A Study on Technical and PM Emission Characteristics on Diesel Engines Using Biodiesel Based Palm Oil

Van Viet Pham

Abstract—The transport industry is facing problems such as the exhaustion of fossil fuels and the threat of pollution from emissions from internal combustion engines. The use of alternative fuels is considered as one of the effective solutions to address the pressure on fuel prices and environmental pollution. Using biofuels is considered an emerging solution to ensure energy security in transportation and environment friendliness. Palm oil-based biodiesel is a relatively abundant fuel source and is compatible with traditional diesel engines with little change to the engine structure. The paper focuses on the possibility of using biodiesel derived from palm oil with the volume ratio of 5%, 10% and 15% on Vikyno EV2600 engine. Thereby, it will analyze and evaluate the technical features and emission level of the engine compared to traditional diesel fuel. In addition, this study is also worth the impact of the blend ratio of palm oil-based biofuel with diesel to the PM emission level of the test engine.

Index Terms—PM emission, biodiesel, palm oil, diesel engines.

I. INTRODUCTION

Currently, the socio-economic development and improving the quality of life in Vietnam in particular and in the world in general are existing many issues that need to be addressed in that development strategy [1]. In which, the rising is the energy and the environment, the energy and environment policies are always placed on top of each country in the national development strategy [2]; Vietnam is also in the general situation of the world [3]. That is the exhaustion of energy (gasoline, oil, gas ...) and environmental pollution [4].

Besides, environmental pollution is the top concern of mankind. In particular, the transport sector is a significant source of pollution due to engine exhaust as well as noise [5]. Currently, according to statistics, the fuel that the vehicles consume only accounts for 1/3 of the global energy but discharges into the environment a toxic gas accounting for 70% of the emissions [6]. The scarcity of fossil fuels in addition to the increased demand for fuel leads to an increase in the quality of petroleum and the backward structure and technology of automobile engines making the environment more and more polluted. more important [7],[8]. To cope with that situation, the study of finding other types of fuels to replace each part to completely replace fossil fuels will be exhausted [9] in the future and environmentally friendly due to internal combustion engines because It is an urgent and important issue [10]. Environmentally friendly biodiesel due to its low sulfur content can be extracted from Jatropha tree seeds (Porridge), a plant that grows wild in our northern provinces [11]. The world's Biodiesel school is estimated to reach 37 billion gallons or 140 billion liters in 2016, an annual growth rate of 42% [12]. The EU will continue to be the largest biodiesel market in this decade, followed by the US market. In addition, India plans to replace 50% of fuel oil by 2030.

In Vietnam, Petro Vietnam plans to bring 10% Bio-Diesel (B10) into diesel components to circulate on the market [13]. According to the proposal of the Ministry of Industry and Sojitz Company Office in Hanoi, August 3, 2005, the Ministry of Natural Resources and Environment, as the focal point of the Government of Vietnam, participated and carried out Kyoto letter has confirmed the PIN project to develop biodiesel according to the clean development mechanism (CDM) in Binh Dinh province [14].

The most important finding from Jatropha is to get seeds to produce biodiesel. Jatropha seeds have an oil content of over 30%, from crude oil pressed seeds [15]. Although Biodiesel is produced from a variety of materials: canola, sunflower, soybean, palm oil, animal fat ..., but produced from Jatropha still has the cheapest price, good quality, equivalent to traditional fossil diesel oil [16]. The use of traditional fuels is now being encouraged to switch to using clean (new) fuels to address fuel, environmental pollution, the two biggest concerns today in the world [17]. Therefore, Research on the effect of Jatropha - Diesel mixing ratio on the formation of soot in exhaust gas is true to the development trend of the area [18]. In order to contribute to the general trend in the world and Vietnam in particular in finding alternative fuel sources, solving the problem of energy exhaustion (petrol, oil, gas, etc.) and pollution environment [19]. Through the study of the theory of Biodiesel fuel (Jatropha oil) as well as the formation of pollutants in engine exhaust when using fuel, it helps to better understand the process of forming pollutants when used. Biodiesel-Diesel mixture [20]. In addition, the effect of engine characteristics (basically the moment and heat consumption) will be the parameters that help the author to analyze more objectively [21].

The evaluation of criteria of economic and technical features of diesel engines in experiment is through quantities of power, torque, fuel consumption and other equivalent quantities [22]. So the theoretical basis of the chapter is the foundation, which is the scientific basis not only to guide the organization of experimental practice, but also to analyze and evaluate scientifically the results obtained on the test bench [23].

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II. MATERIALS AND EXPERIMENTAL SETUP

A. Froude Dynamometer Test Systems

The Froude Hofmann AG150 eddy current dynamometer is rated at 150 kW and has a maximum operating speed of 8000 rpm. It is one of a range of dynamometers that have been designed specifically for testing engines and their components in many applications including Research and Development Quality Audit, Endurance, Production and Overhaul. AG dynamometers range 30 to 750 kW [24]. Power absorption can be in either direction of rotation \( n_d \) standard or high-speed versions are available to meet individual testing requirements. Operating in numerous test cells throughout the world, Froude Hofmann AG dynamometers have demonstrated themselves to be a first class investment providing accurate performance and cost effective, reliable service.

The dynamometer consists of a shaft/rotor assembly mounted within a casing supported on a rigid baseplate. The power absorbed by the dynamometer is controlled by varying the magnetic field generated by coils housed within the casing [20]. As the shaft rotates, the rotor cuts the magnetic field and eddy currents are generated within the loss plates. These eddy currents act to oppose the rotation of the shaft applying a load to the prime mover and generating heat in the loss plates. Thus the absorbed engine power appears as heat in the loss plates, which is dissipated by cooling water flowing through specially designed passages machined into the rear of the loss plates. The speed is measured by an electromagnetic pulse pick up and a toothed wheel mounted on the shaft half coupling hub. The bedplate also supports the external water connections and the electrical terminal box that interfaces the dynamometer to the control system [15].

B. Install Test Bench and Engine

![Schematic diagram of the engine test bench](https://example.com/schematic.png)

Fig. 1. Schematic diagram of the engine test bench

<table>
<thead>
<tr>
<th>TABLE I: SPECIFICATIONS OF EV2600N ENGINE</th>
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<tbody>
<tr>
<td>Parameters</td>
</tr>
<tr>
<td>Model</td>
</tr>
<tr>
<td>Type</td>
</tr>
<tr>
<td>Bore x Stroke (mm)</td>
</tr>
<tr>
<td>Displacement (cm³)</td>
</tr>
<tr>
<td>Continuous output (HP/rpm)</td>
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<tr>
<td>Maximum output</td>
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<tr>
<td>Maximum torque (kgm/rpm)</td>
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<tr>
<td>Compression ratio</td>
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<tr>
<td>Fuel</td>
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<tr>
<td>Fuel tank capacity (l)</td>
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<tr>
<td>Specific fuel consumption (g/HP/hr)</td>
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<tr>
<td>Lubricating oil</td>
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<tr>
<td>Lubricating oil capacity (l)</td>
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<tr>
<td>Combustion system</td>
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<td>Starting system</td>
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<tr>
<td>Cooling system</td>
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</tbody>
</table>

| Cooling water capacity (l) | 4.7 |
| Weight (kg) | 192 |
| Dimensions: L x W x H (mm) | 943 x 453 x 667 |

AVL 733S is a measure of fuel consumption and temperature regulation of liquid fuel. Set Opus 40 is a device to analyze the composition of pollutants in engine exhaust. Measured emissions components include: HC, CO, \( \text{CO}_2 \), \( \text{O}_2 \), NOx. DiLmoke 4000 Diesel Tester analyzes% soot in the exhaust composition. Through the OPAC [%]. Displays engine speed and lubrication temperature through various types of sensors attached to the engine of the device.

C. Testing Process

Running Vikyno EV2600 test engine: Experimental process based on the content, objectives and requirements of the topic. In this topic, I experimented to measure indicators of technical features and pollution levels of engines when
using mixed types of B5, B10, B15[25].

Experimental order: Experiments were conducted through 04 main stages: fuel run DO, B5, B10 and B15. In order to compare and evaluate emissions of Vikyno EV2600 experimental engines when using fuels DO, B5, B10 and B15, it is necessary to set some limited conditions of experiment.

III. RESULTS AND DISCUSSION

A. The engine speed curve with traditional diesel fuel

In 30% mode of the gear position

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<tbody>
<tr>
<td>1200</td>
<td>3.77</td>
<td>29.67</td>
<td>231.64</td>
<td>9992.51</td>
</tr>
<tr>
<td>1400</td>
<td>5.31</td>
<td>35.91</td>
<td>193.82</td>
<td>8361.19</td>
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<tr>
<td>1600</td>
<td>5.45</td>
<td>32.21</td>
<td>216.07</td>
<td>9320.65</td>
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<tr>
<td>1800</td>
<td>6.58</td>
<td>34.59</td>
<td>223.22</td>
<td>9629.09</td>
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<tr>
<td>2000</td>
<td>7.38</td>
<td>34.84</td>
<td>223.26</td>
<td>9631.10</td>
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<tr>
<td>2200</td>
<td>7.41</td>
<td>32.00</td>
<td>239.73</td>
<td>11204.15</td>
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TABLE II: EXPERIMENTAL DATA OF DIESEL FUEL DO-30% OF THE GEAR POSITION

![Fig 2. Torque and power characteristics when using DO at 30% load](Image)

Through the experimental data of preparing experiments and experiments, collecting experimental data [27]. Built motor speed characteristics through the relationship between torque, power and fuel consumption compared to engine speed at different load levels.

Through the graph, we see that, at 1800-2000rpm, the motor works less stable, so the generated moment has a big jump. Even so, the fuel consumption of the engine is still lower than when the engine uses B5 fuel [18]. The process of preparing experiments and experiments, collecting experimental data [27]. Built motor speed characteristics through the relationship between torque, power and fuel consumption compared to engine speed at different load levels.

![Fig 3. Performance characteristics and specific fuel consumption when using B10 at 30% load](Image)

Through the engine power generated and the amount of heat consumed we can grasp the combustion process in the engine [28]. Thereby, most of the causes of forming polluting substances are created. The heat consumption of the engine when using B5, B10, and B15 fuels is larger than when using Diesel fuel. This shows that the thermal efficiency of the engine when using B5, 10, and 15% fuel is smaller than when using Diesel [21].

![Fig 4. The comparison of concentration of PM when using Diesel, B5, B10, B15 at 30% of load](Image)

As shown in the Figure 4, we can see that: with a 30% load of Diesel fuel use, it benefits economically and technically. The generation of engine power has a great influence from the source of fuel [13]. With the low heat of Bio fuel is lower than Diesel fuel, the viscosity is higher but especially the fuel itself has no molecular oxygen, so the burning process of the fuel still has no big impact from the above properties [29]. Through the graph shown in Figure 4, we can calculate the average increase and decrease level of the concentration of PM emissions [30] in engine exhaust when using the four above fuels as follows: The concentration of PM in engine exhaust when using Bio fuel is 5%, 19% lower than Diesel fuel. The concentration of HC in engine exhaust when using Bio fuel 10% increased 29% compared to Diesel fuel. The concentration of PM in engine
exhaust when using Bio fuel is 15%, 11% lower than Diesel fuel.

IV. CONCLUSION

Through the evaluation, analysis and comparison of experimental results of engines using Biodiesel - Diesel fuel with the ratio of mixing volume of respectively 5%, 10% and 15%. I come to the following conclusions:

Mixed fuel B5%, B10%, B15% can be used as fuel for Diesel engines. When using B5%, B10%, B15%, it is possible to share diesel fuel supply system without changing the structure. Engine capacity and torque generated when using DO fuel is higher than B5, 10, and 15% fuels during the experiment according to engine speed characteristics. The economic and technical features of the engine when using B10% fuel are comparable to that of using Diesel fuel, B5% and B15%. There is a decrease in capacity and poor stability at high speeds, a significant increase in caloric consumption, especially B5%. The amount of heat consumption is almost increased compared to DO, some modes (especially at high speed), Bio’s heat consumption is lower. B10% fuel is used as the fuel for the most optimal engine in B5, 10, and B15 fuels for reducing the concentration of pollutant emissions, especially soot concentrations at different loads as well as condensation.

Economic-technical properties.

REFERENCES


