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Comparison of Engine Performance and Emissions for W20 and P20 Methyl Ester Blends as Fuel

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Abstract

Demand for energy in transportation, industrial and other energy sectors has led to the huge consumption of fossil fuels. This has directly affected on climatic issues, global warming as well as financial status of a country. In order to reduce these problems biofuels have been used in the engines. The present work reports the performance and emission studies conducted on an engine for W20 (waste cooking oil methyl ester 20% + diesel 80%) blend and P20 (pongamia methyl ester 20% + diesel 80%) blends on volume basis tested on a single cylinder 4-stroke water cooled compression ignition direct injection engine. At 2.2kW engine loading Brake Thermal Efficiency (BTE) for W20 and P20 blends are 2.11% and 5.92% lesser than that of diesel fuel. Brake Specific Fuel Consumption (BSFC) for W20 and P20 blends are 2.386% and 0.198% higher than that of diesel respectively. Exhaust Gas Temperature (EGT) for W20 and P20 blends are 6.89% and 3.44% greater than that of diesel respectively. Carbon Monoxide (CO) emissions for W20 and P20 blends are 0.046%, 0.04% lower, Carbon Dioxide (CO_2) emissions for W20 and P20 blends are 0.33% and 0.18% higher than that of diesel respectively. Hydro Carbon (HC) emissions for W20 blend is 56% higher and P20 blend is 12% lower when compared with diesel. Oxides of Nitrogen (NOx) for W20 and P20 blends are 18.87% and 1.72% larger than that of diesel. Therefore, P20 blend fuel is good when compared to W20 blend fuel.

Keywords: *Emissions, P20, W20, Blend Fuel*

1.0 Introduction

Fossil fuels have now been an integral part of life throughout the globe. In recent years' transportation sector, mining sector, industrial sector, agricultural sector and many other sectors are in need of more energy. Energy for majority of sectors such as underground mining mainly depends on fossil fuels as many of the equipments are run by burning fossil fuels. The emissions released from these fossil fuels in the mines are harmful to the labourers. In India every year due to rise in energy demand huge quantity of crude oil barrels have been imported continuously and these imports are rising year by year. On the other hand, huge burning of fossil fuels has also led to rise in global warming levels, increase in harmful emissions, which have resulted in changes in climatic conditions such as irregular rainfalls and drought conditions. To overcome these problems, we need to opt for alternatives which can meet our daily energy demand, also cause less harm to the environment. As an alternative solution there are a lot of non-edible oil seeds available on the earth which if processed carefully, then they can be converted in to biodiesels and can be used in engines. Biodiesels are obtained from plant oilseeds by undergoing

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transesterification process. These biodiesels have good lubricity properties as well as their performance characteristics matches near to that of diesel with lower emissions levels except NO_x. In underground mining these lower emissions from biodiesel can reduce air pollution levels. Biodiesels in rural places are a source of revenue to the farmers as well as an opportunity for birth of local entrepreneurs. Increase in biodiesel consumption not only solves the problems of air pollution, globally warming but also boosts the country's economy by contributing through increase in gross domestic product of a country. M. Jamshaid *et al*.,[1] conducted emission and performance test on B20 blend of cotton seed and palm oil biodiesels. He reported that mixed blended biodiesels have reduced BTE, reduced HC and CO emissions. Siraj Sayyed *et al*.,[2] conducted emission and performance tests on compression ignition engine of direct injection fueled with Karanja, Neem, Jatropha and Mahua as dual biodiesel blends. He concluded that performance parameters such as BTE, Air-Fuel (A/F) ratio, mechanical and volumetric efficiencies decreased, whereas there was a rise in brake specific energy consumption and EGT when compared with neat diesel. Also there was a reduction in CO for D90+JB5+NB5 blend. Sudalaiyandi *et al*.,[3] carried test for the triple biodiesel mixture prepared from rubber seed and linseed oil as fuel for engines. He reported that engine performance with combined biodiesel blends gave optimum results and can be used to run diesel fuelled engines without any modifications. El-Baz *et al*.,[4] conducted test using blends of B10 and B20 from used cooked oil, Jatropha and algal biodiesel blends. They reported that these blends represented higher performance with dropped emissions levels when compared with diesel. Sattar Jabbar *et al*.,[5] experimented test on an engine using mixture of butanol acetone blended with cotton seed biodiesel. He reported that there was a small improvement in Brake Power (BP) resulting in increase in BTE with reduction in HC. Vergel-Ortega *et al*.,[6] conducted test on diesel engine using sunflower oil, palm oil biodiesel blends with ethanol. He concluded that adding ethanol by 4%, there was a slight increase in BTE with reduction in CO, CO_2, HC, NO_x emissions. Ibrahim *et al*.,[7] investigated the performance and emissions of the engine by mixing rubber seed biodiesel and palm biodiesel blends in varying proportions on multi cylinder engine at varying load conditions. He reported that biodiesel blend mixtures when used in engine there was a rise in BTE with drop in BSFC also reduction in engine emissions. Abed *et al.*[8] conducted performance and emission test on a four stroke single cylinder compression ignition engine using waste cooking oil biodiesel blends. He reported that BTE for biodiesel blends of waste cooking oil are shorter, with BSFC and EGT higher when compared to diesel. There was reduction in smoke opacity, CO, CO_2, HC with increase in NO_x emissions.

2.0 Materials and Methods

Waste cooking oil is a domestic product which is obtained after cooking of food, fried items at high temperatures. This is collected from hotels, restaurants and function halls. It is then processed to remove the solid, dust particles then it is further processed by transesterification. In transesterification process waste cooking oil along with ethanol and sodium hydroxide are heated to a temperature of 60°C-70°C for 2 to 3 hours. Then the sample is allowed to settle and water washing process is further carried out to extract methyl ester of waste cooking oil.

Pongamia biodiesel is prepared using pongamia oil seeds. Pongamia oil is extracted from the seeds using

Table 1. Physical properties of diesel, W20 and P20 blends

Properties	Diesel	W20	P20
Mass Density [kg/m^3]	820	839	852
Kinematic viscosity [cSt]	2.41	5.2	5.8
Fire point [°C]	68	78	71
Flash point [°C]	59	65	60
Calorific value [kJ/kg]	44316	41739	41472

oil expeller. Then pongamia oil along with ethanol and sodium hydroxide are heated for 2 to 3 hours at a temperature of 60°C-70°C to undergo transesterification process as explained in the above paragraph. After water washing the sample collected is known as pongamia methyl ester. Pongamia plant is also known as Karanja and Honge. It is easily grown in northern parts of Karnataka. It needs less water, sunny area for its survival.

From the above research works it can be reported that a very less amount of work has been carried on comparison of W20 blend and P20 blend with diesel. The physical properties of diesel, W20 and P20 blends are represented in Table 1.

2.1 Experimental Details

The experimental tests are conducted on a 4 stroke, compression ignition direct injection single cylinder, engine. An engine test setup layout is shown in Figure 1.

Performance and emission tests are carried on a four stroke water cooled single cylinder diesel engine. Diesel, W20 and P20 blends are tested on engine by varying load conditions. For every load applied parameters such as amount of fuel consumed, amount of air consumed, exhaust gas temperature, cooling water inlet, outlet conditions, CO, HC, CO_2 and NO_x emissions are recorded. Once the load is applied we wait for an average time of 20 minutes so that engine attains stabilization condition. Now fuel consumption is recorded on volume basis where time required for 10 cubic centimeters of fuel is consumed by engine. Air consumption is recorded using U-tube manometer with thermocouple mounted on the exhaust gas pipe measuring exhaust gas temperature. Cold water inlet and hot water outlet temperatures are also recorded by thermocouples for 100 liters per hour of water supply regulated by rotameter. Engine emissions are recorded by AVL 444 exhaust gas analyzer as shown in Figure 2 for the blends tested.

Table 2. Detailed engine specifications

Parameter	:	Specifications
Engine make	:	Kirloskar
Engine Power	:	3 kW
Speed	:	1500rpm
Compression ratio	:	16.5:1
Number of cylinder	:	1
Number of strokes	:	4
Bore	:	87.5mm
Stroke length	:	110mm
Injection pressure	:	200 bar
Injection timing	:	23°bTDC
Dynamometer	:	Eddy current type
Cooling	:	Water cooled

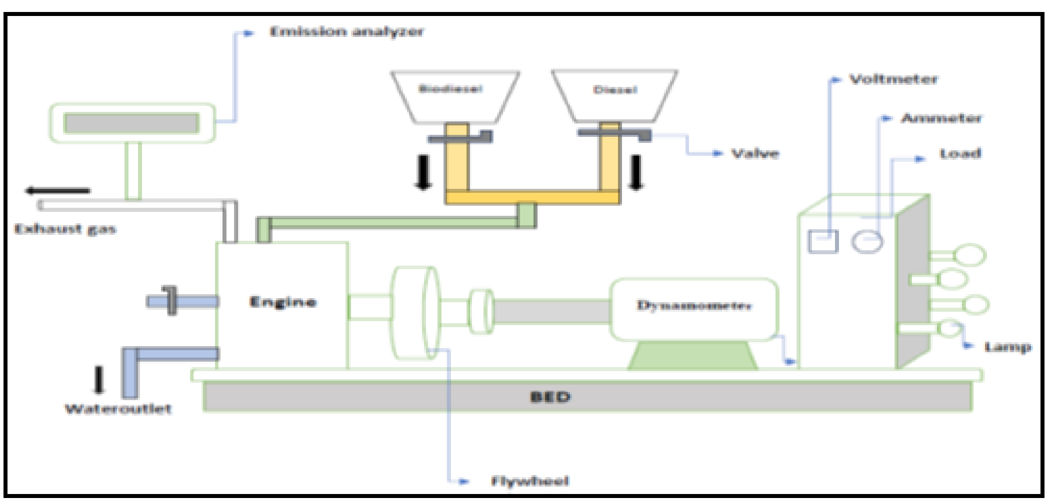

Figure 1. Experimental layout for a four stroke water cooled single cylinder compression ignition direct injection engine.

Figure 2. AVL 444 five gas analyser.

The compression ignition engine specifications are listed in Table 2

3.0 Results and Discussions

3.1 Brake Thermal Efficiency

It is defined as the quantity of energy contributed by the fuel to the useful power generated as engine output. Brake thermal efficiency rises with increment in load input for biodiesel blends and diesel as shown in Figure 3. Diesel fuel has highest energy conversion efficiency when compared to biodiesel blends. At 2.2kW brake thermal efficiency for W20 blend is 2.11% and P20 blend is 5.92% lower than that of diesel. This is due to lower energy content present in the biodiesel blends with higher density values resulting in reduced vaporization and poor atomization.

3.2 Brake Specific Fuel Consumption

It is the ratio of rate of total fuel consumption to the maximum engine power output. It is mainly influenced by quantity of fuel injected, mass density and heating value properties of fuel. BSFC drops with increment in load for biodiesel blends and diesel as shown in Figure 4. W20 and P20 blends follow the diesel trend with slight variation. At 2.2kW brake specific fuel consumption for W20 blend is 2.386% and P20 blend is 0.198% higher than that of diesel.

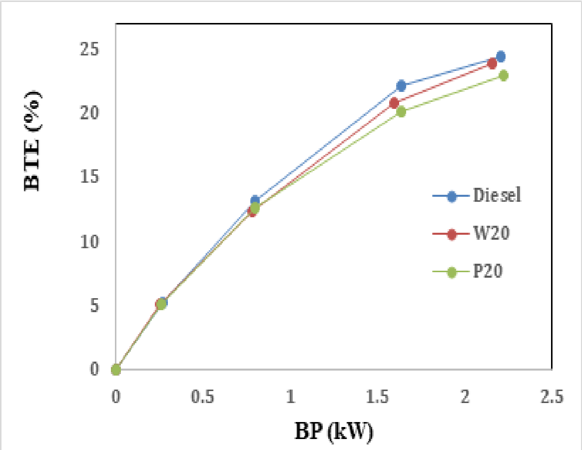

Figure 3. Comparison of W20 and P20 on BTE at various BP.

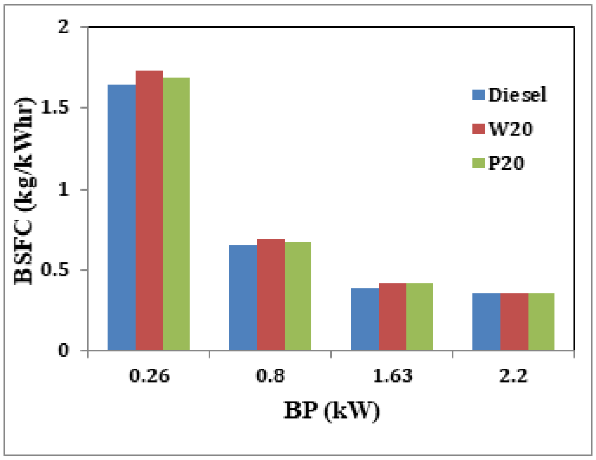

Figure 4. Comparison of W20 and P20 on BSFC at various BP.

It is mainly due to increase in viscosities, more quantity of fuel injected, improper mixing with air in combustion chamber resulting in poor combustion.

3.3 Exhaust Gas Temperature

It is also an engine parameter which represents the combustion quality developed within the combustion chamber and heat energy utilized for developing brake power. It rises with increment in loads for all the fuels tested as represented in Figure 5. EGT for blends of biodiesel is less in comparison with diesel up to a load of 1.63kW, which is mainly because of extra content of oxygen available in the blends of biodiesel resulting in good combustion. At 2.2kW EGT for P20 blend is 3.44% and W20 blend is 6.89% higher than that of diesel which is mainly because of more quantity of fuel injected with less time for combustion resulting in rise in EGT.

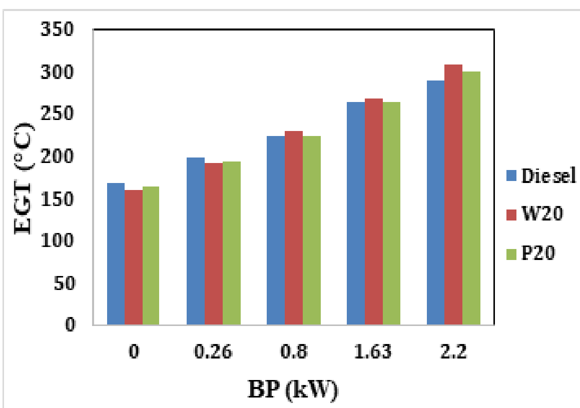

Figure 5. Comparison of W20 and P20 on EGT at various BP.

3.4 Carbon Monoxide

Carbon monoxide is a colourless, toxic, odourless gas developed due to improper combustion. CO for blends of biodiesel decreases with rise in load when compared with diesel as shown in Figure 6. At 2.2kW carbon monoxide emission for W20 and P20 blends are 0.046%, 0.04% lower than that of diesel. This is because of extra content of oxygen present in the biodiesel blends resulting in oxidation.

3.5 Carbon Dioxide

This gas formation is mainly due to complete fuel burning, leading to good combustion inside the engine. It is also a

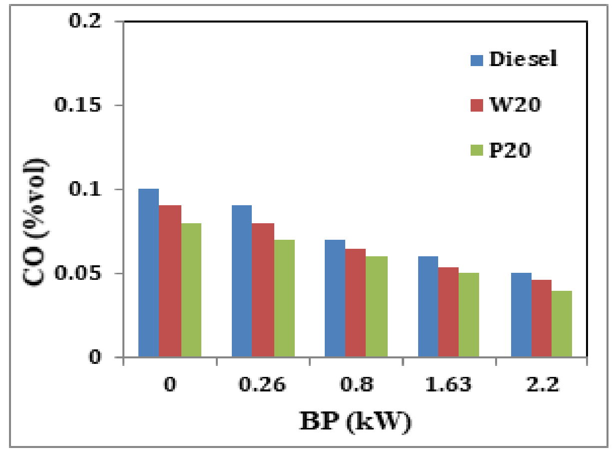

Figure 6. Comparison of W20 and P20 on CO at various BP.

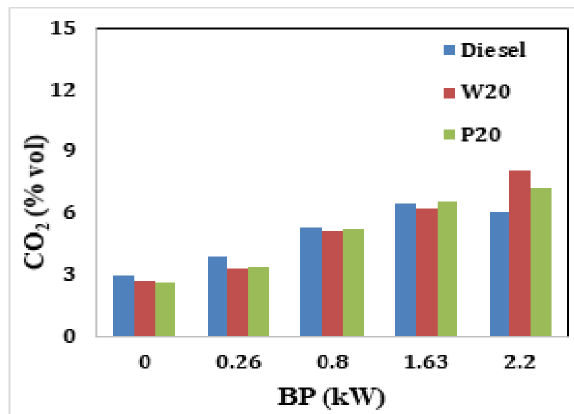

Figure 7. Comparison of W20 and P20 on CO_2 at various BP.

colourless, odourless, non toxic gas. Emission of carbon dioxide gas increases with increment in load for biodiesel blends and diesel as shown in Figure 7. It is lower for blends of biodiesel when compared with diesel up to 1.63kW. At 2.2kW for W20 and P20 blends are 0.33%, 0.18% higher than that of diesel. It is due to the presence of extra oxygen content present in blends of biodiesel leads to oxidation which in turn increases carbon dioxide formation.

3.6 Hydrocarbon

Hydrocarbon emissions are due to insufficient mixing of fuel and air which also leads to improper combustion. Hydrocarbon emission for blends of biodiesel decreases up to part load condition as shown in Figure 8. At 2.2kW,

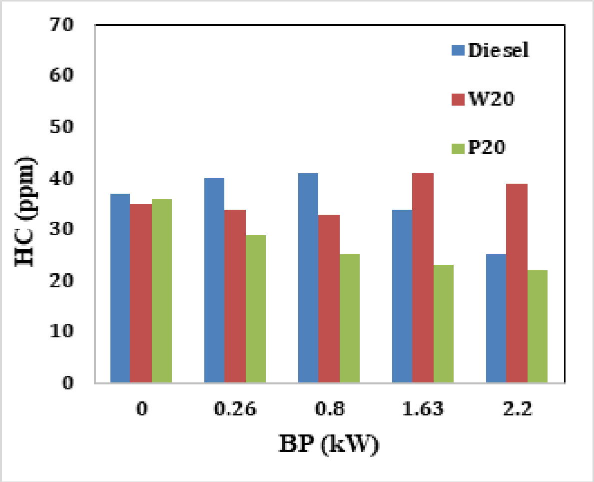

Figure 8. Comparison of W20 and P20 on HC at various BP.

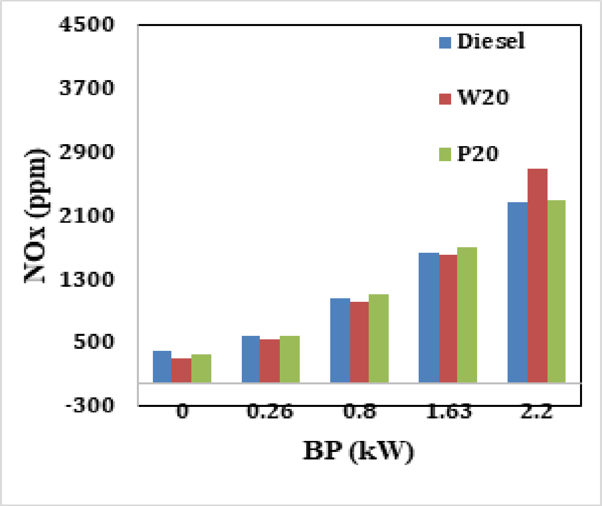

Figure 9. Comparison of W20 and P20 on NOx at various BP.

P20 blend shows 12% lesser emission, W20 blends showed 56% more emission in comparison with diesel. For P20 blend fuel properties such as lower viscosity, lower density which helped for proper mixing of fuel and air, leading to good fuel combustion resulting in low emission.

3.7 Oxides of Nitrogen

Oxides of nitrogen increases with increment in load for blends of biodiesel and diesel as shown in Figure 9. Oxides of nitrogen formation are mainly due to temperature of engine cylinder and oxygen content available in the fuel. At 2.2kW oxides of nitrogen for W20 and P20 blends are 18.87%, 1.724% more than that of diesel. In P20 blend the temperature of exhaust gas is relatively lower when compared to W20 blend and diesel, also proper combustion leads to decrease in NOx emission.

4.0 Conclusions

The experimental research work was carried out to compare the engine performance and emission parameters of W20 and P20 blends. The following conclusions were noted down at 2.2kW engine loading.

- Brake thermal efficiency for W20 and P20 blends are 2.11% and 5.92% lower than that of diesel.
- Brake specific fuel consumption for W20 and P20 blends are 2.386% and 0.198% higher than that of diesel fuel respectively.
- Temperature of exhaust gas for W20 and P20 blends are 6.89% and 3.44% larger than that of diesel respectively.
- Carbon monoxide emissions for W20 and P20 blends are 0.046%, 0.04% lower than that of diesel respectively.
- Carbon dioxide emissions for W20 and P20 blends are 0.33% and 0.18% larger than that of diesel respectively.
- Hydro carbon emissions for W20 blend is 56% higher and P20 blend is 12% lower when compared with diesel.
- Oxides of nitrogen for W20 and P20 blends are 18.87% and 1.72% larger than that of diesel.

It can be concluded that P20 blend has lower temperature of exhaust gas with reduced emissions when compared with W20 blend and can be preferred in engines. Also these blends of biodiesel can be used in underground mining equipments as their emissions are less when compared with the diesel fuel. This helps to reduce the air pollution within the mines.

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