# Emission Characteristics and Fuel Consumption of Biodiesel Obtained from Fish Canning Industry Waste in Agriculture Diesel Engine

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# Emission Characteristics and Fuel Consumption of Biodiesel Obtained from Fish Canning Industry Waste in Agriculture Diesel Engine

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**Abstract**. Increasing the need for fuel oil is something that can't be avoided, while the supply of fossil fuels is running low. Biodiesel is one of the right solutions to overcome this problem. This vast ocean in Indonesia, makes Indonesia the potential to create biodiesel from fish canning industry waste. The purpose of this research is to analyze the effect of dexlite fuel mixture with biodiesel from fish canning industry waste on fuel consumption and exhaust gas opacity in agriculture diesel engines. This type of research uses experimental research. The object of this research is the exhaust emissions and fuel consumption. The results of the study obtained by the researchers are the results of mixing dexlitePertamina (gasoil/high speed diesel oil) fuel with biodiesel of fish waste oil to be used in diesel engines. The highest exhaust gas opacity results in a mixture of 70% dexlite with 30% biodiesel (B30) of 2.6% at 1000 RPM (± 5). The results of the test fuel consumption that most quickly runs out occur in pure dexlite for 131 seconds in 10 ml of fuel at 1000 RPM (± 5). The results of testing the exhaust gas opacity level are increasing, as well as the results of testing fuel consumption which is increasingly economical, due to the high water, carbon and ash content in biodiesel.

## 1. Introduction

Biodiesel is an alternative fuel from renewable energy to replace fossil fuel consumption which has the potential to be developed due to a simple production process and affordable feed stock. Biodiesel, is an alternative fuel for diesel engines, is getting more attention among the many possible options. Biodiesel is a biodegradable and nontoxic fuel which is expected to be a solution [1]. Biodiesel is an ideal fuel for the transportation industry because it can be used in various diesel engines, including agricultural machines. Biodiesel is an alternative fuel that can be used in compression ignition engines because of its similar properties to diesel and a cleaner combustion system. Biodiesel and itsblend have better engine performance including lower particulate matter (PM), HC and CO emissions when compare with the diesel fuel.The use of waste fish oil biodiesel causes higher cylinder pressure along with shorterheat release rate duration when compared to conventional diesel fuel [2]. In addition, more stable combustion without large cycle-to-cycle variations can be achieved using biodiesel and its blends.Fish biodiesel provides a significant reduction in carbon monoxide (CO) and hydrocarbon (HC) emissions under engine load of 15 (Nm) and does not require to modification of an engine diesel[3]. A two-step trans-esterification process is used to convert high FFA oils into methyl esters. The process of disaponification with sodium hydroxide to reduce levels of fatty acids. Experimental optimization

This two-step transesterification method reduces production costs andfind suitable method for the conversion of oils high in free fatty acids to biodiesel [4]. Fat extraction is carried out from fish waste using water as a solvent. Then it is saponified with sodium hydroxide to reduce levels of fatty acids.

Furthermore, the parameter of biodiesel properties is evaluated using ASTM standards to meet the needs of combustion engines [5].Fish waste the form of a fish head, gills, heart and stomach of fish was collected from a traditional market used as raw material for biodiesel production. Two stage process, esterification and transesterification were applied to convert waste fish oil to biodiesel.Heating value of waste fish oil biodiesel was higher (9713 cal/g or 40.67 MJ/kg) than that of used cooking oil biodiesel (9394.1 cal/g) [6].The results of fuels blanding waste anchovy fish oils biodiesel and diesel fuel of 25%:75% (B25), 50%:50% biodiesel–diesel (B50), 75%:25% biodiesel–diesel (B75) usage in a diesel engine test banch single cylinder has average smoke opacity was reduces about 16% and Heating value (KJ/kg) 42655, 41952 and 41249 [7].

## 2. Material and Method

Fish waste oil is obtained from the by-product of the fish canning waste industry in Muncar sub-district of Banyuwangi, the fish that is widely used in the fish canning industry uses *Sardinellasp* ("lemuru fish" in indonesia). Fatty acids contained in fish waste oil *Sardinellasp* include, 5 saturated fatty acids and 8 unsaturated fatty acids which have the highest relative area percentage are 32.06% oleic acid: 30.33% palmitic acid: and 7 myristic acid. , 8%. Oleic acid is unsaturated due to the double bonds, while palmitic acid and myristic acid are saturated fatty acids. This research method uses experimental methods with using Diesel fuel (Dexlite: Pertamina) and biodiesel blending from fish waste with dexlite B0 (Pure Dexlite), B10 (Dexlite 90%, Biodiesel 10), B20 (Dexlite 80%, Biodiesel 20%) and B30 (Dexlite 70%, Biodiesel 30%), with procedure steps are :

### *2.1Esterification*

Fish waste oil plus ash is 1-3% by weight of fish waste oil. Stirring with rate set at 600 rpm with a constant temperature of 60-80$^0$C for 60 minutes, then let it stand for 24 hours, then filtered with filter paper. Then analyzed thelevels of free fatty acid (FFA). For the maximum value of FFA or free fatty acid levels of 2%, the higher the FFA levelwill affect the yield of pure biodiesel, on the other hand, the glycerol content is quite a lot.

**Figure 1.** Esterification

The oil was tested for acidity using the American Oil Chemists' Society (AOCS) method Ca 5a–40 (1989) :

$$FFA\% = \frac{\text{Titrant volume ml} \times (\text{N})\text{oftitrant} \times 25.6}{\text{weight of samples in grams}} \left(\frac{\text{mgNaOH}}{\text{g sample}}\right) \quad (1)$$

### *2.2 Transesterification*

1 gram of NaOH solid is dissolved in methanol with a ratio of 1: 6 moles of oil to moles of methanol then mixed with fish waste oil after adsorption, then stirred with the stirring rate set at 600 rpm with a

constant temperature of 60-80$^0$ C for 60 minutes, after that it was allowed to stand for 24 hours, after that it was filtered with filter paper, to separate the biodiesel from the glycerol.

**Figure 2.** Transesterification

*2.3 Purification*

The finished biodiesel is then purified using distilled water by heating aquades to a temperature of 80-90$^0$C, then mix it into biodiesel with a dose twice the amount of biodiesel, shake it until it becomes homogeneous between the aquades and the biodiesel, then let it sit for 24 hours to separate the biodiesel from the aquades, then separate the aquades from the biodiesel.

**Figure** 3. B0, B10, B20, B30

Agricultural diesel engines used by Yanmar TF55 single cylinder direct injection diesel engines with the following installation units:

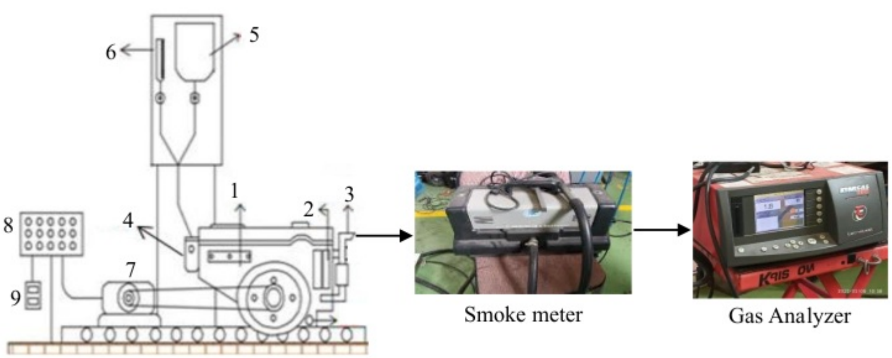


**Figure 4**. Engine Diesel Yanmar TF 55 Test Bench

Where :

1. Engine
2. Radiator Tank
3. Muffler
4. Fuel Filter
5. Fuel Tank
6. Burret
7. Generator
8. Load (lamp)
9. Voltage and Ampermeter

This study analyzed the effect of using a mixture of biodiesel from fish canning waste on exhaust gas opacity and fuel consumption levels. The research procedure is divided into two, namely the first procedure of exhaust gas opacity testing to determine the level of exhaust gas smoke density after using a mixture of biodiesel from fish waste oil every 500 rpm from 1000-2000 rpm. The second procedure is testing the level of fuel consumption to find out how long the fuel and biodiesel mixture from fish waste oil burns in 10 ml of sample. Each test carried out is to compare the results of using pure dexlite fuel with a mixture of dexlite fuel with biodiesel from fish waste oil.

## 3. Result and Discussion

Exhaust gas opacity test to determine the level of opacity resulting from exhaust gas emissions in thecombustion process in a diesel engine [8]. Opacity testing uses a smokemeter on a Yanmar TF 85 MR diesel engine, using a tachometer for measuring engine crankshaft rotation as follows :

**Table 1** Exhaust gas opacity test

| **No** | **Engine Speed (rpm)** | **OPACITY (%)** | | | |
|---|---|---|---|---|---|
| | | B0 | B10 | B20 | B30 |
| **1** | 1000 | 1,2% | 1,6% | 2,1% | 2,6% |
| **2** | 1500 | 2,8% | 4,3% | 3,7% | 4,7% |
| **3** | 2000 | 1,1% | 3,2% | 3,2% | 3,7% |

In table 1, the results of the exhaust gas opacity test data show that the opacity (smoke density) of each sample tends to increase, the more biodiesel mixture there is, the opacity test results tend to increase, because the carbon content and ash content of biodiesel are still quite high, causing a lot of smoke in the combustion residue in the diesel engine.

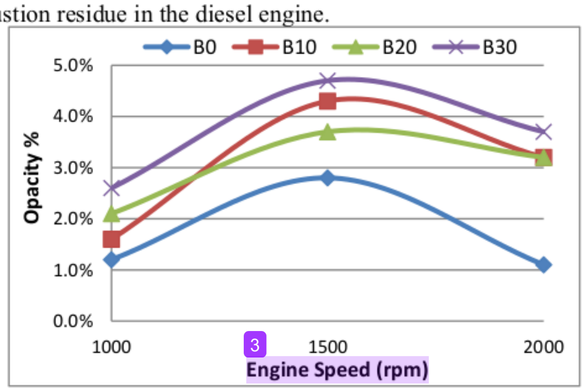


**Figure 5.** Variation of percentage opacity with engine speed

The maximum opacity level for pure dexlite fuel is 2.8%, in a mixture of 90% dexlite fuel + 10% biodiesel (B10) is 4.3%, for a mixture of 80% dexlite fuel + 20% biodiesel (B20) ) of 3.7%, in a mixture of 70% dexlite fuel + 30% biodiesel (B30) of 4.7%. This means that there is more concentrated smoke emitting from the combustion residue in several test samples using a mixture of biodiesel from fish waste oil compared to using pure dexlite fuel. Fuel consumption (FC) test is to determine the amount of fuel burned or consumed per unit time.

$$FC = \left[\frac{V_{fuel} ml}{t_{fuel} second} \times \rho_{fuel}\left(\frac{gr}{ml}\right) \times \frac{3600}{1000}\right]\left(\frac{kg}{hour}\right) \quad (2)$$

Testing the level of fuel consumption using a 10 ml measuring cup on the Yanmar TF 85 MR diesel engine using a stopwatch to measure the length of time it consumes fuel.

**Tabel 2**. Fuel consumption (FC) time

| **No** | **Engine RPM** | **Time of Flowmeter (10 ml) (second)** | | | |
|---|---|---|---|---|---|
| | | B0 | B10 | B20 | B30 |
| **1** | 1000 ± 5 | 131 | 132 | 141 | 142 |
| **2** | 1500 ± 5 | 83 | 86 | 86 | 84 |
| **3** | 2000 ± 5 | 76 | 78 | 84 | 83 |

In the table 2 showed that the results of testing data at level of fuel consumption (FC) each sample tends to experience the increase in time or more efficient. With more blending of biodiesel, make the level of fuel consumption tend to increase in time, because the carbon, ash and water content of biodiesel is still quite high, so that in the combustion process with a mixture of biodiesel more and more it will result in material burn will be difficult to burn.

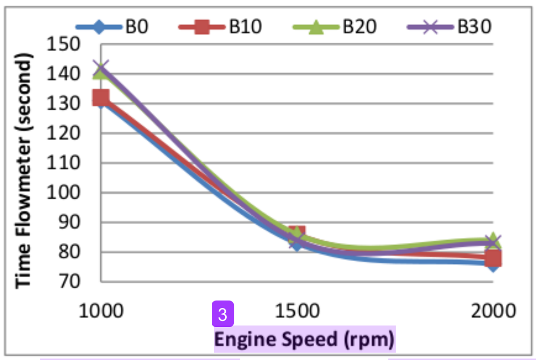


**Figure 6.** Variation of time flowmeter with engine speed

From the graph in Figure 6, the time measured by the flowmeter every 10 ml at engine speed decreases asthe engine speed increases for all types of fuel. This is because the increasing speed of the engine, the fuel that is injected into the combustion chamber increases in volume to compensate for the needs of the combustion process. At 1000 rpm engine speed for all types of fuel has a longer duration than the engine speed of 1500 rpm and 2000 rpm. Overall the use of B20 has a percentage rate of 6.75% longer to spend the 10 ml dose on the flowmeter when compared to B0. While B10 and B30 have an overall longer percentage to spend on fuel per 10 ml of 2.03% and 6.15% of dexlite fuel B0.This is influenced by several factors, including the nature of dexlite fuel which has a lower density level than fuel oil from fish canning waste (B10, B20 and B30).

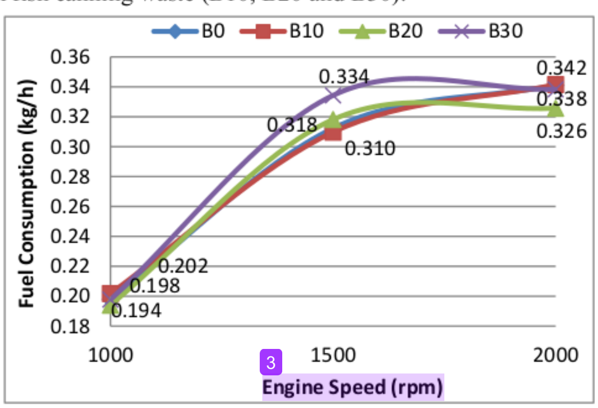


**Figure 7.** Variation of fuel consumption with engine speed

Figure 7 describe the opposite of previousgraph in figure 6 where there is an increase in parabolic with increasing engine speed for all types of fuel used in diesel engine. B10 has a fuel consumption value coincided with B0. While the B20 as a whole has a lower fuel consumption than B0 by 1.6%. And the overall B30 fuel consumption has increased by 2.3% from B0. With the same engine speed of 1500 rpm, B10 has a consumption of 0.31 kg / h, which is lower than B0 of 0.312 kg / h. While at 2000 rpm engine speed, B30 has a consumption of 0.338 kg / h lower than B0 of 0.342 kg / h. So the use of B20 fuel in the Yanmar TF 55 diesel engine is more economical than the use of B0, B10 and B30 fuels.

## 4. Conclusion

The use of biodiesel fuel from fish canning waste resulted in an increase in the concentration of exhaust gas diesel engine when compared to dexlite (B0) fuel with B10 and B20 which had an increase of 3% while B30 was 3.7%. This is because the fuel has a density characteristic of greater than B0. For diesel engine fuel consumption with B20 as a whole is 1.6% lower than B0 fuel.

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