Investigation on the Performance and Exhaust Emission of a Four Stroke CI Engine Using Diesel
Jaysukh.S.Gohil1  Prof. Surendra Agrawal2  Dinesh dabhi3
1,2,3Department of Mechanical Engineering
1,2Surbhi Group of Institute, Bhopal, M.P, India 3Leads Institute of Engg & Tech, Baroda, Gujarat, India

Abstract— Energy storage system plays an important role in electric vehicles. In these energy storage systems, a large number of battery cells are usually connected in series to enhance the output voltage for motor driving. The difference in electrochemical characters will cause state-of-charge (SOC) and terminal voltage imbalance between different cells. In the existing system, a hybrid cascaded multilevel converter which involves both battery energy management and motor drives. Each battery cell can be controlled to be connected into the circuit or to be bypassed by a half-bridge converter. All half bridges are cascaded to output a staircase shape dc voltage. Then, an H-bridge converter is used to change the direction of the dc bus voltages to make up ac voltages. The outputs of the converter are multilevel voltages with less harmonics and lower dv/dt, which is helpful to improve the performance of the motor drives. The imbalance of terminal voltage and SOC can also be avoided. So the life of the battery stack will be extended. In the proposed system, the level of the multi-level inverter can be increased to further reduce the total harmonic distortion without change in the circuit topology.

Key words: Four Stroke CI Engine, Engine Test Rig, Exhaust Gas Analyzer

I. INTRODUCTION
An enormous increase in the number of automobiles in recent years has resulted in greater demand for petroleum products. Depletion of crude oil would cause major impact on the transport sector. The rapid depletion in petroleum reserve and uncertainty in petroleum supply due to political and economic reasons, as well as, the escalation in the petroleum prices have stimulated in search for alternatives to petroleum fuels. The situation is very grave in developing countries like India which import 70% of the required fuel, spending 30% of total foreign exchange on oil imports. In view of this, researcher found and analyzes many energy sources like CNG, LNG, LPG, ethanol, methanol, hydrogen, bio diesel and many more. It is essential that alternatives to diesel fuels must be developed. In the view of these, vegetable oils like palm oil, cotton seed oil, pongamia oil are considered as alternative fuels to diesel which are promising alternatives. Recently, significant problems associated with fossil fuel like short supply, drastically increasing price, non-renewability, contamination of environment, adverse effect on bio systems compiles researcher to search for an alternative fuel, which promises a harmonious correlation with sustainable development, energy conservation, management, efficiency, and environmental preservation has become highly pronounced in the present context.

II. OBJECTIVES
Determining the relationship between diesel engine performance and the percentage of Neem bio-diesel in fuel blends. Determining the relationship between pollutant concentrations in diesel engine exhaust and the percentage of Neem bio-diesel in fuel blends.

III. MATERIALS AND METHODS
A. Experimental Setup:
Experimental setup used is shown in figure 1. Engine specification, exhaust gas analyzer device and other details are discussed in following section. Also, cooling of hydraulic dynamometer is done with water circulation.

1) Engine Specification:

![DIagram](image)

Table 1: Engine Specification

<table>
<thead>
<tr>
<th>Make &amp; Model</th>
<th>Mahindra Engine MDI-3200</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Details</td>
<td>Four stroke, Four cylinder, Vertical, Compression Ignition, Water cooled, Direct injection.</td>
</tr>
<tr>
<td>Bore</td>
<td>90.9 mm</td>
</tr>
<tr>
<td>Stroke</td>
<td>92.4 mm</td>
</tr>
<tr>
<td>Firing Order</td>
<td>1-3-4-2</td>
</tr>
<tr>
<td>Lubricating Oil</td>
<td>SAE 20 / SAE 40</td>
</tr>
<tr>
<td>Max. Power</td>
<td>40 B.H.P @ 3000 rpm.</td>
</tr>
</tbody>
</table>

Multi cylinder, four stroke, water cooled, direct injection CI engine is used for experimental purpose. Figure 1 shows the position of engine in experimental setup. Table 1 shows details of engine specification and other details of engine. Cooling water is circulated at constant flow rate.
2) **Exhaust Gas Analyzer Specification:**

Exhaust gas analyzer shown in figure 2 is used for measurement of different pollutants. Indus made (model PEA 205) exhaust gas analyzer is capable to measure carbon monoxide, hydrocarbon, carbon dioxide, oxygen and nitric oxide range and resolution for each parameter is shown in table 2.

<table>
<thead>
<tr>
<th>Emission</th>
<th>Range</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO (%)</td>
<td>0-15.0</td>
<td>0.01</td>
</tr>
<tr>
<td>CO2(%)</td>
<td>0-20</td>
<td>0.01</td>
</tr>
<tr>
<td>HC (ppm)</td>
<td>0-3000 (Propane)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>0-15000 (Hexane)</td>
<td>1</td>
</tr>
<tr>
<td>O2(%)</td>
<td>0-25.00</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Table 2: Exhaust Gas Analyzer Specification

---

**V. RESULT**

A. **Effect of Bio-Diesel Blending On CI Engine:**

1) **Engine Performance Parameters:**

Experiments are carried out at constant engine speed of 1500 RPM. Load is varied by changing excitation of hydraulic dynamometer. Starting from no load observations are taken for each fuel at six different loads. Observations are taken at time when exhaust gas temperature remains steady. Various performance and emission parameters are measured at each load and test fuel are mentioned below. Using measured data, brake power, brake thermal efficiency, brake specific energy consumption are calculated for each test fuel including diesel.

- Time taken for 20ml fuel consumption.
- Exhaust Gas Temperature.
- Load on Dynamometer.
- Carbon Monoxide.
- Hydrocarbon.

Engine performance with diesel is measured first followed by B20, B40, B60 and B100. Data measured and calculated thus used for comparison with mineral diesel.

**B. Brake Thermal Efficiency:**

Figure 4 clearly indicates, as brake power increases the brake thermal efficiency increases for all fuels viz. diesel, neem bio-diesel and its blends. This may due to at part load, lower cylinder pressure results in incomplete combustion of fuel. As load on engine increases cylinder temperature increase which results into more complete combustion of fuel. Hence BTE is showing increasing trend for increasing brake power or load. However, increasing
brake power further shows reduction in BTE for all fuels. The reason behind this may be, as load increases the fuel air ratio increases and reduction in excess air available. This will result in again incomplete combustion of fuel. Maximum value of BTE with diesel fuel obtained is 39.79% at brake power of 20.34 kW. For B20 fuel, maximum brake thermal efficiency obtained is 43.09% at brake power of 20.34 kW. Maximum BTE for B20 fuel is approximate 8.3% higher compared to diesel. Higher brake thermal efficiency of B20 fuel is contributed towards oxygen content of Neem bio-diesel, which helps in complete combustion of fuel. Reduction in CO percentage further strengthens above reason. The second reason behind this may be higher cetane number of Neem bio-diesel, which results in lower ignition delay and hence maximum pressure developed in the cycle moves close to TDC. There is an added advantage of reduction in duration of combustion with Neem bio-diesel as fuel. Using B40 as fuel, maximum BTE attained is 42.36% at brake power of 20.34 kW which is 6.45% higher compared to diesel fuel. BTE with B40 fuel is somewhat high than diesel but lower than B20 fuel at all loads. The reason behind this may be higher kinematic viscosity of Neem bio-diesel. As Neem bio-diesel percentage increases the kinematic viscosity increases and hence larger droplet diameter forms during atomization. This larger droplet diameter requires more time for complete combustion and results in incomplete combustion and finally brake thermal efficiency. Second reason may be higher cetane number of Neem bio-diesel, which may shift maximum pressure away from TDC which results in lower BTE at higher blend percentage. Peak value of BTE for diesel, B20, B40 and B100 are 39.79%, 43.09%, 42.36%, and 38.65% respectively. The reduction in brake thermal efficiency for B100 is 2.9% compared to diesel. The reason behind this may be higher kinematic viscosity of Neem bio-diesel fuel.

C. Brake Specific Energy Consumption:

Figure 5 shows variation in BSEC with brake power and Neem bio-diesel percentage in blend. Brake specific energy consumption analysis is done instead of brake specific fuel consumption to account the effect of lower calorific value of Neem bio-diesel compared to diesel. Brake specific fuel consumption may be higher even though brake thermal efficiency is higher with Neem bio-diesel blends compared to diesel fuel. This is due to lower calorific value of Neem bio-diesel results in more amount of fuel consumption for same energy input compared to diesel. Lower cylinder temperature and lean fuel air ratio at part load results in incomplete combustion and results in higher values of BSEC for all fuels. Minimum BSEC for diesel, B20 and B40 fuels are 9.04811 MJ/kWh, 8.35475 MJ/kWh and 8.499496 MJ/kWh respectively. B20 fuel has lowest BSEC followed by B40 and diesel fuels. B20 and B40 fuels show approximately 7.6% and 6.06% reduction in BSEC compared to diesel fuel. Inbuilt oxygen content, higher cetane number, similar kinematic viscosity and lower combustion duration compared to diesel may be major contributor for lower BSEC of B20 and B40 fuels. Lowest BSEC for B100 fuel is 9.31528 MJ/kWh. Lowest BSEC for B100 fuel is approximately 3% higher compared to lowest BSEC for diesel fuel. As Neem bio-diesel percentage in blend increase, kinematic viscosity of fuel increase. With higher kinematic viscosity and without change in injection pressure, droplet diameter increases and spray pattern also changes for blends as fuels.

D. Exhaust Gas Temperature:

Figure 6 shows variation in exhaust gas temperature with brake power and Neem bio-diesel percentage in blend. With higher droplet diameter duration for combustion increases which results in shift of peak pressure from TDC. Change in spray pattern with higher droplet diameter may results in fuel impingement on combustion chamber walls and improper mixing of fuel with air.
the shift of peak cylinder pressure to TDC. As peak pressure is achieved at closer to TDC full expansion of gases during expansion stroke may result in lower EGT at outlet. With increase in Neem bio-diesel percentage in blends the oxygen content increases and B40, B100 fuel shows higher EGT as compared to diesel fuel. Higher EGT can be direct measure of lower brake thermal efficiency as heat losses due to exhaust gases increases with temperature. Moreover compact combustion chamber results in lower heat loss to cylinder walls contribute for higher EGT.

E. Engine Emission Parameters:

Figures 7 and 8 compare emissions of Carbon Monoxide and Hydrocarbon Emission using diesel, B20, B40 and B100 as fuels.

F. Carbon Monoxide:

![Graph of Carbon Monoxide Emission vs Brake Power](image)

Fig. 7: Variations in Carbon Monoxide Emission with Brake Power and Bio-diesel Percentage in blend

Figure 7 portrays variations in CO emission with brake power and Neem bio-diesel percentage in blend. CO emission decreases with load starting from no load for all fuels. After reaching minimum value, emission of CO increases again for all fuels. This rise is continued up to the maximum brake power for all fuels. The reason behind high emission of CO at no load may be lower cylinder temperature at no load. As load or brake power increases cylinder temperature also increases. This results in reduction of CO emission and its value reaches to a minimum at brake power of 10.17 kW. Further increase in brake power results in higher emission of CO. The reason behind this is explained here. Everyone know that diesel engines are quality governed engines. Here the amount of air sucked for each cycle is nearly constant and irrespective of load or brake power of the engine. Initially at no or part load amount of fuel is less and sufficient excess air results in complete combustion of fuel hence reduction in CO emission is seen. However with increase in load or brake power more and more amount of fuel is injected. Thus excess air available and in turn air fuel ratio inside cylinder decreases. This will result in higher CO emission. Emissions of CO at 25.42 kW part load for diesel, B20, B40 and B100 fuels are 0.0212 %/Vol., 0.02098 %/Vol., 0.02066 %/Vol and 0.02024 %/Vol. respectively. At this load diesel fuel emits highest amount of CO compared to all other fuels. With increase in Neem bio-diesel percentage in fuel emission of CO reduces at this load. The main reason behind this is inbuilt oxygen content of Neem bio-diesel fuel.

Minimum emission of CO with diesel, B20, B40 and B100 fuels are 0.01696 %/Vol., 0.0159 %/Vol., 0.01643 %/Vol. and 0.01402 %/Vol. respectively at brake power of 15.25 kW. Among all compared fuels, CO emission for B20 is lowest followed by B40, diesel and B100. Nevertheless except B100, all fuels shows similar CO emission result. In spite of inbuilt oxygen contents of Neem bio-diesel, with increase in brake power further CO emission is now higher using blends of diesel and Neem bio-diesel and pure Neem bio-diesel. The main reason behind this is attributed towards the higher kinematic viscosity of Neem bio-diesel and blends. As percentage of Neem bio-diesel increases in blend, kinematic viscosity also increases. Further indirect injection CI engine operates at lower injection pressure hence change in kinematic viscosity may drastically change the spray pattern and in turn fuel distribution also. With same injection pressure, atomization of blends and Neem bio-diesel results in to larger droplet diameter. Larger droplet diameter requires more time for combustion and hence results in incomplete combustion of fuels. This will result in increase amount of CO emission. Moreover, larger droplet diameter may impinging on cylinder wall due to higher momentum worsen the problem. At maximum brake power of 25.42 kW, emission of CO with diesel, B20, B40 and B100 fuels are 0.0212 %/Vol., 0.02098 %/Vol., 0.02066 %/Vol and 0.02024 %/Vol. respectively. CO emission with B100 fuel is 5% higher compared to diesel fuel. Reduction in BTE with B60, and B100 in this brake power range compared to diesel fuel strengthens the above results.

G. Hydrocarbon:

![Graph of Hydrocarbon Emission vs Brake Power](image)

Fig. 8: Variations in Hydrocarbon Emission with Brake Power and Bio-diesel Percentage in blend

Figure 8 shows variations in HC emissions with brake power and Neem bio-diesel percentage in blend. HC emissions are highest at no load for all fuels. The reason behind higher HC emissions at no or part load is lower cylinder temperature. Increase in brake power or load results in reduction in HC emissions for all fuels. The reason behind this is increase in cylinder temperature with rise in brake power or load. HC emissions are lowest at brake power of 25.42 kW for all fuels. HC emissions are highest at no load and decreases with increase in brake power or load. While blending Neem bio-diesel with diesel results in reduced HC emissions at all load. With increase in Neem bio-diesel percentage in blend further reduces the HC emissions. B100 shows lowest HC emissions among all fuels.
fuels. Highest HC emissions for diesel, B20, B40 and B100 fuel are 11 ppm, 10 ppm, 9 ppm and 8 ppm respectively at no load. While using B100 fuel emission of HC reduces approximately half the value of HC emissions using diesel fuel. The primary reason behind less HC emission of Neem bio-diesel is contributed towards oxygen content of Neem bio-diesel. As Neem bio-diesel percentage in blend increases, oxygen content also increases and hence results in reduced amount of HC emissions using Neem bio-diesel as fuel. At brake power of 25.42 KW all test fuels show HC emissions of 7ppm and are almost same for all fuels. The reason behind this may be indirect injection combustion chamber of high speed engines emits less amount of CO and HC. Though figure 4.8 shows same value of HC emission for different blend at maximum brake power, in actual it may be different. Here, lower resolution of exhaust gas analyser may be unable to distinguish minor change.

VI. CONCLUSION

Maximum BTE for B20 fuel is approximate 8.3% higher compared to diesel. Higher brake thermal efficiency of B20 fuel is contributed towards oxygen content of Neem bio-diesel. B20 fuel has lowest BSEC followed by B40 and diesel fuels. With increase in Neem bio-diesel percentage in blends the oxygen content increases and B40, B100 fuel shows higher EGT as compared to diesel fuel. Minimum emission of CO with diesel, B20, B40 and B100 fuels are 0.01696 %/Vol., 0.0159 %/Vol., 0.01643 %/Vol. and 0.01402 %/Vol. respectively at brake power of 15.25 KW. Highest HC emissions for diesel, B20, B40 and B100 fuel are 11 ppm, 10 ppm, 9 ppm and 8 ppm respectively at no load.

VII. Acknowledgement

We would like to express a gratitude to everyone who gave us the every possible guidance and help to learn more about system which imparted more knowledge about the topic. In the first instance we would like to thanks mechanical department of our Institute for giving us permission to commence this project. We would further more like to department of our Institute for giving us permission to the first instance we would like to thanks mechanical system which imparted more knowledge about the topic. In us the every possible guidance and help to learn more about

REFERENCES

[19] Barsic NJ, Hurnke AL. Performance and emission characteristic of a naturally aspirated diesel engine
with vegetable oil fuels. SAE 1981; 1173–87 (paper no. 810262).


[22] Murayama T. Low carbon flower build-up, low smoke and efficient diesel operation with vegetable oil by conversion into monoesters and blending with diesel or alcohol. SAE 1984;5:292–301 (paper no. 841161).


