Emission characteristics of jackfruit peel oil with three hole nozzle

R Mahesh¹, K Surendrababu², Sachin S Kumar³, C T Anoop³ and V P Nuhaiz³

¹Assistant Professor, Aarupadai Veedu Institute of Technology, Chennai
²Associate Professor, Aarupadai Veedu Institute of Technology, Chennai
³UG Student, Aarupadai Veedu Institute of Technology, Chennai
E-mail: mahesh@avit.ac.in

Abstract. There is various energy resources scattered around the world. As the population increases the energy demand is posing challenges to supply of fuels. The emissions from various industries and transports cause the main reason for Greenhouse gas, i.e. carbon emissions. Hence there it is right time to find an alternative fuels such as biofuels from plants and vegetables which is an efficient way to reduce these emissions. Biofuel are produced from crops like wheat, soybean and sugarcane, jackfruit, algae. Although there are various methods in production of biofuel, the most common is transesterification method. In the transesterification process the viscosity of the bio oil is reduced to make it suitable for engine. In this study we deal with analysis of the Emission characteristics of Jackfruit peel oil with three hole nozzle. The following emission characteristic of Hydrocarbon (HC), Nitrogen oxide(NO), Carbon dioxide(CO2), Particulate matters, Carbon monoxide(CO) are investigated in this paper.

Keyword: Performance, Emission, Nozzle, Jackfruit

1. Introduction

Though Electric vehicle are said to be an alternative for fuel vehicle, the high cost of electrical vehicle and the less availability of charging network are always the unresolved challenges. On the other hand Biofuel production is easier due to more land availability for the cultivation of the plants needed for biodiesel production. As these fuels can be produced from vegetable waste and animal waste, it is considered be a best waste management [7]. Though the biodiesel are produced from edible and non-edible vegetables, the best choice will be the non-edible as they
are not consumed. By producing biofuel from waste the dependency on fossil fuels are reduced on a greater level [2]. Some research works have been done on producing biofuel from used cooking oil also [9]. The emission of Nitrogen oxide (NOx), Hydrocarbon (HC), Carbon monoxide (CO), etc in diesel engine is also considers. These emission gases are harmful to human and have to be reduced [1]. Biofuel are always a best solution for reduction of carbon emission. Although biodiesel is produced from various vegetable crops, jackfruit peel oil is one of the best suitable crops, since the availability of jackfruit is more. Picture of Jack fruit peel is shown in Figure 1.

![Figure 1: Jack fruit peel](image)

The bio-oil from the jackfruit peel undergoes transesterification to reduce its viscosity and make it ready for analysis. To improve the efficiency of the engine many researches are being done on various biodiesel mixing at various ratios with diesel.

R. Rajasekar et al [3], has investigated the emission characteristic of coconut acid biodiesel. The outcome was found that the overall performance has increased by 0.93% and emission has been reduced by 3.47%.

V Naresh et al [4], has studied the algae bio-diesel. And has found that Algae 20 is having better characteristics than diesel. Abhijeet P. Shah et al [5] in his study on soybean oil has stated that the performance of the engine has increased while using soybean biodiesel. Mohammed Shamim et al [6], has compared the Mahua and Jujube biodiesels. He has stated that Jujube biodiesel has better result than the Mahua biodiesel.

Deep et al [8], has analyzed blended castor biodiesel with 20% of diesel. She has stated that the emission from this percentage blend is far better than the diesel. Sivaramakrishnan et al [10], has studied the Karanja oil’s characteristics. At the end of his study, he has founded that the Karanja oil’s 25% blend with diesel is the optimum mixing percentage. Sam Sukumar et al [11], has analysed the Pongamia oil blend with the diesel. The result states that Pongamia oil blended with 20% of diesel is safer than diesel. Shukla et al [12], has analyzed the castor oil’s characteristics. The result is found that the mechanical efficiency is increasing with load.

Suresh yaramati et al [13], has studied Spirulina Biodiesel’s performance and has found that 20% blend with diesel gives more performance. Jennifer Pieter Soetardjia et al [14] in her study on bio oil from jack fruit waste and she has stated jackfruit peel has more of acids, hydrocarbons
and nitrogen compounds which makes jackfruit peel oil to be most suitable raw material for biodiesel production. All the above literatures study states that the emissions of various particles like Carbon Monoxide (CO), Carbon dioxide (CO2), Nitric Oxide (NOx), and Hydro Carbon (HC) has been regularized to control the environment pollution. Hence study on various biodiesel characteristic is more significant. The aim of this study is to conduct the research on Jack fruit peel bio-oil mixed with 20%, 40% and 60% of diesel and comparing it with diesel in VCR engine at various load using three hole nozzle.

2. Experimental setup

For this study single cylinder, four stroke variable compression ratio (VCR) engine is used. As shown in the Figure 2, VCR engine setup involves two fuel input containers, one for diesel and the other for biodiesel. Optical sensors are placed below the containers to monitor the fuel utilization. There is a Differential pressure transducer to determine the air flow. Engine is attached to Eddy current dynamometer to check the curving of the system. The combustion pressure is monitored by the piezoelectric transducer. The signal is transferred to Amplifier.

![Working process of diesel engine](image)

Figure 2. Working process of diesel engine

The engine's load and velocity is monitored by dynamometer. The signals from top dead center and the crank angle are transmitted by angle encoder. These signals are transferred to computer through high speed device. The intensity is measured by the exhausted gas analyzer and the level of smoke by smoke meter. The exhaust temperature, atmosphere temperature and coolant temperature are measured by the thermocouple.
2.1. Emission analyzer
Gas Analyzer is used to measure Hydro Carbon, Carbon Monoxide, Carbon dioxide, Oxygen and Nitric Oxide. Non-Scattering infrared is used to measure Hydro Carbon, Carbon Monoxide, Carbon dioxide but electro-chemical technique is used to measure Oxygen and Nitric Oxide. The indented measurement for Hydro Carbon and Nitric Oxide is 1 ppm and for Carbon monoxide, Carbon dioxide, Oxygen it is 0.01% each. The exhaust gas is transmitted through the silencer pipe connected to the mesh separator to reduce the particulate matter.

2.2. VCR engine
The model of VCR engine is shown in figure. 3

![VCR Engine](image)

**Figure 3.** VCR Engine

2.3. Gas analyzer specifications (Type AVL DIGAS)
The exhaust gas is transmitted to the filter to reduce the waste minute particles. When the exhaust gas moves to the exhaust gas analyzer, the moist particles are controlled by the cold traps. After undergoing this process the pure gas is transmitted to sensor to measure the readings. The output is displayed in the monitor and the same is also recorded. The specifications of the various exhaust gases are mentioned in Table 1.

| EXHAUST GAS | MEASUREMENT RANGE |
|-------------|-------------------|
| CO          | 0-10 vol. %       |
| HC          | 0-20,000 ppm      |
| CO2         | 0-20 vol. %       |
| O2          | 0-22 vol. %       |
| NOx         | 0-5000 ppm        |

*Table 1: The measured values of exhaust and measurement ranges*
3. Results and discussions

3.1. Carbon Monoxide VS Load
From the table 2 and figure 4, it shows that Carbon monoxide emission with the three hole nozzle has the highest emission of 0.037, 0.039, 0.042 and 0.043 for corresponding jack fruit peel biodiesel of 20%, 40%, 60% blend and Diesel for various loads. Among the below shown various percentage mixture it is found that Diesel emits more carbon monoxide compared to other.

Table 2: The measured output values of carbon monoxide versus load

| Load (kW) | Biofuel mixture with diesel |
|-----------|----------------------------|
|           | 20% | 40% | 60% | Diesel |
| 0         | 0.011| 0.012| 0.013| 0.014  |
| 3         | 0.017| 0.019| 0.02 | 0.021  |
| 6         | 0.023| 0.025| 0.026| 0.028  |
| 9         | 0.037| 0.039| 0.042| 0.043  |

Figure 4. Variation of Carbon Monoxide with load

3.2. Hydro Carbon VS Load
From the table 3 and figure 5, it shows that Hydro Carbon emission with the three hole nozzle has the lowest emission for jack fruit peel biodiesel of 2.1, 2.4, 2.7 and 3 for corresponding 20%, 40%, 60% blend and Diesel for various loads. Among the shown various percentage mixture it is found that Diesel emits more hydro carbon compared to others.
Table 3: The results of hydro carbon versus load.

| Load | Biofuel mixture with diesel |
|------|----------------------------|
|      | 20% | 40% | 60% | Diesel |
| 0    | 6.25 | 6.5 | 6.75 | 7 |
| 3    | 5.3  | 5.5 | 5.8  | 6 |
| 6    | 4.1  | 4.3 | 4.4  | 4.7 |
| 9    | 2.1  | 2.4 | 2.7  | 3 |

Figure 5. Variation of Hydro Carbon with load

3.3. Carbon Dioxide VS Load

From the table 4 and figure 6, it shows that Carbon Dioxide with the three hole nozzle has the highest emission for jack fruit peel biodiesel of 1.5, 1.7, 1.8 and 1.9 for corresponding 20%, 40%, 60% blend and Diesel for various loads. Among the shown various percentage mixture it is found that Diesel emits more carbon dioxide compared to others.

Table 4: Carbon dioxide vs load

| Load | Biofuel mixture with diesel |
|------|----------------------------|
|      | 20% | 40% | 60% | Diesel |
| 0    | 0.45 | 0.54 | 0.65 | 0.7 |
| 3    | 0.7  | 0.8  | 0.9  | 1 |
| 6    | 1.1  | 1.2  | 1.3  | 1.4 |
| 9    | 1.5  | 1.7  | 1.8  | 1.9 |
3.4. Oxygen VS Load
From the table 5 and figure 7, it shows that Oxygen with the three hole nozzle has the highest emission for jack fruit peel biodiesel of 19.6, 20.15, 20.65 and 21.5 for corresponding 20%, 40%, 60% blend and Diesel for various loads. Among the shown various percentage mixture it is found that Diesel emits more Oxygen compared to others.

Table 5: The variation of Oxygen with load

| Load | Biofuel mixture with diesel |
|------|----------------------------|
|      | 20% | 40% | 60% | Diesel |
| 0    | 8.5  | 9.15| 9.75| 10.5   |
| 3    | 12.81| 13.14| 13.65| 13.9   |
| 6    | 15.89| 16.48| 16.98| 17.35  |
| 9    | 19.6 | 20.15| 20.65| 21.5   |

Figure 6. Variation of Carbon-DiOxide with load

Figure 7. Variation of Oxygen with load
3.5. Nitric Oxide VS Load
From the table 6 and figure 8, it shows that Nitric Oxide with the three hole nozzle has the highest emission for jack fruit peel biodiesel of 230, 266, 271 and 289 for corresponding 20%, 40%, 60% blend and Diesel for various loads. Among the shown various percentage mixture it is found that Diesel emits more Nitric oxide compared to others.

| Load | Biofuel mixture with diesel |
|------|----------------------------|
|      | 20% | 40% | 60% | Diesel |
| 0    | 20  | 28  | 31  | 39     |
| 3    | 70  | 74  | 85  | 111    |
| 6    | 164 | 168 | 200 | 234    |
| 9    | 230 | 266 | 271 | 289    |

Figure 8. Variation of nitric oxide with load

3.6. Smoke Density VS Load
From the table 7 and figure 9, it shows that Smoke Density with the three hole nozzle has the highest emission for jack fruit peel biodiesel of 28.7, 29.1, 29.5 and 32.6 for corresponding 20%, 40%, 60% blend and Diesel for various loads. Among the shown various percentage mixture it is found that Diesel has more Smoke Density compared to others.
Table 7: The smoke density versus load

| Load (kW) | Biofuel mixture with diesel |
|-----------|----------------------------|
|           | 20% | 40% | 60% | Diesel |
| 0         | 14.4| 15.7| 17.1| 19.5   |
| 3         | 19.5| 20.2| 20.6| 21.3   |
| 6         | 23.4| 24.5| 25.9| 27.5   |
| 9         | 28.7| 29.1| 29.5| 32.6   |

Figure 9. Variation of Smoke Density with load

3.7. Specific Fuel Consumption VS Load

From the table 8 and figure 10, it shows that Specific Fuel Consumption with the three hole nozzle has value for jack fruit peel biodiesel of 0.3, 0.31, 0.32 and 0.34 for corresponding 20%, 40%, 60% blend and Diesel for various loads. Among the shown various percentage mixture it is found that Diesel has more specific fuel consumption value compared to others.

Table 8: The Specific fuel consumption versus load

| Load (kW) | Biofuel mixture with diesel |
|-----------|----------------------------|
|           | 20% | 40% | 60% | Diesel |
| 0         | 0   | 0   | 0   | 0      |
| 3         | 0.55| 0.57| 0.58| 0.61   |
| 6         | 0.34| 0.34| 0.37| 0.37   |
| 9         | 0.3 | 0.31| 0.32| 0.34   |
3.8. Break thermal Efficiency VS Load

From the table 9 and figure 11, it shows that Break thermal Efficiency with the three hole nozzle has the highest value for jack fruit peel biodiesel of 27.1, 27.4, 27 and 30.5 for corresponding 20%, 40%, 60% blend and Diesel for various loads. Among the shown various percentage mixture it is found that Diesel has more Break thermal Efficiency compared to others.

Table 9: Break thermal Efficiency versus load

| Load (kW) | Biofuel mixture with diesel | 20%  | 40%  | 60%  | Diesel |
|-----------|----------------------------|------|------|------|--------|
| 0         |                            | 0    | 0    | 0    | 0      |
| 3         |                            | 14   | 15   | 13.5 | 15.6   |
| 6         |                            | 23.2 | 23.2 | 25   | 25.2   |
| 9         |                            | 27.1 | 27.4 | 27   | 30.5   |

Figure 10. Variation of Specific fuel consumption with load

Figure 11. Variation of Break thermal Efficiency with load
4. Conclusion
The above analysis has examined the emission characteristics of jack fruit peel oil. The testing was done in VCR engine (1500 rpm) at various ratios. From the above investigation the below results are obtained,

- Jack fruit peel oil is found to be a hopeful alternative fuel for VCR Engine.
- With or without any modification in CI engine, Jack fruit peel biodiesel can be used directly or combining with minimal ratio of diesel.
- The values of emissions of Carbon Monoxide, Nitric Oxide, Carbon dioxide, Smoke density and Brake thermal efficiency are increasing whereas, Hydro Carbon emission is decreasing with load.

References

[1] Nagendra S, Kiran A.V.N.S, Santosh Kumar B, Swetha D and Saleemuddin S.M 2019 International Journal of Engineering and Advanced Technology Volume-8 Issue-5 2249-8958
[2] Yogendra Rathore, Dinesh Ramchandani and Pandey R.K 2019 Heliyon 10.1016/j.heliyon.2019.e02717.
[3] Rojaasekar R, Ganesan S, Marynishanthi W 2018 International Journal of Ambient Energy 10.1080/01430750.2018.1476261.
[4] Naresh V and Prabhakar S 2018 Journal of Chemical and Pharmaceutical Research 44-35 0975-7384.
[5] Abhijeet P. Shah, Sharad D. Patil 2017 AMSE Journals Vol. 78; pp 337-350
[6] Mohammed Shamim , Syed Aalam C , Manivannan D and Pyyush Kumarn 2017 International Journal of Advanced Engineering Research and Science Vol-4, Issue-2 2349-6495
[7] Srivasatava M.V, Yadav A, Ajeet Kumar and Jeevan V.Tirkey 2017 International Conference on Go Green, Vol.3, pp-01-10
[8] Akash Deep, Sarbjot Singh Sandhu and SubhashChander 2017 Fuel 210 15–22
[9] Prabhhahar M, Sendivelan S, Prakash S and Saravanakumar M 2017 Rasayan j.Chem. Vol. 10 | No. 4 | 1075-1079 0974-1496
[10] Sivaramakrishnan K 2017 Egypt. J. Petrol. 10.1016 03.001
[11] Sam Sukumar and Muralidhra Rao M 2016 International Journal of Mechanical Engineering and Computer Applications Vol 4, No. 1 2320-6349
[12] Shailendra K. Shukla, Jeevan V. Tirkey, and Bhraspati Singh 2016 International Journal of Power and Energy Systems Vol. 36 No. 3
[13] Suresh yaramati and Sakthimurugan V 2016 International Conference on Materials Engineering and Characterizatio 10.1088/1757-899X/574/1/012016
[14] Jennifer Pieter Soetardjia, Cynthia Widjaja, Yovita Djojorahardjoa, Felycia Edi Soetaredjoa, Suryadi Ismadjia 2013 International Conference and Workshop on Chemical Engineering.