Emission characteristics of hibiscus oil with three hole nozzle

K Surendrababu¹, R Mahesh², P Chiranchan Sivoh³, D Aksha³ and A Akhil¹

¹Associate Professor, Aarupadai Veedu Institute of Technology, Chennai
²Assistant Professor, Aarupadai Veedu Institute of Technology, Chennai
³UG Student, Aarupadai Veedu Institute of Technology, Chennai
E mail: ksbtkm@gmail.com

Abstract. Alternative fuels are liquids that can be used in the place of conventional fuels. They are derived from various sources other than petroleum like vegetable oils and animal fats. Biodiesel can be produced domestically making us less dependency on imported fuels. They are less pollutant than diesel engine. This paper deals with comparison between the 20% hibiscus biodiesel and 20% diesel. Hibiscus is produced by transesterification method using potassium hydroxide (KOH) as catalyst. This biofuel is used in tested in four stoke, single cylinder, variable compression engine (VCR). The rated speed of the engine is 1500 rpm. This emission performance is analyzing for three hole nozzles with blends. From the analysis it is found that the Nitrous oxide and particulate matter increases whereas the Hydro carbon emission slightly decreasing with load.

Keyword: Performance, Emission, Hibiscus oil, Three hole nozzle

1. Introduction
As the population is increasing rapidly the demand for the fuels are also increasing. Biodiesel are the best alternative fuel for the conventional fuels like diesel and gasoline. As these biodiesel can be produced vegetable oil and animal oil, the can be manufactured domestically. Biodiesel produces clean energy and it is best suitable as substitute for diesel engine [1-2]. The most important fact is that the biodiesel can be used in the existing engine with or without any modification.

While using biodiesel as a vehicle fuel energy security is increased, air quality is improved and the environmental pollution is reduced [3-4]. At the same time availability of raw material for biodiesel production and sustainability of biodiesel sources can be one of the
limiting factors while using biodiesel [5-7]. Though there are many ways to produce the biodiesel, the most common way is the transesterification method [8-9]. There are various studies made in analyzing various biodiesel [10]. The researcher has studied the production of biodiesel from Hibiscus sabdariffa (Roselle) Seed Oil [11]. They have stated that the biodiesel is having the similar characteristics of diesel. It’s studied about Neem biodiesel and Kanagaraja about Kananja oil biodiesel [12]. The emission characteristic of rice bean biodiesel and about the Rapseed biodiesel have studied on the emission characteristics of Roselle oil [13-14]. There are many researchers have analyzed the emission characteristics of Hibiscus biodiesel also like they all have mentioned that the biodiesel is best alternative fuel for diesel [15].

As the need for clean energy is keep on increasing the research studies on various biodiesel is also increasing. The objective of this study, the hibiscus oil is blended with 20% of diesel and it is compared with 20% of diesel. The testing is done in VCR engine at various loads. Its emission characteristics such are analyzed.

2. Experimental setup
The experimental setup involves four stroke, single cylinder, and VCR engine. As shown in Figure 1

![Figure 1 Working process of diesel engine](image-url)
There are some main components in VCR engines. There is a two different Fuel injection pump one for diesel and other for biodiesel. Both fuel pumps are monitored by a sensor. It is connected with a dynamometer to measure combustion pressure, crank- angle, airflow, fuel flow, temperatures and load. There is a device connected for changing the fuel without stopping the engine. Rotameters are present measure the cool water and calorimeter water flow. The dynamometer controller is controlled to load and engine speed, for measuring the inside pressure of cylinder using Piezoelectric transducer is placed in the engine head. The received Signals are transferred to the resonator.

The exhaust gases are monitored by the AVL exhaust gas analyzer and the reading are measured by AVL smoke meter. The monitor is connected to display the readings and record the same. By using the VCR engine we can measure the performance of engine which includes the brake, frictional and indicated power. The brake thermal and indicated thermal efficiency is monitored. The mechanical efficiency and the specific fuel consumption of the biofuel are also displayed in the monitor. The model of VCR engine is shown in figure 2.

3. Emission Analyzer
AVL Gas Analyzer is used to measure Hydro Carbon, Carbon monoxide, Carbon dioxide, Oxygen and Nitric oxide present in the exhaust gases. Non-scattering infrared is used to measure Carbon monoxide, Carbon dioxide and Hydro carbon. But electrochemical method is used for Oxygen and Nitric Oxide. The measurement intention of Hydro Carbon and Nitric Oxide is 1ppm each and Carbon monoxide, Carbon dioxide, Oxygen is 0.01% each.

4. Gas Analyzer Specifications (Type AVL DIGAS)
The exhaust gas is transmitted to the filter first to remove the unwanted particles. Then it is transmitted through a cold trap to remove the moist in the gas. After undergoing these
processes the pure gases is passed through the sensor to measure the readings. The output is displayed in the monitor and it is also recorded for future reference. The exhaust gas analyzer specifications are mentioned in Table 1.

**Table 1** The measured values of exhaust and measurement ranges

| 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        |

5. Results and discussion

5.1. Carbon Monoxide VS Load

From the table 2 and figure 3, it shows that Carbon monoxide emission with the three hole nozzle has the highest emission 0.03 and 0.4 for corresponding hibiscus 20% and diesel 40%, for various loads. From the result it shows that diesel emitted more Carbon Monoxide when compared to Hibiscus oil.

**Table 2** Carbon monoxide versus load

| Load | Hibiscus 20% | Diesel 20% |
|------|--------------|------------|
| 0    | 0.02         | 0.03       |
| 3    | 0.02         | 0.03       |
| 6    | 0.02         | 0.03       |
| 9    | 0.03         | 0.04       |

**Figure 3** Variation of Carbon Monoxide with load
5.2. Hydro Carbon VS Load
From the table 3 and figure 4, it shows that Hydro Carbon emission with the three hole nozzle has the lowest emission 2.89 and 3.18 for corresponding hibiscus 20% and diesel 40%, for various loads. From the result it shows that diesel emitted more hydro carbon compared to Hibiscus oil.

| Load (kW) | Hibiscus 20% | Diesel 20% |
|-----------|--------------|------------|
| 0         | 4.5          | 5          |
| 3         | 4.13         | 4.75       |
| 6         | 3.86         | 4.24       |
| 9         | 2.89         | 3.18       |

![Figure 4](image)

**Figure 4** Variation of Hydro Carbon with load

5.3. Carbon Dioxide VS Load
From the table 4 and figure 5, it shows that Carbon Dioxide with the three hole nozzle has the highest emission, 1.6 and 2.1 for corresponding Hibiscus 20% and Diesel 20% for various loads. Among them it is found that diesel emitted more CO2 compared to Hibiscus.

| Load (kW) | Hibiscus 20% | Diesel 20% |
|-----------|--------------|------------|
| 0         | 0.8          | 0.6        |
| 3         | 1            | 0.9        |
| 6         | 1.1          | 1.2        |
| 9         | 1.6          | 2.1        |
5.4. Oxygen VS LOAD

From the table 5 and figure 6, it shows that Oxygen with the three hole nozzle has the highest emission of 19.78 and 19.99 for corresponding Hibiscus 20% and Diesel 20% for various loads. Among them it is found that diesel emitted more Oxygen compared to Hibiscus.

**Table 5 Oxygen vs load**

| Load (kW) | Hibiscus 20% | Diesel 20% |
|-----------|-------------|------------|
| 0         | 19.33       | 19.42      |
| 3         | 19.46       | 19.52      |
| 6         | 19.37       | 19.49      |
| 9         | 19.78       | 19.99      |

**Figure 5** Variation of Carbon-dioxide with load

**Figure 6** Variation of Oxygen with load
5.5. Nitric Oxide VS LOAD

From the table 6 and figure 7, it shows that Nitric Oxide with the three hole nozzle has the highest emission of 232 and 248 for corresponding Hibiscus 20% and Diesel 20% for various loads. Among them it is found that diesel emittes more Nitric oxide Hybiscus.

Table 6 Nitric Oxide vs load

| Load | Hibiscus 20% | Diesel 20% |
|------|--------------|------------|
| 0    | 39           | 38         |
| 3    | 94           | 101        |
| 6    | 154          | 165        |
| 9    | 232          | 248        |

![Figure 7 Variation of Nitric Oxide with load](image)

5.6. Specific Fuel Consumption VS Load

From the table 7 and figure 8, it shows that Specific Fuel Consumption with the three hole nozzle has value of 0.32 and 0.36 for corresponding Hibiscus 20% Diesel 20%, for various loads. Among them it is found that diesel has more Specific Fuel Consumption compared to Hibiscus.

Table 7 Specific Fuel Consumption vs load

| Load | Hibiscus 20% | Diesel 20% |
|------|--------------|------------|
| 0    | 0            | 0          |
| 3    | 0.46         | 0.56       |
| 6    | 0.32         | 0.37       |
| 9    | 0.32         | 0.36       |
Figure 8 Variation of Specific Fuel Consumption with load

5.7. Break thermal Efficiency VS Load
From the table 8 and figure 9, it shows that Break thermal Efficiency with the three hole nozzle has the highest value of 25.8 and 24.5 for corresponding Hibiscus 20% and Diesel 20% for various loads. Among them it is found that Hibiscus has more Break thermal Efficiency compared to Diesel.

Table 8 Break thermal Efficiency vs load

| Load (kW) | Hibiscus 20% | Diesel 20% |
|-----------|--------------|------------|
| 0         | 0            | 0          |
| 3         | 20.3         | 15.5       |
| 6         | 22.9         | 22         |
| 9         | 25.8         | 24.5       |

Figure 9 Variation of Break thermal Efficiency with load
6. Conclusion
From the above experiment of the comparison of the emission characteristics hibiscus oil 20% blended with diesel and diesel 20% and test conducted in VCR engine (1500 rpm) with three hole nozzle, the below results are founded.

- By analyzing the emitted gas with various loads it is found that hibiscus oil emits less Hydro carbon when compared to diesel.
- Carbon mono oxide, Carbon dioxide, Nitric oxide and Oxygen emission levels are more in diesel than the hibiscus oil.
- The specific fuel consumption of hibiscus is less whereas its break thermal efficiency is more when compared with diesel.
- Hibiscus oil is a promising alternate fuel for diesel and it can be used directly or blending with diesel without any changes in CI engine.

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