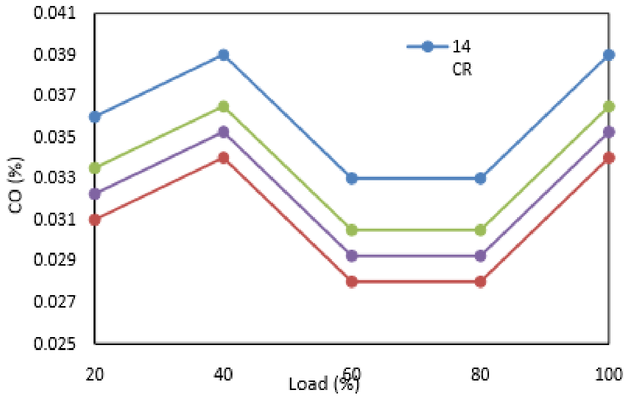

Fig. 20: Load vs. CO Emission for Diesel

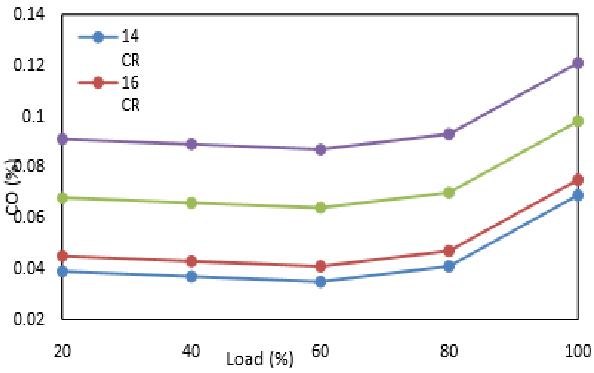

Fig. 21: Load vs. CO Emission for BD1

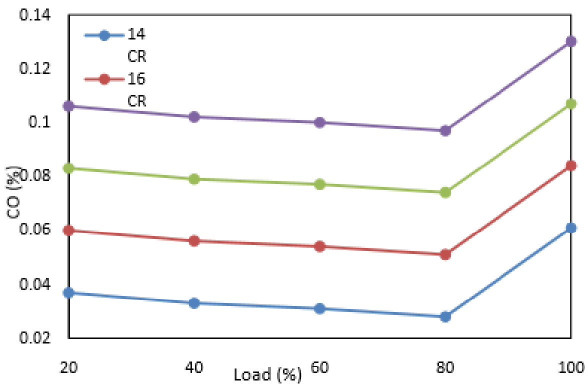

Fig. 22: Load vs. CO Emission for BD2

3.3 CONCLUSIONS

- Smooth working of the engine is observed with mahua oil by blending with diesel without any modifications.
- Percentage increase in esterified mahua oil increases the viscosity of diesel.
- Increase in percentage of mahua oil increases the cetane number of the blend.
- A slight increase in brake thermal efficiency and decrease in specific fuel consumption is observed in the case of esterified mahua oil compared to that of diesel.

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4. PAPER 3

EC Prasad Nidumolu investigated performance and emission analysis of Palm oil methyl ester (PME) blended with diesel in a single cylinder direct injection diesel engine. This project is aimed to investigate experimentally the performance of DI diesel engine at varying loads when fuelled with the blends of Palm Methyl Esters (PME) and Diesel. The experiments were conducted on a widely used diesel engine without design modifications. All the tests were conducted at the steady state and constant speed. The effect of the varying load was evaluated in terms of Brake Thermal Efficiency (BTE), Mass flow rate, Brake Specific Fuel Consumption, Exhaust gas temperature and Exhaust emissions by operating the engine with different blends of fuel. Experimental results showed that when the engine was operated with the blends of B0, B20, B40 and B60 at full loads the engine produced BTE's of 34.19%, 32.67%, 30.0% and 27.35% which are very close to that of the Brake Thermal Efficiency obtained with diesel alone. This is due to better combustion of fuel particularly at the blend of B20 (32.67%) the thermal efficiency was closer to diesel is 34.19%. Particularly at full load CO emission was 0.025% for diesel and 0.02%, 0.012%, 0.007% for the blends B20, B40 and B60.The NOX contents were found to be more for blends compared to diesel at all loads. This was due to the combustion and presence of intrinsic oxygen in the fuel blends. Based on the performance and emission characteristics, the B20 blend palm oil was found to be the optimum blend.

Table 5: Properties of Palm Oil Methyl Ester

Type of fuel	Flash Point (°C)	Fire Point (°C)	Kinematic Viscosity (CST)	Calorific value kJ/kgK
Diesel	60	65	2.28	43500
B20	68	76	3.15	38282
B40	74	82	3.57	34059
B60	106	117	4.38	31056
B100	164	171	5.9	29500
IS for Bio diesel	120	130	2.5-6	37270

4.1 Results and discussions

4.1.1 Brake Power vs. Brake Thermal Efficiency

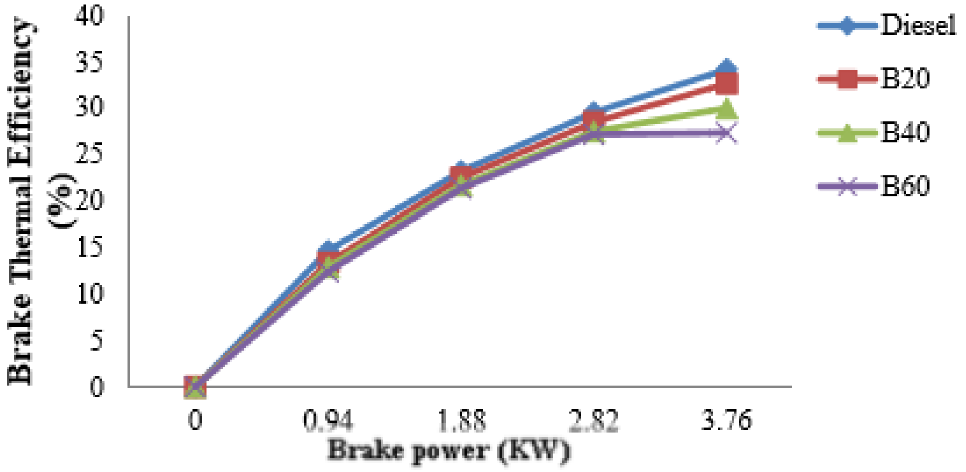

Fig. 23: Brake Power vs. Brake Thermal Efficiency

4.1.2 Brake Power vs. Specific Fuel Consumption

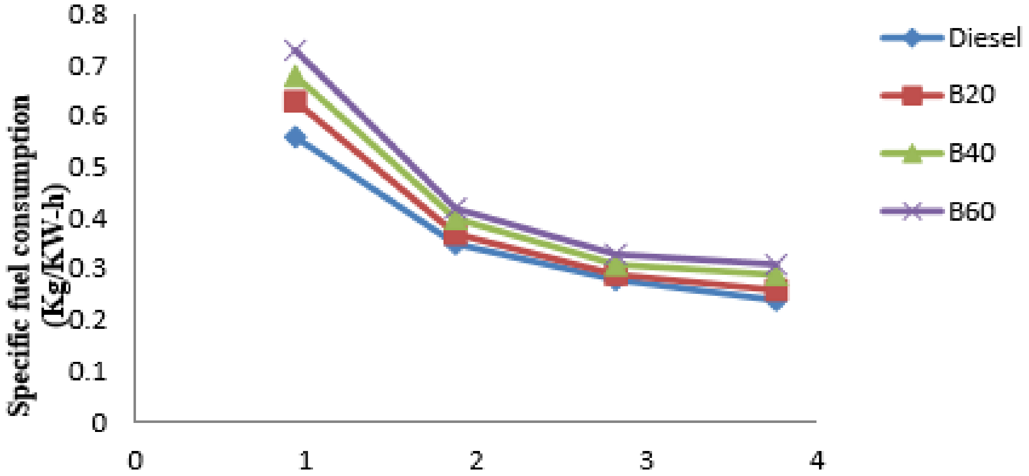

Fig. 24: Brake Power vs. specific fuel consumption

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4.1.3 Brake Power vs. Carbon Monoxide

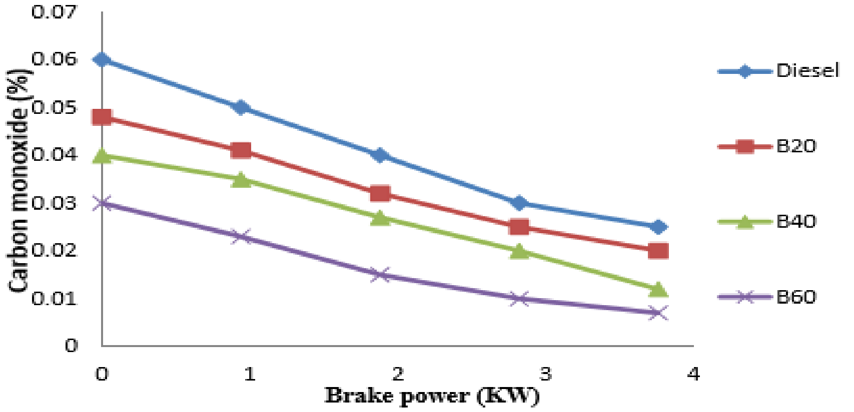

Fig. 25: Brake Power vs. CO Emission

4.1.4 Brake Power vs. Carbon Dioxide

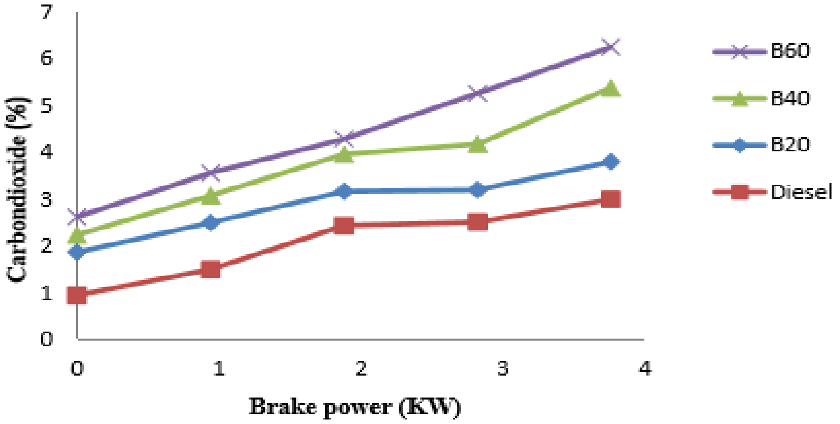

Fig. 26: Brake Power vs. CO2 Emission

4.1.5 Brake Power vs. Hydro Carbon Emission

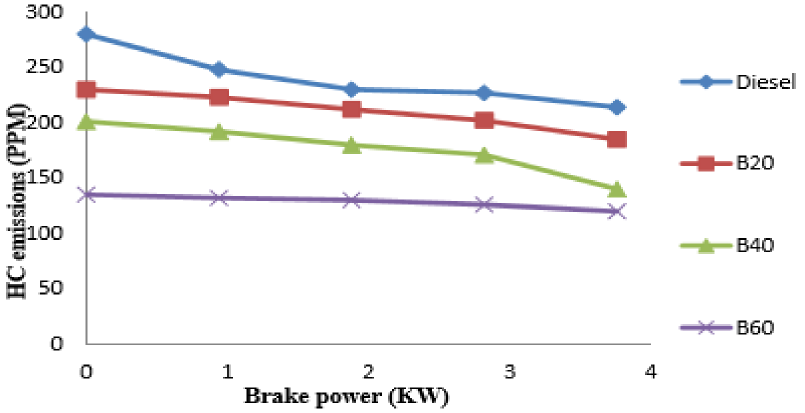

Fig. 27: Brake Power vs. HC emission

4.1.6 Brake Power vs. NOx Emission

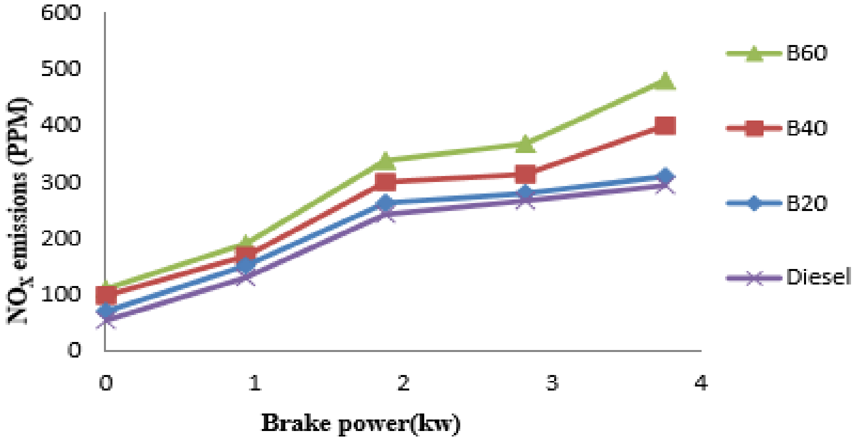

Fig. 28: Brake Power vs. NOx Emission

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4.2 Conclusions

Experimental analysis of all the blends has shown a marginal decrease in the brake thermal efficiency at higher loads while there was an appreciable increase in fuel consumption at part loads compared to diesel. Since exhaust gas temperatures are higher, NOx and CO2 emissions are also higher for the blends than diesel. The CO emissions decrease with increasing in the blend due to intrinsic oxygen content in the oil.

The following are the major conclusions that were drawn from the result of the study on performance and emission characteristics of a diesel engine using biodiesel.

- Based on the performance and emission parameters B20 has good BTE and CO2 Emission, NOX and HC Emissions which is at an acceptable range.
- The Brake thermal efficiency value at maximum brake power for this optimum blend is 32.6% compared to 34.19% for base diesel.
- For the optimum blend mass of fuel consumption is 0.02Kg/KW-h higher compared to diesel due to low calorific value.
- The CO emissions are decreased with increasing in the blending ratio of palm biodiesel with diesel this is due to oxygen content present in the fuel.
- The CO2 emissions increased with an increased blending ratio of palm biodiesel to diesel because of complete combustion quality in palm biodiesel.
- UHC is decreased with increasing the load for all blends, palm oil is an oxygenated fuel which gives good combustion efficiency. So, less amount of unburned fuel in the exhaust.
- NOX Emission is increased with increasing the load this is due to the excess amount of oxygen supplied causes the higher NOX Formation.

5. PAPER 4

Bridjesh investigated performance and emission analysis diesel engine using calophyllum inophyllum biodiesel blends at various compression ratios. Blends of Calophyllum inophyllum biodiesel and diesel blends are prepared to use as fuel on variable compression ratio diesel engine. The variations on performance parameters like brake specific fuel consumption, brake thermal efficiency and exhaust emissions like nitric oxides, hydro carbon, carbon monoxide are assessed and analysed

5.1 Experimental setup

Table 6: Specification of the engine

Particulars	Specifications
Engine make	Kirloskar, Type 1
NO of cylinders	Single
NO of strokes	Four
Bore & Stroke	87.5 mm &110 mm
Power & Speed	5.5 kW &1500 rpm
Compression Ratio Range	12:1 to 18:1
Injection Pressure	200 Bar

5.2 Results and discussions

5.2.1 Load vs specific fuel consumption

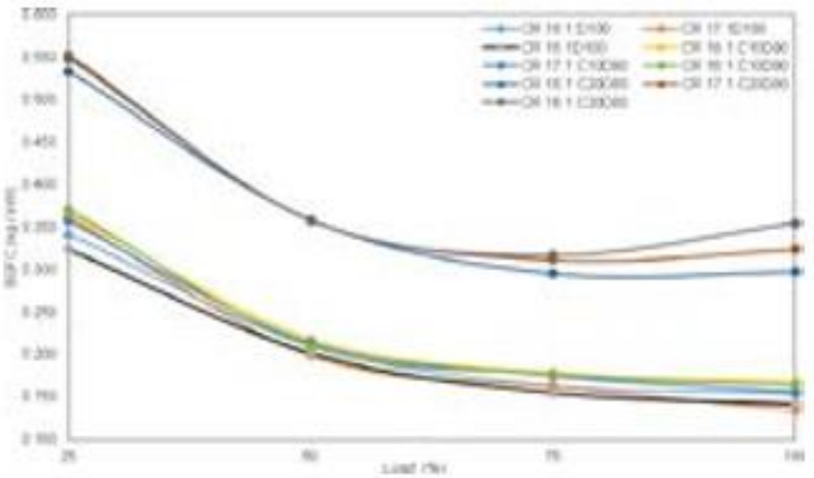

Fig. 29: Load vs. Specific Consumption

5.2.2 Load vs. Brake Thermal Efficiency

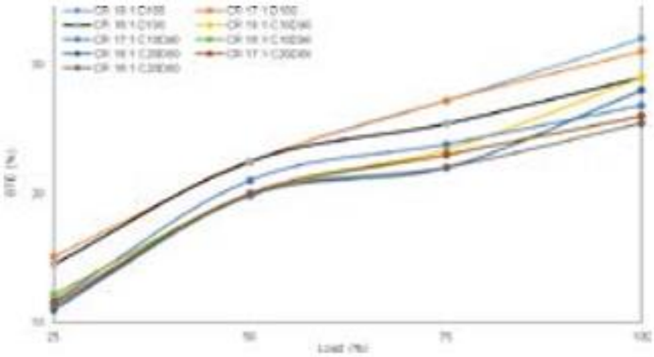

Fig. 30: Load vs. BTE

5.2.3 Load vs. NOx Emission

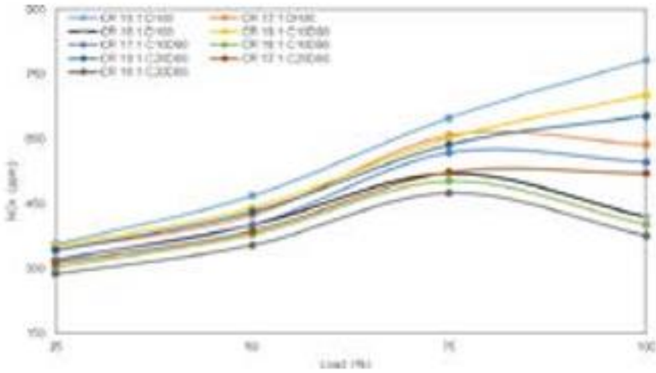

Fig. 31: Load vs. NOx Emission

5.2.4 Load vs HC Emissions

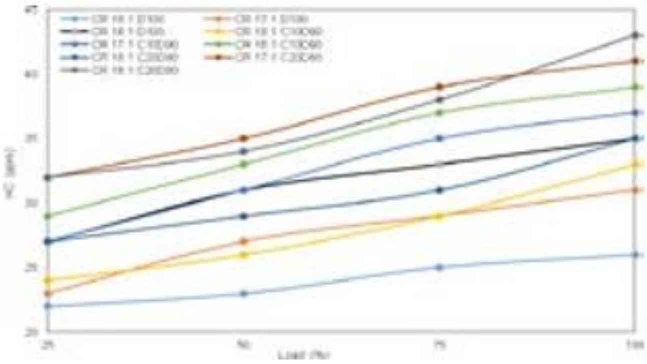

Fig. 32: Load vs. HC Emission

5.2.5 Load vs. CO

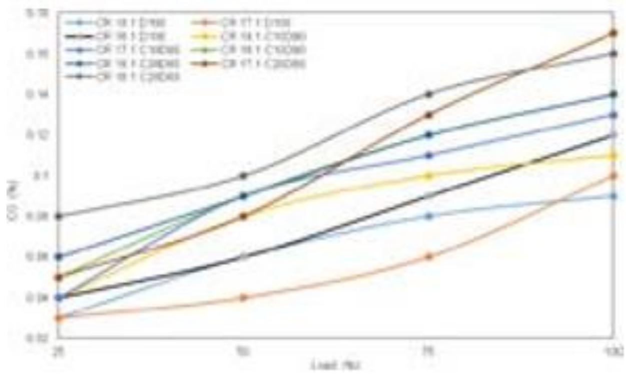

Fig. 33: load vs. CO

5.3 Conclusion

An experimental study, to evaluate and analyse the performance and exhaust emissions of Calophyllum inophyllum biodiesel blends at various compression ratios on a variable compression ratio diesel engine and the conclusions are drawn as follows:

- As the compression ratio increases, the BSFC increases at full load. The BSFC for C10D90 and C20D80 are 0.141 kg/kWh and 0.298 kg/ kWh respectively. The average increase in BSFC was 13% for Calophyllum inophyllum biodiesel blends.
- As the load increases, BTE of the fuel blends also increases. The maximum BTE for C10D90 and C20D80 were found to be 29% and 28% respectively. Whereas for D100, it was 32%.

- With the higher amount of oxygen and lower heating value of Calophyllum inophyllum biodiesel blends, NOx emission reduced by 43% and 42% for C10D90 and C20D80 blends respectively.
- HC emission increased by 15% and 18% for C10D90 and C20D80 blends respectively.

6. PAPER 5

K. Sandeep Kumar investigated the performance and emission analysis of Mahua oil methyl ester (MOME) blended with diesel along with additive of diethyl ether in a single cylinder direct injection diesel engine. The various test fuels are prepared by varying the percentage of MOME in the bio-diesel blend keeping volume of diethyl ether constant. The series of tests were conducted using various blends M20DEE20D60, M30DEE20D50, D100 in VCR research engine at a standard compression ratio of 16:1 at all loads. Results showed that there is a rise in Brake Specific Fuel Consumption (BSFC) with the rise in the percentage of MOME in biodiesel blend when compared to diesel, but Break thermal efficiency (BTE) slightly increases with increase in the percentage of MOME in a biodiesel blend. The emissions of CO, NOX and HC were reduced with an increase in the percentage of MOME in biodiesel blend, but CO2 emissions were increased.

Table 7: Properties of Mahua oil

S. no	Parameters	Units	Diesel	M20DEE20D60	M30DEE20D50
1	Kinematic viscosity @40°c	cSt	2.98	2.79	3.42
2	Gross calorific value	Kcal/kg	10666	8730	8420
3	Density @30°c	g/cc	0.845	0.564	0.890
4	Cetane index	--------	52	53	54

6.1 Results and discussions

6.1.1 Load vs. Brake Specific Consumption

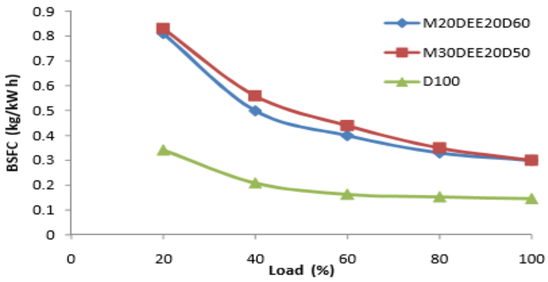

Fig. 34: load vs. BSFC

6.1.2 Load vs. Brake Thermal Efficiency

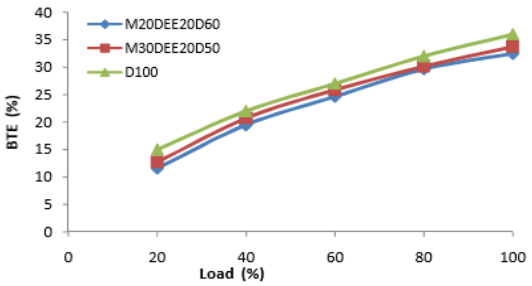

Fig. 35: load vs. BTE

6.1.3 Load vs. CO

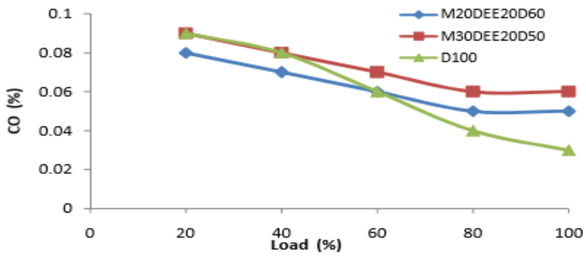

Fig. 36: load vs. CO_2

6.1.4 Load vs. HC

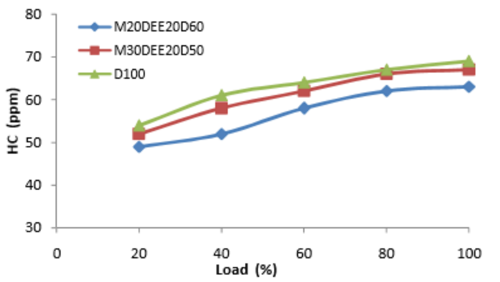

Fig. 37: load vs. HC

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6.1.5 Load vs. CO2

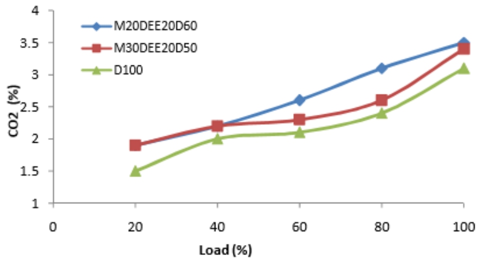

Fig. 38: load vs. CO2

6.1.6 Load vs. NOx

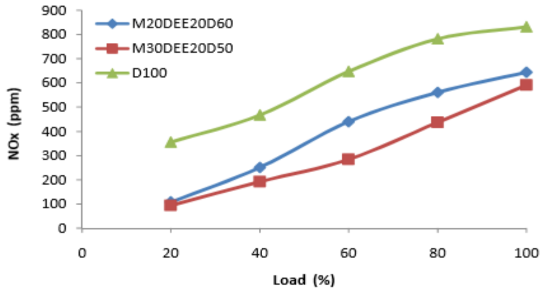

Fig. 39: load vs. NOx

6.2 Conclusion

The properties of Mahau biodiesel are found to be in par with properties diesel except for its calorific value. With the addition of DEE in the blends improved the cetane number of biodiesel which leads to good combustion of fuel. The BSFC increased with increase in the proportion of MOME Biodiesel in the blends. BTE of Biodiesel blends is lower than the brake thermal efficiency of diesel. But there is a slight increase in BTE is observed for M30DEE20D50 compared to M20DEE20D50. The amount of CO, NOx, CO2 and HC in exhaust emission reduced with an increase in the percentage of MOME in the blends. However, the level of emissions increased with increase in engine load for all fuels tested. The Emission of CO2 is higher for mahua biodiesel compared to that of diesel for all loading conditions. The addition of Di-ethyl Ether in blends reduces the Exhaust Emissions and improves Performance. Hence it is concluded that Mahua Biodiesel could be safely blended with Diesel up to 30% without significantly affecting the engine performance (Brake Specific Fuel Consumption (BSFC), Brake Thermal Efficiency (BTE) and emissions (HC, CO, NOx) were reduced and thus could be used as a suitable alternative fuel for diesel engines.

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