CHAPTER I

INTRODUCTION

1.1. Research Background

Boiler (steam boiler) is one machine that plays a very important role in a palm oil mill and a sugar factory in producing quality palm oil and sugar. In the operation of the boiler (steam boiler) it is necessary to pay attention to the type of fuel and the heating value of the fuel. So that the boiler (steam boiler) can work well, and thus the steam produced can meet the needs of the palm oil and sugar mills in producing palm oil and sugar [1].

Boilers in Palm Oil Mills and Sugar Mills are like the heart in the human body, so they play a very vital role in the evaluation carried out to improve boiler performance. One of the things that can be done is by optimizing boiler fuel. The fuel system is all the equipment used to provide the fuel to generate the required heat. The equipment needed for the fuel system depends on the type of fuel used in the system [2].

Sumatra Island has unique characteristics and having the most significant contribution to the development of plantations in Indonesia. Indonesia is ranked 1st in the world for oil palm plantations, with a 54% share, while sugar cane for Sumatra Island has around 1%. Plantations on the Sumatra Island have several important commodities, including: Oil palm plantations have 7.1 million ha, while sugarcane plantations themselves have 148.4 thousand ha [3].

Oil palm is one type of plantation crop that occupied an important position in the agricultural and plantation sectors. Palm oil is Indonesia's reliable commodity which is developing so rapidly. Optimal land for oil palm must refer to three factors: the environment,

the physical properties of the ground, and the chemical properties of the soil or soil fertility. Oil palm crops of the commercial plantations can grow well in a temperature range of 24-28°C. To obtain maximum results in oil palm cultivation, it is necessary to pay attention to the physical and chemical properties of the soil, including soil structure and good soil drainage. [4].

In line with the increasing production of palm oil from year to year, there will also be an increase in the volume of waste. Generally, solid waste from the palm oil industry contains high organic matter, which impacts environmental pollution. Improper handling of waste will pollute the environment. Various efforts have been made to process and increase the economic value of palm oil solid waste. Palm oil waste is the residue of oil palm plantations that is not included in the main product or by-product of the palm oil processing process, either in the form of solid waste or liquid waste. Palm oil solid waste can be in empty fruit bunches, shells, and fibre (coir).

The use of fossil fuel-based energy in Indonesia is very familiar, such as coal, petroleum, and natural gas used as fuel for power generation, transportation, and others. This non-renewable energy has limited availability. If this energy runs out, it cannot be renewed. There are also many negative impacts of non-renewable energy on the surrounding environment. Renewable energy is the answer to these problems. In Indonesia itself various kinds of renewable energy can be utilized and maximized. One of the potential renewable energies in Indonesia is shells and bagasse, due to Indonesia has many industrial on the sectors of plantation and agriculture. Waste from these industries such as palm oil waste, bagasse waste can be used as an alternative fuel to replace coal or petroleum. [5]

Therefore, the author feels it necessary to analyse the fuel's calorific value and the pressure within the combustion chamber with shell and bagasse fuel. Based on the

descriptions that have been mentioned, the author takes the title **"Analysis of Effect for Calorific Value of Mixed Shells and Bagasse as Boiler Fuel on Boiler Efficiency"**.

1.2. Formulation of the problem

Based on the problem background above, it can be concluded several formulations of the problem as follows:

1) Determine what percentage of the boiler efficiency ratio if using a mixture of sugarcane bagasse and palm shell's fuel.

2) Find out how much steam comes out of the boiler to the steam turbine using a mixture of shell fuel and bagasse

3) What is the impact of combustion occurs in the boiler combustion chamber with a mixture of shell and bagasse fuels.

4) Looking for boiler efficiency

1.3. Limitation of problem

The discussion of this analysis is focused on finding the calorific value of the fuel mixture between shells and sugarcane bagasse and looking for a pressure comparison in the boiler combustion chamber using a fuel mixture between shells and sugarcane bagasse, as well as calculating the steam coming out from the boiler to the steam turbine.

1.4. Research purposes

1. Analysing fuel characteristics of shell and bagasse

2. Comparing the characteristics / properties of shell fuel with sugar cane bagasse's fuels.

1.5. Benefits of research

The benefits of the research are to find out whether the mixture of fuel between shell and sugarcane bagasse can produce good combustion in the boiler combustion chamber, as well as can produce good steam, and whether it can later be used as fuel in the future.

1.6. Systematic of writing

The author tries to describe as follows:

CHAPTER I INTRODUCTION

CHAPTER II LITERATURE REVIEW

CHAPTER III RESEARCH METHODOLOGY

CHAPTER IV RESULTS AND DISCUSSION

CHAPTER V CONCLUSIONS AND SUGGESTIONS

CHAPTER II

BASIS OF THEORY

2.1 Definition of Boiler

Boiler can be defined as a device used to transfer heat or heat produced from fluid combustion. Boilers are used to produce hot water, saturated steam (steam at a saturated temperature), or superheated steam (steam heated above the saturation temperature), one type of boiler used in the research area is the Takuma water pipe boiler series N-325-600 as shown in figure 2.1
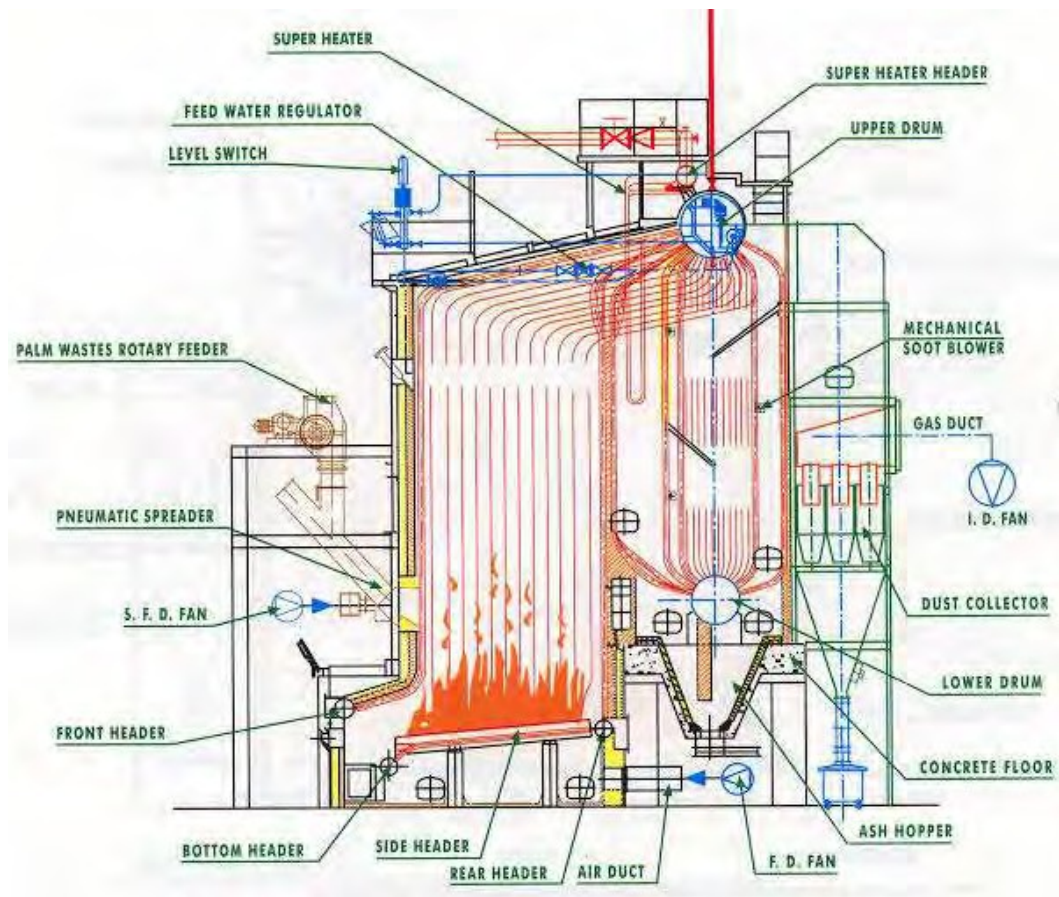
Figure 2.1. Takuma Water Pipe Type Boiler Series N-325-600.

2.2 Types of boiler types

Boilers are divided into two parts, namely fire-tube boilers and water-tube boilers:

2.2.1. Fire Pipe Boiler

Fire-tube boilers are the simplest type of boiler. This boiler allows to be applied to low up to medium steam requirements. This is possible because the design is no more complicated than a water pipe boiler. The size of the fire-tube boiler is also relatively smaller, and allows it to be moved very easily.

According to their names, fire-tube boilers deliver hot gases from combustion to pipes covered by water. Various designs of 6 different pipelines are made to maximize heat absorption from the combustion exhaust gases. The water level in the boiler tank must be maintained at a high level to avoid overheating. On the other hand, this boiler is also equipped with a safety relief valve which functions to release excess pressure so as to avoid explosions. Many types of fire-tube boilers are also equipped with the advanced steam heating systems to produce superheated steam. However, fire-tube boilers have limited water vapor production which is only a maximum of 2500 kg/hour with a maximum pressure of 10 bar. The type of fire pipe is shown in Figure 2. below.
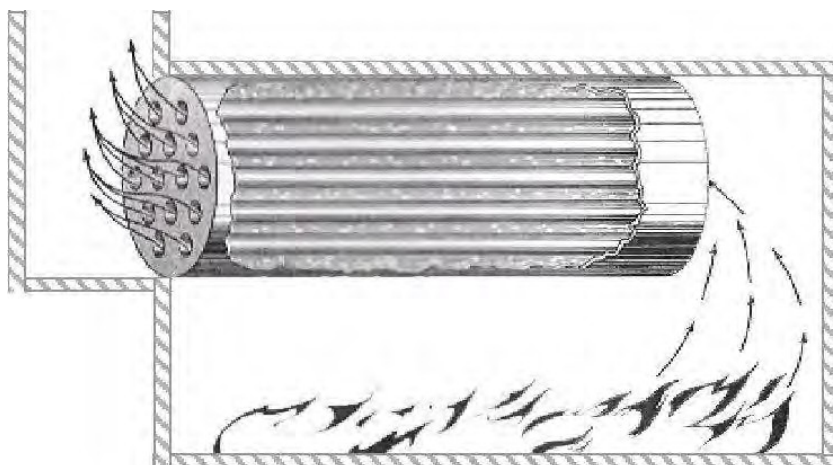

Figure 2.2 Fire Pipe

Advantages and disadvantages of Fire-tube boiler:

Advantages:

1. Does not require particular settings, so that the installation process is easy and quick.

2. The initial investment for this fire tube boiler is cheap.

3. The shape is more compact and portable.

4. For 1 HP boiler does not require a large area.

Disadvantages:

1. Steam operating pressure is limited to a low pressure of 18 bar.

2. When compared to fire tube boilers, the steam capacity is relatively small

3. The combustion chamber is difficult to reach so it is hard to be cleaned, repaired, and inspected.

4. A lot of heat energy is wasted directly into the stack so that the efficiency value is low.

1.2.2. Water Pipe Boiler

In a water pipe boiler, water is in the pipe while hot gas located outside the pipe. These water pipe boilers can operate at very high pressures up to more than 100 Bar. Water pipe boilers have the characteristics of producing high steam capacity and pressure. Based on the boiler type, the construction installed in the boiler can be straight and curved. In parallel, it is installed straight pipes in the boiler connected by 2 headers. In horizontal, above the pipe arrangement, a header is installed which is connected to the steam drum. The arrangement of the two headers has a certain inclination that aims to regulate the circulation of steam in the boiler.

The working method of the water pipe boiler is that the ignition process occurs outside the pipe, then heat is generated which used to heat up the pipe containing water. Through the economizer, the water is first conditioned, then the steam is initially generated, collected in a steam-drum. Through the secondary superheater and primary superheater stages, after adjusting the pressure and temperature, the steam is released to the main distribution pipe.

Inside the water pipe, there must be conditioning of the flowing water for minerals or other substances dissolved in the water. The type of water pipe boiler is shown in Figure 3. below.
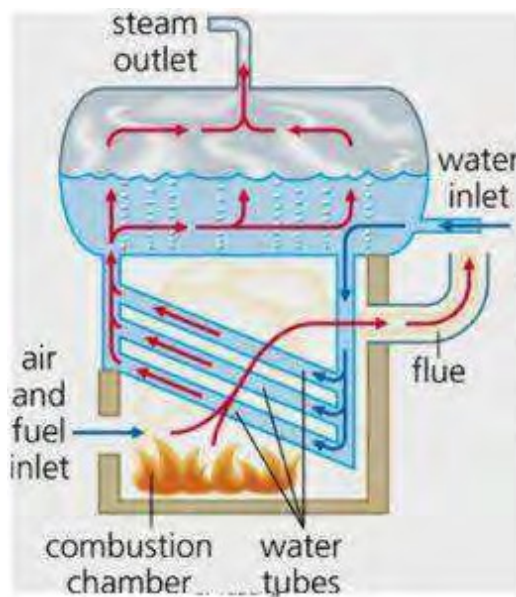

Figure 2.3. Water pipe

Advantages of water pipe boilers:

1. Large steam capacity up to 450 TPH.

2. Operating pressure reaches 100 Bar.

3. Compared with fire-tube boilers, water-tube boilers have higher efficiency values.

4. To carry out inspections, cleaning, and repairs, it can be done through a furnace that is easily accessible.

Disadvantages of water pipe boilers:

1. The construction process is more detailed.

2. The initial investment is relatively more expensive.

3. The handling of water entering the boiler in this system is more sensitive so it needs to be maintained and requires supporting components for this.

4. The construction requires a large area because it is able to produce a larger steam capacity and pressure.

1.3. Boiler Components

1. Kitchen (Furnace)

That is the place where the fuel is burned and smoke gas is formed. The furnace wall is basically a thick layer of refractory asbestos flanked on the outside of a thick plate as the outer casing of the boiler and as insulation from the outside air. At the outer section facing the fire there is an arrangement of vaporizer pipes called as the water tube wall, which will receive heat from the flue gases by means of radiation at the lower level. Furnace chamber is limited by:

a. Fire alley

b. Fire pipe

2. Evaporative Pipes (Riser)

Those convert combustion energy into steam potential energy.

3. Economizer

Namely the water heater pipes located at the back of the flue gas passage which will be used to preheat the boiler feed water before it is put into the drum so as to increase efficiency and reduce large temperature differences on the drum wall. The advantages of using an economizer are:

a. Saving 15-20% fuel.

b. Shortening the operating time of water to steam.

c. With the condition of hot filling water in the boiler, it can reduce the concentration of air (O2) in the boiler due to oxygen is the fastest gas damages the boiler, so that the use of an economizer in the boiler can reduce damage and reduce the formation of scale in the boiler as well as steam line.

4. Burners

It is an equipment that sprays fuel and air inside so that both are burned in the furnace.

5. Chimney (stack)

The stack functions as a channel to dispose of fuel gas out of the boiler. In addition to be made high, stack at a certain height in order to obtain sufficient stack draft and prevent the formation of sulfuric acid from the reaction of sulphur contained in the combustion waste gases with H_2O contained in the external air. Sulfuric acid formation must be prevented because it is highly corrosive.

6. Level Glass

This level glass has very important function to determine the water level in the boiler. The level glass consists of 2 glass pipes equipped with clear and easy-to-read level indicators.

7. Water Circulation (Blow Down)

Water circulation in the boiler is expected to reduce the concentration of chemical substances, mud impurities and prevent foam from forming due to the binding of chemical solids to the steam. There are 2 types of circulation (blow down) in this boiler, namely rear blow down and side blow down.

8. Water Flow Meter

There is 1 water flow meter that functions to start and stop filling water to the boiler which is run by a pump.

9. Manometer (Pressure Gauge)

Serves to find out how much steam pressure in the boiler.

10. Pressure Switch

There are 2 sets of pressure switches that function to automatically control the boiler pressure, so that the desired boiler steam pressure can be adjusted.

11. Safety Valve

Safety Valve serves to remove steam or steam. It works mechanically when the boiler steam pressure exceeds the maximum pressure.

12. The Man Hole

Serves as a door for people to enter the boiler in order to clean or check the water chamber and fire passage.

13. Pump

1 pump is used for pumping water from the main tank to the Softener Tank. 2 other pumps will pump water from the feed water tank to the boiler and 1 pump is used for pumping fuel to the boiler, but only one unit is used.

14. Steam Drum

Steam Drum can also be called as the main drum or the main drum which is located at the top of the boiler, containing partially saturated water and partially saturated steam, this saturated water is obtained from the economiser and the steam is obtained from the riser pipes.

1.4. Heat Transfer

Heat transfer is the science of predicting the energy transfer that occurs due to a temperature difference between two different materials or fluids. Because the basic nature of heat is heat energy will move its places from the high temperature to the low temperature. The quantity or amount of heat transfer is directly proportional to the temperature difference. There are three basic types of heat transfer, namely conduction, convection, and radiation.

1.4.1. Heat Transfer by Conduction

Heat transfer by conduction (propagation) is a way of transferring heat from objects that have a high temperature to a low temperature, regardless of the object's motion. Usually occurs in solids.

1.4.2. Heat Transfer by Convection

Heat transfer by convection (flow) is a way of heat transfer, where heat also moves along with the fluid (air, water) that carries it. Heat will flow by conduction from surfaces to adjacent fluid particles, heat transfer in such way will increase the temperature of these fluid particles, then the fluid particles will move to a lower temperature where the fluid will mix with other fluid particles.

Heat transfer by convection can be divided into two types, namely:

a. Natural convection, heat flows naturally, for example due to differences in density (density). A vessel containing (fluid), when the bottom is heated, then the less density fluid moves up and the higher density fluid moves down.

b. Forced convection, heat flows by force, such as pumps, blowers, radiators etc.

1.4.3. Heat Transfer by Radiation

Heat Transfer by Radiation (radiating) is heat transfer without an intermediary, where heat flows from high temperatures to low temperatures when the object is separated in space, even if there is a vacuum between the objects, such heat turns into electromagnetic waves.

1.5. Fuel

Fuel is a material which, when burned, can continue the combustion process by itself, accompanied by the release of heat. Fuel is burned with the aim of obtaining the heat, to be used either directly or indirectly. For example, the use of heat from the direct combustion process is:

1. cooking in household kitchens

2. heating installation

while samples for indirect use of heat are:

1. the heat is converted into mechanical energy, for example in a combustion engine,

2. the heat is converted into electrical energy, for example in diesel power plants, gas power and steam power.

The fuel used in the boiler is generally classified as follows:

1. Solid fuel

2. Liquid fuel

3. Gas fuel

There are three elements required for combustion, namely:

1. fuel

2. oxygen from combustion air

3. temperature to start combustion

Because the boiler that the author discusses is using shell and sugarcane bagasse's fuel, the combustion system used is a solid fuel combustion system (shell) and a solid fuel combustion system (sugarcane bagasse).

2.5.1. Solid fuel (shell)

The shell is a by-product of palm oil processing which can be used as boiler fuel; in addition, it can also be used as charcoal, shells, empty fruit bunches and fibres can be used as power plants. The following is a Flowchart of the utilization of Empty Fruit Bunches, Shells, and Fibbers into Electricity.

Based on the thickness and thinness of the shell, the types of palm oil are known as follows.

Figure 2.4. Palm Oil Shell

a. Dura type

This type has the characteristics of a thin fruit flesh (mesocarp), a thick shell (endocarp) (2-8 mm), a large core (endosperm), and no fibrous ring. The percentage of fruit flesh is 35-60% with oil bath is 17-18%. The Deli dura type is the dura type originating from the Bogor Botanical Gardens (originally from Africa which was entered in 1848), then developed in Deli, which is the surrounding area of Medan (formerly known as the Deli kingdom). Today the Deli dura type is widely used in oil palm breeding.
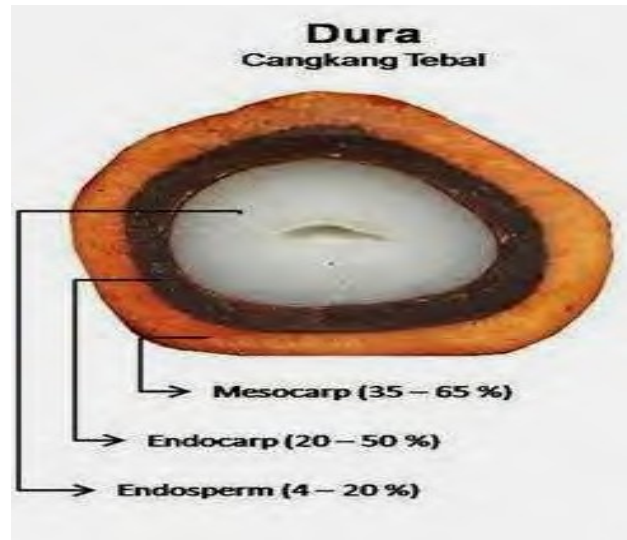
Figure 2.5. Dura-Typed Shell

b. Pisifera type

This type has the characteristics of thick flesh, does not have a shell but there is a ring of fibres that surrounds the core. The core is very small when compared to the type of Dura or Tenera. The ratio of the fruit flesh to the fruit is high and the oil content is high as well. Pisifer-typed palm oil flowers are usually sterile. This type of oil palm is only used as the "father tree" in Dura or Deli Dura's cross breeding.
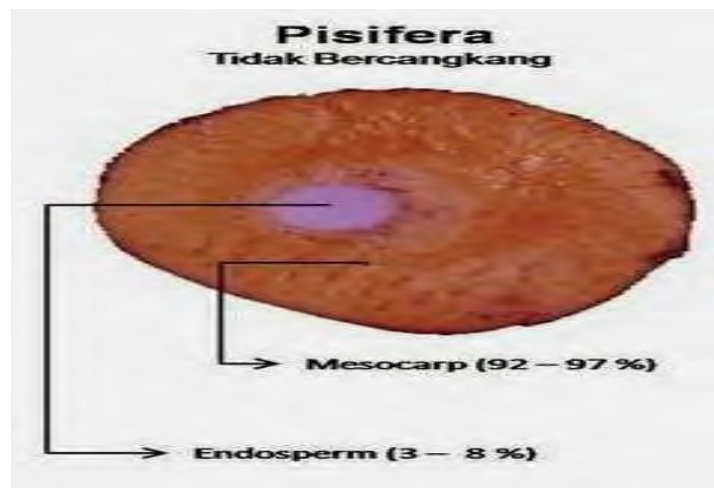

Figure 2.6. Pisifera- Typed Shell

c. Tenera type

This type is the result of a cross breeding between the Dura and Pisifera types. This type has a shell thickness of 0.5-4 mm, has a ring of fibres although not as much as Pisifera, while the core is small. The ratio of fruit flesh to fruit is 60-90%, oil bath is 22-24
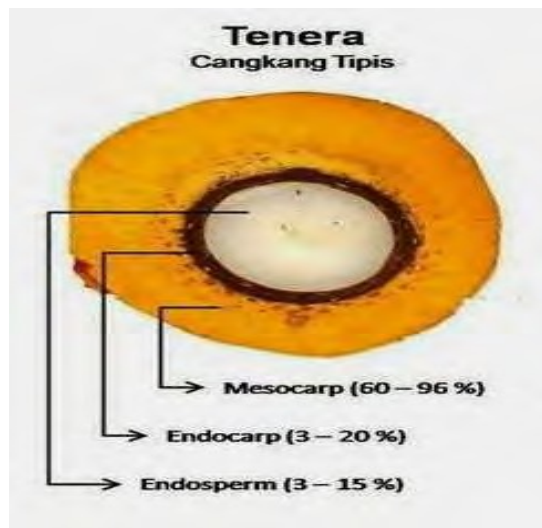

Figure 2.7. Tenera- typed shell

1.5.2. Solid fuel (sugarcane bagasse)

Sugarcane Bagasse is a waste from processing sugar cane into sugar, which is the main fuel for steam boilers in sugar factories, but the utilization of bagasse is not yet optimal until now. In order to obtain maximum benefits from bagasse, it is necessary to examine what factors affect its effectiveness.

Figure 2.8. Sugarcane Bagasse

2.6. Burning Process

2.6.1. Combustion Principle

The combustion process is a rapid chemical reaction between fuel and oxygen (O2) from the air, accompanied by light and produces heat. The main combustion products are carbon dioxide (CO_2), water vapor (H_2O) and accompanied by heat energy.

While other combustion products are Carbon monoxide (CO), ash (ash), NOx, or SOx depending on the type of fuel. In combustion the process that occurred is oxidation with the following reaction:

    a. Carbon + oxygen = Carbon dioxide + heat

    b. Hydrogen + oxygen = water vapor + heat

    c. Sulphur + oxygen = Sulphur dioxide + heat

Some things occur in the combustion process:

a. Combustion with less air

It's said to be a rich mix. This combustion produces a reduction flame. Reduction flames are characterized by long, sometimes smoky flames. This state is also called incomplete combustion.

In this process, heat transfer is reduced and heat is lost due to excess fuel and there is unburned fuel in addition to combustion products result such as CO, CO_2, water vapor, and N_2.

b. Burning with excess air.

It's said to be a lean mix. This combustion produces an oxidation fire. In this process, less heat transfer and lost heat occur due to excess air and combustion products such as CO_2, water vapor, O_2 and N_2.

c. Optimum air combustion

In this process there is maximum heat transfer and minimum heat loss and the presence of combustion products such as CO_2, water vapor, and N_2. In combustion, the definition of primary air is an air is mixed with fuel in the burner (before combustion) and secondary air is an air entered into the combustion chamber after the burner, through the chamber located around the end of the burner or through other places on the kitchen wall.

In general, the fuel has turned into a vapor (combustible vapor) before burning. To accelerate the occurrence of "combustible vapor", a misting process is needed. The fog grains have a very large surface area, thus accelerating evaporation.

2.6.2. Three T- Combustion

The purpose of good combustion is to release all the heat contained in the fuel. This is done by controlling the "three T" of combustion, namely:

1. Temperature, a sufficiently high temperature to ignite and maintain ignition of the fuel,

2. Turbulence, Turbulence or good mixing of oxygen and fuel, and

3. Time, sufficient enough time for complete combustion.

Commonly used fuels such as natural gas and propane are usually composed of carbon and hydrogen. Water vapor is a by-product of hydrogen combustion, which can take heat from the flue gases, which may be used for further heat transfer.

Natural gas contains more hydrogen and less carbon per kg than fuel oil, so it produces more water vapor. As for the result, more heat is carried away in the exhaust when burning natural gas.

2.7. Calorie Balance

The combustion process in the steam boiler can be described in the form of an energy flow diagram or a Sankey diagram. Figure 9 graphically illustrates how the incoming energy from the fuel is converted into energy streams of various uses and becomes heat and energy's loss streams.

The heat balance or energy balance is a balance between energy input (input) with useful energy (output) and energy loss (loss). As incoming energy or energy supply (Qin) is the amount of energy resulting from fuel combustion.

The heat balance is the balance of the total energy entering the boiler towards those leaving the boiler in different forms. The aim of energy assessment is to reduce the energy loss that can be avoided, by increasing energy efficiency (Unep, 2006).
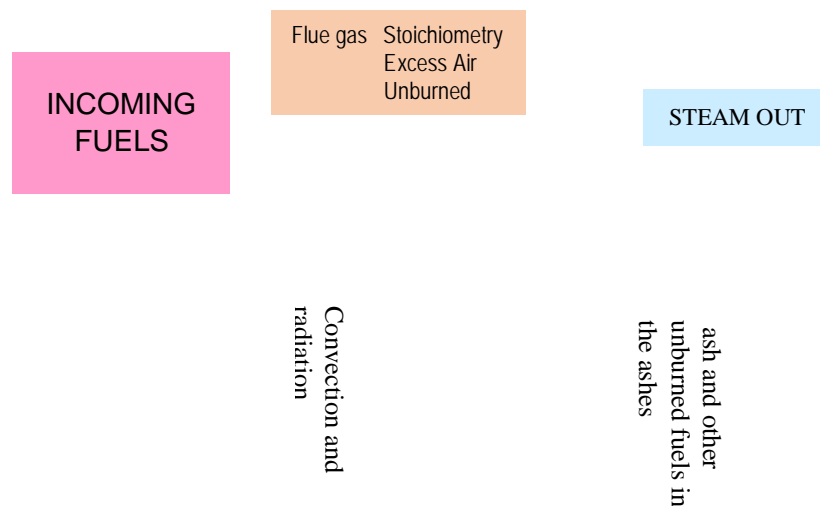
Figure 2.9. Sankey chart

Steam Boilers (source: Energy Efficiency Guide for Industry in Asia-

www.energyefficiencyasia.org)

In figure 2.9, the thick arrows indicate the amount of energy contained in each flow and give an illustration of the various losses that occur in the steam boiler. The energy enters the steam boiler is energy that comes from fuel, there is some energy lost during the fuel combustion process that occurs as shown in some pictures of orange, blue, green and yellow arrows, while the amount of steam comes out is the energy produced from the fuel combustion process and the evaporation process that occurs in the boiler.

1. Boiler efficiency

Boiler efficiency can be calculated in two ways, namely:

1. Direct method

Boiler Efficiency $(\%) = \dfrac{Q \, x \, (Hg-Hf)}{q \, x \, GCV}$ x 100

 Parameters monitored for boiler efficiency calculations using the direct method are:

   a.   The amount of steam produced per hour (Q) in kg/hour.

   b.   Amount of fuel used per hour (Q) in kg/hour.

   c.   Working pressure (in bar) and superheat temperature (^{o}C), if any.

   d.   Feed water temperature(^{o}C).

   e.   Type of fuel and Gross Calories Value (GVC) in kcal/kg fuel.

2. Indirect method

      What is meant by indirect boiler efficiency calculation is an indirect calculation involves the main components of the boiler efficiency formula, namely the output and input energy, in addition to calculate the existing losses. Indirect efficiency calculations are carried out in a reverse manner, focusing on parameters of losses and energy credits. What is meant by energy credits are secondary energies that enter the boiler other than primary energy from fuel. While losses are wasted energy parameters that are not converted into heat energy in water vapor. The calculation and measurement instructions for these parameters are very detailed and are described through standardization.

      The indirect method is carried out in great detail on every parameter measured, so that the level of accuracy is considered much better than the direct method. But of course, this indirect method requires a more significant cost because it requires special equipment in it. For this reason, many people consider this indirect method to be more suitable for use in large-scale boilers, and certainly not very ideal for calculating the efficiency of small boilers.

Practically the boiler efficiency can be calculated using a graph of heat losses and excess air. In this case, the author will use the direct method in performing calculations to determine the efficiency occurs in the boiler.

The process occurs in the boiler is the water enters the boiler is heated to become steam, then the heat is needed by the boiler for heating a water becoming steam with a steam production capacity of 1 Ton boiler. Theoretically, the energy balance is written as follows:

$$Q + hin = hout + W \tag{2.1}$$

Since there is no activity occurs in the boiler, $W = 0$ thus, the equation becomes $Q + h_{out} - h_{in}$. These conditions are actual conditions, where $= h_{in} = h_1$ dan $h_{out} - h_2$. Thus, the formulation to calculate the amount of heat needed for heating the water to be steam with a steam production capacity of a 1 ton boiler is:

$$Qin = S (h_2 - h_1) \tag{2.2}$$

Thus, in order to get the heat generated by the boiler is written as follows:

$$M = p_{water} \, X \, Q_{water} \tag{2.3}$$

$$Qboiler = \dot{m} (h_2 - h_1)$$

For the combustion process in the boiler used a mixture of shell fuel and sugarcane bagasse so that the amount of fuel consumption, (kg fuel/hour) can be calculated, mathematically and written as follows:

$$B_e = \frac{Q}{NKB} \tag{2.4}$$

Comparison of the amount of steam produced to fuel consumption, E (kg steam/kg of fuels).

$$E = \frac{S}{Be} \tag{2.5}$$

So that the heat generated by the fuel can be mathematically written as follows:

$$Q\text{fuels} = M \times N_{KB} \times 100\% \tag{2.6}$$

Then to determine the efficiency of the boiler based on the known formula, it can be written as follows:

$$\eta_{BOILER} = \frac{QBOILER}{QFUELS} \times 100\% \tag{2.7}$$

Specific gravity (SG) is the zratio of the density of a fluid to the standard (reference) fluid, and for determining the thickness of the liquid it can be formulated as follows:

$$SG_{fluid} = \frac{\rho\text{fluid}}{\rho\text{water}} \tag{2.8}$$

$$\rho_{fluid} = \rho_{\text{water}} \times SG_{fluid}$$

CHAPTER III

RESEARCH METHODS

3.1. Time and place

1.1.1. Time

This research is conducted during the eighth semester of the 2018 – 2019 academic year and estimated to be completed in approximately 6 months.

1.1.2. Place

The following are places where the final project will be carried out, including the following:

1. UMA Campus

The University of Medan Area is the place where the author carries out his undergraduate work in the form of mentoring from the guiding lecturer, taking library references, searching the internet for materials related to the final project.

2. Industry

PT. Perkebunan Nusantara IV Kebun Timur and PT. Perkebunan Nusatara II are the place where the author requesting for data on boiler specifications, performance and usability as well as requesting for guidance from employees and technical assistant managers from the industry concerned.

The research uses the sampling method of sugarcane bagasse and shell, which are by-product of processing sugarcane and oil palm at the palm oil mill belonging to PT. Perkebunan Nusantara IV and sugar factory of PT. Perkebunan Nusantara II. Samples are taken as much as 4 times, and each sample will be tested to determine the value of the total calorific value contained in the shell and sugarcane bagasse. At the same time, the condition of the boiler output steam will be observed in the form of steam pressure and temperature.

The results of all observations will then be processed to obtain the efficiency of the steam boiler. All researches are conducted at PT. Perkebunan Nusantara IV and in collaboration with the manufacturing and factory installations. The order of implementation of this research is as follows:

1) Sampling of palm oil shell and sugarcane bagasse

A sampling of palm oil shell and sugarcane bagasse are carried out in the last section, or at the place when sugarcane bagasse and shells will enter the combustion chamber of the boiler.

2) Observation/recording of dry steam conditions.

Steam observations are carried out at the same time as the sampling of palm oil shells and sugarcane bagasse are taken. This is done to obtain a correlation between the condition of sugarcane bagasse and palm oil shells with the steam condition resulting from the combustion of a mixture between sugarcane bagasse and palm oil shells as steam boiler fuel. Steam observations are carried out to determine the steam pressure and temperature of the steam coming out of the steam boiler and then heading the steam turbine.

3.2 Tools and Materials

Below are the tools and materials used in carrying out the research.

3.2.1. Tool

1. Bomb Calorie Meter

A bomb calorimeter is a tool used to measure the amount of heat (calorific value) released during complete combustion (in excess O_2) of a compound, food, fuel. A number of samples are placed in an oxygenated tube immersed in the medium (calorimeter) and the sample will be burned by an electric fire from a metal wire attached to the tube. As shown in Figure 3.1. as follows.

Figure 3.1. Bomb Calorimeter

2. Laboratory Thermometer

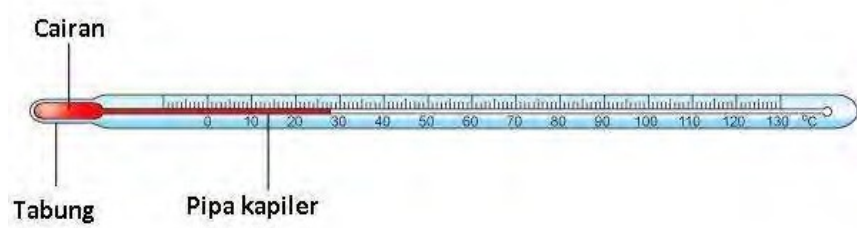Figure 3.2. is a laboratory thermometer that serves to measure the cold temperature or heated water.

Figure 3.2. Laboratory Thermometer

3. Digital Scales

Figure 3.3. is a digital scale that serves to weigh the mass of an object with an accuracy of 0.1 gram -1.2 kg.

Figure 3.3. Digital scales

3.2.2. Ingredients

1. Palm Oil Shell

Figure 3.4. is an oil palm shell used as a testing material, which was obtained from PT. Perkebunan Nusantara IV, with a total sample of 1 kg.

Figure 3.4. Palm Oil Shell

2. Sugarcane Bagasse

Figure 3.5. is bagasse used as a testing material, which is obtained from PT. Perkebunan Nusantara II, with a sample size of 1 kg.

Figure 3.5. Sugarcane Bagasse

3.3. Testing Steps

Steps are involved in conducting this analysis are as follows.

1. Initial

When visiting the location, the author will take samples, namely at PT. Perkebunan Nusantara IV and at PT. Perkebunan Nusantara II.

2. Field Study

Conduct surveys and studies in the Industries of PT. Perkebunan Nusantara IV and at PT. Perkebunan Nusantara II. for 3 months to understand how the boiler works and the components of the boiler directly. Viewing the working process on the boiler machine. and also taking samples in the industry as much as 1 kg for each sample. Then those samples are taken to the Medan State Polytechnic Lab for direct combustion testing that occurs in the calorie meter bomb combustion chamber starting from the process of burning shells and

sugarcane bagasse as well as burning from mixing between sugarcane bagasse and shell's fuels until the fuel is inserted into the calorie bomb meter engine.

3. Data on shells and sugarcane bagasse

The data taken is shown in table 3.1.

Table 3.1. Boiler Operating Conditions in the Palm Oil and Sugarcane Industry.

1	Pipe Type	Water Pipe
2	Operating Steam Capacity	1 ton/hour
3	Kinds of Fuel	Palm Oil Shells and Sugarcane Bagasse
4	Water Temperature Inside Boiler	80° C
5	Exit Steam Water Temperature	120° C
6	Inlet Water Pressure	353 K
7	Exit Vapor Pressure	0,7 MP_a
8	Pump Water Pressure	5.1 $kgcm^2$
9	Water discharge	5 m^3/hours
10	Operation	24 hours/day

1. The method of analysis carried out includes:

   • Total fuel consumption/hour

   • Amount of steam generated on fuel consumption

   • Calculation of heat generated from mixing palm oil shell and sugarcane bagasse fuel

   • Boiler efficiency

2. Analysis and Calculation for Test Result Data

   After taking the data, then the data is analyzed in order to get the results of the fuel efficiency of the water pipe boiler with a capacity of 2 tons/hour using a mixture of palm oil shells and sugarcane bagasse's fuels.

3.4. Analysis Flowchart

Figure 3.6. is a flow chart of test analysis
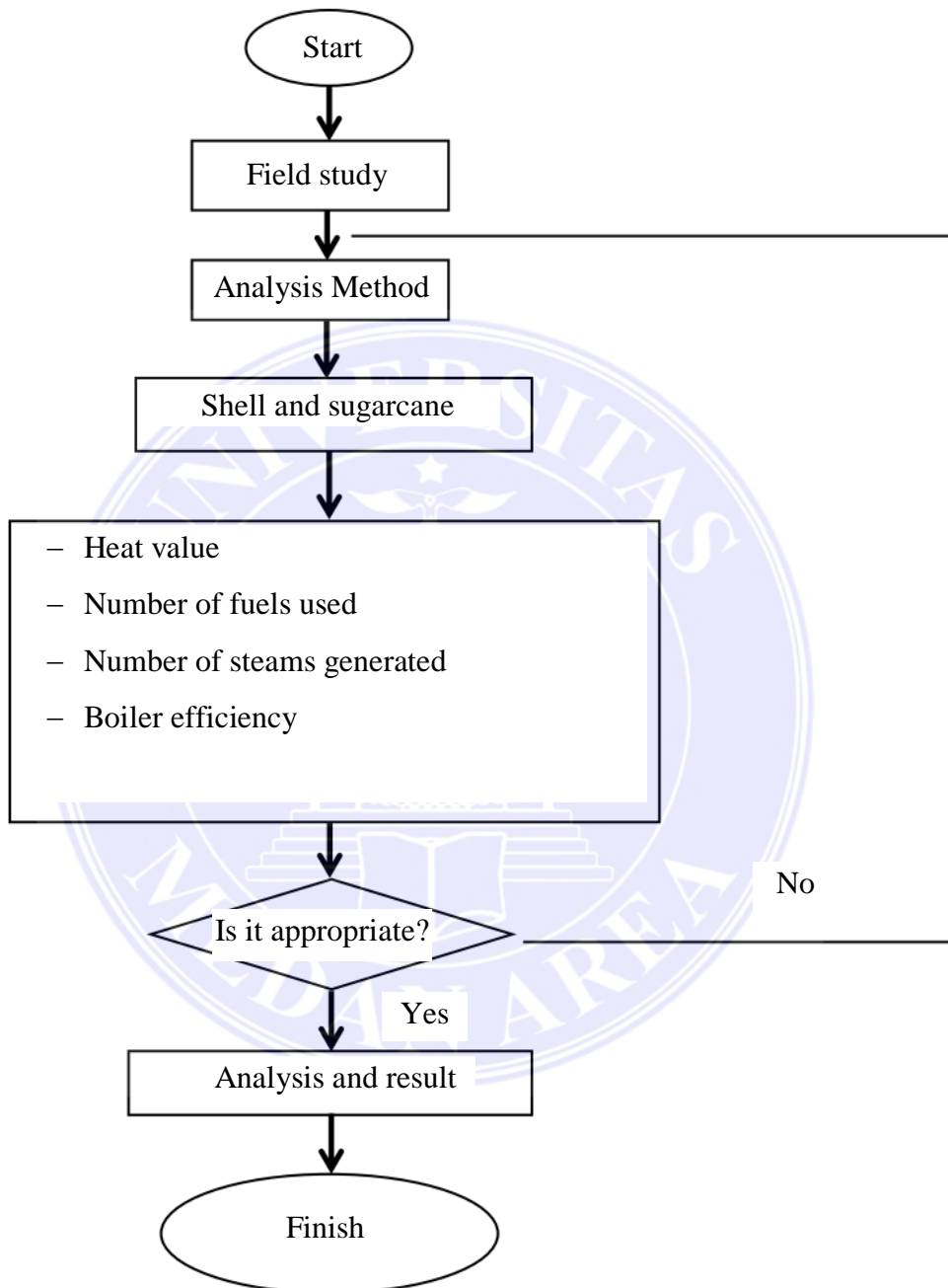
It is low fuel consumption but high fuel consumption while the use of 100% shell fuel has high efficiency but lower fuel consumption than 100% sugarcane bagasse fuel, mixture of 70% sugarcane bagasse 30% shell, and mixture of 70% shell and 30% sugarcane bagasse.

CHAPTER V

CONCLUSIONS AND SUGGESTIONS

5.1. CONCLUSION

Based on the calculation results, it can be concluded that using 100% shell fuels has a higher efficiency value, which is 57% than 100% sugarcane bagasse fuel, the mixture of 70% sugarcane bagasse and 30% shell, and the mixture of 70% shell and 30% sugarcane bagasse, so that the performance of the boiler engine is fuelled by 100% shell fuels is better than the boiler engine is fuelled by 100% sugarcane bagasse fuel, the mixture of 70% sugarcane bagasse and 30% shell, and also the mixture of 70% shell and 30% sugarcane bagasse. On the use of 100% sugarcane bagasse fuel, the mixture of 70% sugarcane bagasse and 30% shell, and also the mixture of 70% palm oil shell and 30% sugarcane bagasse, the risk of crust and soot formation is very large because 100% sugarcane bagasse fuel, a mixture of bagasse 70% and 30% shell, and also a mixture of 70% shell and 30% bagasse have more sulfur elements than 100% shell's mixed fuels, so the maintenance must be carried out at least once a week while using 100% shell's mixed fuels due to the risk is more negligible, so that the treatment is sufficiently done for once every two weeks. Thus, the changes in fuel consumption from 100% sugarcane bagasse, a mixture of 70% sugarcane bagasse and 30% shell, and also a mixture of 70% shell and 30% sugarcane bagasse into 100% shell fuels can be concluded as one way to improve boiler engine work efficiency.

5.2. SUGGESTION

The author suggests that in order to further improve the working efficiency of the boiler engine is to carry out processing / maintenance of the arena to produce quality hot steam, one of which depends on the correct processing / treatment to control the purity of hot steam, deposits, and corrosion although there it will be impacting to be more costs, and also must be carrying out routine control and cleaning of the components of the boiler engine, especially the components related to improving the working efficiency of the boiler engine.

PROOFREADING

1.	in a palm oil mill and sugar factory in the process of producing quality palm oil and sugar	:	in a palm oil mill and a sugar factory in producing quality palm oil and sugar
2.	The equipment required in the fuel system depends on the type of fuel used in the system	:	The equipment needed for the fuel system depends on the type of fuel used in the system
3.	The Sumatra Island has quite unique characteristics and having the largest contribution to the development of plantations in Indonesia	:	Sumatra Island has unique characteristics and having the largest contribution to the development of plantations in Indonesia
4.	has a share of around 1%. Plantations on the Sumatra Island	:	has around 1%. Plantations on the Sumatra Island
5.	properties of the land	:	properties of the ground
6.	which has an impact on environmental pollution	:	which impacts environmental pollution
7.	plantations that are not	:	plantations that is not
8.	can be in the form of empty	:	can be in empty
9.	energy for the surrounding	:	energy on the surrounding
10.	the calorific value of the fuel and also the pressure	:	the fuel's calorific value and the pressure
11.	As for the benefits of the research	:	The benefits of the research
12.	requires a greater cost	:	requires a more significant cost
13.	very suitable for calculating	:	very ideal for calculating
14.	the density of the fluid it can be formulated	:	the thickness of the liquid it can be formulated
15.	the risk is smaller	:	the risk is more negligible
16.	which obtained	:	which was obtained
17.	Bomb calorimeter	:	A bomb calorimeter
18.	a fuel consumption graph/hour at below	:	a fuel consumption graph/hour below
19.	The Figure 4.3. is a graph	:	Figure 4.3. is a graph
20.	sulphur	:	sulfur
21.	has a high efficiency	:	has high efficiency
22.	having the largest contribution	:	having the most significant contribution