Experimental Investigation for the usage of Diesel - Jatropha – Rice bran Biodiesel Mixture Blends in Four Stroke Diesel Engine

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Abstract. In last few decades, the demand of fossil fuel increases due to the enormous increases in vehicle population. There is a shortage of crude oil supply due to the excess need of fossil fuel. This urges the researchers to switch to renewable resources, like biofuels. Biodiesels can be produced successfully from plants such as palm, jatropha, rapeseed, rice bran, soyabean, corn etc. The use of biodiesel will considerably reduce the emissions also and thus increases the engine performance. The oil is converted to biodiesel with the help of trans-esterification process. The properties, emission characteristics and performance for the Compression Ignition (CI) of the fuel process are examined for biodiesel which is blended with two oils (rice bran and Jatropha oil blend mixture) by using this experimental study. The results indicate that the calorific value for the dual blends of biodiesel decreases with an increase in biodiesel concentration in the blends of diesel- biodiesel mixture. It is found that the brake thermal efficiency is lower for biodiesel blends. For higher ratio of blends, biodiesel blends gives lower HC and NOx emissions.

Keywords: CI engine, Biodiesel, jatropha oil, rice bran oil, transesterification, performance, emission.

1. Introduction
Transportation is the widely used element for the day-to-day functioning throughout the World. If there is any lacking in this transportation affects the economy of the country. So, life without transportation is highly unimaginable. The daily life of people’s transportation includes both private and public sector owned road transport vehicles, trains, planes and boats. However, transportation using fossil fuels lead to harmful environment and also it spoils our health. The problem is most of the transport facilities in our day-to-day life requires gasoline, which is mainly derived from the fossil fuels. Though there is a depletion of fossil fuels, demand increases drastically each and every day. This causes hike of the piece for gasoline and its products. In order to solve this issue, the researchers started producing alternate fuels. It is also found that diesel machines constitute a major part in the transportation sector. This in turn increase in demand for the diesel fuel and also it increases its price. India is spending around 20,000 crores a year for importing crude oil alone. This leads to the massive research for alternative fuel to substitute the fossil fuels and for the reduction of NOx[1-5].
Alternative fuels are renewable, eco-friendly, which in turn reduces the dependency of petroleum fuels and helps to protect the nature by decreasing the pollution levels. The higher levels of CO\textsubscript{2} are produced by the combustion of fossil fuels and also the production of other gases that form the greenhouse effect in the atmosphere. Thus, the scarcity of fossil fuels and the growing emissions of combustion which are the major phenomena for pollution and their hike in costs make biomass more attractive\cite{6-8}.

Biodiesel is produced by the Transesterification process where esters are transformed from one form to another form. The main advantage for the biodiesel over another fossil fuel is eco-friendly. By providing the subsidy for the cultivation of non-food crops will increase the production and utility of biodiesel. The higher heating values for biodiesels are in the range of 39–41 MJ/kg and for the gasoline it is 46MJ/kg which is slightly higher than biodiesel, Petro-diesel is 43 MJ/kg or crude-petroleum is 45.53MJ/kg, but higher than that of coal (32–37 MJ/kg)\cite{9-12}.

The combustion of Biodiesel petroleum diesel is similar and it concerns with regulated pollutants. Biodiesel efficiency is higher than gasoline. Though there are many advantages comparing to Petro diesel, few conditions like cold start problems, the lower energy content, difficulty in pumping of higher viscosity fuels and higher corrosion as measured with copper strip corrosion method are the main disadvantages of biodiesel. Fuel consumption of biodiesel is increased when compared to pure Petro diesel, in proportion to the share of the biodiesel content.

2. Methodology and its setup
The setup that is employed in this research process is discussed below.

2.1 Equipment setup
A 4-stroke Single Cylinder Diesel Engine as shown in figure 1. is connected to the eddy current dynamometer for loading purpose and it is provided with instruments used for measuring crank angle and combustion pressure. The signals received from the sensors are processed in computer and the $P_\theta$–PV diagrams are generated. Airflow, temperatures, fuel flow, load and temperature measurement devices are interfaced with computer system and the setup has stand-alone panel box which consists of air box, transmitters for air, manometer, fuel tank, fuel measuring unit, and fuel flow measurements, process indicator and engine indicator. Rotameters are provided for cooling water and calorimeter water flow measurement and this setup enables the study of engine performance for measuring Brake Power, Brake Thermal Efficiency, Indicated Power, Frictional Power, Indicated Thermal Efficiency, Mechanical Efficiency, Volumetric Efficiency, Specific Fuel Consumption (SFC), A/F ratio and heat balance. “Engine Shaft” which is a LabVIEW software package for Engine Performance Analysis and it is provided for on-line performance evaluation\cite{13-15}.
2.2 Specifications

Table 1. Specifications

| Product | 4 Stroke Single Cylinder Diesel Engine (Computerized) |
|---------|-----------------------------------------------------|
| Engine  | Make: Kirloskar, Model: TV1, Type: Single cylinder4 stroke Diesel, Water Cooled, Power: 5.2kW at 1500 rpm, Stroke: 110 mm, Bore: 87.5 mm - 661 cc, CR 17.5 |
| Dynamometer | Eddy Current and Water-Cooled Setup |
| Propeller Shaft | Universal Joint |
| Fuel Tank | Capacity 15 litrefitted with glass fuel metering column |
| Load Indicator | Digital type with Range 0- 50 Kg and Supply 230VAC |
| Load Sensor | Load cell of strain gauge type with range 0- 50 Kg |
| Fuel Flow Transmitter | DP transmitter, Range 0- 500 mm WC |
| Air Flow Transmitter | Pressure transmitter, Range (- ) 250 mm WC |

2.3 Procedures

By maintaining optimum cooling rate, experiments areconducted on the diesel engine to find optimum cooling rate. By using diesel fuel efficiency is verified and the equipment is standardized. Thefollowing step-by-step method is adopted for the experimental analysis.

1. Connect the electrical instruments to the panel as it required.
2. Check the engine lubricating oil level.
3. Check the level of fuel within the tank.
4. Enable the motor and calorimeter to pump the water and change the flow rate.
5. Reset the dynamometer.
6. Open the cock for fuel flow.
7. Start the engine with crank.
8. The engine is made to run for 10 minutes under idling condition with no load, to ensure warm and stable operating conditions.
9. Note down all parameters of thermal efficiency over a data acquisition device for no load condition.
10. Repeat the experiment for different loads, and report the readings.
11. After finishing the experiment release the load and then turn off the engine.
12. Let the water flow for a couple of minutes, and then shut off the flow.

3. Results and Discussions
Based on the results obtained from the experiment, detailed study is presented.

3.1 Performance Characteristics and its study
The diesel engine is operated using three different blends of biodiesels like B10 (Biodiesel 10% and Diesel 90%), B15 (Biodiesel 15% and Diesel 85%) and B20 (Biodiesel 20% and Diesel 80%) and with pure diesel and the performance of engine is determined for each blend. The optimum blend of high efficiency is determined as a result of this experiment.

![BRAKE POWER VS BRAKE THERMAL EFFICIENCY](image)

**Figure 2.** Brake Power (BP) vs Brake Thermal Efficiency (BTE)

The variation of BTE against BP for dual blends (jatropha and rice bran) and pure diesel is shown in the figure 2. We can observe in the graph that BTE gets higher with every increase BP for all the blends of biodiesel for certain range and drops slightly when it reaches a certain limit of BP. At a load of 5 kW, all the blend reaches an almost nearer value. The biodiesel with different blends such as B10, B15 and B20 were used. In which all the blends consist of half the amount of both the biodiesel. Thus, the biodiesel blends have lower brake thermal efficiency than diesel. Among these three blends the B10 has higher brake thermal efficiency than other two blends. The increase of efficiency is due to the present of more oxygen content in biodiesel which produces combustion higher than diesel. The blends of biodiesel have higher density, viscosity and lower calorific value than diesel. This increase of thermal efficiency is may due to the heat loss reduction and increasing power with load.
The variation of specific fuel consumption against brake power is shown clearly in figure 3. It is observed from the graph that the specific fuel consumption is decreased with increase in brake power. The consumption of biodiesel is higher when compared to diesel fuel. The speed increases after certain level, the brake power decreases and the decrease in the thermal efficiency which increases the specific fuel consumption. The percent of fuel required is higher to operate the engine compared to higher brake power of the engine due to the less heat losses at the higher loads. At initial stage the fuel required to run the engine is high due to less compression of the engine. When the brake power increases the compression also get increased which in term less fuel is required. Thus, among these three blends the B20 has higher fuel consumption as compared to other blends. At higher brake power the blends B15 and B20 almost possess closer values. In case of B10, it possesses lower consumption at almost highest variation in consumption as compared to other blends.
The variation of Volumetric Efficiency against Brake Power is shown in the figure 4. It can be interpreted from the graph that volumetric efficiency decreases with increase in brake power. On comparing with pure diesel there is no much variation in dual blend biodiesels. The volumetric efficiency at the average brake power, is constant for all the blends of biodiesel. B10 and B15 has almost have same volumetric efficiency at certain average brake power. The volumetric efficiency of pure diesel is about 85.31% at 5 kW. Where B10 has volumetric efficiency of about 84.31%, and B20 has volumetric efficiency of about 84.73 % at this same power. Thus, there will be no much deviation in volumetric efficiency.

![BRAKE POWER VS INDICATED THERMAL EFFICIENCY](image)

**Figure 5**: Brake Power Vs Indicated Thermal Efficiency (ITE)

The graph in the figure 5 shows variation of indicated thermal efficiency against brake power and it is interpreted that the indicated thermal efficiency of all blends is higher at lower brake power and decreases with increase in brake power and nearly constant for average brake power and again starts decreasing with higher brake power. Among the three blends, B10 has higher indicated thermal efficiency. Pure diesel has lesser indicated thermal efficiency at initial stage of brake power on compared with biodiesel. From 1-2.8 kW of brake power, the indicated efficiency of B10 has decreasing sharply, Where B15 has almost constant value and B15 has decreasing slightly. From 2.5-3.8kW the indicated thermal efficiency of B10, B15 and B20 has nearly constant value but there is a slight variation. From 3.7-4.9, the indicated thermal efficiency of B10 and B15 drops with increasing brake power and B20 has nearly constant value.
The variation of mechanical efficiency against brake power is shown in the figure. 6. It can be observed from the graph that Mechanical efficiency increases with increases in brake power. It is clear that all the blends of biodiesel have almost nearest value of volumetric efficiency. The pure diesel has slightly higher mechanical efficiency than biodiesel blends. Thus, lower calorific value and higher viscosity of biodiesel is the major reason for this. Thus, diesel has mechanical efficiency of about 72.28% at 5 kW power where B10 and B20 has the mechanical efficiency of about 69%.

3.2 Combustion Characteristics

The figure. 7 shows the variation of cylindrical pressure against the crank angle. After reaching the Top Dead Centre (ATDC)the range between 4 to 9 deg, Peakpressure is occurred. It is clear from the graph that the B20 blend reaches the highest cylindrical pressure among all the blends. B10 and B15 has the almost same cylindrical pressure. At no load condition, it is observed that heat is released in premixed combustion phase, but in full load condition, heat is released with significant amount which also takes place in the diffusion combustion phase. Thus, increasing in biodiesel percentage increases the cylindrical pressure to a maximum extend. Thus, diesel at the crank angle range of4-9 deg has the peak pressure.
3.3 Emission Characteristics

The figure 8. shows the variation of Carbon monoxide against brake power. The graph shows that the CO emissions are lower for initial brake power and they nearly constant for certain range and starts increasing with increasing brake power. At 5 kW brake power, the CO emission of all blends increases tremendously. Thus, it is more efficient at lower brake power. Among all the blends, B20 has lower CO emissions. The CO emissions of biodiesel is lower compared to the diesel at lower brake power. The biodiesel has CO emission at higher brake power than diesel. These CO emissions formed as a result of incomplete combustion. At 2.5 kW brake power, all the blends posseses lower CO emissions and have highly efficient.

The variation of Hydrocarbon emissions against brake power is shown in the figure 9. The graph shows that HC emissions are lower for initial stage of brake power and starts increasing with increasing brake power and tremendously increases at higher brake power. Among the three blends, B20 has lower hydrocarbon emissions than other blends. Thus, biodiesel has lower HC emissions than diesel at the case of higher ratio of blends. At lower blends the biodiesel is not so efficient than diesel. At average brake power the HC emissions of all blends are increasing slightly and reaches a
peak value when crosses a certain limit of brake power. Thus, increase in biodiesel percentage will enables complete combustion of fuel and helps in decreasing HC emissions at average brake power.

![BRAKE POWER VS NOX](image)

**Figure 10. Brake Power vs NOX**

The variation of NO\(_X\) emissions against brake power is shown in the figure 10. The graph shows that there is an increase in NO\(_X\) emissions with increases in brake power. At the initial stage of brake power, the NO\(_X\) emissions of all blends are lower and increases sharply with increases in brake power. Among this blend, it is clear that B20 has lower NO\(_X\) emissions than other blends. At average brake power all the blends possess similar NO\(_X\) emissions. Thus, on comparing with the diesel the biodiesel has lower NO\(_X\) emissions. Thus, at 5 kW of brake power, the B10 has NO\(_X\) emissions of 1532PPM and B15 has NO\(_X\) emissions of 1547PPM and B20 has NO\(_X\) emissions of 1457PPM, where diesel has a NO\(_X\) amount of 1564PPM. Thus, B20 has lower emissions compared among other blends and diesel. Thus, at the higher blends of biodiesel reduces NO\(_X\) emissions about higher percentage.

![BRAKE POWER VS CO2](image)
The variation of CO₂ emissions against brake power is shown in the figure 11. The graph shows that the CO₂ emissions increases with increases in brake power. It is clear from the graph that CO₂ emissions are almost constant for all the blends. At the initial stage B20 has lower CO₂ emissions. At 3 kW brake power all the blends attain a constant value and after this load there will be no variation in CO₂ emissions for all blends. Thus, both the diesel and biodiesel has almost similar emissions. The biodiesel has lesser emissions than diesel at lower brake power. At higher brake power the CO₂ is not so efficient than diesel. Thus, CO₂ emissions are not so being reduced effectively using a biodiesel.

Smoke is an ill effect of combustion process. It is the combination of gases, liquid and airborne solid particulates produced during combustion of fuels in the engines and smoke is generally of three types such as grey smoke, blue smoke and white smoke. Smoke causes various issues and health effects to the environment and humans. It is measured in terms of opacity.

The figure 12. shows the variation of smoke opacity against brake power. The graph shows that as the brake power increases, there is an increase in smoke opacity. All the blends of biodiesel increase sharply with increase in brake power. They possess nearly same values and there is no much deviation. The smoke opacity of diesel is almost equal to the biodiesel. Among all the blends B10 has lower smoke opacity.

4. Conclusion
The performance and emission characteristics of dual blends (jatropha and rice bran oil) of biodiesel with diesel are experimented with the CI engine. From the experimental work performed the results are concluded as follows,

- While comparing to pure Diesel fuel, the Brake Thermal Efficiency of biodiesel is lower.
- The specific fuel consumption of biodiesel is larger than the diesel fuel
- Thus, there will be no much deviation in volumetric efficiency for the biodiesel blends when related to the diesel fuel.
- At the initial stage of brake power, pure diesel has lesser indicated thermal efficiency than biodiesel.
- The diesel has lower CO emissions than biodiesel blends at high power condition
The biodiesel has lower HC emissions than diesel at the case of higher ratio of blends. Thus, at the higher blends of biodiesel reduces NOx emissions about higher percentage. CO2 emissions are not so being reduced effectively using a biodiesel.

Inference

The inference of this study are as follows:

- The blend ratio is a critical element in the performance of the engine.
- For further improvement it is required to study different oils with different ratio of blends.

References

1. B. K. Abdalla, and F. O. A. Oshaik, (2013) Base-transesterification process for biodiesel fuel production from spent frying oils. Agricultural Sciences, 4, 85-88. doi: 10.4236/as.2013.49B015.
2. Abhishek churasia, Joginder Singh and Ajay Kumar, (2016), “production of biodiesel from soyabean oil biomass as renewable energy source”, journal of environmental biology, vol.No.37, pp.1303-1307.
3. Antony Raja S., D.S. Robinson smart and C. Lindon Robert Lee, (2011), “Biodiesel production from Jatropha oil and its characterization”, Research Journal of Chemical Sciences, Vol.No.1, pp.81-87.
4. AvinashB,Dr. Y T krishnegowda, prof. Chethana G D, (2016), “Experimental investigation on Four Stroke Diesel Engine using Diesel-jatropha/ Rice bran/soybean biodiesel mixture blends”, International journal of scientific research in science, Engineering and technology, Vol.No.2, pp.85-88.
5. DantasM.B.,A.R.Albuquerque,L.E.B.soledade,N. Queiroz,A.s.Maia,I.M.G.Santos,A.L.Souza,E.H.S.cavalcanti,A.K.barro,A.G.Souza,(2011), “biodiesel from soyabean oil, castor oil and their blends”, journal of thermal analysis and calorimetry,Vol.No.106,pp.607-611.
6. Fabiano B., A.P. Reverberi, A. Del Borghi and V.G. Dovi, (2012), “biodiesel production via transesterification”, journal of Pleiades, Vol.No.46, pp.673-680.
7. Forson F.K., E.K. Oduro, E. Hammond-Denkoh, (2003), “performance of Jatropha oil blends in a diesel engine”, Journal of renewable energy, Vol.No.29, pp.1135-1145.
8. Gulzar Ahmad Nayik, Amir Gull, Ishrat Majid, Khalid Muzaffar, (2015), “Rice bran oil, the future Edible oil of India: A mini Review”, Journal of Rice Research: open Access, Vol.No.3, pp.801-804.
9. May Ying Koh, TinialdatyMohd. Ghazi, (2011), “A Review of biodiesel production from Jatropha curcasL. oil”, Journal of Renewable and sustainable Energy Reviews, Vol.No.15, pp.2240-2251.
10. Shailendra Sinha, Avinash Kumar Agarwal, Sanjeev Garg, (2007), “Biodiesel development from rice bran oil: Transesterification process optimization and fuel characterization”, Journal of energy conservation and management, Vol.No.49, pp.1248-1257.
11. Sharankumar, Venkatesh, R Sai Syam, (2019), “performance test on Karanja, Neem,Mahua biodiesel blend with diesel in single cylinder IC engine”, International research journal of mechanical engineering and technology, Vol.No.6, pp.1568-1574.
12. Shivakumar Vasmate, Sreenuraja.M, Prasad Biradar, ShashikantKushnoore, (2016), “experimental on multi blend biodiesel using jatropha and Pongamia biodiesel on single cylinder diesel engine with base line of diesel fuel”, International journal of mechanical engineering and technology, Vol.No.7, pp.273-281.
13. Srithar K., K. Arun Balasubramanian, V. Pavendan, B. Ashok Kumar, “experimental investigation on mixing of two biodiesel blend with diesel as alternative fuel for diesel engines”, journal of king saud university, Vol.No.29, pp.50-56.
14. Taslim, Iriany, O Bani, S Z D M parinduri and P R W Ningsih, (2018), “Biodiesel production from rice bran oil by transesterification using heterogeneous catalyst natural zeolite modified with K2Co3”, journal of TALENTA-CEST, Vol.No.32, pp.1125-1131.

15. Tint Kywe, Mya Oo, (2009), “Production of Biodiesel from Jatropha oil in Pilot plant”, Journal of Proceedings of world Academy of Science, Engineering and Technology, Vol.No.38, pp.481-486.

16. Venkateshwara Rao P, (2015), “dual biodiesel-diesel blends performance on diesel engines as alternative fuel”, International research journal of mechanical engineering and technology, journal of mechanical engineering and technology, journal of mechanical engineering and technology, Vol.No.2, pp.643-647.