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Experimental Evaluation of a VCR Diesel Engine Performance Fueled with Methyl Ester of Rice Bran Oil

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ABSTRACT

In the world, day to day increases consumption of energy with increase the productionrate of automobile. With the current consumption rate if it has been quoted that there will be great shortage of petroleum products in upcoming decades. For this reason research is going on alternative fuels. It is better to develop the engine which can work on bio diesel and one can add methanol in the bio diesel and use the blends of that. For this purpose, it is necessary to check the performance characteristics of the blends with the conventional diesel fuels. In this investigation, rice bran methyl ester was used in four strokes, single cylinder variable compression ratio type diesel engine. Tests were carried out at different injection pressures with various blends of rice bran methyl ester. The results proved that the use of bio diesel (produced from rice bran oil) in compression ignition engine is a viable alternative to diesel.

Introduction

Day to day increasing the need of automobiles and the shrinking crude oil reserves, India is to be necessarily dependent on imports of crude petroleum and petroleum products. In an Internal combustion engines it is well known fact that about 30% of the heat energy supplied is lost through the coolant and the 30%of the heat energy supplied is wasted through the exhaust and 10% of the heat energy supplied lost due to friction. Therefore the remaining only 30% of energy utilization for useful purposes. The advantages of biodiesel as diesel fuel are ready availability, renewability, higher combustion efficiency, lower sulfur. The main advantages of biodiesel include domestic origin, reducing the dependency on imported petroleum. 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 ofcompression ratio (VCR) in diesel engineshave 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 cylindervariable compression ratio diesel engine using rice bran oil biodiesel.

Materials & Methods

In this research work the fuels used were conventional diesel fuel, rice bran oil biodiesel and methanol. These fuels were purchased from the Gandhi KrishVignan Kendra Agricultural university, Bangalore, Karnataka state, India and local markets. Fuel properties such as density, viscosity, net heating value, flash point and fire point of rice bran oil biodiesel and methanol are determined in the laboratory as shown in the table1.

Research engine test setup

Experimental set up used for this research work consists of a single cylinder, four stroke, variable compression ratio (computerized) diesel engine connected to eddy current type dynamometer for loading. The detailed specifications of the engine used as shown in Table 2. Windows based Engine Performance Analysis Software Package ‘‘Engine soft” was taken for on line performance evaluation. Figure: 1 shows the

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schematic diagram of engine test rig. The tests were conducted at the rated speed of 1500 rpm at different loads (3 kg, 6 kg, 9 kg, 12 kg, and 15 kg) at different compression ratios (VCR-18, VCR-16, & VCR-14) and also at different injection pressures (IP 220 bar, IP 200 bar & IP180 bar).The engine was started with standard diesel fuel and warmed up.

Table 1. Properties of diesel, rice bran oil biodiesel and bio methanol

Property parameters	Diesel Fuel	Rice Bran Oil Biodiesel	Methanol
Density at 20^0 C (g/cm^3)	0.82	0.96	0.78
Viscosity at 40^0C (mm^2/s)	3.4	4.56	1.35
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 2. Specifications of the diesel engine

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

Experimental results were obtained at different loads 3 kg, 6 kg, 9 kg, 12 kg, and 15 kg (20%, 40%, 60%, 80% and 100%) on the engine with the diesel fuel at different variable compression ratios (VCR-18, VCR-16 & VCR-14)and at different injection pressures (IP 220 bar, IP 200 bar& IP 180 bar). In the same manner the test was conducted with the blend of 90% diesel and B10%(5% biodiesel and 5% methanol), blend of 80%diesel B20% (15%biodiesel and 5% methanol), and 70%diesel B30%(25%biodiesel and 5% methanol). Different methods are there for using methanol in diesel engines. The directly blended fuel does not require any modifications to diesel engines. Hence direct blending method was used in this test. The experiment tests were conducted with these three blends and measured brake power (B.P), brake specific fuel consumption (BSFC), brake thermal efficiency (BTHE), mechanical efficiency (ME), volumetric efficiency (VE) and exhaust gas temperatures.

The brake power was measured by using an electrical dynamometer. Exhaust emissions such as Carbon Monoxide, Carbon Dioxide, Nitrogen Oxides, Hydrocarbons and unused Oxygen were measured by AVL Di Gas 444 exhaust analyzer and the smoke opacity by AVL smoke meter for diesel fuel and a blend of biodiesel-methanol blends separately under all load conditions. The results from the engine with a blend of rice bran oil biodiesel methanol were compared with the baseline parameters obtained during engine fuelled with diesel fuel at rated speed of 1500 rpm.

Fig 1. Schematic diagram of engine test rig

Results and Discussions

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

The Brake Specific Fuel Consumption 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 20% and 4% lower than that of the diesel fuel at low load of the engine. The BSFC increased by 20%, with the blends B30% and diesel fuel compared with the blend B20%. The BSFC increased with the increase of methanol percentage in the diesel-biodiesel-methanol blends at all loading conditions of the engine. It is due to the lower heating values of biodiesel and methanol compared with diesel fuel.

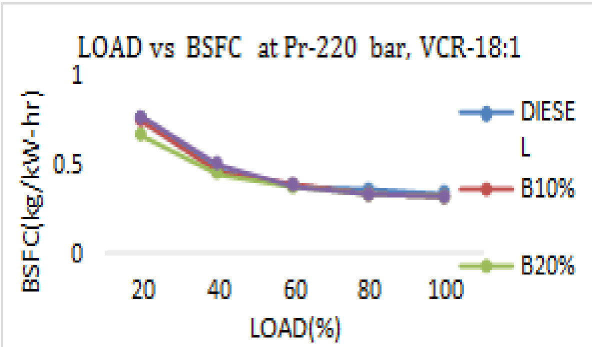

Fig 2. Vary of BSFC with load at 220 bar IP& VCR18:1

The vary of BSFC with load for diesel fuel and diesel-biodiesel-methanol blends at 220 bar injection pressure and VCR 16:1 is shown in the Figure 3.

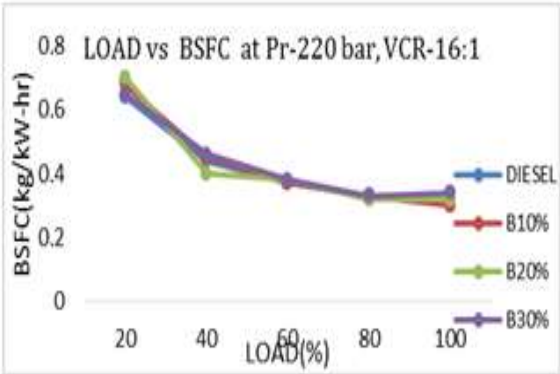

Fig 3. Vary of BSFC with load at 220 bar IP & VCR16:1

The Brake Specific Fuel Consumption 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 BSFC increased with the increase of methanol percentage in the diesel-biodiesel-methanol blends at all loading conditions of the engine. It is due to the lower heating values of biodiesel and methanol compared with diesel fuel.

The vary of BSFC with load for diesel fuel and diesel-biodiesel-methanol blends at 220 bar injection pressure and VCR 14:1 is shown in the Figure 4.

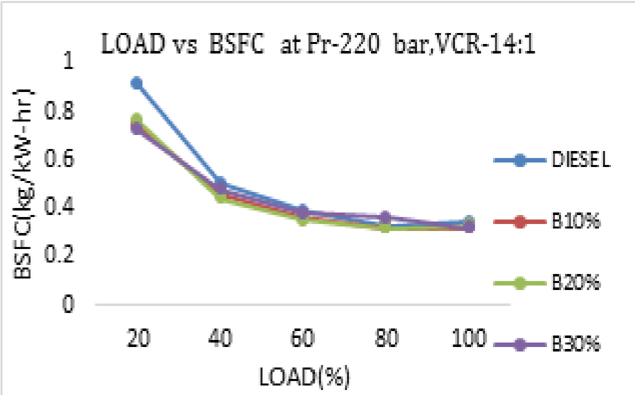

Fig 4. Vary of BSFC with load at 220 bar IP & VCR 14:1

The Brake Specific Fuel Consumption 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% was 10% lower at low load of the engine when compared to that of the diesel fuel. The BSFC increased with the increase of methanol percentage in the diesel-biodiesel-methanol blends at all loading conditions of the engine.

The vary of BSFC with load for diesel fuel and diesel-biodiesel-methanol blends at 200 bar injection pressure and VCR 18:1 is shown in the Figure 5.

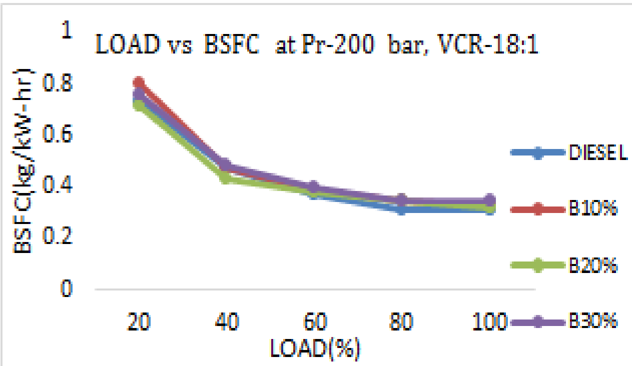

Fig 5. Vary of BSFC with load at 200 bar IP & VCR 18:1

The Brake Specific Fuel Consumption at 200 bar IP and at VCR 18:1 was reduced with load for all the fuel modes. The BSFC of B20% was lower at low load and medium load of the engine when compared to that of the diesel fuel, B10% and B30% blends. The BSFC of the blend B10% and B30% was higher than that of the diesel fuel with the load at all fuel modes.

The vary of BSFC with load for diesel fuel and diesel-biodiesel-methanol blends at 200 bar injection pressure and VCR 16:1 is shown in the Figure 6.

The Brake Specific Fuel Consumption at 200 bar IP and at VCR 16:1 was reduced with load for all the fuel modes. The BSFC of conventional diesel fuel was low at low load of the engine as compared to that of the B10% and B30% blends. The BSFC was high at all load of the engine when compared to that of the diesel fuel, B10% and B20% blends.

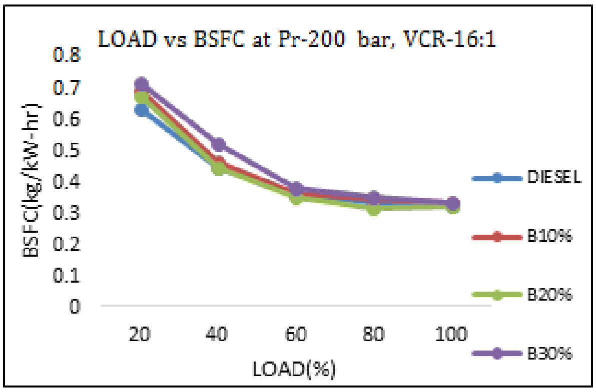

Fig 6. Vary of BSFC with load at 200 bar IP & VCR16:1

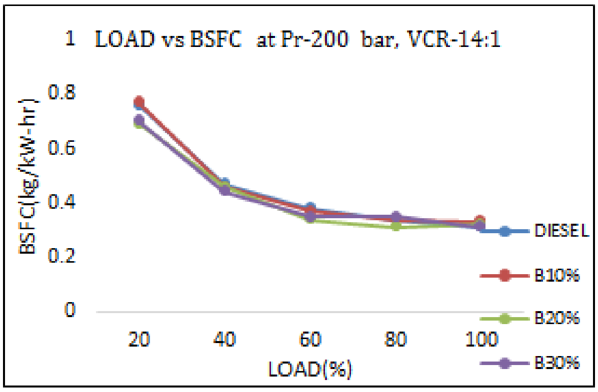

Fig 7. Vary of BSFC with load at 200 bar IP & VCR14:1

The vary of BSFC with load for diesel fuel and diesel-biodiesel-methanol blends at 200 bar injection pressure and VCR 14:1 is shown in the Figure7.

The Brake Specific Fuel Consumption at 200 bar IP and at VCR 14:1 was reduced with load for all the fuel modes. The BSFC of the diesel fuel & blend B10% was high at low load of the engine as compared to that of the B20% and B30% blends. The BSFC of the blend B20% was low at full load of the engine when compared to that of the diesel fuel, B10% and B30% blends.

The vary of BSFC with load for diesel fuel and diesel-biodiesel-methanol blends at 180 bar injection pressure and VCR 18:1 is shown in the Figure 8.

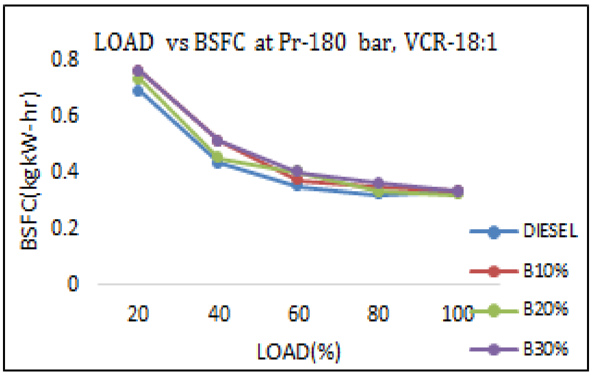

Fig 8. Vary of BSFC with load at 180 bar IP & VCR 18:1

The Brake Specific Fuel Consumption at 180 bar IP and at VCR 18:1 was reduced with load for all the fuel modes. The BSFC of the diesel fuel and blend B20% was low at all low loads of the engine as compared to that of the blend B10% and B30%. The BSFC of the blend B30% was high at full load of the engine.

The vary of BSFC with load for diesel fuel and diesel-biodiesel-methanol blends at 180 bar injection pressure and VCR 16:1 is shown in the Figure 9.

The Brake Specific Fuel Consumption at 180 bar IP and at VCR 16:1 was reduced with load for all the fuel modes. The BSFC of the blend B30% was high at all low loads of the engine as compared to that of the blend B10%, B30% and diesel fuel. The BSFC of the blend B10% was low at all load of the engine than that of the blend B20%, B30% and diesel fuel.

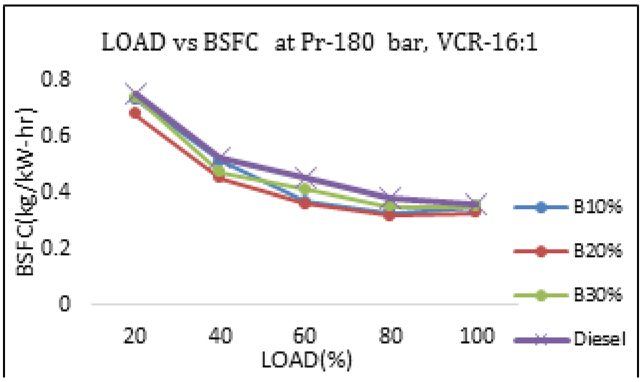

Fig 9. Vary of BSFC with load at 180 bar IP & VCR 16:1

The vary of BSFC with load for diesel fuel and diesel-biodiesel-methanol blends at 180 bar injection pressure and VCR 14:1 is shown in the Figure 10.

The Brake Specific Fuel Consumption at 180 bar IP and at VCR 18:1 was reduced with load for all the fuel modes. The BSFC of the blend B30% was high at all low loads of the engine as compared to that of the blend B10%, B30% and diesel fuel. The BSFC of the blend B10% was low at all load of the engine than that of the blend B20%, B30% and diesel fuel.

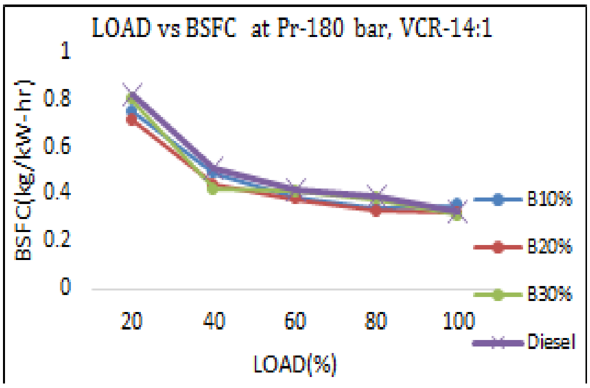

Fig 10. Vary of BSFC with load at 180 bar IP & VCR 14:1

The Brake Specific Fuel Consumption at 180 bar IP and at VCR 14:1 was reduced with load for all the fuel modes. The BSFC of the blend B30% was high at all low loads of the engine as compared to that of the blend B10%, B30% and diesel fuel. The BSFC of the blends B20% and B20% was low at all load of the engine than that of the blend B30% and diesel fuel.

The vary of brake thermal efficiency (BTE) with load for diesel fuel and diesel-biodiesel-methanol blends at 220 bar injection pressure (IP) and VCR 18:1 is shown in the Fig. 11. The brake thermal efficiency at 220 bar IP and at VCR 18:1 was increased with load for all fuel modes. The brake thermal efficiency of the blend B20% was higher than that of the conventional diesel fuel over the entire range of the load. The reason may be the extended ignition delay and the leaner combustion of biodiesel, resulting in a larger amount of fuel burned in the premixed mode of the methanol blends. The maximum brake thermal efficiency was observed with B15M5 at all the loading conditions of the diesel engine and it was 3% higher than that of diesel fuel and B30% respectively at full load of the engine. It may be due to the reduction in the density and viscosity of the fuel by the addition of methanol.

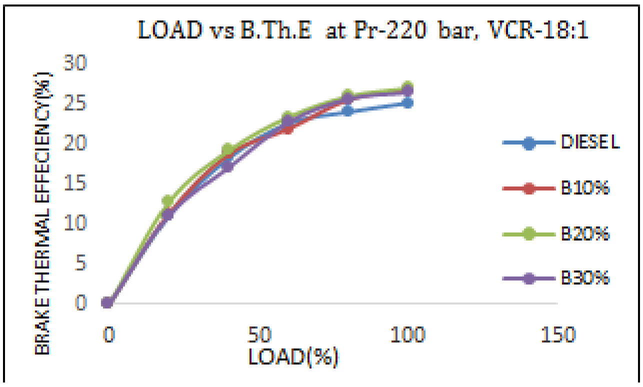

Fig 11. Vary of BTE with load at 220 bar IP & VCR 18:1

The vary of BTE with load for diesel fuel and diesel-biodiesel-methanol blends at 220 bar injection pressure and VCR 16:1 is shown in the Fig. 12.

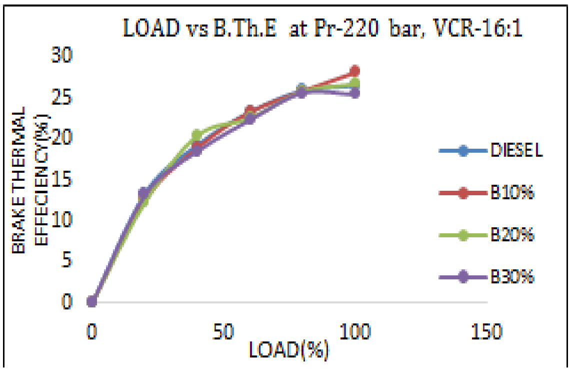

Fig 12. Vary of BTE with load at 220 bar IP & VCR 16:1

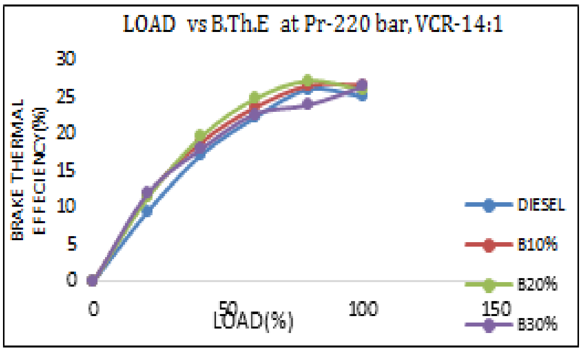

Fig 13. Vary of BTE with load at 220 bar IP & VCR14:1

The brake thermal efficiency at 220 bar IP and at VCR 16:1 was increased with load for all fuel modes. The brake thermal efficiency of the blend B10% and B20% was higher than that of the conventional diesel fuel over the entire range of the load.

The maximum brake thermal efficiency was observed with B1M5 at all the loading conditions of the diesel engine and it was 5% higher than that of diesel fuel and B30% respectively at full load of the engine. It may be due to the reduction in the density and viscosity of the fuel by the addition of methanol.

The vary of BTE with load for diesel fuel and diesel-biodiesel-methanol blends at 220 bar injection pressure and VCR 14:1 is shown in the Fig. 13.

The brake thermal efficiency at 220 bar IP and at VCR 14:1 was increased with load for all fuel modes. The brake thermal efficiency of the blend B20% was higher than that of the conventional diesel fuel over the entire range of the load. The reason may be the extended ignition delay and the leaner combustion of biodiesel, resulting in a larger amount of fuel burned in the premixed mode of the methanol blends. The minimum brake thermal efficiency was observed with diesel fuel at full load of the engine and it was 5% lower than that of blend 20%.

The vary of BTE with load for diesel fuel, biodiesel and diesel-biodiesel-methanol blends at 200 bar injection pressure and VCR 18:1 is shown in the Fig. 14.

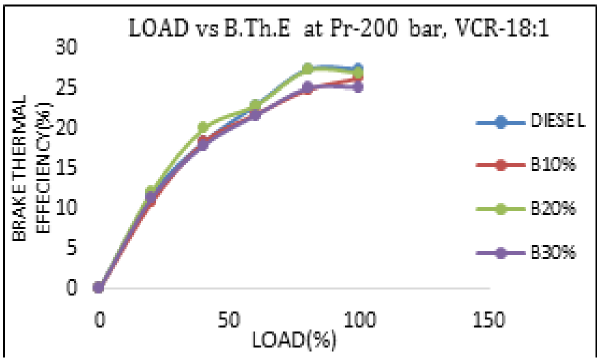

Fig14. Vary of BTE with load at 200 bar IP & VCR 18:1

The brake thermal efficiency at 200 bar IP and at VCR 18:1 was increased with load for all fuel modes. The brake thermal efficiency of the blend B20% was higher than that of the conventional diesel fuel over the entire range of the load. The reason may be the extended ignition delay and the leaner combustion of biodiesel, resulting in a larger amount of fuel burned in the premixed mode of the methanol blends. The minimum brake thermal efficiency was observed with B10% and B30% at full load of the engine.

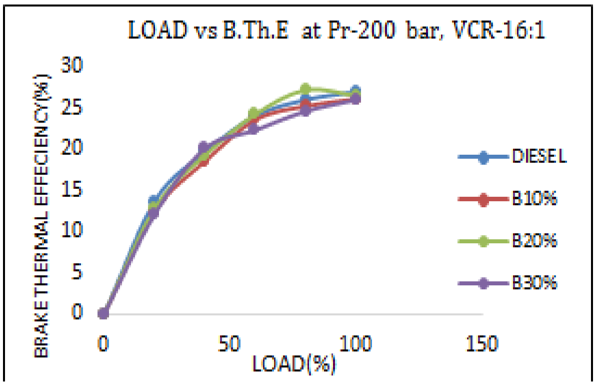

Fig 15. Vary of BTE with load at 200 bar IP & VCR 16:1

The vary of BTE with load for diesel fuel and diesel-biodiesel-methanol blends at 200 bar injection pressure and VCR 16:1 is shown in the Fig. 15.

The brake thermal efficiency at 200 bar IP and at VCR 16:1 was increased with load for all fuel modes. The brake thermal efficiency of the blend B20% was higher than that of the conventional diesel fuel over the entire range of the load. The reason may be the extended ignition delay and the leaner combustion of biodiesel, resulting in a larger amount of fuel burned in the premixed mode of the methanol blends. The minimum brake thermal efficiency was observed with B10% and B30% at full load of the engine.

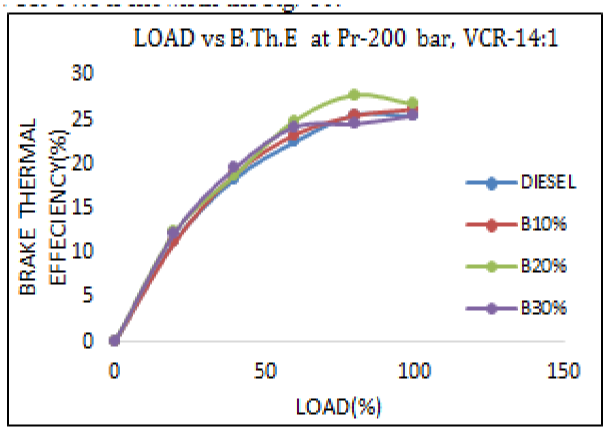

Fig 16. Vary of BTE with load at 200 bar IP & VCR 14:1

The vary of BTE with load for diesel fuel and diesel-biodiesel-methanol blends at 200 bar injection pressure and VCR 14:1 is shown in the Fig. 16.

The brake thermal efficiency at 200 bar IP and at VCR 14:1 was increased with load for all fuel modes. The brake thermal efficiency of the blend B20% was higher than that of the conventional diesel fuel over the entire range of the load. The minimum brake thermal efficiency was observed with diesel fuel at all load of the engine.

The vary of BTE with load for diesel fuel and diesel-biodiesel-methanol blends at 180 bar injection pressure and VCR 18:1 is shown in the Fig. 17.

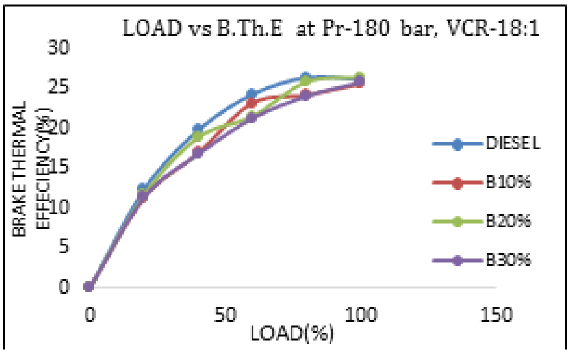

Fig 17. Vary of BTE with load at 180 bar IP & VCR 18:1

The brake thermal efficiency at 180 bar IP and at VCR 18:1 was increased with load for all fuel modes. The brake thermal efficiency of diesel fuel was higher than that of the diesel –biodiesel-methanol blends over the entire range of the load. The minimum brake thermal efficiency was observed with the blend B30% at all load of the engine.

The vary of BTE with load for diesel fuel and diesel-biodiesel-methanol blends at 180 bar injection pressure and VCR 16:1 is shown in the Fig. 18.

The brake thermal efficiency at 180 bar IP and at VCR 16:1 was increased with load for all fuel modes. The brake thermal efficiency of the blend B10% was higher than that of the conventional diesel fuel over the entire range of the load. The minimum brake thermal efficiency was observed with diesel fuel at medium load of the engine.

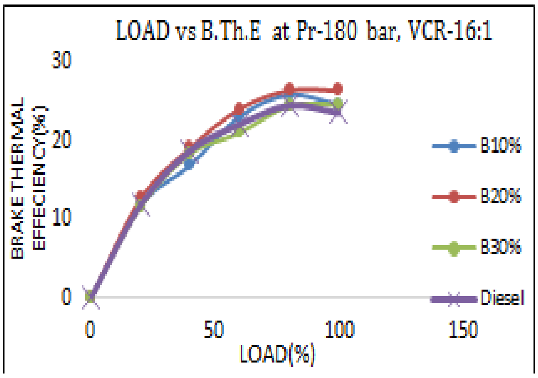

Fig 18. Vary of BTE with load at 180 bar IP & VCR 16:1

The vary of BTE with load for diesel fuel and diesel-biodiesel-methanol blends at 180 bar injection pressure and VCR 14:1 is shown in the Fig. 19.

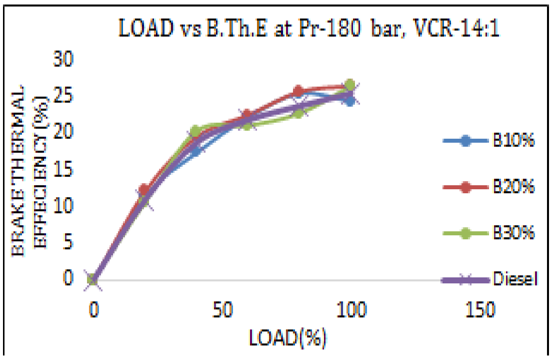

Fig 19. Vary of BTE with load at 180 bar IP & VCR 14:1

The brake thermal efficiency at 180 bar IP and at VCR 14:1 was increased with load for all fuel modes. The brake thermal efficiency of the blend B10% was higher than that of the conventional diesel fuel over the entire range of the load. The minimum brake thermal efficiency was observed with diesel fuel at medium load of the engine. The minimum brake thermal efficiency was observed with blend B20% at full load of the engine.

The vary of Volumetric efficiency (VE) with load for diesel fuel and diesel-biodiesel-methanol blends at 220 bar injection pressure (IP) and VCR 18:1 is shown in the Fig. 20. The volumetric efficiency at 220 bar IP and at VCR 18:1 was increased at medium load of the engine for all fuel modes. The volumetric efficiency of the blend B10% was higher than that of the conventional diesel fuel over the entire range of the load. The minimum volumetric efficiency was observed with diesel fuel at medium load of the engine.

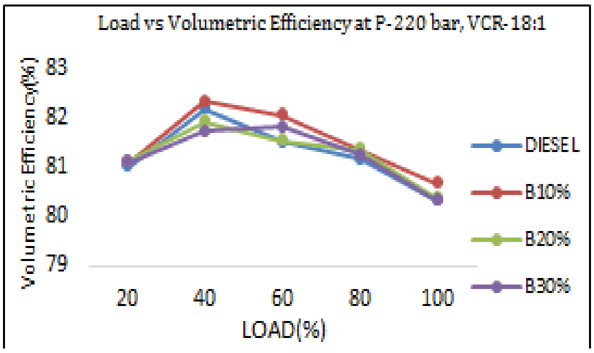

Fig 20. Vary of VE with load at 220 bar IP & VCR-18:1

The vary of Volumetric efficiency (VE) with load for diesel fuel and diesel-biodiesel-methanol blends at 220 bar injection pressure (IP) and VCR 16:1 is shown in the Fig. 21.

The volumetric efficiency at 220 bar IP and at VCR 16:1 was increased at medium load of the engine for all fuel modes. The volumetric efficiency of the blend B10% and B20% was higher than that of the conventional diesel fuel over the entire range of the load. The minimum volumetric efficiency was observed with blend 30%l at all load of the engine.

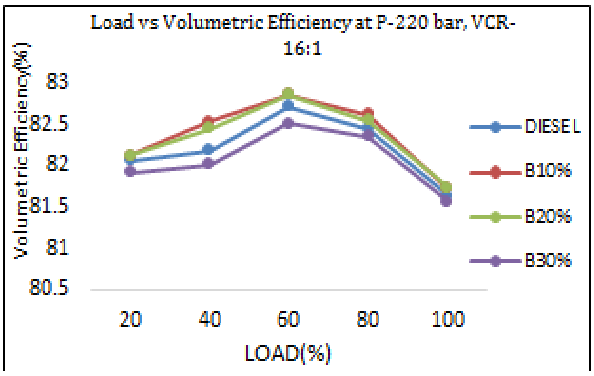

Fig 21. Vary of VE with load at 220 bar IP & VCR 16:1

The vary of Volumetric efficiency (VE) with load for diesel fuel and diesel-biodiesel-methanol blends at 220 bar injection pressure (IP) and VCR 14:1 is shown in the Fig. 22.

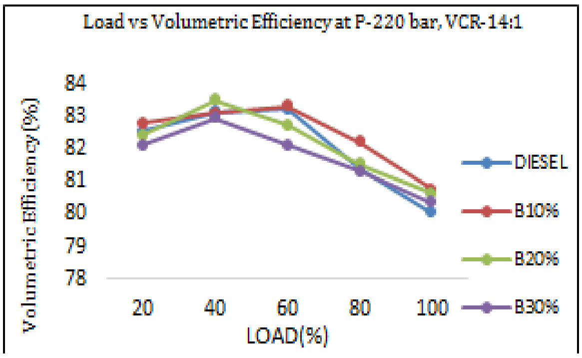

Fig 22. Vary of VE with load at 220 bar IP & VCR 14:1

The volumetric efficiency at 220 bar IP and at VCR 14:1 was increased at medium load of the engine for all fuel modes. The volumetric efficiency of the blend B10% was higher than that of the conventional diesel fuel over the entire range of the load. The minimum volumetric efficiency was observed with blend 30%l at all load of the engine.

The vary of Volumetric efficiency (VE) with load for diesel fuel and diesel-biodiesel-methanol blends at 200 bar injection pressure (IP) and VCR 18:1 is shown in the Fig. 23.

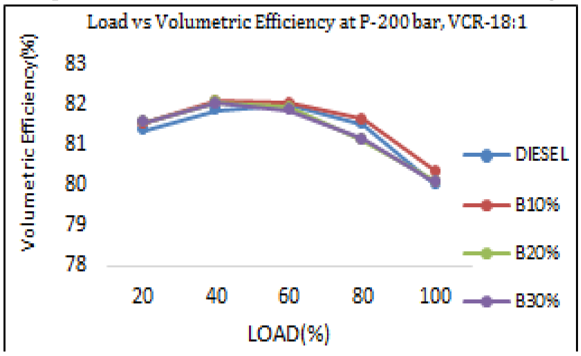

Fig 23. Vary of VE with load at 200 bar IP & VCR18:1

The volumetric efficiency at 200 bar IP and at VCR 18:1 was increased at medium load of the engine for all fuel modes. The volumetric efficiency of the blend B10% , B20% and B30% was higher than that of the conventional diesel fuel over the entire range of the load. The minimum volumetric efficiency was observed with diesel fuel at all load of the engine.

The vary of Volumetric efficiency (VE) with load for diesel fuel and diesel-biodiesel-methanol blends at 200 bar injection pressure (IP) and VCR 16:1 is shown in the Fig. 24.

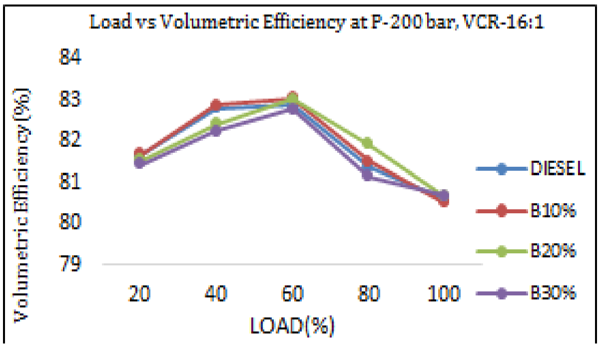

Fig 24. Vary of VE with load at 200 bar IP & VCR 16:1

The volumetric efficiency at 200 bar IP and at VCR 16:1 was increased at medium load of the engine for all fuel modes. The volumetric efficiency of the blend B10% and B20% was higher than that of the conventional diesel fuel over the entire range of the load. The minimum volumetric efficiency was observed with blend B30% at all load of the engine.

The vary of Volumetric efficiency (VE) with load for diesel fuel and diesel-biodiesel-methanol blends at 200 bar injection pressure (IP) and VCR 14:1 is shown in the Fig. 25.

The volumetric efficiency at 200 bar IP and at VCR 16:1 was increased at medium load of the engine for all fuel modes. The volumetric efficiency of the blend B10% and B20% was higher than that of the conventional diesel fuel over the entire range of the load. The minimum volumetric efficiency was observed with blend B30% at all load of the engine.

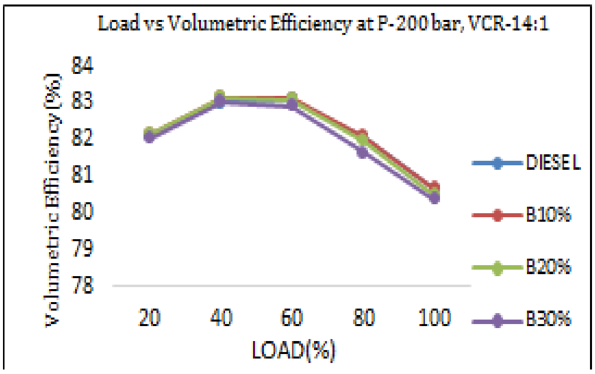

Fig 25. Vary of VE with load at 200 bar IP & VCR 14:1

The vary of Volumetric efficiency (VE) with load for diesel fuel and diesel-biodiesel-methanol blends at 180 bar injection pressure (IP) and VCR 18:1 is shown in the Fig. 26.

The volumetric efficiency at 180 bar IP and at VCR 18:1 was increased at medium load of the engine for all fuel modes. The volumetric efficiency of the blend B10% and B20% was higher than that of the conventional diesel fuel over the entire range of the load. The minimum volumetric efficiency was observed with diesel fuel at all load of the engine.

The vary of Volumetric efficiency (VE) with load for diesel fuel and diesel-biodiesel-methanol blends at 180 bar injection pressure (IP) and VCR 16:1 is shown in the Fig. 27.

The volumetric efficiency at 180 bar IP and at VCR 16:1 was increased at medium load of the engine for all fuel modes. The volumetric efficiency of the blend B10% and B20% was higher than that of the conventional diesel fuel over the entire range of the load. The minimum volumetric efficiency was observed with diesel fuel at all load of the engine.

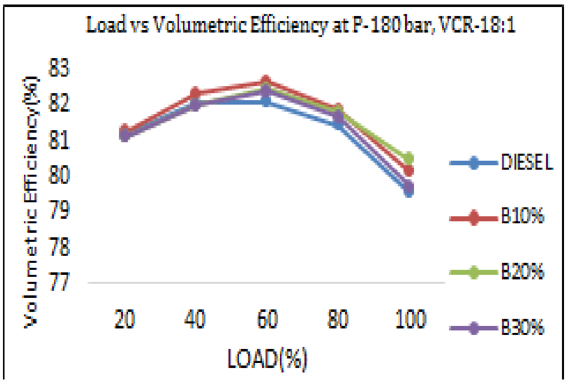

Fig 26. Vary of VE with load at 180 bar IP & VCR 18:1

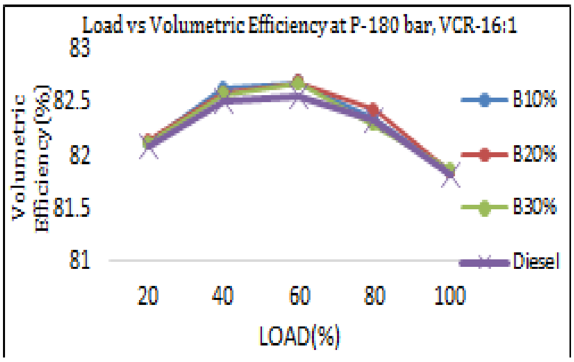

Fig 27. Vary of VE with load at 180 bar IP & VCR 16:1

The vary of VE with load for diesel fuel and diesel-biodiesel-methanol blends at 180 bar IP and VCR 14:1 is shown in the Fig. 28.

The volumetric efficiency at 180 bar IP and at VCR 14:1 was increased at medium load of the engine for all fuel modes. The volumetric efficiency of the blend B20% and B30% was higher than that of the conventional diesel fuel over the entire range of the load. The minimum volumetric efficiency was observed with diesel fuel at all load of the engine.

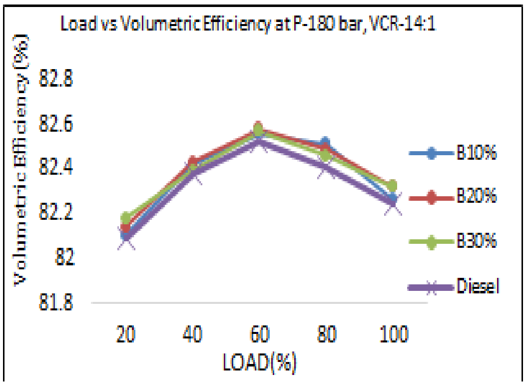

Fig 28. Vary of VE with load at 180 bar IP & VCR-14:1

Conclusions

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 volumetric efficiency of blend 10% was higher at 220 bar IP and at VCR 18:1 with load for all the fuel modes. The

- minimum volumetric efficiency of blend 30% fuel was observed at 180 bar IP and at VCR 16:1 with load for all the fuel modes.

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