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EXPERIMENTAL INVESTIGATION OF THE EFFECT OF PERFORMANCE AND EMISSIONS OF A VARIABLE COMPRESSION RATIO DIESEL ENGINE RUNNING WITH RICE BRAN OIL

Mr. V. Nageswara Reddy*1 and Dr. G. Sreenivasa Rao2
*1R.G.M. College of Engg. & Tech, Nandyal, A.P., India,
2Professor, R.V.R. & J.C. Engg. College, Guntur, A.P., India

ABSTRACT

At present days petroleum based fuels are obtained from limited reserves. Therefore, those countries not having these resources are facing a foreign exchange crisis, mainly due to the import of crude petroleum oil. Hence it is necessary to look for alternative fuels, which can be produced from materials available within the country. In this investigation, rice bran methyl ester (RBM) was used in four stroke, single cylinder variable compression ratio type diesel engine. The results proved that the use of biodiesel (produced from rice bran oil) in compression ignition engine is a viable alternative to diesel. In this work the engine performance and exhaust emissions were measured at different variable compression ratio (VCR-18, VCR-16 & VCR-14) and at different injection pressures (220 bars, 200 bar & 180 bar) with different blends of biodiesel rice bran oil.

Keywords: *Bio-diesel, Rice Bran Oil, Variable Compression Ratio, Injection Pressure, Performance, Emissions.*

I. INTRODUCTION

As the need of automobiles increases and the shrinking crude oil reserves. Most of the countries are to be necessarily dependent on imports of crude petroleum and petroleum products. Due to the increase in price of petroleum and environmental concern about pollution coming from automobile emission, biodiesel is emerging as a developing area of high concern [1]. Rice bran oil is extracted from rice bran, which is a by-product of rice milling process. As rice production is a renewable process the availability of rice bran for oil extraction is also renewable in nature. The world is confronted with the twin crises of fossil fuel depletion and environmental degradation. Alternative fuels, promise to harmonize sustainable development, energy conversion, management, efficiency and environmental preservation. Vegetable oil is a promising alternative to petroleum products [2]. Experimentally investigated and found the effect of injection pressures in diesel engine [3]. The effect of compression ratio (VCR) in diesel engines have been studied in detail at many places [4]. Engine tests were conducted with biodiesel derived from refined rice bran oil [5] only and not with crude rice bran oil methyl ester. As the FFA content of refined oil is less than 3% it can be easily converted into biodiesel by base catalyzed reaction alone [6-7]. Earlier research works on biodiesel indicated that B20 (20% of biodiesel mixed with 80% of diesel on volume basis) will be an optimum fuel blend for CI engine rather than neat biodiesel [8]. Investigated a diesel engine using rubber seed oil biodiesel blends and found that the lower blends increases the efficiency of the engine and lowers the fuel consumption compared to the higher biodiesel blends [9]. Performed performance, emission and combustion analysis using waste cooking oil biodiesel blends on a variable compression ratio engine and found that longer ignition delay and reduction in carbon monoxide emission [10]. The aim of the present study is to investigate the performance (Brake thermal efficiency, Brake specific fuel consumption, and Mechanical efficiency) characteristics of a single cylinder variable compression ratio diesel engine using rice bran oil biodiesel.

II. MATERIALS & METHODS

In this research work the fuels used were conventional diesel, rice bran oil biodiesel and methanol. Fuel properties of rice bran oil biodiesel and methanol are determined in the laboratory as shown in the table 1.

Property parameters	Diesel Fuel	Rice Bran Oil Biodiesel	Methanol
Density at 20^0 C (g/cm^3)	0.82	0.96	0.78
Viscosityat	3.4	4.56	1.35

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40^0C (mm^2/s)			
Flash Point ^{0}C	57	160	21
Fire Point ^{0}C	60	175	25
Cetane Number	45	54	10
Calorific value (KJ/kg)	43,500	39,800	28,700

Table 1: properties of diesel, rice bran oil biodiesel and bio methanol

2.1 RESEARCH ENGINE TEST SET UP

Experimental set up used for the research work consists of a single cylinder, four strokes, and variable compression ratio diesel engine. The detailed specifications of the engine used as shown in Table 2. Fig:1 shows the schematic diagram of engine test rig.

Make	Kirloskar Model AVL
No of strokes per cycle	04
No of Cylinders	01
Combustion chamber position	Vertical
Cooling Method	Water cooled
Starting Method	Cold Start
Ignition Technique	Compression Ignition
Stroke Length (L)	110 mm
Bore Diameter (D)	87.5 mm
Rated Speed	1500 r.p.m.
Rated Power	3.5 KW
Compression ratio	12:1 To18:1

Table 2: Specifications of the diesel engine

Figure: 1 Schematic diagram of engine test rig.

Experimental results were obtained at different loads (20%, 40%, 60%, 80% and 100%) on the engine. In the same manner the test was conducted with the blend B10%, B20% andB30%.The experiment tests were conducted with these three blends and tested engine performance. The emissions coming from engine exhaust were measured under all load conditions. The results were compared with the baseline parameters obtained during engine fuelled with diesel fuel.

III. RESULTS AND DISCUSSIONS

Experimental results obtained from the research work pertaining to the performance of the engine were demonstrated with the help of graphs. The vary of Brake Specific Fuel Consumption (BSFC) with load for diesel and blends at 220 bar injection pressure (IP) and VCR 18:1 is shown in the figure 2.

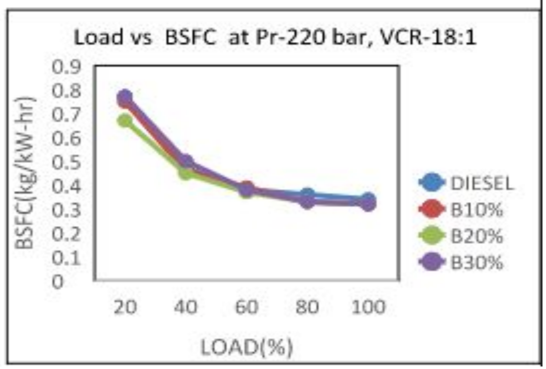

Fig: 2 Vary of BSFC at 220 bar IP and at VCR-18:1.

The BSFC at 220 bar IP and at VCR 18:1 was reduced with load for all the fuel modes. The BSFC of B20% and B10% were lower than that of the diesel fuel at low load of the engine.
The vary of BSFC with load of diesel and blends at 220 bar IP and at VCR 16:1 is shown in the figure 3.

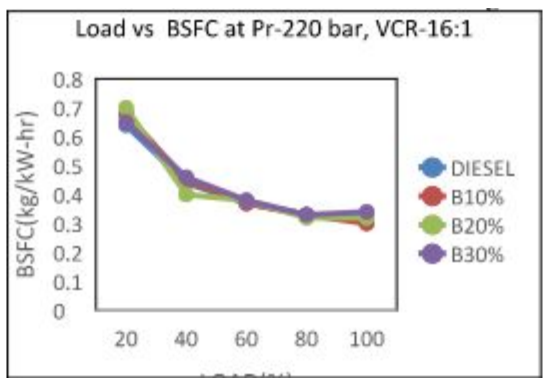

Fig: 3 Vary of BSFC at 220 bar IP and at VCR-16:1.

The BSFC at 220 bar IP and at VCR 16:1 was reduced with load for all the fuel modes. The BSFC of B20% was 10% higher at low load and 10% lower at medium load when compared to that of the diesel fuel, B10% and B30%.
The vary of BSFC with load of diesel and blends at 220 bar IP and at VCR 14:1 is shown in the figure 4.

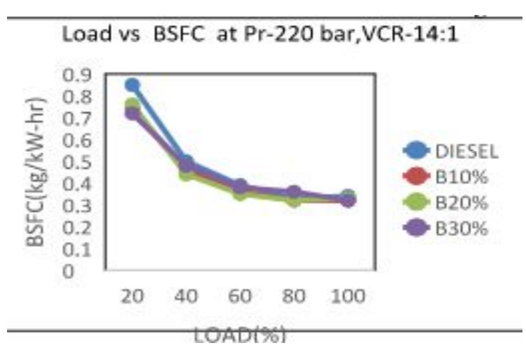

Fig: 4 Vary of BSFC at 220 bar IP and at VCR-14:1.

The BSFC at 220 bar IP and at VCR 14:1 was reduced with load for all the fuel modes. The BSFC of B10%, B20% and B30% were low at low load of the engine.

The vary of BSFC with load at 200 bar IP and at VCR 18:1 is shown in the figure 5.

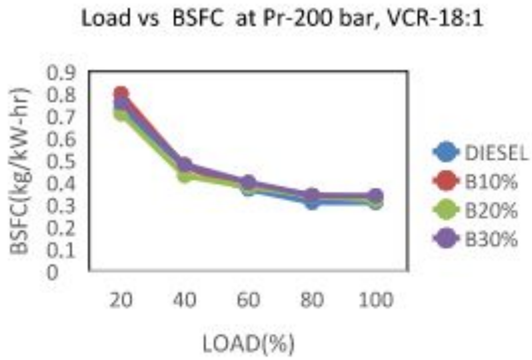

Fig: 5 Vary of BSFC at 200 bar IP and at VCR-18:1.

The BSFC at 200 bar IP and at VCR 18:1 was reduced with load for all the fuel modes. The BSFC of B20% was low at low load of the engine.

The vary of BSFC with load at 200 bar IP and at VCR 16:1 is shown in the figure 6.

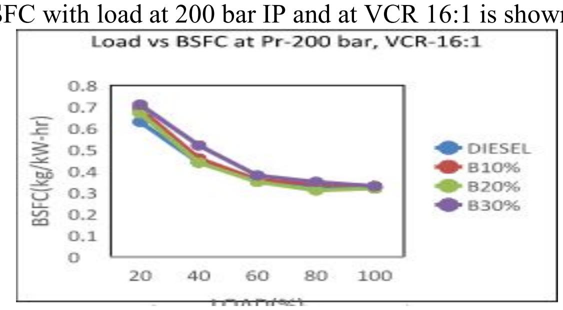

Fig: 6 Vary of BSFC at 200 bar IP and at VCR-16:1

The BSFC of diesel was low at low load of the engine as compared to that of the B30% blends.

The vary of BSFC with load of diesel and blends at 200 bar IP and VCR 14:1 is shown in the figure7.

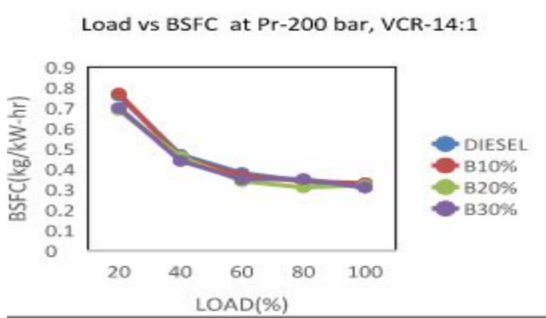

Fig: 7 Vary of BSFC at 200 bar IP and at VCR-14:1

The BSFC of the diesel was high at low load of the engine. The BSFC of the blend B20% was low at full load of the engine. The vary of BSFC with load of diesel and blends at 180 bar IP and at VCR 18:1 is shown in the figure 8.

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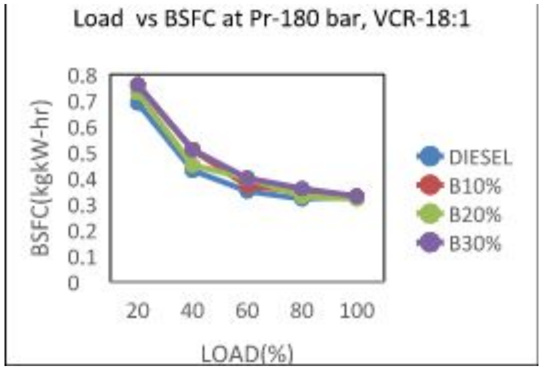

Fig: 8 Vary of BSFC at 180 bar IP and at VCR-18:1

The BSFC of the diesel was low at all low loads of the engine. The BSFC of the blend B30% was high at all load of the engine. The vary of BSFC with load of diesel and blends at 180 bar IP and VCR at 16:1 is shown in the figure 9.

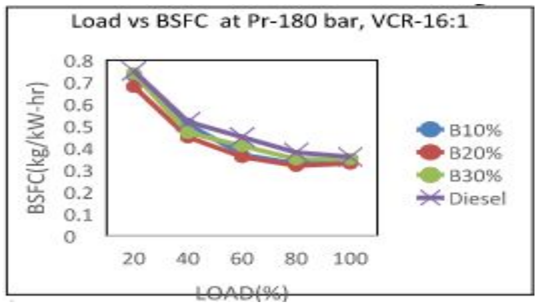

Fig: 9 Vary of BSFC at 180 bar IP and at VCR-16:1

The BSFC of the blend B30% was high at all low loads of the engine. The BSFC of the blend B10% was low at all load of the engine.

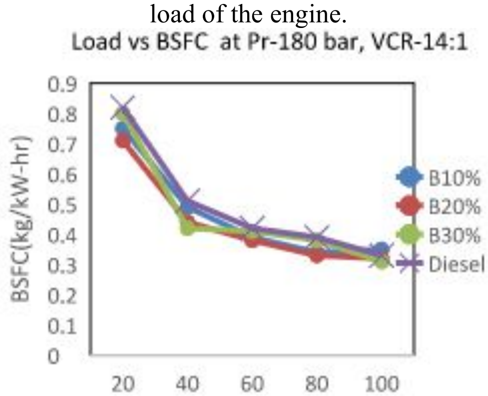

Fig: 10 Vary of BSFC at 80 bar IP and at VCR-14:1

The vary of BSFC with load of diesel and blends at 180 bar IP and at VCR 14:1 is shown in the figure 10.

The BSFC of the blend B30% was high at all low loads of the engine. The BSFC of the blends B20% was low at all load of the engine.

The vary of brake thermal efficiency (BTE) with load of diesel and at 220 bar injection pressure (IP) and VCR 18:1 is shown in the figure 11.

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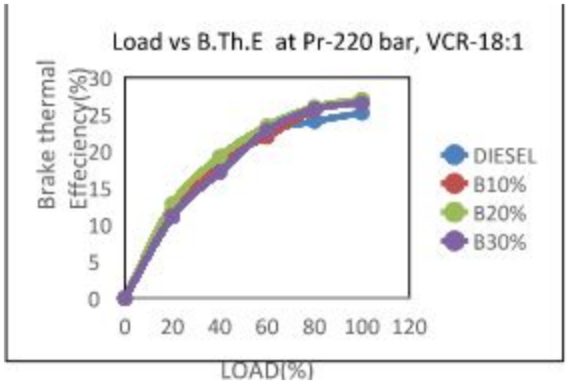

Fig: 11 Vary of BTE at 220 bar IP and at VCR-18:1

The BTE at 220 bar IP and at VCR 18:1 was increased with load of the blend B20% over the entire range of the load. The vary of BTE with load of diesel and blends at 220 bar IP and at VCR 16:1 is shown in the figure 12.

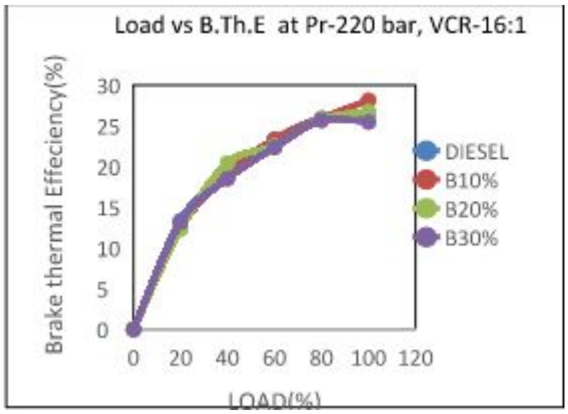

Fig: 12Vary of BTE at 220 bar IP and at VCR-16:1

The BTE of the blend B10% and B20% was high over the entire range of the load. The maximum BTE was observed with the blend B10%.

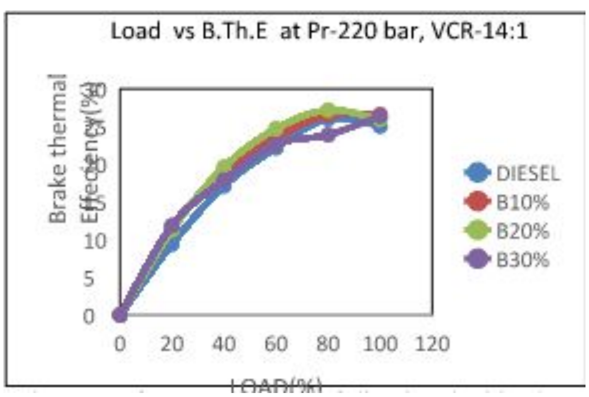

Fig: 13Vary of BTE at 220 bar IP and at VCR-14:1

The vary of BTE with load of diesel and blends at 220 bar IP and at VCR 14:1 is shown in the figure13. The BTE of the blend B20% was high over entire range of the load on the engine. The vary of BTE with load of diesel and blends at 200 bar IP and at VCR 18:1 is shown in the figure14.

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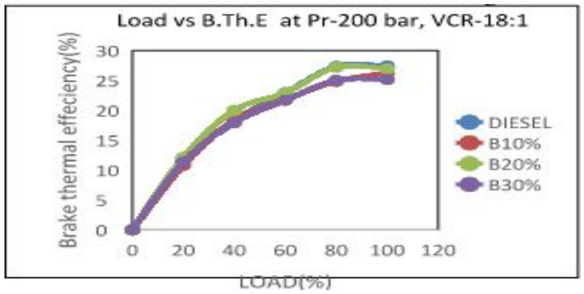

Fig: 14Vary of BTE at 200 bar IP and at VCR-18:1

The BTE of the blend B20% was high over the entire range of the load. The minimum BTE was observed with B10% and B30% at full load of the engine.

The vary of BTE with load of diesel and blends at 200 bar IP and at VCR 16:1 is shown in the figure15.

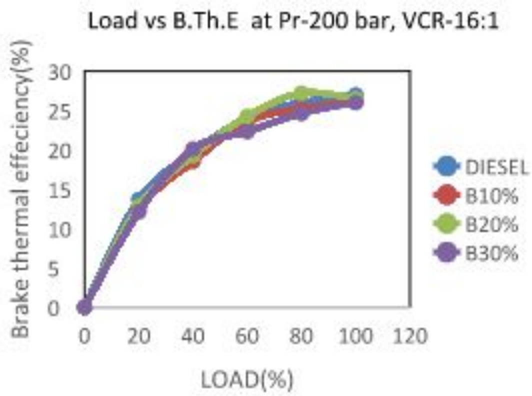

Fig: 15Vary of BTE at 200 bar IP and at VCR-16:1

The BTE of the blend B20% was higher than that of the conventional diesel over the entire range of the load. The minimum BTE was observed with B10% and B30% under all load condition of the engine. The vary of BTE with load of diesel and blends at 200 bar IP and VCR 14:1 is shown in the figure16.

The BTE of the blend B20% was higher than that of the conventional diesel over the entire range of the load. The minimum BTE was observed with B10% and B30% under all load condition of the engine.

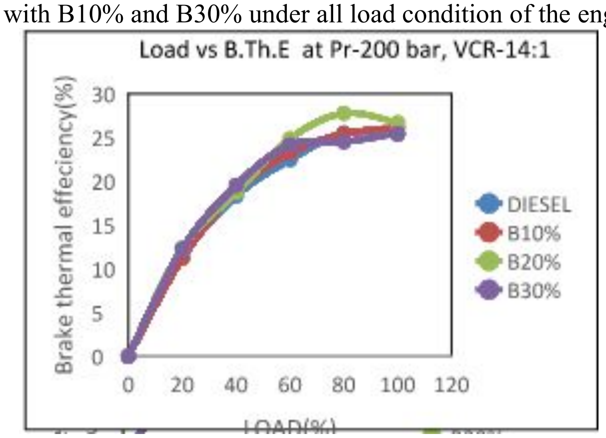

Fig: 16Vary of BTE at 200 bar IP and at VCR-14:1

The vary of BTE with load of diesel and blends at 180 bar IP and at VCR 18:1 is shown in the figure17

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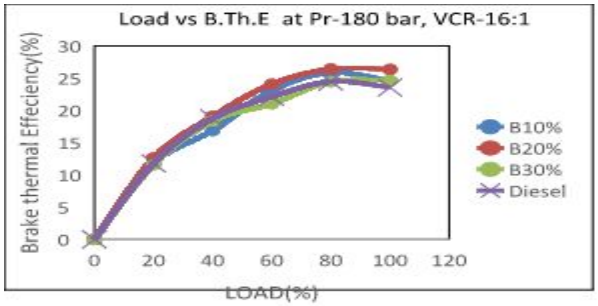

Fig: 17Vary of BTE at 180 bar IP and at VCR-18:1

The BTE of diesel was high than that of the diesel –biodiesel-methanol blends over the entire range of the load. The minimum BTE was observed with the blend B30% at all load of the engine.

The vary of BTE with load of diesel and blends at 180 bar IP and VCR 16:1 is shown in the figure 18.

The BTE of the blend B10% was high than that of the diesel fuel over the entire range of the load. The minimum BTE was observed with diesel and 30% of blend at medium and higher load of the engine.

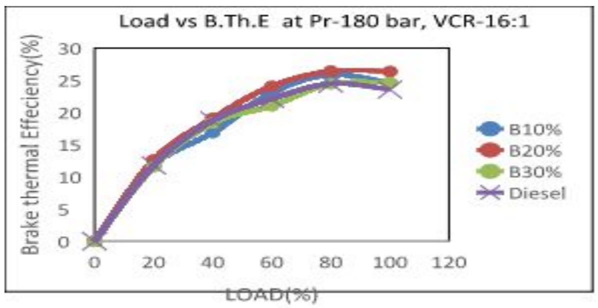

Fig: 18Vary of BTE at 180 bar IP and at VCR-16:1

The vary of BTE with load of diesel and blends at 180 bar IP and at VCR 14:1 is shown in the figure 19.

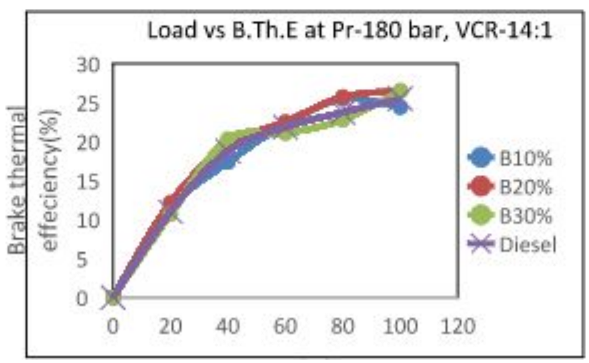

Fig: 19Vary of BTE at 180 bar IP and at VCR-14:1

The BTE of the blend B10% was higher than that of the conventional diesel fuel over the entire range of the load. The minimum BTE was observed with diesel fuel at medium load of the engine.

The vary of Nitrogen Oxide(NOX)with load at 220 bar IP at VCR-18:1 is shown in the figure 20

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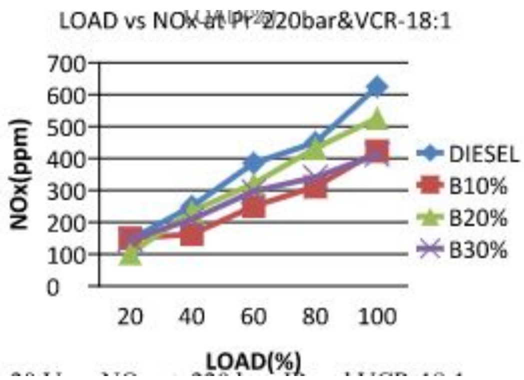

Fig:20 Vary NOX at 220 bar IP and VCR-18:1

The NOx emissions of blend B10% were less at medium and high loads. It is due to the higher oxygen content and combustion temperature of the biodiesel.

The vary of NOx of diesel and blends at 220 bar IP and at VCR-16:1 is shown in the figure 21

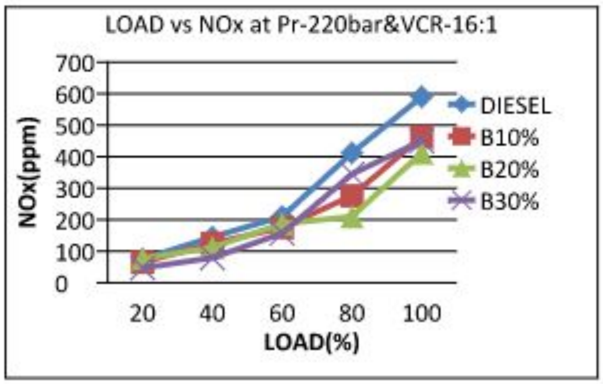

Fig:21 Vary NOX at 220 bar IP and at VCR-16:1

The NOx emissions of blends at IP 220 bar were lower at low loads and increased at medium and high loads on the engine The NOx emissions of B20% were less than that of the diesel.

The vary of NOx with load at 220 bar IP and at VCR-14:1 is shown in the figure 22

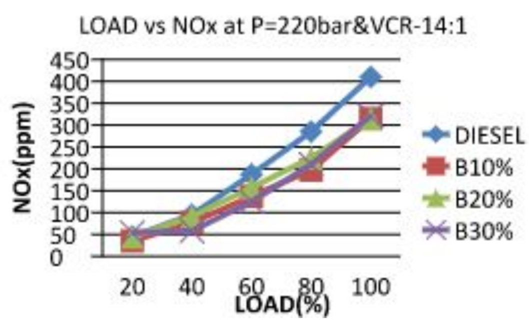

Fig: 22 Vary NOX at 220 bar IP and VCR-14:1

The NOx emissions of diesel were slightly high at medium load and full load conditions. At full load conditions, the NOX emissions of diesel were high at IP 220 bar and VCR of the engine is 14:1.

The vary of NOx with load at 200 bar IP and at VCR-18:1 is shown in the figure 23.

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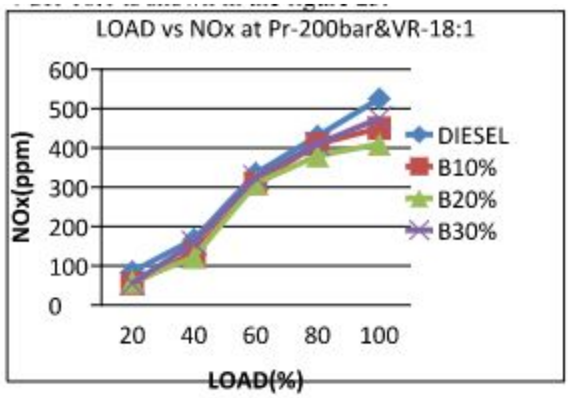

Fig: 23 Vary NOX at 200 bar IP and at VCR-18:1

The NOx emissions of diesel and blends emissions were increased with the increasing of the load. At full load conditions of the engine, the NOX emissions of blend B20% of were low at all load of the engine

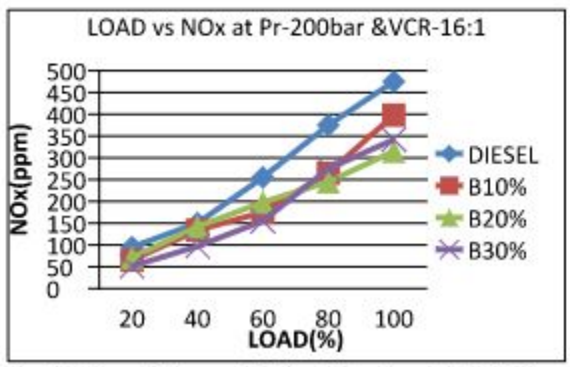

Fig: 24 Vary NOX at 200 bar IP and at VCR-16:1

The vary of NOx with load at 200 bar IP and at VCR-16:1 is shown in the figure 24.

The NOx emissions of diesel were increased at all load conditions, when compared with emissions of blends at IP 200 bar and at VCR16:1 of the engine. The NOx emissions of blends B20% and B 30% were low under all loads on the engine. The vary of NOx with load at 200 bar IP and at VCR-14:1 is shown in the figure 25.

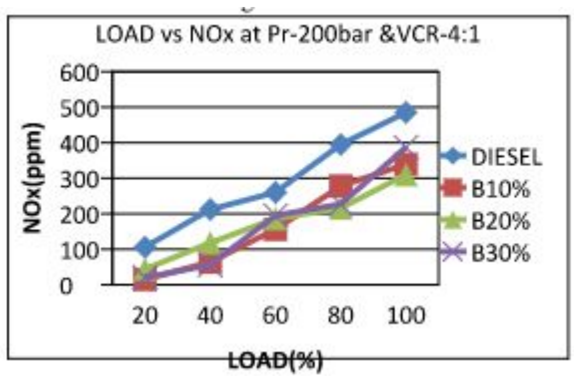

Fig: 25 Vary NOX at 200 bar IP and VCR-14:1

The NOx emissions of diesel were high at all load conditions at IP 200 bar and at VCR 14:1. The NOx emissions of blends B10%, B20% and B 30% were almost similar under all load conditions of the engine.

The vary of NOx with load at 180 bar IP and at VCR-18:1 is shown in the figure 26.

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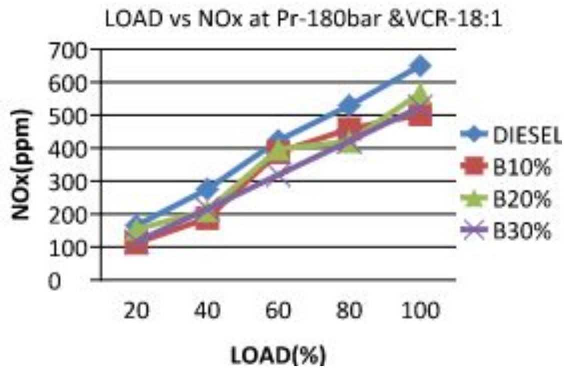

Fig: 26 Vary NOX at IP 180 bar and VCR-18:1

The NOx emissions of diesel were high at all load on the engine. The NOX emissions of blends at IP 180 bar and at VCR 18:1 were shows similar results at all loads on the engine.

The vary of NOx with load at 180 bar IP and at VCR-16:1 is shown in the figure 27.

The NOX emissions of diesel and blends at IP 200 bar and at VCR 16:1 were increased with increasing the load on the engine. The NOx emissions of diesel-biodiesel-methanol blends B30% were decreased at full load on the engine

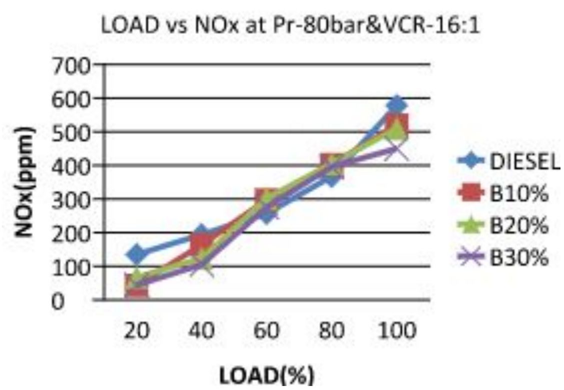

Fig: 27 Vary NOX at 180 bar IP and at VCR-16:1

The vary of NOx with load at 180 bar IP and at VCR-14:1 is shown in the figure 28.

LOAD vs NOX at Pr-80bar&VCR-14:1

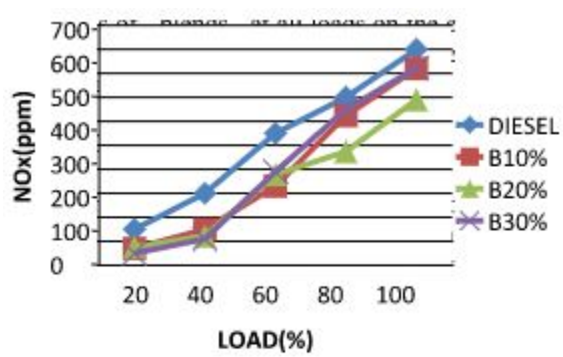

Fig: 28 Vary NOX at 180 bar IP and VCR-14:1

The NOx emissions of diesel at 180 bar IP and at VCR 14:1 were high as compared to that of the NO_X emissions of blends at all loads on the engine. The NOx emissions of B20% and B 30% were decreased at full load on the engine.

IV. CONCLUSIONS

The performance characteristics of conventional diesel and rice bran oil biodiesel-methanol blends were investigated on a single cylinder diesel variable compression ratio engine. The conclusions of this investigation are as follows:

- The Brake Specific Fuel Consumption of blend 30% was higher at 220 bar IP and at VCR 18:1 with load for all the fuel modes. The BSFC of diesel fuel was higher at 220 bar IP and at VCR 18:1 with load for all the fuel modes.
- The brake thermal efficiency of blend 10% was higher at 200 bar IP and at VCR 16:1 with load for all the fuel modes. The minimum brake thermal efficiency of diesel fuel was observed at 180 bar IP and at VCR 16:1 with load for all the fuel modes.
- The Nitrogen Oxides emissions were increased with increased of the rice bran biodiesel at all loads and speeds of the engine. But NO_X emissions were low at all loads and all compression ratios of the engine compared with the conventional diesel fuel at all injection pressures and all compression ratios. The minimum CO emissions were observed with the blend B20% (5%methanol, 15% rice bran oil) at 220 bar injection pressure and at VCR-14.

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AUTHOR DETAILS

Mr.V.Nageswara Reddy received his B.Tech. degree in mechanical engineering from Marathwada University , Maharashtra, and Master degree from JNTU Hyderabad, India. He is now a pursuing PhD at Achrya Nagarjuna University, Andhra Pradesh, India.
Mobile: 9912478935.