Proceeding

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THE 3rd SRIWIJAYA INTERNATIONAL SEMINAR ON ENERGY SCIENCE AND TECHNOLOGY 2010 (SISEST - 2010)

Theme :
"New and Renewable Energy Development for Solving Energy Crisis"

PALEMBANG, 3 - 4 NOVEMBER 2010

SRIWIJAYA UNIVERSITY
SOUTH SUMATERA - INDONESIA

Organized by:

The National Strategic Prime Research (New & Reneweble Energy Development) Rusnas PEBT Sriwijaya University

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CONTENTS

Performance Check Of Biodiesel Application On Boiler Used In Biodiesel's Pilot Plant Unsri

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Abstract

The optimalisation of biodiesel exploitation becoming 5 % in the year 2025 later as energy resource in this country which has written in National Energy Policy (KEN, 2003 – 2020) have been the reasons to improve biodiesel technology. Biodiesel has been known as one of the renewable material and ha sthe potential to reduce exhaust gas emission in diesel engine. Biodiesel is a diesel fuel made from natural, renewable source such as vegetable oil and animal fats. Fats and oil are chemically reacted with an alcohol (methanol) to produce chemical compounds known as fatty acid methyl ester (ME) or biodiesel. In this research it is used 10%, 20% and 30% methyl ester (crude palm oil mixed with petroleum diesel fuel) compared with 100% petroleum diesel fuel. Blends of up to 30% biodiesel hopes can be used in nearly all diesel equipment and do not need modification of the engine. The result of investigation, the use of biodiesel can decrease of emissions of No x , CO 2 , CO, and HC.

Key Words : Biodiesel, Boiler, Emissions, Steady State, KEN,

1. Introduction

Biodiesel Crude Palm Oil (CPO) is the substitution of alternative diesel fuel that has a characteristic similar to diesel fuel. As a fuel, biodiesel has several advantages, i.e. environmentally friendly because it produces gas emissions better than diesel fuel, which is free of sulfur, the smoke number is low, a high cetane number so that a better combustion efficiency and can always be updated.

Testing the use of biodiesel has been widely used by researchers, especially in the transportation, while the use of biodiesel in industrial equipment such as the boiler is still small, therefore in this study the authors studied the achievement of steady state conditions of combustion in the boiler be seen from the steam and the steam pressure produced, as well as test parameters that were analyzed is the ratio of fuel mixture of diesel and palm oil biodiesel, fuel consumption and exhaust emissions (CO, CO2, HC, NOx, Smoke).

Issues

An effort to support government programs in accordance with the Regulation of the Minister of Energy and Mineral Resources No. 32 of 2008 which establishes the use of Bio Fuel by 5% in industrial and commercial. But not many research results are published on the use of CPO as a mixture of biodiesel fuel for industrial equipment causes many people are still hesitant to utilize biodiesel in factories and industries.

This research is important because it is closely related to the large amount of consumption of fuel in producing steam and exhaust gas produced. The result of combustion in the boiler visits from saturated steam generated steam and the steam pressure, and parameters measured analysis is the fuel consumption (% V) and exhaust emissions (CO, CO2, HC, NOx, Smoke) with a mixture ratio of fuel between diesel and palm oil biodiesel (B10, B20, B30),

2. LITERATURE REVIEW

2.1. Biodiesel

Biodiesel is one alternative liquid fuel for diesel engines that can be renewable. Biodiesel made from vegetable oils or animal, 10-20% alcohol, and 0.35-1,5% catalyst (Tikkel, 2000).

Biodiesel can be used in any diesel engine without modification, the use of motor fuel biodiesel known to reduce levels of smoke density, opacity level concentrations of smoke from the engine of machinery and older vehicles. In addition, biodiesel has several advantages compared to diesel.

2.1.1. CPO Biodiesel as Alternative Fuel Mixture

The process of making biodiesel from vegetable oil often called transesterification process. Transesterification process is the process of changing a type ester into another ester (Tickell, 2000). To make biodiesel is used three main components of vegetable oil, alcohol and catalyst. Biodiesel has the chemical and physical properties similar to petroleum diesel (diesel) that can be used directly for diesel engines or blended with petroleum diesel.

The advantages of using biodiesel:

- A high cetane number, which is a number that indicates whether or not a good measure of fuel quality based on the nature of the speed of fuel in the engine combustion chamber. The higher cetane number, the faster combustion and better efficiency thermodynamics.
- High flash point, which is the lowest temperature that can cause burning steam biodiesel, so biodiesel is safer from fire hazards when stored or distributed at the time rather than solar.
- Does not contain sulfur and benzene which have the nature of carcinogens, and can be decomposition naturally.
- Adding a better engine lubrication than diesel fuel so that it will extend the life of the machine.
- Can easily be mixed with regular diesel fuel in various compositions and does not require any engine modifications.
- Reduce black smoke from diesel engine exhaust flue gas is significantly despite the addition of only 5% - 10% volume of biodiesel into diesel fuel

2.1.2. Industrial Development and Research Biodiesel CPO

One effort to circumvent this problem is to develop an integrated biodiesel plant with crude palm oil and biodiesel plant is prioritized as a fuel source in the company concerned (CPO-Biodiesel Integrated Model / ICBM).

This approach will provide some benefits in terms of accelerating the development of CPO-based biodiesel, as well as technical and economical benefits, as follows:

1. Accelerating the development of biodiesel based alternative energy
2. Optimization of existing resources at the factory CPO.
3. Increased value-added palm oil-based industries.
4. Decreased risk of palm oil business.
5. Enhance energy security in the countryside.

2.1.3 Effect of Using Biodiesel to the Environment

On the other hand, the side effects caused by pollution from burning oil is very diverse from respiratory problems to global warming. Troubleshooting the problem caused by some elements contained in combustion fumes, among others:

- HC (hydrocarbons) that can interfere with breathing organism,
- NOx (Nitrogen Oxide), which can cause acid rain,
- CO (Carbon Monoxide), which when in high concentrations will cause respiratory failure that can cause death within a few minutes,
- CO_2 (Carbon Dioxide) which causes the greenhouse effect on the ozone layer causing global warming,
- SO_2 (Sulfur Dioxide), which will turn into SO_3 when mixed with air that cause acid rain. The use of biodiesel can also reduce emissions of carbon monoxide, total hydrocarbons, particulate matter, and sulfur dioxide. A nitrous oxide emission is able to be reduced by the addition of catalytic converters.

Tabel.2.1. Characteristics of physical chemical properties of diesel fuel and oil

	Solar	MES
Methyl Ester (%)	-	100
Iso paraffin + Naphthenes (%)	55	-
Paraffin (%)	20	-
Aromatic (%)	25	-
Density (g/cm^3)	0,8520 – 0.8750	0,8624
Viscosity (cSt)	3.2 – 4,0	5,55
Flash Point (°C)	55 – 176	172
Cetane Number	50 – 53	62.4
Water Content (%)	0,005 – 0,3	0,1
LHV (MJ/kg)	43,43	40,67

2.2. Diesel Oil

Diesel fuel is a distillate fuel types used for compression ignition engines (Suharno, 2006) causing the compressed air pressure and high heat that can burn, are sprayed by the quality of fuel injector shown with the cetane number, the higher cetane number shows that it is more flammable, the lower number indicates more slow-burning. The use of diesel oil in general is for fuel in all types of diesel engines with high speed (above 1000 rpm), which can also be used as fuel for direct combustion in small kitchen, which is mainly want a clean burning.

2.2.1 Diesel Fuel Properties

Fuel physically have special properties which include the following:

- *Cetane Number*

  Cetane number is a diesel fuel property that indicates the quality of combustion of the fuel, the higher the cetane number, the shorter ignition delay time.

  Cetane number is determined on the basis of two reference fuels:

  - n-*cetane* (*hexadecane*) $C_{16}H_{34}$, with a value of 100 cetane number
  - hepthamethylnonane (HMN), $C_{12}H_{34}$ gives 15 value

  Cetane number testing according to standard ASTM D-613 is determined from the equation:

  CN bahan bakar = % n-cetane + 0,15% HMN

  cetane number can affect the cold ignition, combustion, heating, engine vibration, acceleration, and density of exhaust gas.

- *Spesific Gravity* dan *Density*

  Specific gravity is the mass ratio of a substance at a certain temperature to the mass of pure water with an equal volume of the same or different temperatures. The density is the weight of fluid per unit volume at 15° C and 101.325 kPa with units of measurement such as kg/m^3.

- Viscosity

  Viscosity is a property that states the liquid fuel resistance to flow of or the shear resistance of a liquid fuel.

- Sulfur content

  The content of sulfur always exists in petroleum, and if it implies excessive then this may damage the machine because it is corrosive.

- Content of Water

  The amount of water content in diesel fuel can cause a decrease in combustion temperature, resulting in foaming and is corrosive (if it reacts with sulfur to form acid)

- Pour Point

  Pour Point is a number that states the lowest point of the temperature of fuel oil, so the oil can still flow due to the force of gravity.

- Flash Point

  Flash Point is the minimum temperature of the fluid at the time of the steam out of the fluid surface and direct light for a moment. Flash Point has no effect on engine performance, but it is very influential at the time of storage and handling of diesel oil.

- Distillation range

  Distillation range is affected by fuel viscosity. Distillation range determines the motor output power, ignition, and exhaust gas quality.

- Color

  Determination of the color of petroleum products are mainly used for factory control purposes or an important characteristic quality, because the colors easily observed by the user of the product.

2.2.2 Specific Fuel Consumption

Stating the size of fuel consumption by an engine or motor, generally expressed in units of fuel per unit power output, or can also be defined by the amount of fuel consumption by motor to produce power a Hp for 1 (one) hour.

$$\text{Sfc} = \frac{3600\dot{m}}{Nt} \frac{kg.bahan.bakar}{HPxjam}$$

with:
sfc = specific fuel consumtion
= Mass of fuel consumed (kg)
= Pv (p = density of fuel,
v = volume of fuel consumed
N = power generated motor (Hp)
t = time required to consume as much fuel m kg (seconds)

2.3 Boilers

Boilers are often found in industrial utilization, boiler or Indonesian language called "ketel uap" used for heating, drying, preservative processes and energy generation and boiler making progress very fast. Achievements boiler will decrease with time and load cycles of usage.

2.3.1. Boiler Capacity

Boiler capacity is the number of steam boilers produced in kg / h at Evaporator Continue Maximum Rate (MCR).

$$GE = G (h2 - hl) / 539, kg / hour$$

in which:
G = actual capacity, kg
hl = enthalpy of feed water, kcal / kg
h2 = enthalpy of steam type, kcal / kg
The heat of vaporization of water = 539 kcal / kg at 100 ° C

2.3.2. Heat Balance

The process of combustion in the boiler can be described in terms of energy flow diagram. This diagram illustrates graphically how the input energy from the fuel is converted into energy flow with a variety of uses and a flow of heat and energy loss.

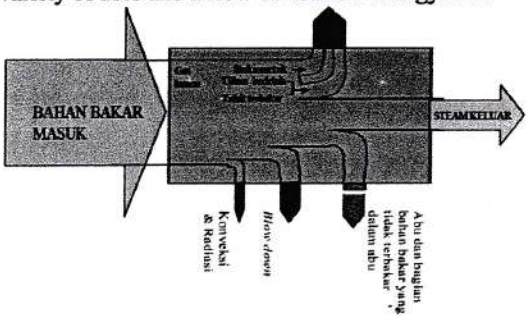


Figure 2.2. Boiler Energy Balance Diagram

2.3.3. Combustion Process

Combustion is the rapid oxidation of fuel accompanied by heat production, or heat and light. Complete combustion of fuel is possible only if there is sufficient oxygen supply.

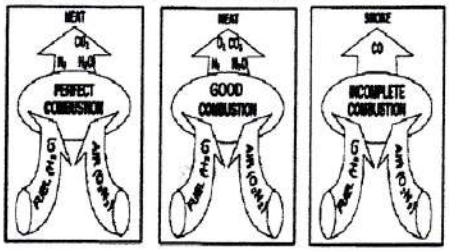
In certain conditions, carbon may also combine with oxygen to form carbon monoxide, by releasing a small amount of heat (2,430 kcal / kg of carbon). Burning carbon to form CO_2 which will generate more heat per unit of fuel than when produce CO or smoke.

C	$+O_2$	→	CO_2 +8.084 kkal/kg Karbon
2C	$+O_2$	→	2CO +2.430 kkal/kg Karbon
$2H_2$	$+O_2$	→	$2H_2O$ +28.922 kkal/kg Hidrogen
S	$+O_2$	→	SO_2 +2.224 kkal/kg Sulfur

Each kilogram of CO that formed is loss of heat 5654 kCal (8084-2430).

2.3.4 Burning of Three T

The objective of good combustion is to release all the heat contained in the fuel. This is done by controlling the "three T's" that is burning (1) high Temperature is enough to ignite and maintain ignition of fuel, (2) Turbulence or mixing of oxygen and fuel is good, and (3) sufficient Time for complete combustion.



2.3.5. Boiler Energy Efficiency

Energy efficiency related to combustion, heat transfer, avoidable losses, energy consumption for auxiliary equipment, water quality and blow down. Loss of energy and energy efficiency opportunities in the boiler can be connected with the combustion, heat transfer, avoidable losses, high energy consumption for auxiliary equipment, water quality and blow down.

Various kinds of opportunities for energy efficiency in a boiler system can be linked to:

1. **Temperature Control Chimney**

The temperature of the chimney should be as low as possible. However, the temperature should not be so low that water vapor will condense on the chimney wall.

2. **Preheating Feed Water use economizers**
   Typically, the flue gas leaving the modern 3-pass boiler shell temperature of 200 to 3000C.
3. **Preheating Combustion Air**
   Preheating of combustion air is an alternative to feed water heating. In order to improve thermal efficiency by 1 percent, combustion air temperature must be raised by 200C.
4. **Incomplete Combustion**
   Incomplete combustion can arise from lack of air or excess fuel or poor distribution of fuel. It is obvious from the color or smoke, and must be corrected immediately.
5. **Excess Air Control**
   The table below provides the theoretical amount of combustion air required for various types of fuel.
6. **Minimizing Radiation and Convection Heat Loss**
   Heat loss from the boiler shell is usually a certain energy loss, irrespective of the output of boiler. With modern boiler design, this loss is only 1.5 percent of gross calorific value at full speed, but will increase to around 6 percent if the boiler operates at only 25 percent output. Repair or enlargement insulation can reduce heat loss from the boiler walls and piping.
7. **Automatic blow down control**
   Uncontrolled continuous blow down is very wasteful. Automatic blow down controllers can be installed that sense and respond to boiler water conductivity and pH. Blow down 10 percent in 15 kg/cm2 boiler efficiency by 3 percent yield loss.
8. **Reduction and Loss of Soot Formation of Crust**
9. **Pressure Drop in Steam Boiler**
   This is an effective way of reducing fuel consumption, if allowed, by 1 to 2 percent.
10. **Variable Speed Control for Fans, Blowers and Pumps**
    Variable speed control is an important way in energy savings. Generally, combustion air control valve is influenced by closing the damper is installed in forced and induced draft fan.
11. **Cost Control Boilers**
    The maximum efficiency of the boiler does not occur at full load, but at about two-thirds of the full load. If the load on the boiler decreases further, efficiency also tends to decrease.
12. **Proper Boiler Scheduling**
    Due to the optimum efficiency of the boiler occurred at 65-85 percent of full load, will usually be more efficient, overall, to operate fewer boilers at higher loads than to operate in large quantities at low loads.
13. **Boiler Replacement**
    The potential savings from the replacement of a boiler depends on the changes that have been anticipated on the overall efficiency.

3. RESEARCH METHODOLOGY

3.1. Tools and Test Equipments

3.1.1 Types of Fuel

Tabel 3.1 Characteristics of the chemical properties of diesel fuel and palm oil

Parameter	Diesel	MES
Iso paraffin + Naphthenes (%)	55	-
Paraffin (%)	20	-
Aromatic (%)	25	-
Density (g/cm^3)	0,8520 – 0,8750	0,8624
Viscosity (c.St)	3,2 – 4,0	5,55
Flash Point (^{o}C)	55 - 176	172
Cetane Number	50 - 53	62,4
Water Content (%)	0,005 – 0,3	0,1
LHV (MJ/kg)	43,43	40,67

Table 3.2. MES Vegetable Oil Composition (percent)

Miristat	2
Palmitat	42
Stearat	5
Oleat	41
Linoleat	10
Linolenat	-

3.1.2 Equipments

Table 3.3. Boiler spesification

Type	Steam Boiler/SB 60
Model	Cylinder Vertical

Design Pressure	4,5 Bar
Capasity	60.000 k.cal/h
Work Pressure	3 Bar
Hidrostatic Pressure	6 Bar
Temperatur	150 °C
Weight	600 kg

3.1.3 Exhaust Emission Test Equipment

Figure 3. AUTOCHEK GAS 4/5

3.2. Research Description

Boiler that has been filled with water burned, put the fuel into the boiler (with a ratio of biodiesel to diesel fuel is determined), i.e. B0, B10, B20, and B30 to generate steam that will be used for transferring heat to the process of making biodiesel. Volume of fuel consumption is measured at specified intervals (every 3 minutes for 45 minutes) and exhaust gas emissions that occur during the combustion process is measured with test equipment exhaust emissions.

4. RESULTS AND DISCUSSION

a. Analysis of Fuel Consumption

The analysis can be done from data obtained after the graph is integrated into a fuel consumption of diesel fuel needed by 100% smaller than the use of biodiesel fuel blend B10, B20 and B30.

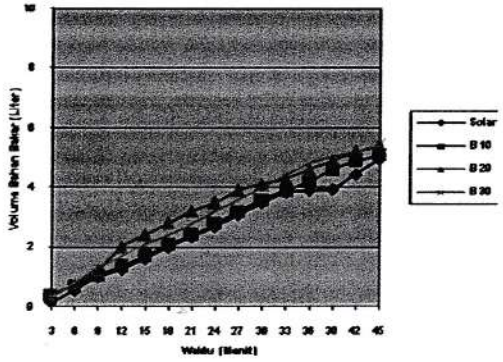


Figure 4.1 Graph analysis of fuel consumption versus time

b. Exhaust Temperature Analysis

Flue gas temperature in a mixture of B30 highest when compared with the mixture of B10 and B20 at the same end of the test that reached 120.3°C.

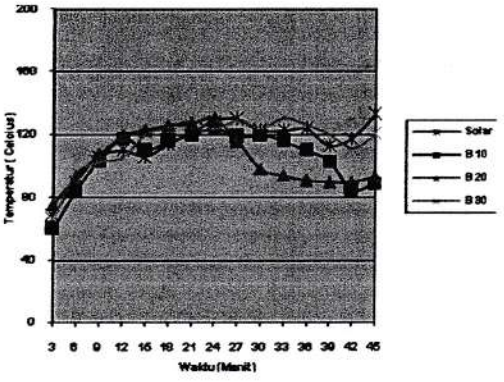


Figure 4.2 Graph analysis of the exhaust gas temperature versus time

c. Exhaust Emission Analysis

1 *Smoke*

Levels of smoke in a mixture of B10 and B20 compared with the use of diesel fuel in the boiler was far different. In the biodiesel mixture can be sure there is no smoke emission test results obtained.

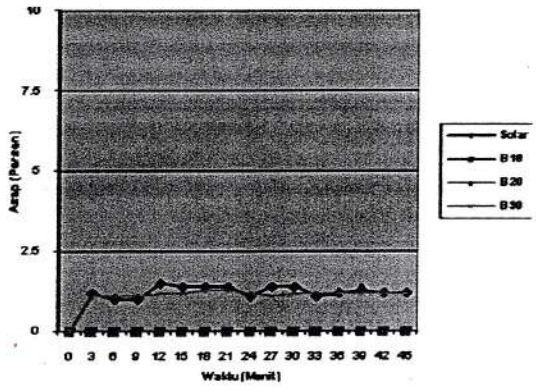


Figure 4.3 Graph analysis Smoke versus Time

2. *Carbon Dioxide (CO_2)*

Carbon Dioxide (CO_2) increases with increasing ratio of biodiesel to diesel fuel.

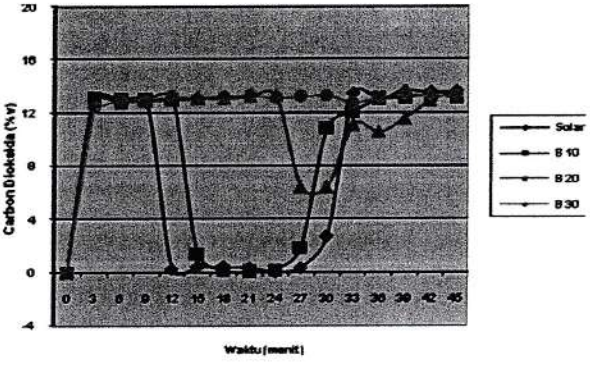


Figure 4.4 Graph Analysis Percent CO_2 Versus Time

3. *Carbon Monoxide* (CO)

From the results of measurements, emissions Carbon Monoxide (CO), which occurs is not seen clearly. Increased percent biodiesel blend, reducing CO but began to increase at B10 and B20 at 0.01% and 0.02%, this is due to occur in the boiler combustion inefficiencies resulting from lack of air in the combustion process.

4. Hydro Carbon (HC)

The small value of the HC means more efficient combustion process that occurs in the engine.

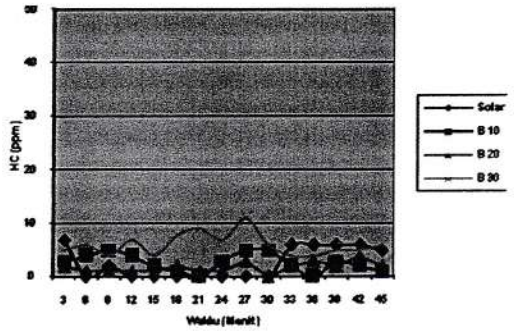
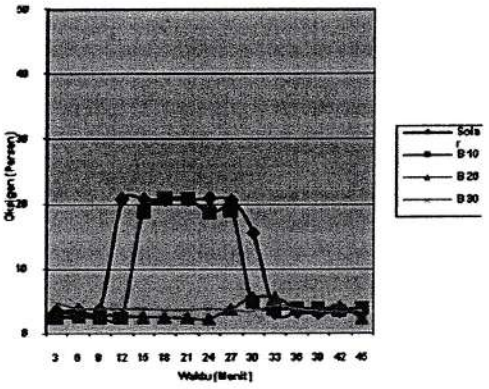


Figure 4.5 Graph analysis Hydro Carbon Versus Time

From the graph above shows the combustion fuel mixture of B20 and B30, the flue gas in the form of HC is relatively more stable when compared with the use of B10 fuel mixture and / or diesel fuel. This was possible because the composition of diesel from vegetable raw materials that have certain chemical properties.

5. Oxigen (O_2)



Fi

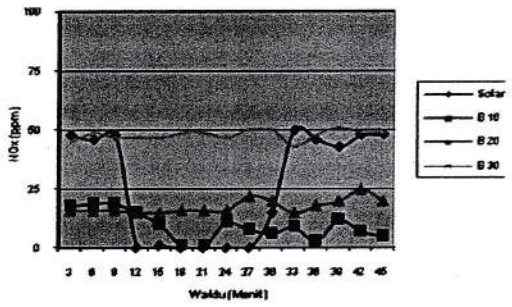
gure 4.6 Graph analysis Oxigen Versus Time

The amount of O_2 which is the maximum allowable 20%, the smaller the better, which means

the air entering the engine, can be fully utilized for combustion.

6. Analysis of NOx Emissions

NOx formation depends on the presence of oxygen and temperature of combustion



Gambar 4.7 Graph analysis volume NOx Versus Time

NOx values increased to a mixture of B30 compared to other fuel mixtures. But the value of NOx generated from the emission test of biodiesel blend is still below the emission standard for NOx emission limit standard is 250 ppm.

d. Analysis of Air Fuel Ratio (AFR)

In fact it is hard to tune up the engine to get the AFR value of 14.7.

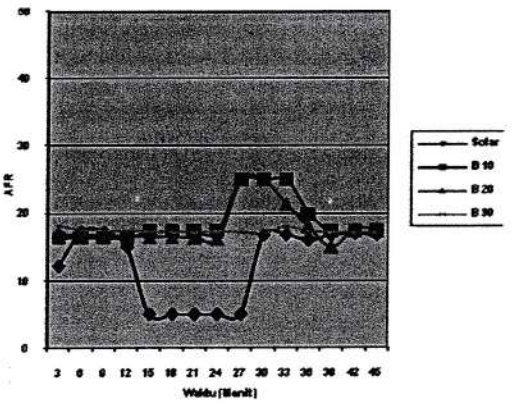


Figure 4.8 Graph analysis AFR Versus Time

Therefore, this AFR values ranged from 14.5 until 15.5. If the value is less than it then mixing fat (mostly diesel fuel) will be occured, otherwise if the value of AFR in excess of that figure means of mixing thin (mostly air).

e. Lambda

Lambda is the ratio of fuel-air mixture that occurs with the ideal ratio of fuel (1:14,7).

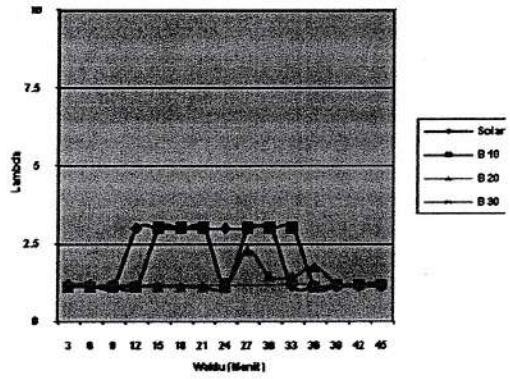
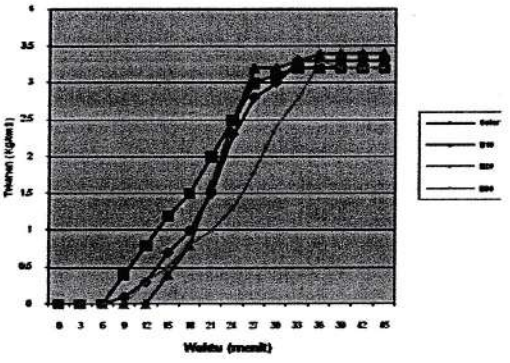


Figure 4.9 Graph analysis Lambda Value Versus Time

If the value of Lambda is less than that number means there is a mix of fat (mostly gasoline), while if the value of Lambda in excess of that figure indicates lean mixtures (mostly air).

f. Steam Pressure related to Time



Graph. 4.10 Analysis of Increased Steam Pressure versus time

To a mixture of B10 fuel, seen an increase in steam that began at minute 6 (six) with the increase of steam that is more stable than the use of other fuel mixture, this happens due to the combustion process

better and more efficient so that the combustion heat produced more efficiently.

5. CONCLUSIONS AND SUGGESTIONS

Conclusions

1. For fuel consumption in boilers, obtained data that consumption of a mixture of B20 and B30 fuel in the combustion process turns their consumption consume more fuel than diesel fuel use at the same time frame.
2. To achieve steady state condition in the boiler, in this study showed that the faster is to use a B10 blend with the achievement of the saturated condition of steam more quickly when compared to other biodiesel blend and environmentally friendly.

Suggestions

As for suggestions that can be given is the use of B10 biodiesel fuel blend was better to use and fit for use in the engine because the combustion process more efficient and environmentally friendly. but need further study in depth the characteristics of biodiesel and CPO further, so that the target the use of biofuels in the national energy mix for industrial and commercial circles to 20% by 2025 can be achieved.

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