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PERFORMANCE AND EMISSION EVALUATION OF A VCR DIESEL ENGINE USING MAHUA OIL METHYL ESTER

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ABSTRACT

An experimental study was conducted on the performance and emission characteristics of Variable Compression Ratio (VCR) Diesel engine with mahua oil methyl ester (MOME) blend. A four strokes, single cylinder, and water cooled engine of 3.5 kW rating and compression ratio 17:1, 17.5:1 and 18:1 was used for the experiment. Also the blend of B10 (10%MOME+90% Diesel), B20 (20%MOME+80% Diesel) and B30 (30%MOME+70% Diesel) biodiesel was used for conducting the performance and emissions tests at varying load conditions.

Various parameters such as brake thermal efficiency, brake specific fuel consumption and exhaust gas temperature emission of carbon monoxide, hydrocarbons, smoke and oxides of nitrogen gases in exhaust were recorded were recorded. The important properties of mahua methyl esters were compared with diesel fuel. The test results indicate that the fuel of B20 and compression ratio of 18 can be used in diesel engines without any engine modifications.

Key words: Bio-diesel, VCR Engine, Performance, Emission, Mahua oil.

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1. INTRODUCTION

Increasing petroleum prices, increasing threat to the environment from exhaust emissions and global warming have generated intense international interest in developing alternative nonpetroleum fuels for engines. The growing concern due to environmental pollution caused by the conventional fossil fuels and the realization that they are non-renewable have led to search for more environment friendly and renewable fuels.

An alternative fuel must be technically feasible, economically competitive, environmentally acceptable, and readily available. One possible alternative to fossil fuel is the use of oils of plant origin like vegetable oils and tree borne oil seeds. The alternative diesel fuel can be termed as biodiesel.

Among various options investigated for diesel fuel, biodiesel obtained from vegetable oils has been recognized world over as one of the strong contenders for reductions in exhaust emissions. The properties of the Mahua Oil were found to be within the biodiesel limits of various countries. Hence the Mahua Oil can be used as a substitute for diesel, for sustainable development of rural areas and as a renewable fuel.

Scientific name of Mahua oil is "Madhukaindica", botanical name is "Madura long folia". It is derived from a tropical tree belonging to the family Sapotaceae. Bio diesel from Mahua seed is important because most of the states of India is found abundantly. Mahua seed contain 30-40 percent fatty oil called Mahua oil.

Figure 1.1 Mahua seed

The Mahua tree starts bearing seeds from seventh year of planting. Mahua seed oil is a common ingredient of hydrogenated fat in India Due to high viscosity; mahua oil was transesterified into mahua oil methyl ester before using for the present work.

2. LITERATURE REVIEW

H. Raheman, S.V. Ghadge et al., [1] analysed the performance of biodiesel obtained from mahua oil and its blend with high speed diesel in a Ricardo E6 engine and he noticed that reductions in exhaust emissions and brake specific fuel consumption together with increase brake power, brake thermal efficiency made the blend of biodiesel (B20) a suitable alternative fuel for diesel and thus could help in controlling air pollution.

N. Saravanan, G. Nagarajan, et al., [2] Investigated Biodiesel is a fatty acid alkyl ester, which is renewable, biodegradable and non-toxic fuel which can be derived from any vegetable oil by transesterification. Engine performance tests showed that power loss was around 13% combined with 20% increase in fuel consumption with Mahua oil methyl ester at full load. Emissions such as CO, HC were lesser for Mahua ester compared to diesel by 26% and 20% respectively. Oxides of N_2 were lesser by 4% for the ester compared to diesel.

A. Haiter Lenin, et al.,[3] analyzed the mahua methyl esters and its blends with diesel were used as fuel. Various proportions of mahua methyl ester fuel blends (25% and 50%) were used for conducting the performance tests at varying load conditions. The test results indicate that the fuel of B25 can be used in diesel engines without any engine modifications.

Sukumar Puhan, G. Sankaranarayanan, et al., [4] in this investigation, Mahua Oil Ethyl Ester was prepared by transesterification using sulfuric acid (H2SO4) as catalyst and tested in a 4-stroke direct injection natural aspirated diesel engine. Results showed that brake thermal efficiency of Mahua Oil Ethyl Ester (MOEE) was comparable with diesel and it was observed that 26.36% for diesel whereas 26.42% for MOEE. Emissions of CO, HC, oxides of nitrogen and Bosch smoke number were reduced around 58, 63, 12 and 70%, respectively, in case of MOEE compared to diesel. Based on this study, MOEE can be used a substitute for diesel in diesel engine.

Sharanappa Godiganur, et al.,[5] analyzed the use of biodiesel fuel as substitute for conventional petroleum fuel and he noticed that the volumetric blending ratios of biodiesel with conventional diesel fuel were set at 0, 20, 40, 60, and 100. The results indicate that with the increase of biodiesel in the blends CO, HC reduces significantly, fuel consumption and NOx emission of biodiesel increases slightly compared with diesel.

M. C. Navindgi, et al.,[6] had investigated the performance of biodiesel obtained from mahua oil and its blends with diesel from 20%, 40% and 60% by volume for running a diesel engine.

The reductions in exhaust emissions and brake specific fuel consumption together with increase brake power, brake thermal efficiency made the blend of biodiesel (B20) a suitable alternative fuel for diesel and thus could help in controlling air pollution.

Himangshu Sekhar Brahma, et al., [7] had investigated the study of diesel engine emission characteristics using Mahua biodiesel (mahua oil methyl ester) with the help of a Three Way Catalytic converter (TWC) with DEF (Diesel Exhaust Fluid) by running the engine in steady state conditions. Almost 90% NOX emissions got reduced and the emission values recorded were much less when compared to Bharat stage- IV Norms for selected engine at all operated loads with retrofit arranged.

Gaurav Atravalkar, et al., analyzed the Vegetable oils offer an advantage of comparable fuel properties with diesel. It was found that Mahua could be easily substituted up to 20% in diesel without any significant difference in power output, brake specific fuel consumption and brake thermal efficiency. The performance of engine with Mahua oil blends improved with the increase in compression ratio from 16:1 to 20:1.

S.Rajasekaran, R.Gurumani et al., had tested Mahua oil methyl ester (MOME) as the alternate fuel for investigation. The exhaust gas temperatures were measured for different loads for pure diesel, pure Mahua oil and varying blends of diesel and Mahua oil in order to analyze the NOx emission levels.

3. METHODOLOGY

This chapter explains the methodology followed for the present work which starts from the baseline operation of a CI engine using direct injection of diesel. The methodology also involved development of experimental setup using a single cylinder, water-cooled, naturally aspirated, four-stroke diesel engine with all necessary instrumentation to measure the performance and emission characteristics.

In this method the VCR engine is used to implement the evaluation of performance and emissions of MOME biodiesel. The performance of the engine with mahua oil blends improved with the increase in compression ratio from 16 to 20:1. Hence the ratios 17:1, 17.5:1 and 18:1 are selected in this project to optimize. And also three blends of B10, B20 and B30 are selected to optimize the mahua biodiesel.

Hence by using the above methodology which compression ratio is best and which blend is best to optimize.

4. EXPERIMENTAL SETUP

The technical specifications of the engine used for the present work are given in table 5.1. It is a single cylinder, water cooled, naturally aspirated DI diesel engine having a rated output of 3.5 kW at 1500 rpm.

The schematic of the experimental setup used in this investigation is shown in Figure4.1

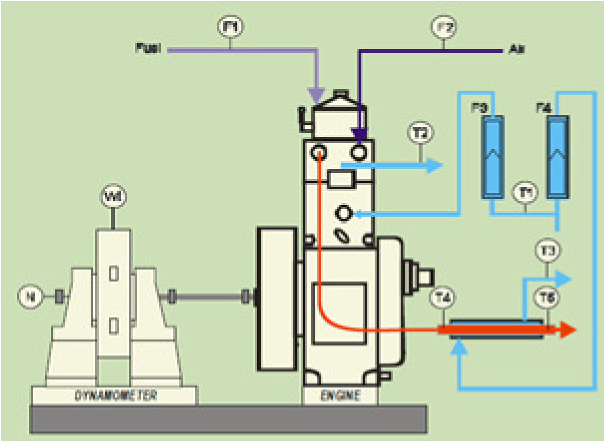

Figure 4.1 Schematic of the experimental setup

The setup consists of single cylinder, four stroke, VCR (Variable Compression Ratio) Diesel engine connected to eddy current dynamometer for engine 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.

The setup has stand-alone type independent panel box consisting of air box, fuel tank, and manometer, fuel measuring unit, digital speed indicator and digital temperature indicator. Engine jacket cooling water inlet, outlet and calorimeter temperature is displayed on temperature indicator.

Figure 5.2 Experimental setup

Rota meters are provided for cooling water and calorimeter flow measurement. The setup enables study of VCR engine performance for brake power, BMEP, brake thermal efficiency, volumetric efficiency, specific fuel consumption, and air fuel ratio and heat balance. Set up is supplied with MS Excel program for Engine Performance Analysis.

5. RESULTS AND DISCUSSION

The results obtained from the present work are discussed in this chapter. The performance and emission characteristics of the engine observed during the present work are detailed. All the results are presented with a comparison between the characteristics of conventional diesel, mahua oil methyl ester in conventional mode with blend B10, B20 and B30 and compression ratio of 17:1,17.5:1 and18:1 are discussed

PERFORMANCE CHARACTERISTICS

5.1. Brake Thermal Efficiency

The effect of brake thermal efficiency over various loads is shown in Figure. There is a steady rise in brake thermal efficiency as the load increases.

For CR 17:1

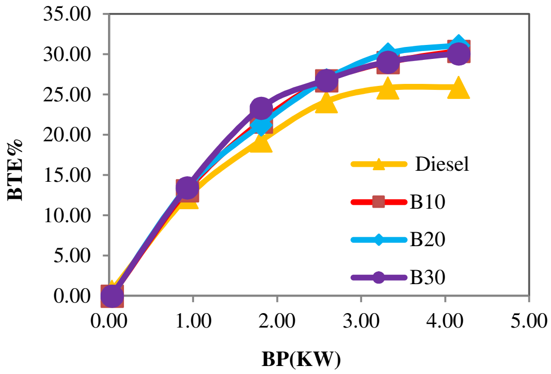

Figure 5.1 Brake power Vs Brake thermal efficiency

For CR 17.5:1

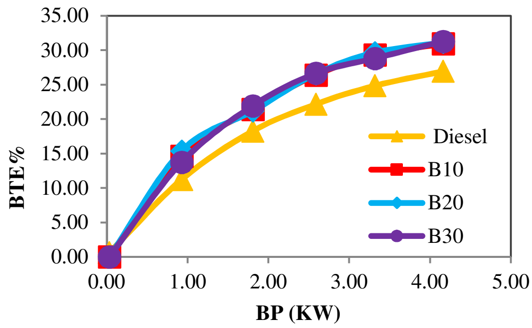

Figure 5.2 Brake power Vs Brake thermal efficiency

For CR 18:1

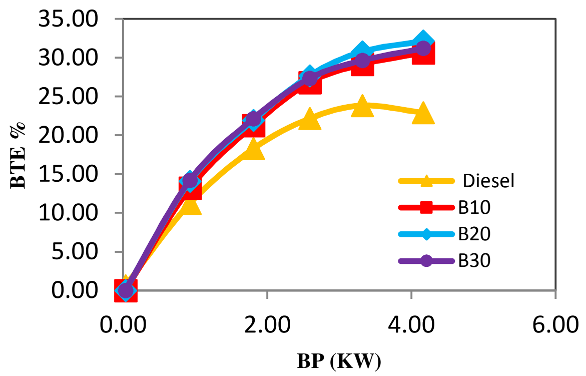

Figure 5.3 Brake power Vs Brake thermal efficiency

5.2. Brake Specific Fuel Consumption

The effect brake specific fuel consumption over various loads is shown in Figure. There is a gradual decrease in brake specific fuel consumption as the load increases.

For CR 17:1

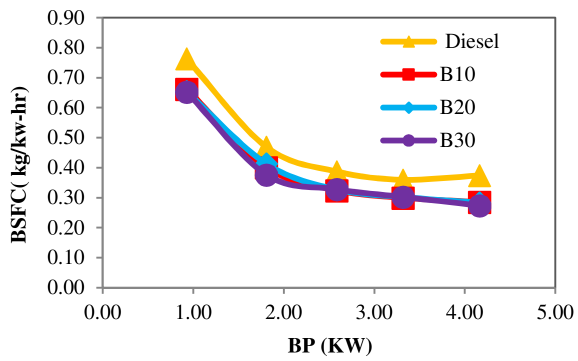

Figure 5.4 Brake power Vs BSFC

For CR 17.5:1

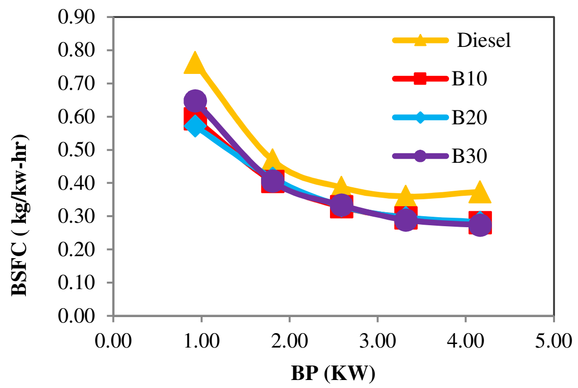

Figure 5.5 Brake power Vs BSFC

For CR 18:1

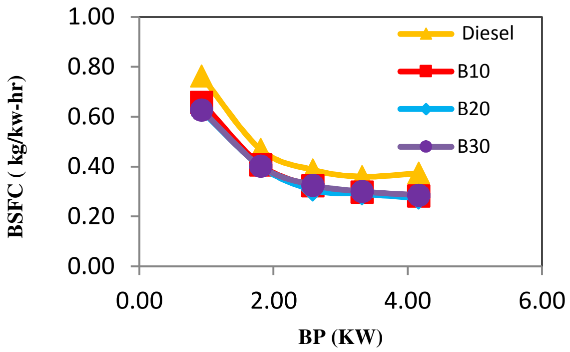

Figure 5.6 Brake power Vs BSFC

6.3. Exhaust Gas Temperature

The effect exhaust gas temperature over various loads is shown in Figure. There is a gradual increase in exhaust gas temperature as the load increases.

For CR 17:1

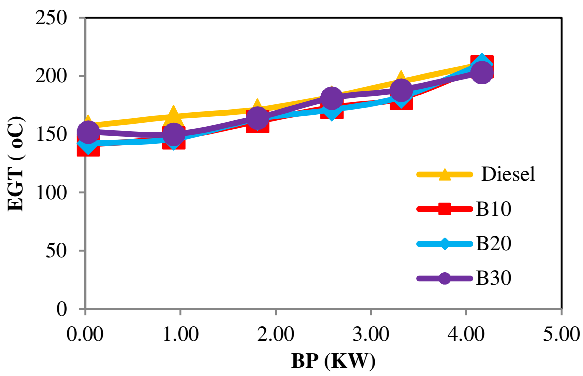

Figure 5.7 Brake power Vs Exhaust gas temperature

For CR 17.5:1

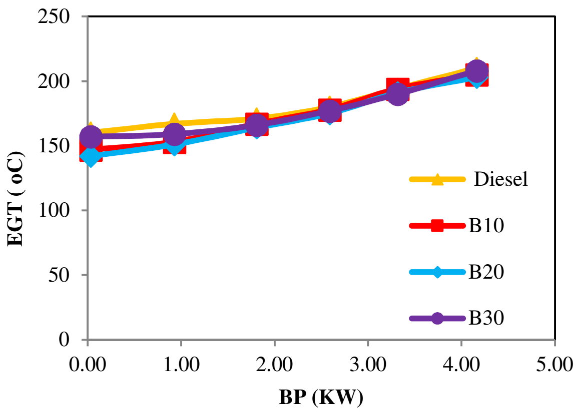

Figure 5.8 Brake power Vs Exhaust gas temperature

For CR 18:1

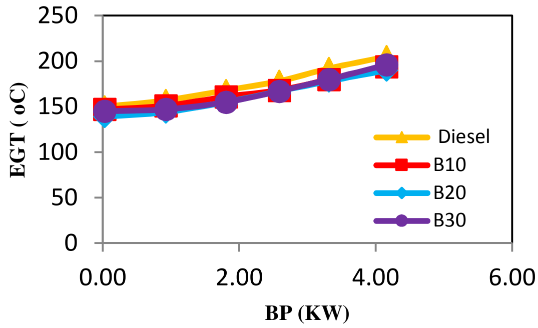

Figure 5.9 Brake power Vs Exhaust gas temperature

The EGT is slightly higher for CR18 than CR17. The blend lowers the exhaust gas temperature over the entire range of the load. This is a welcome feature as it would prolong the life of the exhaust valve.

EMISSION CHARACTERISTICS

5.4. Carbon Monoxide Emissions

The effect of carbon monoxide over various loads is shown in Figure. There is a gradual decrease in carbon monoxide as the load increases.

For CR 17:1

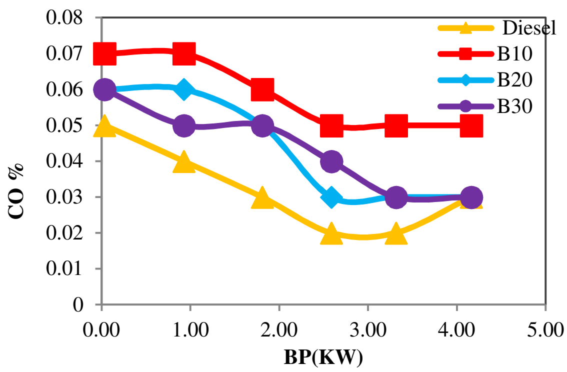

Figure 6.3.1.1 Brake power Vs CO

For CR 17.5:1

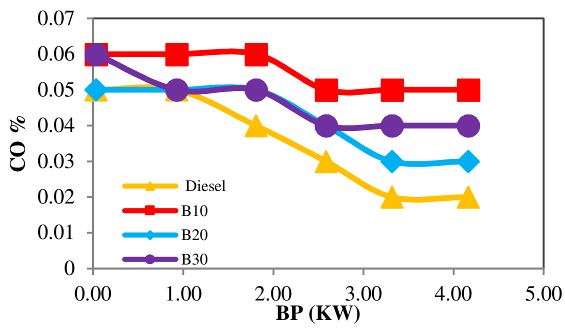

Figure 5.10 Brake power Vs CO

For CR 18:1

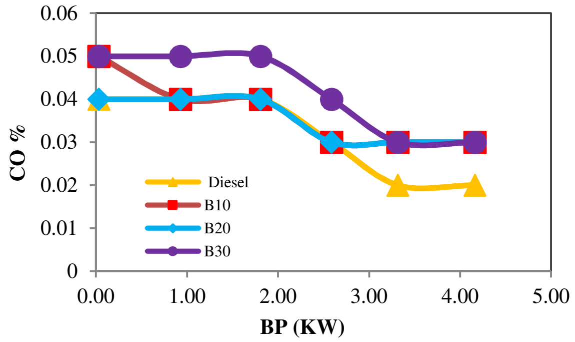

Figure 5.11 Brake power Vs CO

6.3.2. Hydrocarbon Emissions

The effect of hydro carbon over various load is as shown in Figure. There is a gradual increase in hydro carbon as the load increases.

For CR 17:1

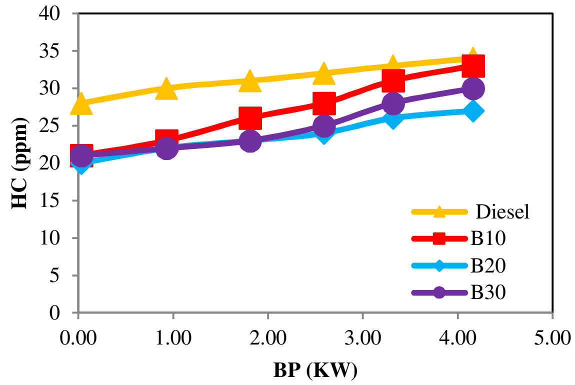

Figure 5.12 Brake power Vs HC

For CR 17.5:1

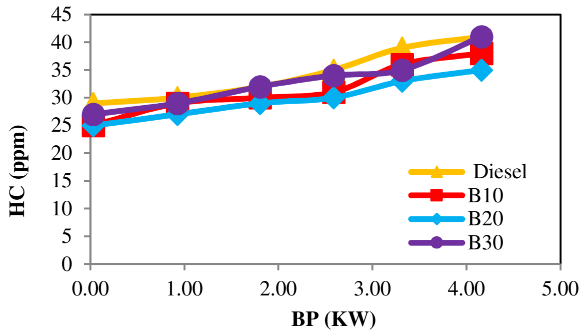

Figure 5.13 Brake power Vs HC

For CR 18:1

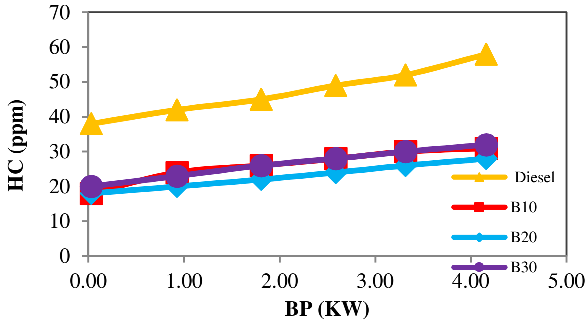

Figure 5.14 Brake power Vs HC

6.3.3. Oxides Of Nitrogen Emissions

The effect of oxides of nitrogen over various load is as shown in Figure. There is a gradual increase in oxides of nitrogen as the load increases.

For CR 17:1

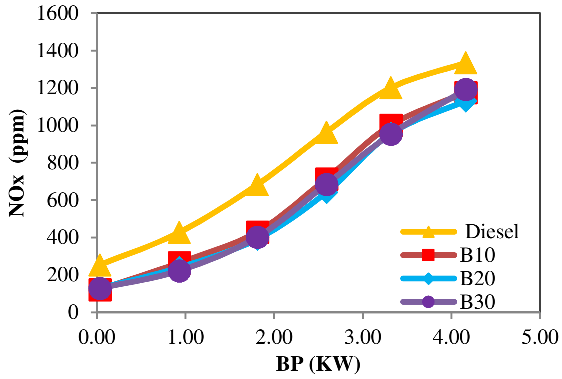

Figure 5.15 Brake power Vs NOx

For CR 17.5:1

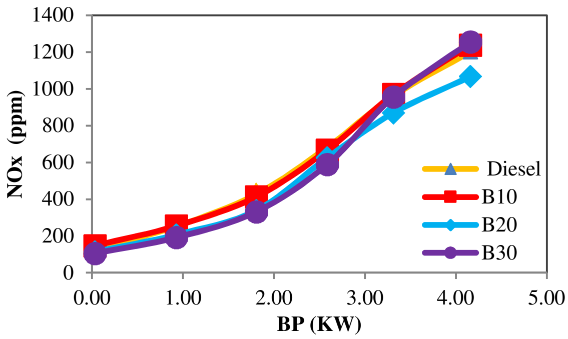

Figure 5.16 Brake power Vs NOx

For CR 18:1

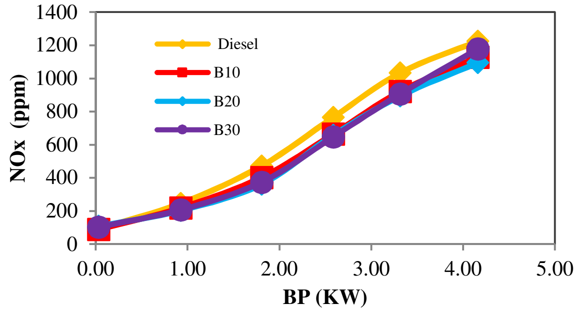

Figure 5.17 Brake power Vs NOx

6.3.4. Smoke Emissions

The effect of smoke over various load is as shown in Figure. There is a gradual increase in smoke as the load increases.

For CR 17:1

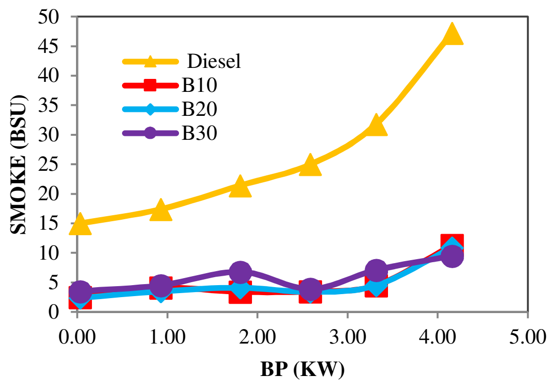

Figure 5.18 Brake power Vs Smoke

For CR 17.5:1

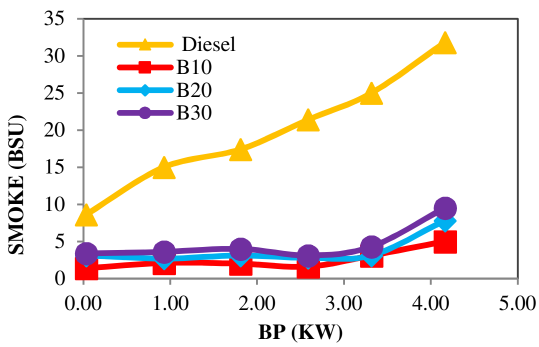

Figure 5.18 Brake power Vs Smoke

For CR 18:1

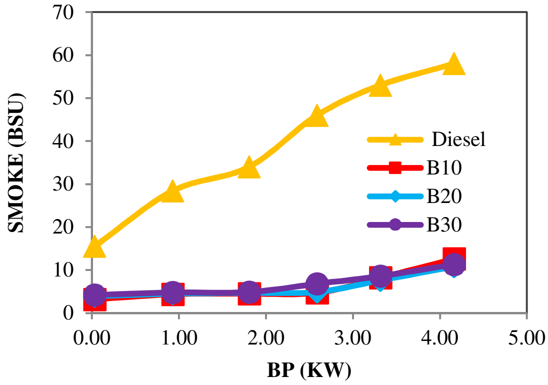

Figure 5.19 Brake power Vs Smoke

8. CONCLUSION

An experimental study was carried out on a VCR engine, compression ratios of 17:1, 17.5:1 and 18:1 using mahua oil methyl ester blends of B10, B20 and B30 were used the performance and emission characteristics were compared with the characteristics of conventional diesel. The following conclusions were inferred from the experiments:

- There is a steady increase in brake thermal efficiency.
- There is a gradual decrease in brake specific fuel consumption.
- There is a gradual increase in exhaust gas temperature.
- The emission of CO is high and the other emissions HC, NOx and Smoke are reduced by using MOME biodiesel.

Hence based on the investigation B20 (20% MOME+80%diesel) can be a better substitute fuel and CR18 is better compression ratio for VCR diesel engine without any modification.

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