Experimental Investigations on Performance of Mixture of Jatropha and Cottonseed Biodiesel as Alternative Fuel for Diesel Engines

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1. Abstract

The increasing industrialization and motorization of the world has led to a steep rise for the demand of fossil fuels. Petroleum-based fuels are obtained from limited underground fossil fuel resources. These finite resources are extremely concentrated in certain regions of the world. Hence, it is necessary to look for alternative fuels which can be produced from locally available resources within the country such as biodiesel. Biodiesel is one of the potential alternatives to petroleum diesel, as its properties are very comparable to diesel. In the previous studies there are several works on the consumption of biodiesel and its blends in diesel engines have been performed and it is evident that single biodiesel offer acceptable engine performance and emissions for diesel engine operation. But, very few works have been conducted with the combination of diesel and two different biodiesel as an alternative fuel. In this context, this study have been investigated the performance and emission characteristics of the mixture of Jatropha and Cottonseed biodiesel (B_{20}JCB) with the conventional diesel in diesel engine. The Vertical, 4-Stroke cycle, Single acting, Single cylinder, high speed compression ignition diesel engine was used for the experiments. The eddy current electrical dynamometer was used to read the engine performance and the exhaust emission was analyzed using Cryptone290 five gas analyzer. The blend were prepared as B_0(pure diesel), B_{20} JB (Jatropha biodiesel blend), B_{20} CB (Cottonseed biodiesel blend), and B_{20}JCB (Jatropha and Cottonseed biodiesel blend) for the comparison. The result investigated that mixing of biodiesel from Jatropha and Cottonseed oil were used to improve the high viscosity and density of cottonseed biodiesel, and to provide better cold weather operation of cottonseed biodiesel. From the performance test results the mixture of

Jatropha and Cottonseed biodiesel blend (B_{20}JCB) shows 4.14% reduction of brake thermal efficiency compared to pure diesel (B_0). And brake specific fuel consumption of B_{20}JCB was increased by 20.3% compared to pure diesel(B_0). From the emission test result B_{20}JCB shows 0.02% reduction of CO, but HC and NO_X emission was increased by 13.2% and2.3% respectively compared to B_0. Generally, it may be concluded from the experimental investigations that the mixture of Jatropha and Cottonseed biodiesel blend can become an alternative source of fuel in the future.

Key words: Biodiesel, Jatropha, Cottonseed, transesterification, characterization, diesel engine, performance, emission

2. INTRODUCTION

Currently most countries in the world are dependent on petroleum fuel to fulfill their energy requirements. Increase in energy demand due to growth in population has affected the underground fossil fuel resources. In order to counter this problem, researchers are looking for alternative sources of energy. Biodiesel is one of the potential alternatives to petroleum diesel, as its properties are very comparable to diesel. Moreover, biodiesel is mainly derived from renewable feedstocks like edible, non-edible oils or animal fats .

3.MATERIALS AND METHODS

In order to successfully achieve the general as well as specific objectives of the study there would be a combination of materials and methods planned to use. These are the extraction of the oil from the Jatropha seed, production of biodiesel from jatropha and cottonseed oil, characterizing the properties of the biodiesel produced, blending, and performance and emission testing of the blended fuels in the diesel engines.

3.1. Materials

The Jatropha seed was obtained from Batti and cottonseed oil was purchased from Addis mojjo oil company. Methanol, Potassium hydroxide, and Distilled water were purchased from chemical selling and suppliers companies (Ranchem chemicals Plc, Addis Abeba) for laboratory scale amount. All chemicals used for the research were analytical grade. Additional materials were used for biodiesel production in this research: volumetric flasks, beakers, measuring cylinders, separator funnels, protective equipment's, thermometer, hot plate with magnetic stirrer and digital balance.And the material were used for performance and emission testing: Vertical, 4-Stroke cycle, Single acting, Single cylinder, high speed compression ignition diesel engine, eddy current dynamometer and Cryptone 290 five gas analyzer.

4. RESULTS AND DISCUSSION

This chapter discuss the result of each test. Effect of load on engine performance and emission characteristics of jatropha biodiesel, cottonseed biodiesel, mixture of jatropha and cottonseed biodiesel blend and pure diesel were investigated in the test engine. Engine performance was measured in terms of brake specific fuel consumption, brake thermal efficiency and specific energy consumption and engine exhaust emission was measured in terms of carbon mono oxide (CO), carbon dioxide (CO_2), nitrogen oxide(NO_X),and hydrocarbon(HC).And the engine performance and exhaust emission of standard diesel fuel was compared with all tested blends.

4.1. Extraction of Jatropha Oil

The amount of oil extracted from the seeds was calculated according to the formula given in the methodology (Eq.3.1). The machine extracts about 20% (m/m ratio) of Jatropha oil (i.e. from 20 kg Jatropha seed 4 kg oil were obtained) from the seed sample. If the residue from mechanical pressing was again continued to chemical extraction method, more oil had been expected from the sample; but this method was not applied to the residue after mechanical pressing.

4.2. Biodiesel Yield

The biodiesel production was done by transestrification reaction process using methanol alcohol and KOH catalyst. After washing five times by distilled water and drying the biodiesel production yield is found to be 82% and 80 % for cottonseed and Jatropha, respectively.

Table 4-1 Reaction Condition and Biodiesel Yield

Sample name	Molar ratio	Oilsample (ml)	Methanol (ml)	KOH (%W/V)	Reaction temp.(^{o}c)	Reactiontime (minutes)	Yield %
Cottonseed	1:6	500	150	1	53	45	82
Jatropha	1:6	500	150	1	60	40	80

4.3. Characterization Result

Characterization was done to know the properties of the biodiesel produced whether it satisfies the ASTM standards for biodiesel prior to testing its performance in the existing diesel engines without doing any modification. The characterization results of the biodiesel produced from Jatropha and Cottonseed oil and their mixture were shown in the Table 4.2. From the table 4.2, the density of Jatropha biodiesel was lower than that of cottonseed biodiesel. The density observed by all sample biodiesel was within the range given by American Society for Testing and Material (ASTM D-6751) standards. Compared to the Jatropha biodiesel the viscosity of cottonseed biodiesel is higher.

Table 4-2 The properties of biodiesel produced

No	Property	Test method ASTM	Diesel limit	Test Results		
				100% CB	100% JB	50% CB+ 50%JB blend
1	Density @ 15 °C, g/ml	D 4052	0.86-0.90	0.8836	0.8813	0.8824
2	Density @ 20 °C, g/ml	D 4052	0.6-0.90	0.8801	0.8778	0.8790
3	Flash point,°C	D 93	Min. 130	>165	>175	>165
4	Kinematic viscosity @ 40 °C	D 445	1.9-6.0	4.32	4.29	4.31
5	Cloud point, ^{o}c	D 2500	as Reported	+12	+5	+8

4.4. Engine Performance Testing

Engine performance was measured in terms of brake specific fuel consumption, brake thermal efficiency and specific energy consumption. In this section the engine performance of standard diesel fuel was compared with all tested blends.

4.4.1. Brake Specific Fuel Consumption

The brake specific fuel consumption founded relative to the brake power for all tested fuel samples of B_0, B_{20}JB, B_{20}CB and B_{20}JCB are given below. Pure diesel fuel have less amount of brake specific fuel consumption than other biodiesel blends. And jatropha biodiesel which has low brake specific fuel consumption as compared to cottonseed biodiesel and their mixtures. The mixture of jatropha and cottonseed biodiesel blends results become between reading of jatropha biodiesel and cottonseed biodiesel.

Table 4-3 Brake specific fuel consumption for B_0, B_{20}JB, B_{20}CB, B_{20}JCB

Brake power (kW)	Brake Specific fuel consumption(kg/kwh)			
	B_0	B_{20}JB	B_{20}CB	B_{20}JCB
1.5072	0.35915	0.39809	0.66526	0.5316
3.0144	0.27068	0.28321	0.47202	0.37615
4.5216	0.2491	0.30285	0.37094	0.33697
6.0288	0.3059	0.3123	0.42433	0.368315

From above tabulated table it can draw the following figure to compare the performance. It shows the variation of brake specific fuel consumption relative to the brake power for all tested fuel samples of B_0, B_{20}JB, B_{20}CB and B_{20}JCB.

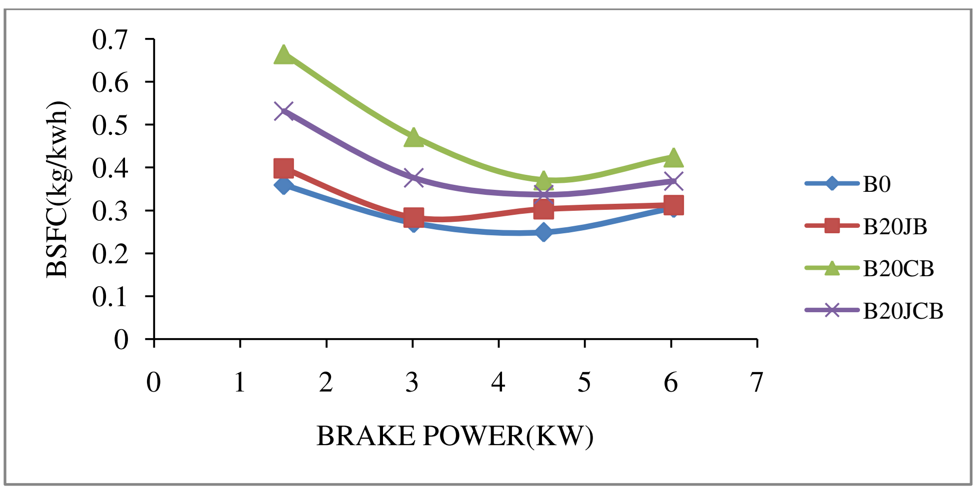

Figure 4-1 Effect of brake power on Brake specific fuel consumption for B_0 and B_{20}

From figure 4.1 above the specific fuel consumption at maximum load for B_0, B_{20}JB, B_{20}CB and B_{20}JCB were 0.3059 kg/kWh, 0.3123 kg/kWh, 0.42433 kg/kWh and 0.3683kg/kWh respectively. The brake specific fuel consumption at maximum load for B_{20}CB is higher which followed by B_{20}JCB and B_{20}JB. The brake specific fuel consumption at maximum load increment for B_{20}JB, B_{20}CB, B_{20}JCB was 2.09%, 38.7%, 20.3%, respectively as compared with diesel fuel.

From the figure 4.1 shown above since biodiesel has lower calorific value than diesel fuel, the specific fuel consumption of biodiesel blended fuels become higher compared to the diesel. The brake specific fuel consumption is higher at low load because at this load incomplete combustion of fuel is happen. Brake specific fuel consumption has little reduction at medium load, because at medium load the best cylinder filling occur and good engine breathing is taken at this load. At maximum load the fuel consumption increase, because the friction loss and energy loss exists.

4.4.2. Brake Thermal Efficiency

The brake thermal efficiency founded relative to the brake power for all tested fuel samples of B_0, B_{20}JB, B_{20}CB and B_{20}JCB are given below. Pure diesel fuel have high amount of brake thermal efficiency than other biodiesel blends. And jatropha biodiesel which has high brake thermal efficiency as compared to cottonseed biodiesel and their mixtures. The mixture of jatropha and cottonseed biodiesel blends results become between reading of jatropha biodiesel and cottonseed biodiesel blend.

Table 4-4 Brake thermal efficiency for B_0, B_{20}JB, B_{20}CB, B_{20}JCB

Brake power (KW)	Brake thermal efficiency(%)			
	B_0	B_{20}JB	B_{20}CB	B_{20}JCB
0	0	0	0	0
1.5072	23.2032	20.9333	12.5264	16.73
3.0144	30.7863	29.4244	17.6546	23.54
4.5216	33.4429	27.516	22.4716	25.003
6.0288	27.305	26.7005	19.637	23.16

From above tabulated table it can draw the following figure to compare the performance. It shows the variation of brake thermal efficiency relative to the brake power for all tested fuel samples of B_0, B_{20}JB, B_{20}CB and B_{20}JCB.

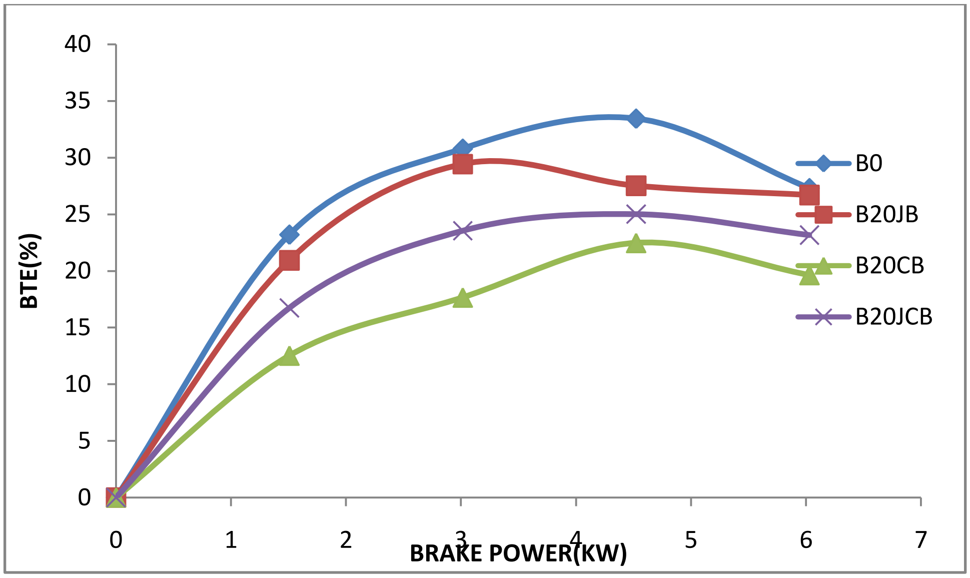

Figure 4-2 Effect of brake power on brake thermal efficiency for B_0 and B_{20}

From the figure 4.2 shown above all biodiesel blendes have lower brake thermal efficiency than diesel fuel, this is because biodiesel have higher viscosity and lower calorific values to compare the neat diesel. Higher viscosity of biodiesel blend was decreases atomization and fuel vaporization, which results in a more uneven combustion than that of diesel fuel. For all biodiesel blend and pure diesel the brake thermal efficiency is lower at low load and became increase when the load increases. [4] discussed a project, Proton Exchange Membrane (PEM) energy unit are progressively being refered to by governments as a conceivable pathway to the decrease of ozone depleting substance outflow. It is one of the forthcoming force hotspots for car applications, prepare machines, stationary cogeneration frameworks, and portable electronic gadgets. Be that as it may, the dryness of the film of a PEM power device diminishes the ionic conductivity, bringing about execution decrease. In this work, a two-dimensional model is utilized to examine the fundamental and collaboration impacts of five outline factors, at three levels in a proton trade layer (PEM) energy unit. Investigation is directed for working possibilities of 0.7 and 0.6V and a scope of current densities. An engine that picks up its energy from a hydrogen tank and a power device Stored in a tank. The substance vitality from the hydrogen will be changed over into electrical vitality by the power device to push the prepare at up to most extreme speed of 80km/hr. Prepare apparatuses like Fans, lighting may likewise keep running on PEM energy unit. This new hydrogen prepare is along these lines ideal for shorter, calmer extends of the system that jolt hasn't yet come to.

From figure 4.2 above the brake thermal efficiency at maximum load for B_0, B_{20}JB, B_{20}CB and B_{20}JCB was, 27.305%, 26.7%, 19.637% and 23.16% respectively. The brake thermal efficiency at maximum load for B_{20}JB is higher which followed by B_{20}JCB and B_{20}CB. The brake thermal efficiency at maximum load decrease for B_{20}JB, B_{20}CB and B_{20}JCB was 0.6%, 7.60% and 4.145%, respectively as compared with diesel fuel.

4.4.3. Brake Specific Energy Consumption

Figure below shows that the variation of brake specific energy consumption with respect to brake power(kw) for B_0,B_{20}JB,B_{20}CB and B_{20}JCB. The curve shows that at the lower brake power there is a higher energy consumption of the engine for all blendes. At the higher brake power the energy consumption was also somewhat increased.

Table 4-5 Brake Specific energy consumption for B_0, B_{20}JB, B_{20}CB, B_{20}JCB

Brake power (KW)	Brake specific energy consumption(kJ/kWh)			
	B_0	B_{20}JB	B_{20}CB	B_{20}JCB
1.5072	15515.1	17197.5	28739.4	22968.4
3.0144	11693.5	12234.8	20391.3	16313
4.5216	10764.64	13083.3	16020.1	14551.7
6.0288	13184	13482.29	18331.2	15906.7

From above tabulated table it can draw the following figure to compare the performance. It shows the variation of specific energy consumption relative to the brake power for all tested fuel samples of B_0, B_{20}JB, B_{20}CB and B_{20}JCB.

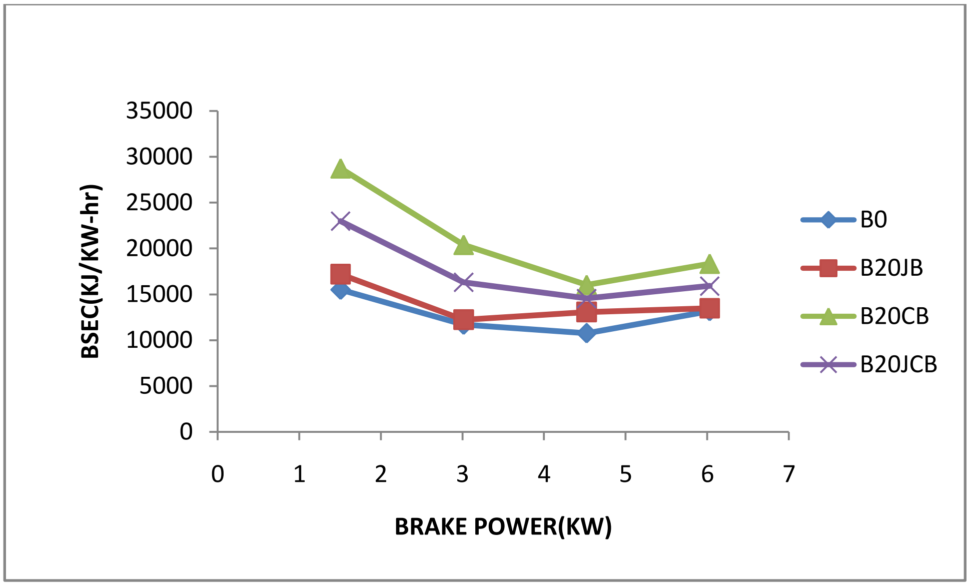

Figure 4-3 Effect of brake power on Brake specific energy consumption for B_0 and B_{20}

Figure 4.3 shows the specific energy consumption for all biodiesel blend is higher compared with petrol diesel. BSEC is an ideal variable because it is dependent on calorific value of the fuel. The high specific energy consumption is due to the lower energy content of the biodiesel. Hence, the specific energy consumption of the biodiesel blends is higher as compared to that of diesel. And the specific energy consumption for all biodiesel blend and pure diesel is higher at low load because at this load incomplete combustion of fuel is happen. Brake specific fuel consumption has little reduction at medium load, because at medium load the best cylinder filling occur and good engine breathing is taken at this load. At maximum load the specific energy consumption little increase, because the friction loss and energy loss exists.

From figure 4.3 above the specific energy consumption at maximum load for $B_{0,}B_{20}$JB, B_{20}CB and B_{20}JCB were 13184 kJ/kWh, 13482 kJ/kWh, 18331.2 kJ/kWh and 15906.7kJ/kWh respectively. The specific energy consumption at maximum load forB_{20}CB is higher which followed by B_{20}JCB and B_{20}JB. The brake specific energy consumption at maximum load increment for B_{20}JB, B_{20}CB and B_{20}JCB was 2.26%, 39%, 20.6%, respectively as compared with diesel fuel.

5. CONCLUSIONS AND RECOMMENDATIONS

From the experimental results the following conclusions were formulated.

- The amount of oil extracted from the jatropha seed was 20% mass by mass ratio.
- Laboratory production of biodiesel from jatropha oil and cottonseed oil was done using transesterification method with methanol alcohol and KOH as catalyst.
- Biodiesel produced from jatropha and cottonseed oil is completely miscible with each other and with diesel fuel thus allowing the use of blends of diesel and biodiesel in any percentage.
- The characteristics of biodiesel produced from Cottonseed oil show the higher viscosity and density than that of Jatropha oil. The mixture of Jatropha and Cottonseed oil biodiesel gives the lesser viscosity and density. The flash points of Cottonseed, Jatropha and the blend of both biodiesel were within the standard.
- The properties of biodiesel from cottonseed oil at low temperatures are poorer than those of Jatropha oil. The biodiesel blends of Jatropha biodiesel with cottonseed biodiesel cause to the improvement for the operation in cold weather.
- Brake specific fuel consumption for mixture of Jatropha and Cottonseed (B_{20}JCB) blend is higher than B_{20}JB but lower than B_{20}CB. The brake specific fuel consumption of B_{20}JCB is increased by 20.3% compared with pure diesel.
- The brake thermal efficiency observed by B_{20}JCB is lower than B_{20}JB but higher than B_{20}CB. The reduction of Brake thermal efficiency for B_{20}JCB is 4.3% as compared to pure diesel.
- The brake specific energy consumption for B_{20}JCB is lower than B_{20}CB but higher than B_{20}JB. It shows 20.6% increment than pure diesel.
- The amount of CO emission for B_{20}JCB is equal for B_{20}JB but higher than that of B_{20}CB.CO emission of B_{20}JCB is reduced by 0.02% compared with petrol diesel.
- CO_2 emission of B_{20}JCB is lower than other blends and equal for pure diesel. HC emission of B_{20}JCB higher than other blends and pure diesel. HC emission for B_{20}JCB is increased by 13.2% compared to petrol diesel.
- The nitrogen oxide (NO_X) emission of B_{20}JCB is lower than B_{20}JB but higher than B_{20}CB. It shows 2.3% increment than pure diesel.

From the performance test result it is seen that the specific fuel consumption and specific energy consumption get increase and thermal efficiency reduce for biodiesel blends compared to the petro diesel fuel. This is because of the fact that biodiesels has less energy content and higher viscosity compared to petro diesel. But this little reduction in performance can be compensated with lots of its advantages like its usage in unmodified engine, better lubricity, renewability, degradability, very less contribution to global warming, and its provision of great ecological advantages in terms of erosion control and wasteland recovery.

From emission test result it has seen that the CO emission for biodiesel is reduce and HC,CO_2 and NO_X emission are increase for biodiesel blends compared to pure diesel fuel. This is because of the fact that biodiesels are oxygenated fuels and hence has less energy content and low viscosity compared to petro diesel.

6. REFERENCES

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