# Fuel Performance of Biodiesel from Microalgae

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**Abstract**
Fuel performance of biodiesel produced from transesterification of microalgae was evaluated to assess its potential as alternative fuel in diesel engine. The biodiesel was produced from transesterification of microalgae Chlorella Vulgaris using K-pumice as catalyst. The engine used in the study was Yanmar 3009D, a small diesel engine with an output power rating of 14.2 kilowatts. The experiments showed comparable power and torque when the engine was run using both the commercial diesel and the algal biodiesel. Biodiesel from microalgae was able to establish a torque of equal to 45.5 N-m while commercial diesel had 48.25 at an engine speed of 2800 rpm. Net break power of Algal biodiesel and commercial diesel are 13.57kW and 13.50kW, respectively. Algal biodiesel had been found to have higher brake-specific fuel consumption and it has a lower exhaust concentrations of nitrogen oxides, oxides of carbon and total hydrocarbons when compared to the commercial diesel. Blending commercial diesel with concentration of algal biodiesel of up to 50% did not show significant change in the performance and emission of the commercial diesel.

**Keywords:** Biofuel, transesterification, K-pumice, power, torque

## 1. Introduction

This research was conducted to determine the feasibility of the production of biodiesel from microalgae. It assessed the physical and chemical properties of algal biodiesel and compared it to the commercial diesel. The study tested the engine performance of the algal biodiesel and its exhaust emissions. Blends of commercial diesel and algal biodiesel were made to identify engine performance in each blend. It was the intent of this study that a viable supplemental fuel can be made to lessen our dependence upon fossil fuels.

## 2. Materials and Methods

The product biodiesel was prepared in different blends for test analysis as described below:

1) 10% AB and 90%CD = B10 AB
2) 20% AB and 80%CD = B20 AB
3) 50% AB and 50%CD = B50 AB
4) 80% AB and 20%CD = B80 AB
5) 100% AB = B100

Test equipment for the fuel blends is the the 3-cylinder Yanmar 3009D diesel engine rated at 14.2 kW. Its bore and stroke is 72mm with a displacement of 0.897 liters. It has an indirect injection combustion system and a compression ratio of 22.6:1. The engine load was controlled by a water-cooled eddy current absorption dynamometer with a Dynamatic® EC 2000 controller. The maximum braking power of the dynamometer of the smaller Yanmar engine was rated at 22.4 kW (30 hp) at 6000 rpm. National Instruments (NI) data acquisition equipment (DAQ) was installed in different parts of the test engines and the test cell.

## 3. Results and Discussions

The values of the flash point are higher for the algal biodiesel when it is compared to the commercial diesel, indicating a fuel of good quality in terms of safety. Water and sediment are below the limit with kinematic viscosity higher that translates into better fuel efficiency. Acid number are also below the limit but it has a higher cloud point than the commercial diesel.

**Table 1.** Fuel Properties of Diesel and Algal Biodiesel

| Property | Method | Specs | Diesel | B100 |
|---|---|---|---|---|
| Flash Point, ºC | D93 | Min 130 | 128 | 180 |
| Water, Sediments | D2709 | 0.05 max | 0.01 | 0.04 |
| Viscosity, $mm^2/s$ | D445 | Min 6.0 | 2.3 | 4.8 |
| Sulfur, ppm | D5453 | 15 max | - | - |
| Cetane number | D613 | Min 47 | - | - |
| Cloud point, ºC | D2500 | report | -35 | 12 |
| Acid number | D664 | 0. 5 max | 0.04 | 0.55 |
| Heating Value | D4809 | report | 42.7 | 39.4 |

SAE J1349 Power test code procedures were the basis used for the performances of the engines at full load using the fuels tested. Baseline engine performance and emissions tests were performed using commercial diesel. Gradual increase in power until reaching the maximum is observed at different engine speeds and spirals down (see Fig. 1). Decrease in power is believed to be associated with the increases in friction due to high enginer speeds.

Comparison of the engine brake power at different fuel blends shows that there is negligible power loss when using the different proportion of Algal biodiesel and diesel (Fig. 2).

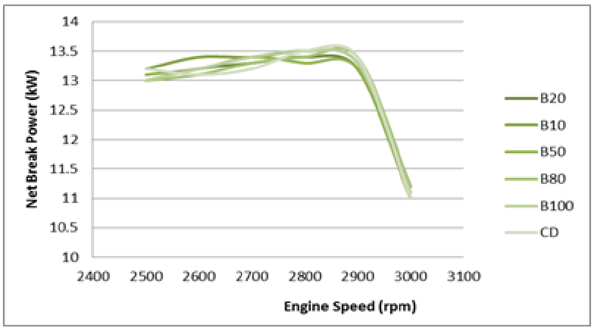


**Figure 1**. Net Break Power at various engine speeds

The increase in engine power when using algal biodiesel can be attributed to the higher viscosity of the fuel, which enhances fuel spray penetration, and thus improves air-fuel mixing. High lubricity of biodiesel may also have contributed in reduced friction loss and thus improve the brake effective power.

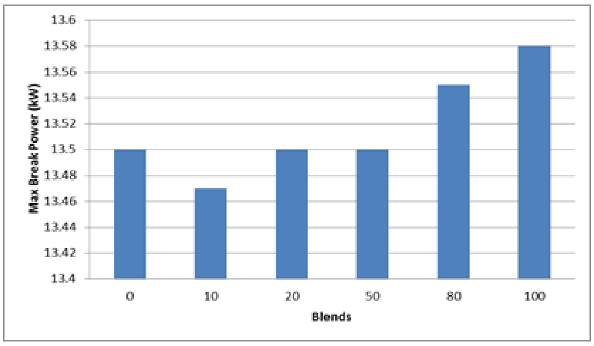


**Figure 2.** Net Break Power at variuos fuel blends

Torque decreases because the engine is unable to ingest a full charge of air at higher speeds. At lower engine speed, it was observed that the best blend was B80 but B50 had a better torque at a slightly higher engine speed.

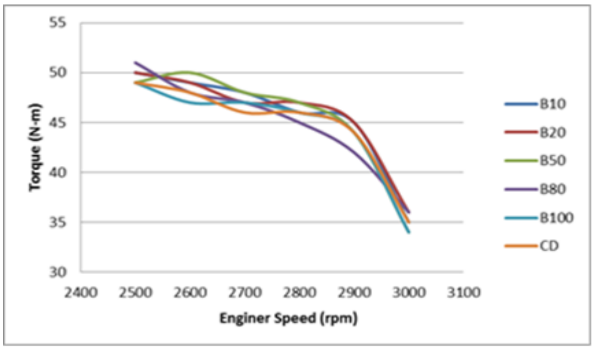


**Figure 3**. Torque at various engine speeds

There was a slight variation in peak torque values for biodiesel blends compared to regular commercial diesel. The peak torque values for B10, B50 and B100 fuel blends were higher than that for commercial diesel. B20 AB obtained the least peak torque value with 45.25N-m, while B50 PME obtained the highest with 48.34 N-m.

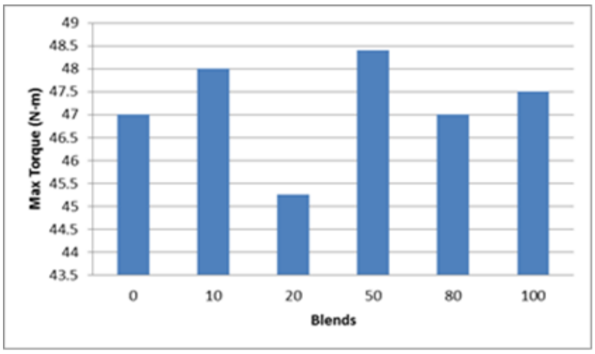


**Figure 4**. Torque at variuos fuel blends

The NOx concentration was found to increase as the percentage of PME biodiesel in a blend is increased, reaching as high as 28% when using pure biodiesel. Commercial diesel had the lesser CO2 concentration (5.5%) while algal biodiesel has approximately 16%. CO2 emissions increase when an engine is ran on biodiesel due to more efficient combustion.

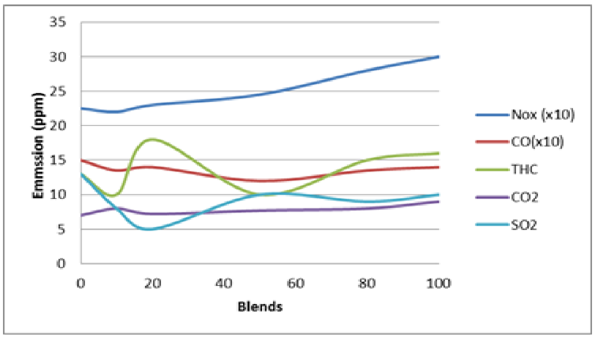


**Figure 5.** Exhaust emissions at various fuel blends

## 4. Results and Discussions

Comparable power and torque were delivered by biodiesel while BSFC was found to be higher as compared to the reference diesel. Analyses of the exhaust emissions of pure algal biodisel showed higher NOx, NOx emissions but lower CO2, CO and THC emissions. SO2 remained below 10 ppm and lower than that produced by the reference diesel.

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