

# AN EXPERIMENTAL STUDY OF DI DIESEL ENGINE FUELLED WITH EMULSION FUEL

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**Abstract---**Engine performance in term of fuel consumption and exhaust temperature of a diesel engine fuelled with emulsion fuel were observed. Emulsion fuel used in this experiment is a blend of 79% of diesel fuel, 20% of water and 1% of surfactant. This experiment compares the effect of usage between emulsion fuel and diesel fuel to single cylinder diesel engine. This experiment is conducted using a single cylinder diesel engine brand Yanmar TF 120, 4 stroke, water cooled. The engine speed is set up to 1200, 1500, 1800 and 2100 rpm and the data is taken at each engine speed. The data that is observed and collected is fuel consumption and exhaust gas temperature at each engine speed of every fuel type usage. From analysis of the experiment, it is observed that the fuel consumption due to usage of emulsion fuel is lower compared to diesel fuel after the content of the diesel fraction (79% diesel content) in the emulsion fuel is taken into account. The amount of energy consumed when emulsion fuel used (without 79% of diesel oil content is taken into account) is lower than diesel fuel by 14.7%. For the exhaust temperature, the temperature due to usage of emulsion fuel is same with diesel fuel for engine speed 1200, 1500 and 1800rpm while for 2100 rpm, the exhaust temperature when the engine is operating with emulsion fuel is lower than the diesel fuel.

**Keywords:** emulsion fuel, diesel fuel, fuel consumption, diesel engine

## I. INTRODUCTION

Diesel engine is a preferred power sources that is used for power plant and also internal combustion engine around the world due to its good efficiency and drivability. Due to its widely usage, it also cause rise of demand and usage of fossil fuel. A significantly rise of fuel price especially back in several years before cause people to start finding ways to reduce the usage of fossil fuel. One of the alternatively developed ways is through emulsion of fuel.

H. Ishida (2005)<sup>[1]</sup> stated that for water-in-oil emulsion, there are several problems in producing a stable emulsion fuel that means stable and uniform dispersion of insoluble water particles in fuel and also a stable state during its transportation through fuel line to combustion chamber. It is also stated that many manufacturers have tried to produce a stable emulsion fuels using variants of surfactant in blending hydrocarbon fuel with water with ratio between 20% to 40%. The use of the emulsion fuel that contains too much water can never be a good energy-saving technology owing to the increase in fuel consumption rate due to the large decrease in the combustion efficiency.

There are three different processes to produce emulsified fuel as stated by Y.K Tseng and H.C Cheng (2011)<sup>[2]</sup>. The first method is directly mixing the chemical additive to the heavy oil, and then stirs it. The product of this method results the reduction of fuel consumption that is below 5% and after deducting the cost of the chemical additives, the reduction is only 2 to 3%. The second method is usage of homogeneous machines to homogenize heavy oil and break up the asphalt sludge which is easy to deposit. Plus, the mixture ratio of oil and air can be improved and also the pipe and burner nozzle blockage can be reduced as well as, that will conducive to have more favorable combustion and to improve the energy efficiency by 2 ~ 3%, which is still considered small. The third method is adding the right amount of water and additives into heavy oil, and after proper mixing procedures, so that water molecules become the dispersed phase is surrounded by the oil molecules, the emulsified oil production is completed. The results of this last method gives 4 to 6% of the energy saving effect compared to the first two methods, which is clearly more cost-effective.

M. Nadeem et.al (2006)<sup>[3]</sup> stated that emulsified fuel is one of the potentially effective techniques to reduce exhaust emission from diesel

engines. Water- in-diesel emulsified formulations are reported to reduce the emissions of NO<sub>x</sub>, SO<sub>x</sub>, CO and particulate matter (PM) without reducing the engine's performance. The obtained experimental results indicate that the emulsions stabilized by gemini surfactant have much finer and better distributed water droplets as compared to those stabilized by conventional surfactant. The biggest reduction in PM, NO<sub>x</sub>, CO and SO<sub>x</sub>

emission was achieved by the emulsion stabilized by gemini surfactant containing 15% water contents.

The main purpose of this study is to investigate the effect of usage of emulsion fuel as an alternative fuel compared to ordinary diesel fuel. The fuel consumption and exhaust gas temperature for both fuel usages is taken and compared.

## II. ENGINE TEST AND DETAILS

A direct-injection diesel engine (model TF120 YANMAR), single cylinder water cooled is used for testing. The engine specification is shown in Table 1. A schematic layout of the experimental setup is depicted in Figure 1. The engine experimentally works on four-stroke cycle and operated at 2100, 1800, 1500, and 1200 rpm with no load exerted on it. The engine is run using diesel

fuel for the beginning at 1200rpm. The fuel consumption and exhaust gas temperature for this engine speed is taken. The procedure is repeated at 1500, 1800 and 2100 rpm and then same procedure applied for emulsion fuel usage. At the end of the test, the engine was run with diesel fuel to flush out emulsion fuel from the fuel line and injection system.

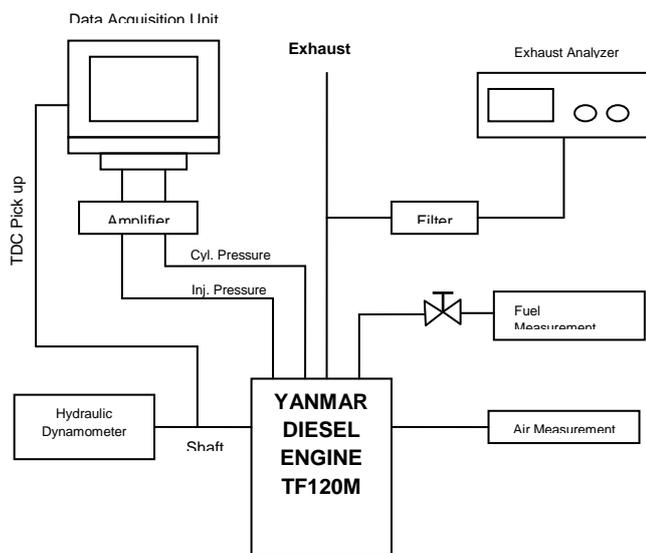


Figure 1: Experimental setup

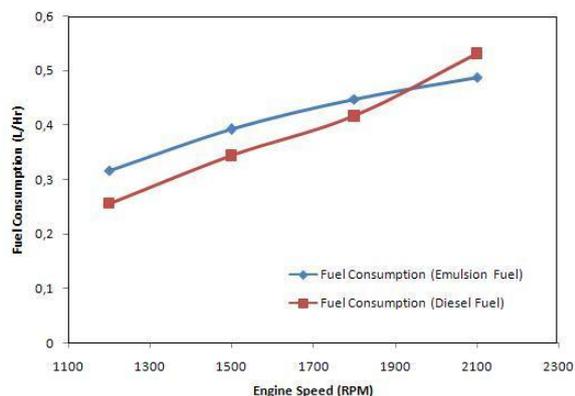
Specification	
Engine Type	YANMAR TF120
Number of Cylinder	1
Bore x stroke (mm)	92 x 96
Displacement (L)	0.638
Continuous Output (HP)	10.5 HP at 2400 rpm
Rated output (HP)	12 HP at 2400 rpm
Cooling system	Radiator
Dry weight (kg)	102

Table 1: Testing Engine Specification

## III. RESULTS AND DISCUSSIONS

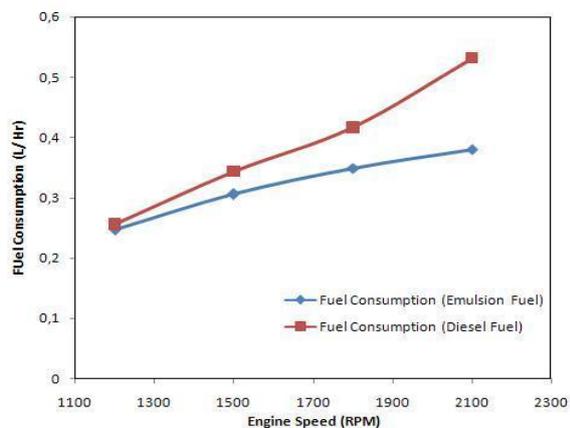
Graph of comparison for both usage of fuel in term of fuel consumption is plotted in the same graph. Figure 2 shows fuel consumption for both usages of

fuel. From the graph, it is found that the fuel consumption when emulsion fuel used higher than diesel fuel by 34.19% before the ratio of the diesel oil in the emulsion fuel is taken into account except for engine speed of 2100 rpm.



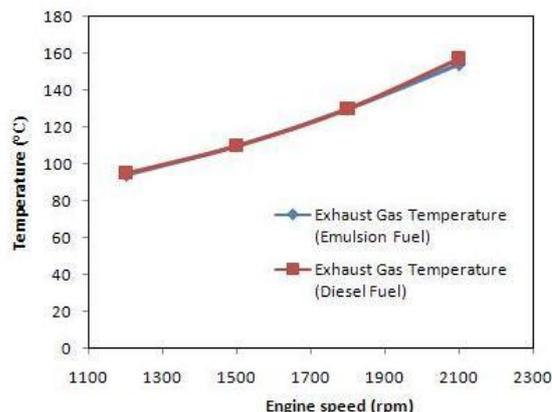
**Figure 2:** Fuel Consumption Comparison before Ratio of Diesel Fuel in Emulsion Fuel is Taken into Consideration

Figure 3 shows the comparison of fuel consumption between emulsion fuel and diesel fuel after the ratio of diesel oil in the emulsion fuel is considered. From the graph, the fuel consumption of emulsion fuel is lower than diesel fuel by 17.19%.



**Figure 3:** Fuel Consumption Comparison after Ratio of Diesel Fuel in Emulsion Fuel is taken into consideration

Figure 4 shows the exhaust gas temperature comparison between emulsion fuel and diesel fuel usage for various engine speed. The exhaust gas temperature due to emulsion fuel usage is lower compared to diesel fuel at engine speed of 1200 rpm and 2100 rpm. While at engine speed of 1500 rpm and 1800 rpm, the exhaust gas temperature is same for both fuel usages. The exhaust gas temperature due to emulsion fuel usage is lower than diesel fuel by 0.813% in average.



**Figure 4:** Exhaust Gas Temperature

Engine Speed (rpm)	Fuel Consumption (L/Hr)	Fuel Use (kJ/Hr)
1200	0.2559	11.81
1500	0.3436	15.86
1800	0.4164	19.22
2100	0.5314	24.53

\*Calorific Value for Diesel: 46.165 kJ kg<sup>-1</sup>

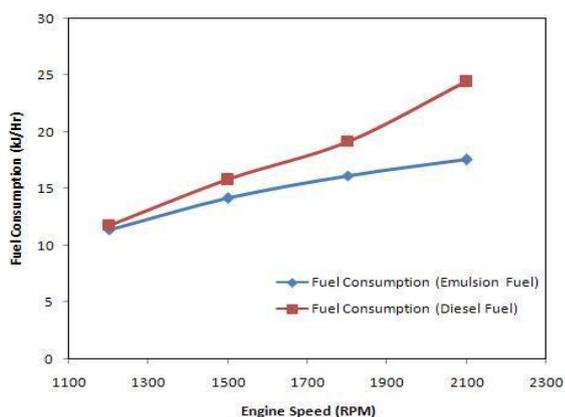
**Table 2:** Fuel Consumption for Diesel Fuel

Engine Speed (rpm)	Fuel Consumption (L/Hr)	Fuel Use (kJ/Hr)
1200	0.3158	11.39
1500	0.3921	14.14
1800	0.4478	16.15
2100	0.4871	24.53

\*Calorific Value for Emulsion Fuel: 36.0671 kJ Kg<sup>-1</sup>

**Table 3:** Fuel Consumption for Emulsion Fuel

Table 2 and 3 shows the fuel consumption (kJ Hr<sup>-1</sup>) for diesel fuel and emulsion fuel. From both figure, it is shown that the fuel consumption for emulsion fuel is lower than the diesel fuel. The difference can be seen in Figure 5 which is the emulsion fuel consumption is lower than diesel fuel by 14.7%.



**Figure 5:** Fuel Consumption (kJ Hr<sup>-1</sup>) Comparison between Diesel Fuel and Emulsion Fuel

#### A. Discussion

When 20% of water is mixed into diesel, two different layers of water and diesel will form in short time. To get a stable mixture of diesel and water, a surfactant is mixed along with diesel and air to make water-in-oil emulsion fuel. Emulsification of these three different liquid produced a white, creamy solution and able to maintain in stable phase for one week. Preliminary results shows that emulsion fuel can be used in diesel engine.

From the results obtained, the fuel consumption of the emulsion fuel is higher than the diesel fuel, but when the percentage of diesel oil (79%) in emulsion fuel is taken into consideration, the fuel consumption is lower compared to 100% of diesel fuel is used as shown in **Figure 3**. The fuel consumption of emulsion fuel when calorific value is taken into account shows that emulsion fuel still produce lower fuel consumption compared to diesel fuel as shown in **Figure 5**.

#### IV. CONCLUSIONS

From this experiment, the fuel consumption and exhaust gas temperature of single cylinder diesel engine operating with emulsion fuel is observed and compared with diesel fuel. From the test conducted, the following conclusions are made:

- Fuel consumption when emulsion fuel is used is higher than diesel fuel if the ratio of diesel oil in emulsion fuel is not taken into account.

- If the ratio of diesel oil in emulsion fuel is taken into consideration, the fuel consumption for emulsion fuel is lower.

- The fuel consumption of emulsion fuel in kJ Hr<sup>-1</sup> is lower than diesel fuel.

- Exhaust gas temperature due to usage of both fuels is same except for engine speed of 1200rpm and 2100rpm. The percentage of difference of exhaust temperature between the fuels is small (less than 1%).

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