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PERFORMANCE OF VARIOUS BIOFUEL BLENDS ON BURNER SYSTEM

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ABSTRACT

Biofuel is known as a potential replacement of fossil fuel nowadays. In Malaysia, one of the simplest ways to produce Biodiesel is mainly by blending palm oil together with conventional diesel fuel (CDF). The performance study of the Biodiesel is essential in order to justify that Biodiesel is better than CDF as fuel. The temperature profiles along the combustor have been studied in this research. The reduction of exhaust pollutants is also studied by using gas emission analysis of Biodiesel. The objective of this study is to determine the optimum blend for best performance while producing less emission compared to CDF; and also to investigate the flame pattern of the blend. The results show that Biodiesel blend of B5 perform better at stoichiometric mixture and that all the emissions of Biodiesel blends are lower than that for CDF.

Keywords: *Biofuel, CDF, Oxides of nitrogen, carbon monoxide, sulphur dioxide*

1.0 INTRODUCTION

Biodiesel is a diesel-type fuel made by separating glycerin from animal and vegetable oils to create methyl esters. It is an alternative fuel that can be used in diesel engines and provides power similar to Conventional Diesel Fuel (CDF). Recent environmental and economic concerns (Kyoto Protocol) have prompted resurgence in the use of Biodiesel throughout the world. In 1991, the European Community, (EC) proposed a 90% tax reduction for the use of biofuels including Biodiesel and today, 21 countries worldwide produce Biodiesel [1]. By knowing that palm oil is one of the highest yielding crops Malaysia has a genuine and rare opportunity to explore and exploit the biofuels markets globally. On 21st March 2006, Malaysian government successfully released the states National Biofuel Policy which is known as the first step of the nation towards developing palm oil as a major source of biofuel [2]. In conjunction with that, the objective of this study is to determine the performance of various blends of biofuel. Blend of Refined, Bleached and Deodorized Palm Oil (RBDPO) and diesel is selected as the biofuel. Several parameters have been studied such as temperature profiles,

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emissions and flame length. This performance study is limited to RBDPO biofuel blends B2, B5, B10 and B15.

2.0 BIOFUELS IN MALAYSIA

The National Biofuel Policy, Malaysian Palm Oil Board (MPOB) works very closely with Malaysian government to conduct research on palm oil regarding the feasibility and capability of the oil towards biofuel production [3],[4]. Malaysian national electricity provider, Tenaga Nasional Berhad has been testing the possibility of using palm oil biofuel for power generation. Studies were conducted by MPOB on the usage of RBDPO without any chemical modifications as a substitute to petroleum diesel. RBDPO/ petroleum diesel blends were tested for industrial use and for transportation [5].

The fuel properties of RBDPO/ petroleum diesel blends (B2, B5, B100) were tested and evaluated and it was concluded that the resultant fuel blends exhibited advantages and fuel characteristics that are better compared to that of RBDPO and petroleum diesel are used solely as fuel. The production flow chart of RBDPO can be seen in Figure 1.

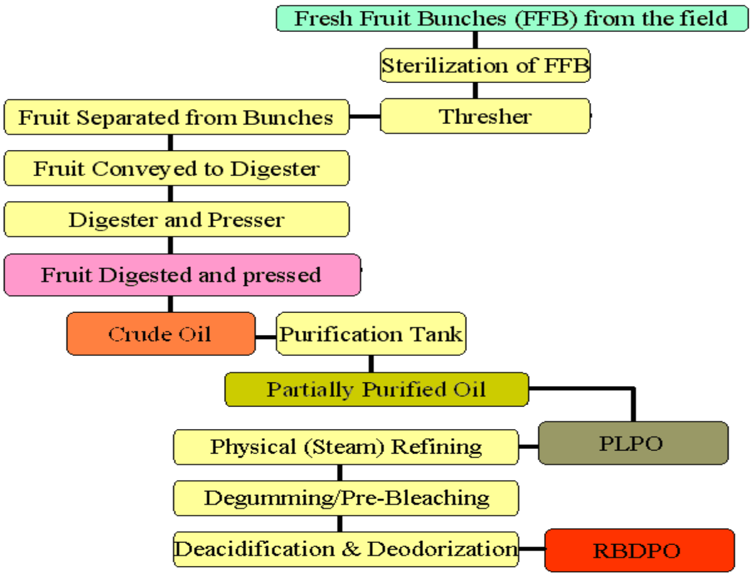

Figure 1: Production Flow Chart of Refined, Bleached and Deodorized Palm Oil (RBDPO)

(Source: MPOB, Golden Hope)

3.0 RESEARCH METHODOLOGY

This experiment investigates the gas emissions performance of biofuels compared to CDF at different equivalent ratio. This experiment was conducted by using different types of biofuel blends derived from RBDPO and CDF with different equivalent ratios. Equivalent ratio is defined as the actual fuel-air ratio to the stoichiometric fuel-air ratio.

3.1 Blending Biodiesel

To obtain the mixture of B2, B5, B10, and B15 the correct amount of RBDPO has to be mixed and blended with the correct amount of diesel fuel. The method used to blend biodiesel is hand-stirred method. This method is applied because the electric stirrer that was developed cannot be fabricated due to insufficient fund of the project at that time. Thus, the hand-stirred method was applied.

In this method, a mixture of RBDPO and CDF is stirred for over two (2) hours and the stirring direction is ensured to be constant. The amount of RBDPO is added volumetrically to CDF to obtain the blends. The amount of CDF used for every sample is consistent, i.e. 15 liters. Only the amount of RBDPO was varied according to the blends. Table 1 shows the amount of RBDPO needed to obtain biodiesel blends.

Table 1: Volume of RBDPO used for blends

Biodiesel Blends	Volume of RBDPO (Liter)
B2	0.30
B5	0.75
B10	1.50
B15	2.25
B20	3.00
B22	3.30
B25	3.75

In order to assure that the sample has been mixed thoroughly for each blend, the specific gravity of the biodiesel was measured using a hydrometer. The values of specific gravity were then compared with the calibration graph as shown in Figure 2, below.

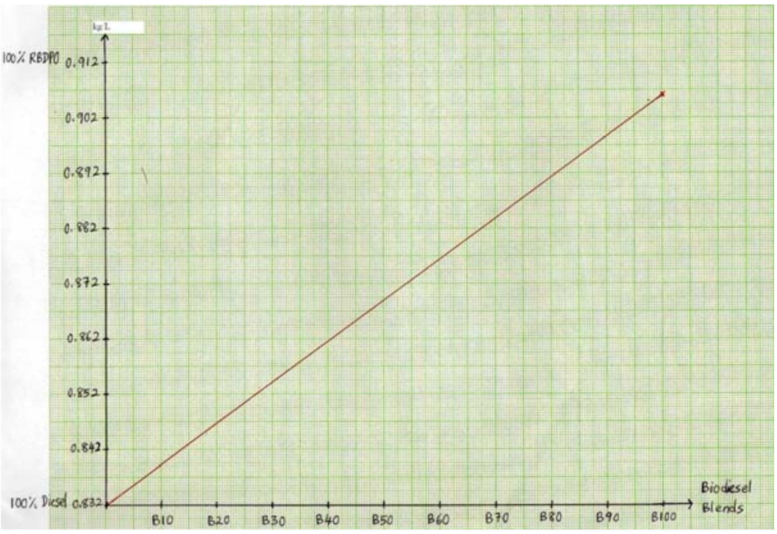

Figure 2: Specific Gravity Plot of Various Biofuel Blends

Table 2 shows the percentage of errors involved in measuring specific gravity of each blends.

Table 2: Values of specific gravity by experiment and calibration

Specimen	Specific Gravity Value (kg/L) by Experiment	Specific Gravity Value (kg/L) from Calibration	Percentage of Error Involved (%)
Diesel	0.832	0.832	0
B2	0.834	0.833	1
B5	0.835	0.837	2
B10	0.836	0.838	2
B15	0.841	0.843	2
B20	0.845	0.847	2
B22	0.847	0.848	1
B25	0.850	0.850	0
RBDPO	0.906	0.906	0

3.2 Performance and Gas Emissions

The experimental test rig set-up for the burner tests is shown in Figure 3. The burner and combustion chamber are placed horizontally on a fixed structure. The air is supplied by a main compressor in the combustion laboratory.

For all tests, the exhaust sampling probe is mounted at the end pipe. The gas analyzer used in these tests was the Tocsin IGD gas analyzer that measures oxides of nitrogen and carbon monoxide.

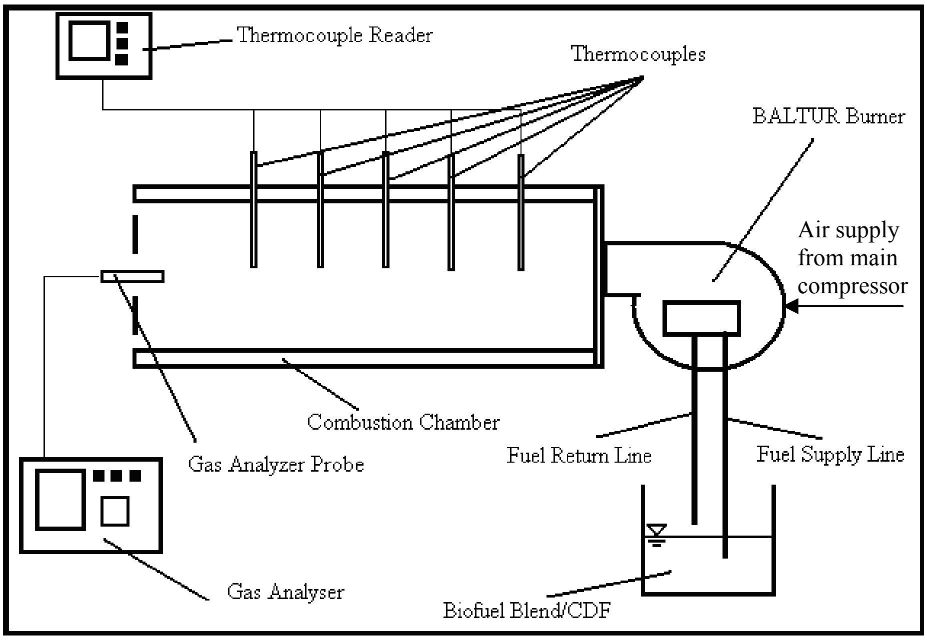

Figure 3: Schematic of Experiment Setup

4.0 RESULTS AND DISCUSSION

4.1 Stoichiometry of Conventional Diesel Fuel (CDF)

Throughout the experiment several parameters such as air speed and mass flow rate of fuel have been measured using air speed indicator and stop watch, respectively. These informations are used to calculate the equivalent ratio of Diesel fuel. Table 3 shows the results of the calculation.

Table 3: Air-Fuel Ratio based on Equivalent Ratio (Φ) of CDF

Equivalent Ratio, ϕ	**V_{AIR} (m/s)**	**$\dot{m}_{FUEL}$ (g/s)**	**m_{AIR} (gram)**	$\frac{A}{F}$
1.39	2.71	3.2	33.00	10.313
1.19	3.18	3.2	38.70	12.094
1.0	3.82	3.2	46.50	14.531
0.88	4.28	3.2	52.10	16.281
0.83	4.52	3.2	55.00	17.188

4.2 Performance of Gas Turbines Using CDF/Biodiesel Blends

The temperature profiles from the combustion of fuels have been analyzed in order to study the performance differences of biodiesel blends compared to CDF. Figure 4 shows the temperature profile of biodiesel blends and CDF at equivalent ratio of 1.0.

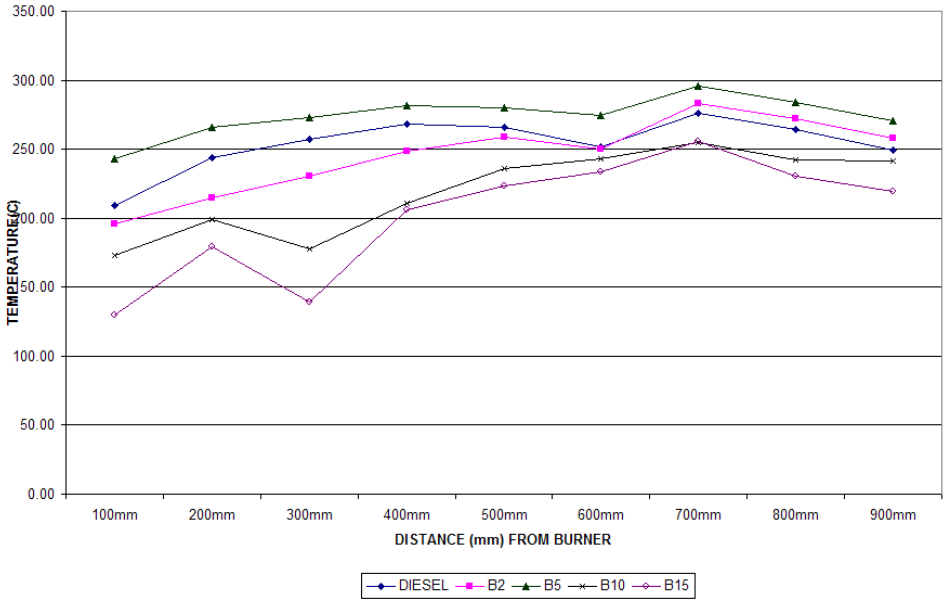

Figure 4: Temperature Profile of CDF/Biodiesel at Equivalent Ratio 1.0

All the curves for the temperature profile showed similar trend. Biodiesel blend of B5 shows the highest temperature. However, the temperature drops when the biodiesel blends were increase up to B15. On the other hand, biodiesel blend of B2 also shows lower temperature profile. The blend of B5 with 5% of RBDPO and 95% CDF contains higher calorific value than other blends.

4.3 Gas Emissions of CDF/Biodiesel

The emission characteristics will indicate the suitability of the Biodiesel blend as the replacement fuel for Diesel. Low emission profiles is essential to make sure less harm is imposed on the environment as engineering is now moving towards green technology.

Figure 5 shows the CO emissions for Diesel and Biodiesel blends at different equivalent ratios. The CO emissions of Biodiesel blends are below the CO emission level of diesel fuel. Emissions of CO increase when the equivalent ratio is getting higher and decrease when the viscosity of blend increases from B2 up to B15.

During combustion process, most of the burned carbon reacts to form carbon dioxide, however some of the carbon stays in the intermediary stage as carbon monoxide. Furthermore, the formation of carbon monoxide is also due to quenching between the air and the wall of combustion chamber. The rising concentration of CO is contributed by equilibrium CO which occurs at richer mixtures [6].

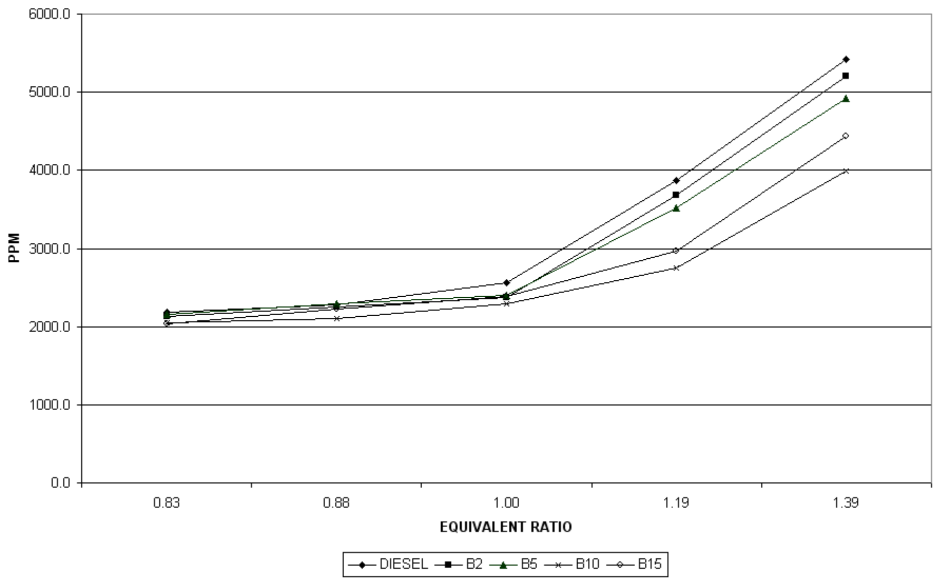

Figure 5: Carbon Monoxide emissions of Biodiesel/CDF

Unburned hydrocarbons (UHC) are fuels that exist in the form of vapor or droplet near the exhaust. The presence of UHC will result in thick smog and the odor of diesel fuel. Figure 6 shows the emissions of UHC for diesel and Biodiesel blends.

The emission of UHC for all Biodiesel blends is lower than that for Diesel fuel. UHC increases when the equivalent ratio increases. At higher equivalent ratio, more fuel combusts and the mixture is rich. So, more fuel and less oxidizer participate in combustion and this let to higher unburned hydrocarbons near the exhaust.

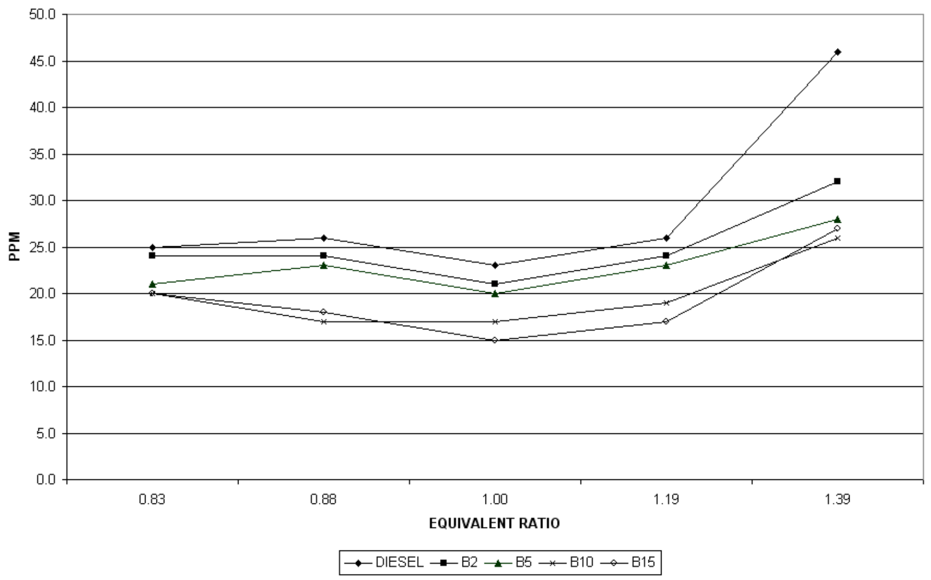

Figure 6: Unburned Hydrocarbon emissions of Biodiesel/CDF

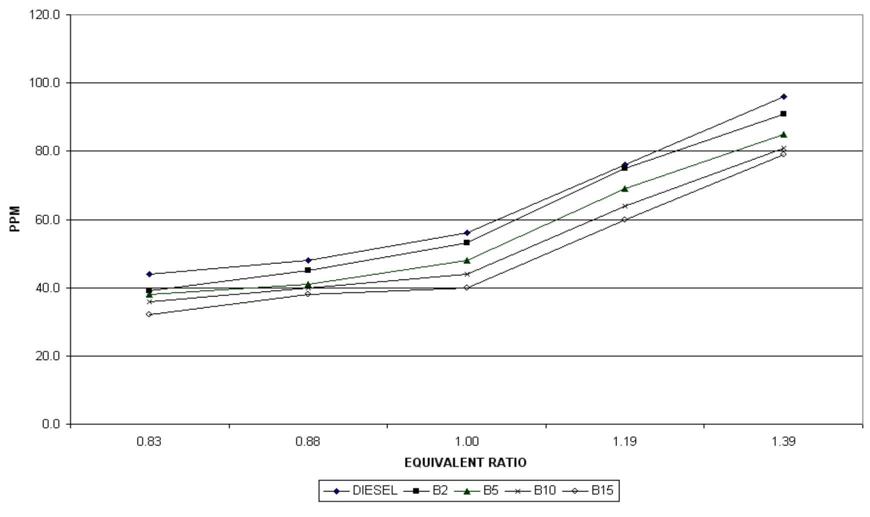

Figure 7: Sulphur Dioxides emissions of Biodiesel/CDF

Sulphur dioxide, SO_2, makes up about 95% of all of the sulphur oxides that is released during combustion. Only 5% of the oxide will form Sulphur Oxide, SO. Figure 7 shows the emission of SO_2 of Diesel and Biodiesel blends at different equivalent ratios.

Biodiesel records low emissions of SO_2 compared to diesel fuel. This shows that Biodiesel contains less sulphur than ordinary CDF. The level of emission increases when the equivalent ratio increases, where the flame is larger and the fuel is rich. Apart from that the emissions of SO_2 decrease when the viscosity of the blends increase from B2 to B15.

4.4 Flame Pattern of CDF/Biodiesel

Flame pattern describes the behavior of the flame with respect to the equivalent ratio for various biodiesel blends. In this study, the relation of flame length to both equivalent ratio and to the blends is investigated. Figure 8 shows the flame length profile for every blend at different equivalent ratios.

Flame length increases when equivalent ratio increases. Higher equivalent ratio denotes that less air enters the combustion process. In this case, combustion produces larger flame and more smoke when the values of equivalent ratio increase. Furthermore, the flame is unstable due to less air entering the combustion chamber at higher equivalent ratios (richer mixture). Thus, the flame grows longer when the equivalent ratio is increased.

Furthermore, flame length increases when the biodiesel blends increase. Lowest value of flame length is observed for diesel at every equivalent ratio, while the flame length increases when the blend increases from B2 up to B15. This is mainly because the increasing volume of RBDPO provides more carbon on each blend from B2 to B25 because the RBDPO blended with CDF provide fusion of palmytic acid to the hydrocarbon chain that increases the number of carbon.

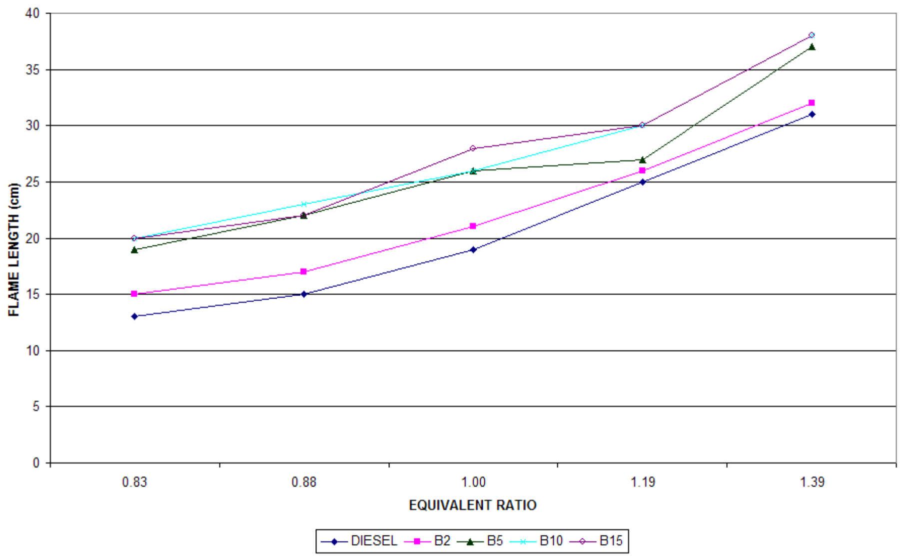

Figure 8: Flame length of Biodiesel/CDF at various equivalent ratios

5.0 CONCLUSIONS

According to the plots of temperature profiles and gas emissions, B2 and B5 show remarkable results in terms of performance at equivalent ratio of 1.0. However, the B5 blend shows overall best performances even when compared to CDF at same condition. Biodiesel blend of B5 is chosen as the best mixture between CDF and RBDPO in terms of performance in burner system and lower gas emissions compared to CDF.

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