CHAPTER I

INTRODUCTION

1.1 Background

The boiler is a power plane that is widely used and considered in the industrial world in Indonesia. Where boilers are usually used for prime movers are also used for heating.

In general, boilers require fuel to produce steam. Where the fuel used in the form of solid fuel, liquid fuel and gas fuel.

There is an energy crisis at this time, then many countries are competing to find fuel other than fossil fuels. In Indonesia, boilers still use much fossil fuels, in the form of oil, coal and natural gas. To reduce dependence on fossil fuels, many industries in Indonesia use alternative fuels that are found surroundings of the company. Such as shells and fibre used as fuel for boilers, which are found in the Indonesia palm oil industries.

This plan contains the planning of a boiler in industry, namely a palm oil factory which plays an important role in the production process, which is to drive the turbine. The steam produced will be used for the palm oil production process. After knowing the importance of the role of the boiler in the company, the topic of the water pipe boiler in this planning was taken.

In view of the importance of the role of the boiler, amongst others, it must be able to operate for 24 hours non-stop every day and almost 360 days a year. Thus, the boiler must be maintained in such a way so that the continuity of its operation is well maintained and the occupational safety factor is the main priority. In general, the operational failure of a boiler consists of planning failure, human error failure and maintenance failure. While the influence of the quality of the boiler feeding water is included in the three groups that cause the collapse mentioned above. The risk of all of the above failures can be a huge explosion that causes enormous material and life losses.

In terms of anticipating the operational failure of a boiler that results in an explosion. In planning, a very careful and detailed calculation must be carried out with the accompanying material data sheet that has been approved by the government supervisory body and the work must also be carried out by certified people in this regard.

In addition, the government also applies regulations concerning boiler's occupational safety which have been included in the occupational safety law which has permanent legal force. Thus, if there is an explosion occurs in the boiler, a thorough inspection will be carried out by the occupational safety supervisory agency and the police.

The most severe impact of the quality of the boiler feeding water itself is also the explosion of a boiler, where such unfeasible water will cause corrosion or crusts on the walls of the pipes as well as boiler shells that are exposed to direct heat radiation from the combustion process by getting thinner of the walls caused by boiler water corrosion, then the resistance to pressure will decrease and the crusted boiler pipe will be raising excessive heating of the pipe so that the pipe becomes plastic.

1.2 Problem Formulation

In this thesis analysis, the problems will be discussed need to be formulated, so that the expected analysis can be directed correctly. The scope of the discussion is how much influence of the scaling againts the rate of heat transfer in the water wall pipe. The impact of the low quality of boiler feed water will affect the rate and speed of scale formation on the water wall pipe. Therefore, the limitations of the problem are as follows:

1. Boiler feed water's quality level.
2. The effect of scale formation on the water wall pipe will reduce the heat transfer ability of the water pipe.
3. The amount of heat required to produce steam at the desired boiler operating conditions.

1.3 Problem Limitation

In writing this final project, it is necessary to limit the problem to facilitate the analysis of the problem. The limitations of the situation in this writing among others:

1. Analysing the effect of water quality on the efficiency of the boiler at the PT. Perkebunan Lembah Bakti (PLB).
2. Analysing the heat transfer in the water wall pipe.
3. Analysing the water needs of the boiler.

1.4 Research Objectives

The purpose of doing this writing, among others:

1. To determine the quality of water on the operation of the boiler
2. To determine the quality of boiler water.
3. To determine the efficiency of the boiler.

1.5 Research Benefits

The research results are expected giving benefits as follows:

1. Able to understand and know factors that cause scaling in water pipe boilers and how to overcome them by technicians working in industry, especially those engaged in boilers.
2. This thesis may supplement the literature differences for UMA Mechanical Engineering students.
3. The results of this research can contribute to the improvement of science and technology.

CHAPTER II THEORY BASIS

2.1. Introduction of Boiler

Boiler is a device for converting water into steam with a certain pressure and temperature that will then be used for the heating process or conversion into propulsion. To carry out this process, it is necessary to burn specific areas of the boiler. The fuel used are varies from the popular coal, shell and fibre, fuel oil, electricity, gas, garbage, and others. The Boiler is the most important part of the technological invention which is the trigger for the birth of the industrial revolution.

The earliest record of the discovery of the boiler was in 75 A.D. by a mathematician and physicist from Alexandria named Heros. In three of his books, he wrote about the mechanics and properties of air and introduced the design of a simple steam engine known as the eolipile. This eolipile machine's working principle consisted of a boiler tube connected to a steel ball with a nozzle, with the steam coming out of the nozzle and then made the steel ball rotate. This eolipile method became the basis for the development of subsequent steam engines. Furthermore, discovery-by-discovery grew more, starting from Geovanni Battista in 1538-1615 who introduced steam to make a vacuum tube. Denis Papin in 1647-1712 who introduced a device in the form of a steam digester, Thomas savery in 1650-1715 who was the first to make a steam water pump machine with a vacuum and press system and many more.

Technological developments, the boiler already one of the most important components within an industrial system. Boilers make a significant contribution to the development mechanism system by utilizing natural resources for human benefit. The requirements of Boilers hold a role in the industrial world such as in palm oil processing mill/ Pabrik Pengolahan Kelapa Sawit (PKS), boilers play a role in producing steam for heating, boiling and drying processes in the production process.

Water entering the boiler must have certain quality requirements. So that the steam production and the boiler equipment strength can be maintained according to the original plan. Water treatment before entering the boiler is one of the problems that need attention in planning a boiler. Water coming from the reservoir is pumped into a baffle with an overflow and underflow system with the aim of getting the following solids in river water. Next, add AN-9 aqua flock alum and soda ash in to the water, so that the floating solids turns to be flock and coagulating, making it easy to separate. The amount of chemical addition depends on the quality of the water.

Then the water from its minerals is demineralized or purified, especially if the water is rich in silica. The demineralization system consists of an anion exchanger and a cation exchanger. The anion exchanger functions to exchange salt for hydrolysis and retain silica, while the cation exchanger functions to exchange minerals for acid.

The deaerator functions to reduce the gas dissolved in the water and heats the feeding water temperature. This is achieved by mechanical processes and heating using steam in the pressure deaerator or by a vacuum deaerator. The water that comes out of the deaerator before being fed to the boiler is first injected with chemicals that function to improve the quality of the boiler water so that there is no crust.

The latest development of boiler technology is nuclear energy as the heating materials, where the heat generated from the atomic reactor is used to heat the pipes containing water which are connected to the main tube so as to produce high-temperature and high-voltage water vapor as the driving force for the electric generator turbine.

In the field of engineering, a boiler is an energy conversion engine that uses an external combustion engine system that is most widely used today, especially for small, medium, and large-scale energy generation. In addition, the boiler is an energy conversion engine that has the best efficiency and life time among other energy conversion engines, including combustion engines, gas turbines and jet engines because the remaining calories of combustion can be conditioned in such a way for the purposes of an economizer, super heater and air heater.

The diagrams of the boiler consist of the boiler tube, combustion chamber, safety system and parameters, feed water treatment and filling system and steam treatment system to be used for further energy needs of the five main groups of the above boiler sections, respectively own widely and varied description and calculation. The quality of feed water in a pressurized boiler is very important for the continuity and safety of a boiler, both low pressure and high pressure. In addition to the sustainability and work safety factors, it is also the key to achieving efficient and safe operations for machines and the surrounding environment. Boilers are the most common power/energy generators found in an industry throughout the world, thus, in their development, boilers have systematic rules and laws as the legal basis for their operational implementation and are monitored and routinely inspected by competent government agencies. in the field of health and safety (Ministry of Manpower). One of the laws governing boilers and the like which are classified into the pressured vessel group is:

The Law of Steam 1930, which regulates safety in the use of steam plane. Steam plane according to this Law are boilers, and other tools connected to the boiler, and work with a pressure higher than the outside air pressure. This law prohibits operating or using a steam plane that does not have a permit granted by the head of the occupational safety supervisory position (now the Director general of labour relations development and supervision of Work Norms – Ministry of Manpower). Regarding the steam plane for which permission is requested will be inspected and tested and if it meets the requirements as set out in government regulations, then a new operational permit deed will be issued.

The 1930's steam regulation, which regulates the division of steam engines based on their vapor pressure, namely greater than ½ kg/cm^2 above the outside air pressure and a maximum of ½ kg/cm^2 above the outside air pressure. This regulation contains provisions for obtaining a permit to use steam plane, as well as conditions regarding steam plane that do not require a license deed. This regulation includes technical requirements for the safety of boilers and steam plane other than boilers, steam dryers, steamers, steam vessels, among others regarding the requirements for manufacturing materials, safety equipment and testing procedures.

The Law No. 1 of 1970 which regulates the scope of occupational health, safety and accidents which generally aims to protect workers from all aspects that may have an impact on the surrounding workforce. In addition, there are many other rules that must be met to build, operate and maintain a boiler to ensure its operational feasibility.

In this thesis, the author will criticize the severity of the problem of how to obtain proper water for filling the boiler. Because there are so many types of raw water, all of them are not necessarily suitable for using a boiler.

The impact caused by water quality that does not meet these requirements cannot be directly felt by the boiler operator, it takes about three months to a year before the impact can be felt. Even then, the operator has high analytical ability and sensitivity to feel the symptoms that appear, ranging from a decrease in the productive ability of steam, wasteful use of fuel, the quality of the steam produced is not good, the emergence of shocks in the boiler and the most fatal occurrence is a fatal explosion.

Boiler is an equipment that used to produce (steam) in various purposes. The water in the boiler is heated by heat from the combustion of fuel (other heat sources) so that heat transfer occurs from the heat source to the water which causes the water becomes hot or changes it form into steam. Hotter water has a lower specific gravity than colder water, so there is a change in the specific gravity of the water in the boiler. Water that has a higher density will sink to the bottom.

The boiler system consists of: feed water system, steam system and fuel system. The feed water system provides water to the boiler automatically according to the steam requirements. Various faucets are provided for maintenance and repair purposes. The steam system collects and controls steam production in the boiler. Steam is flowed through steam piping to the user's point. In the whole system, the steam flow is regulated by means of a faucet and monitored by a pressure monitor. The fuel system is all the equipment used to provide the fuel to generate the required heat. The equipment required in the fuel system depends on the type of fuel used in the used technique of the boiler.

2.2 Boiler Feed Water

There are several things that need to be considered in handling boiler feed water, namely (EEA, 2011):

1. Scale Forming (substance causes scale)

If water is boiled and steam is generated, the dissolved solids present in the water will remain in the boiler. If there are a lot of solids in the feed water, they will settle. When the solids have reached a certain concentration level, the presence of the solids encourages the formation of foam and causes water to be carried into the steam. Sediment also causes the formation of scale inside the boiler, resulting in excessive local heating and eventually causing boiler pipe failure. Therefore, it is necessary to control the level of solids concentration in boiling water. The trick is to do a blow down, where some water is removed and replaced with feed water.

2. Substances may cause corrosion

Acid solutions and gases dissolved in water can cause boiler corrosion.

Based on ISO 10392 (1982), the boiler feed water quality that should be met, among others (EEA, 2011):

Table 2.1. Boiler feed water quality

	Up to	21-39	40-59
Maximum total iron (ppm)	0.05	0.02	0.01
Maximum total copper (ppm)	0.01	0.01	0.01
Maximum total silica (ppm)	1.00	0.30	0.10
Maximum oxygen (ppm)	0.02	0.02	0.01

The water used in the treatment process for boiler feed water is obtained from river water, reservoir water, bore wells and other springs. The quality of the water is not the same even though using similar water sources. This is influenced by the environment from which the water comes from. River springs have generally been polluted by population activities and industrial activities; therefore, purification is necessary.

The boiler feed water must meet the specified specifications so as not to cause problems in the continuous operation of the boiler. The water must be free from unwanted minerals and other impurities that can reduce the working efficiency of the boiler.

After the demineralization process, the water is converted into steam, the heat is transferred to the water in the deaerator which is part of the feed system. In the deaerator, gases dissolved in the water are removed, especially oxygen which is the main cause of corrosion. This deaerator cannot remove all dissolved gases; therefore, it is necessary to add a special chemical to expel the existing gases to the limit that is allowed to enter the boiler. These gases can be removed by the deaerator because the gas has a small solubility at high temperature.

Table 2.2. Boiler Feed Water Standard.

Parameter	**Unit**	**Boundary control**
PH	Unit	10.5 – 11.5
Conductivity	Umhos/cm	5000, max
TDS	ppm	3500, max
P – Alkalinity	ppm	-
M – Alkalinity	ppm	800, mak
O – Alkalinity	ppm	2,5 x Sio_2, min
T . Hardness	ppm	-
Silica	ppm	150, max
Iron	ppm	2, max
Phosphate residual	ppm	20 - 50

Parameter	Unit	Boundary control
Sulphite residual	ppm	20 – 50
PH Condensate	unit	8.0 – 9.0

Source = NALCO, REVERENCE

2.3 Boiler Efficiency

The thermal efficiency of Boiler is defined as “the percent of energy (heat) that is effectively removed from the steam produced.

There are two methods of assessing the efficiency of a boiler:

1. Direct method: the energy obtained from the working fluid (water and steam) is compared with the energy contained in the boiler fuel.
2. Indirect method: efficiency is the difference between energy’s loss and input. Thermal energy equipment: boilers and thermal fluid heaters.

   a. Direct method in determining boiler efficiency.

   Also known as the 'input-output method' because it turns out that this method only requires output/output (steam) and heat input/input (fuel) for efficiency evaluation. Efficiency can be evaluated using the formula:

   Boiler efficiency (η) = $\frac{Input\ Heat}{Output\ Heat}$x100

   Boiler Efficiency (η) = $\frac{Q\ x\ (hg-hf)}{q\ x\ GCV}$ X100

The parameters that are monitored to calculate boiler efficiency with the direct method are:

- Amount of steam produced per hour (Q) in kg/hour
- Amount of fuel used per hour (q) in kg/hour

- Working pressure (in kg/cm^2(g) and superheat temperature (Oc), if any feed water temperature (Oc)
- Fuel type and fuel gross heat value (GCV) in kcal/kg of fuel.

Where:

- hg – Enthalpy of saturated steam in kcal/kg of hot steam.
- hf – Enthalpy of feed water in kcal/kg water.

From the above formula, the following calculations can be made:

- Types of shell and fibre-fuelled boilers.
- Amount of steam (dry) produced: 20 tons/hour
- Steam pressure (gauge)/temperature: 265 ^{0}C
- Total use of shells and fibre: 1.6 tons of palm shells/hour and 3,483 tons of fibre/hour.
- Feed water temperature: 105 0C
- GVC shell and fibre: 5164.425 kcal/kg and 4870.7 kcal/kg
- Enthalpy of steam at a pressure of 7.5 kg/cm^2 : 757 kcal/kg(saturated)
- Feed water enthalpy 100 kcal/kg

Boiler enthalpy (η) = $\frac{20x(757-105)x1000}{2x4870,7x1000}$ x 0,1338617 % x0.1338617 %

Advantages of the direct method;

1. Factory workers can quickly evaluate boiler efficiency.
2. Requires few parameters for calculation.
3. Requires few instruments for monitoring.

4. Easily compare evaporation ratio with benchmark data.

Disadvantages of direct method;

1. Does not give instructions to the operator about the cause of lower system efficiency.
2. Not counting the various losses that affecting different efficiency level.

This is a simple example of the calculation used to determine the efficiency of the boiler in the company we are analysing. The results of the above calculations show that the efficiency of the boiler of ....% is relatively low. However, this is maintained because the boiler is also functioned as an incinerator to spend waste in the form of powder from production waste.

2.4 Boiler Filling Water

2.4.1 Water needs

The installed boiler requires a water supply of 10 tons/hour, but the water needs are supplied from two sources of raw materials, namely raw water that has been processed and the remaining condensate water.

In theory, the amount of water that becomes steam is similar with the amount of water from the condensate, but in the process of the steam distribution suffers losses resulting from leakage and the use of uncondensed steam (for non-heat exchanger production processes), so that the condensate water returns to the feed tank around 65% only. With these data, it can be obtained the calculation of the raw water needs.

Total Raw Water needs = Kettle Needs – Condensate Water

Total Raw Water needs = 10,000 – 75%

Total Raw Water needs = 3,500 L/hour

So that raw water treatment must be able to reach a minimum of 3,500 L/hour, from the data used for the basis of further calculations.

2.4.2 Boiler Filling Water Sources

The kinds of water that can be used as boiler feed water are well water and condensate water. Condensate water is pure so it does not need to undergo special treatment, while water from wells needs to be treated first.

a. Boiler Filling Water needs

Basically, the water to be used, especially that used as boiler feed water, must meet the requirements. Water that comes from nature (rivers and soil) does not exist in a pure state, usually there are impurities, amongst other:

1. Suspended substances, such as mud and clay. Usually removed by filtering.
2. Soluble substances, such as mineral salts (salts of magnesium, calcium and others).

Table 2.3 Requirements for boiler filling water and boiler water

Water Specification	**Kettle Filler**	**Kettle Water**
Hardness	< 0.1 OD	<0.1 OD
Ph	7.5-8.0	10.0-10.8

Water Specification	Kettle Filler	Kettle Water
TDS	Not real	max 1500
Palkali	50 ppm	300 ppm
M Alkali	100 ppm	500 ppm
Chlorine	Not real	max 70 ppm
Sulphite	30 ppm	max 60 ppm
Oxygen	Not real	Not real
Silicate	Not real	Max 30ppm
Fe	Kettle Filler	Kettle Water
P205	< 0.1 OD	<0.1 OD

Source: pullman kellogs(1980)

2.5 Boiler Feed Water Needs

Boiler or boiler is a device for a steam generator where this steam functions as a caloric energy transfer agent. The heat energy contained in the steam is expressed by the enthalpy of heat.

1. Things that affect boiler efficiency are fuel and boiler feed water quality. Parameters that affect boiler feed water quality include: Dissolved oxygen, in high amounts that may cause corrosion of boiler equipment.
2. Turbidity, can settle on piping and process equipment and disrupt the process.
3. PH. If it is not in accordance with the boiler feed water quality standards, it can cause corrosion of the equipment.
4. Hardness is the content of Ca and Mg ions that can cause scale on equipment and boiler piping, causing local overheating.

5. Fe, can cause coloured water and settle in water lines and boilers when oxidized by oxygen

In general, the water that will be used as boiler feed is water that does not contain elements that can cause deposits, which may form scales on the boiler and water that does not contain ingredients that can cause boiler corrosion.

The following are the requirements for boiler feed water quality standards:

Table 2.4 Boiler Feed Water Quality Standard

Parameter	Unit	Size
PH	unit	10.5-11.5
Conductivity	Ymhos/cm	5000, max
TDS	ppm	3500, max
P-Alkalinity	ppm	-
M- Alkalinity	ppm	800, max
O – Alkalinity	ppm	2.5 x SiO2, min
T – Hardness	ppm	-
Silica	ppm	150, max
Iron	ppm	2, max
phosphate residual	ppm	-
Sulphite residual	ppm	20.50
PH Condensate	unit	8.0 – 9.0

Table 2.5 Water Content

Working Pressure (Bar)									
		0 - 20.7	20.8 - 31.0	31.1 - 41.4	41.5 - 51.7	51.8 - 62.1	62.2 - 68.9	69.0 - 103.4	103.5 - 137.9
Feed water									
Dissolved oxygen (measured before oxygen scavenger addition)		0.04	0.04	0.007	0.007	0.007	0.007	0.007	0.007
Total Iron	mg/l	0.1	0.05	0.03	0.025	0.02	0.02	0.01	0.01
Total copper	mg/l	0.05	0.025	0.02	0.02	0.015	0.015	0.01	0.01
Total hardness (CaCO3)	mg/l	0.3	0.3	0.2	0.2	0.1	0.05	not detectable	
Non volatile TOC	mg/l	1	1	0.5	0.5	0.5	0.2	0.2	0.2
Oily matter	mg/l	1	1	0.5	0.5	0.5	0.2	0.2	0.2
pH at 25		7.5 - 10.0	7.5 - 10.0	7.5 - 10.0	7.5 - 10.0	7.5 - 10.0	8.5 - 9.5	9.0 - 9.6	9.0 - 9.6
Boiler Water									
Silica	mg/l	150	90	40	30	20	8	2	1
Total alkalinity CaCO3	mg/l	350	300	250	200	150	100	not specified	
Free hydroxide alkalinity CaCO3	mg/l	not specified					not detectable		
Specific conductance at 25 without neutralization	mS/cm	3500	3000	2500	2000	1500	1000	150	100

Source: boiler water quality standards according to APAVE (association of electrical and steam unit owners)

2.6. Boiler Feed Water External Treatment

External treatment is used to remove suspended solids, soluble solids (especially calcium and magnesium ions which are the cause of major scale formation) and dissolved gases (oxygen and carbon dioxide).

Existing external treatment processes are:

1. Coagulation and flocculation
2. Sedimentation
3. Filtration
4. Demineralization
5. Softening
6. Deaeration

The initial treatment method is simple sedimentation in the settlement tanks or settling in clarifiers with the help of coagulants and flocculants. Pressurized sand filter, with aeration to remove carbon dioxide and iron.

1. Coagulation and flocculation

Coagulation and flocculation are the process of providing coagulant and flocculant materials into boiler feed water by injection. Coagulation is a charge neutralization process so that the particles can be close to each other. Flocculation is the process of joining the particles together, which are already close to each other so that the particles will mutually attract and form flocs, as figure below.

Figure 2.1 coagulation and flocculation

To reduce turbidity at the inlet of the clarifier, chemicals are injected, namely:

a. Aluminium Sulphate (Al2(SO4)3. 18 H2O)

b. Sodium Hydroxide (NaOH)

c. Chlorine (Cl2)

d. Coagulant Aid (Polymer)

2. Sedimentation

The purpose of sedimentation is to provide an opportunity for large particles to settle and finer particles will require a longer settling time.

Figure 2.2 Sedimentation

3. Filtration

Processing by filtration can be done by filtering suspended solids in water before the water is filled into the boiler. The best filter efficiency when the unit is operating at the lowest flow rate, solids will pass through the medium carrying the solids with them. Thus, at high pressure, the media will come out when backwashing is done.

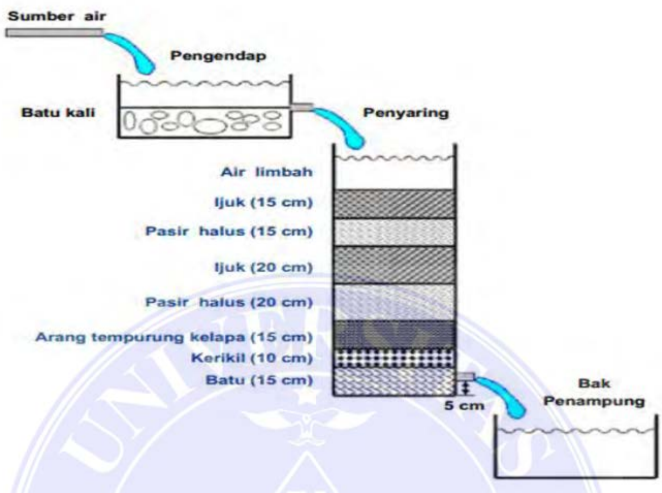

Figure 2.3 filtration

4. Demineralization

Demineralization serves to free water from the elements silica, sulphate, chloride (chloride) and carbonate by using a resin. Process flow diagram as shown below:

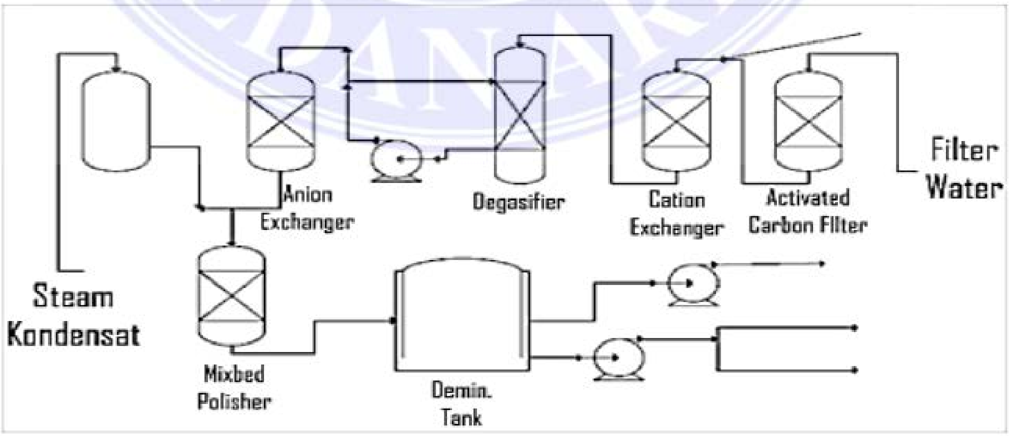

Figure 2.4 Demineralizer Flowchart

a. Cation Exchanger

This process aims to remove metallic elements in the form of positive ions contained in water using R-SO_3H cation resin (Dowex Upcore Mono A-500 type). This process is carried out by passing water through the bottom, where the metal will be bound by the resin. This R-SO_3H resin is a strong acid, therefore it is called a strong acid cation exchanger resin.

This process produces acids such as acids such as HCl, H_2SO_4 and other acids. Acidity ranges from Ph 2.8 – 3.5, to obtain the active resin again, regeneration is carried out by adding HSO_4 to the resin.

b. Degasifier

From the cation tower the water is passed to the degasifier which functions to remove CO_2 gas formed from carbonic acid in the previous process.

The reactions occur are:

H2CO3 -----> $H_2O + CO_2$

The process in this degasifier takes place at a vacuum pressure of 740 mmHg using a steam ejector, in this tank there is a netting ring as a medium to expand the contact area so that the incoming water is initially injected with steam. While the steam ejector output is condensed by injecting water from the top. and then accommodated in a seal pot as a recovery tank feed, then CO_2 will be released as a light fraction and water will fall to the bottom as a heavy fraction.

c. Anion Tower

Serves to absorb or bind negative ions contained in the water content that comes out of the degasifier. The resin on the anion exchanger is R = NOH (Type Dowex Upcore Mono C-600). This reaction produces H_2O, therefore demin water is always neutral. Furthermore, the anion tower outlet water enters to the mix bed polisher from the top. The water coming out of this tank has a pH = 7.5 – 8.5.

To obtain the active resin again, regeneration is carried out by adding NaOH to the resin.

d. Mix Bed Polisher

Serves to remove metal residues or acids from the previous process, so that the water that comes out of the mix bed polisher is expected to be clean of cations and anions. In the mix bed polisher, two types of resin are used, namely cation resin and anion resin, both functions to remove residual cations and anions, especially sodium and residual acid as silica compounds, with the following reaction:

Cation reaction:

$Na_2SiO_3 + 2\ R - SO_3H \text{ ----> } 2\ RSO_3Na + H_2SiO_3$

Anion Reaction:

$H_2SiO_3 + 2\ R = N - OH \text{ ----> } 2\ R{=}N\text{-}SiO_3 + H_2O$

The mineral-free water is put into the polish water tank and used for boiler feed water. The water that comes out of this mix bed polisher has a pH between 6 – 7. (Anonymous. 1994)

e. Deaeration

In deaeration, dissolved gases, such as oxygen and carbon dioxide, are removed by preheating the feed water before entering the boiler. All-natural water contains dissolved gases in solution. Certain gases, such as carbon dioxide and oxygen, significantly increase corrosion. When heated in a boiler system, carbon dioxide (CO_2) and oxygen (O_2) are released as gases and combine with water (H_2O) to form carbonic acid (H_2CO_3).

Removal of oxygen, carbon dioxide and other gases that cannot be condensed from boiler feed water is critical to the life of boiler equipment as well as safe operation. Carbonic acid corrodes metal reducing equipment and piping life. This acid also dissolves iron (Fe) which if returned to the boiler will experience sedimentation and causes the formation of scale in the boiler and pipes. This scale not only contributes to decreasing equipment life but also increases the amount of energy required to achieve heat transfer.

2.7 Ion Exchange

Groundwater is initially collected in a pull-out tank equipped with a pump to be flowed into a holding tank which also functions as a settling basin. The water that comes out of the settling basin is clear but there are still floating impurities, therefore the water is then filtered through a sieve to separate these particles.

Filtered water still invites dissolved substances that cause hardness. To remove these dissolved impurities, substances that can absorb ions in the solution are used. With ion exchanger, it is expected that the water used in the process has a hardness as little as possible even zero (0) so as not to cause scale.

2.7.1 Resin as Ion Exchanger

Ion exchanging resin is a solid material has a certain part (positive or negative ions) that can be removed and exchanged with other chemicals from the outside.

Based on the type of ion / charge exchanged, resins can be divided into 2:

1. Cation Exchanging Resin is positive Ion exchanged
2. Anion Exchanging Resin is negative Ion exchanged

Ion Exchange is the process of absorbing ions by the resin with means of ions in the liquid phase (usually with a water solvent) absorbed through chemical bonds because they react with solid resins. The resin itself releases other ions in exchange for the absorbed ions. During the operation, each ion will be exchanged with a replacement ion until the entire resin is saturated with the adsorbed ion.

Ion exchange resins are often used to remove hardness in water. Water enriches minerals calcium and magnesium is known as “hard water”. Water hardness can be divided into two types, namely:

1. Temporary hardness, caused by carbonate salts (CO_3-) and bicarbonate (HCO_3-) of calcium (Ca) and magnesium (Mg).
2. Fixed hardness, caused by the presence of chloride salts (Cl-) and sulphate (SO42-) of calcium (Ca) and magnesium (Mg).

2.7.2 Zeolites as Ion Exchangers

Zeolite is a mineral that found in many rocks which are layer of sedimentary soil formed from heaps of volcanic ash due to volcanic eruptions. Its formation in nature is very dependent on the environment, the age of the rocks and the depth of the soil surface, so that different types of zeolites can occur in the same rock.

Zeolite has very distinctive properties, when dehydrated, zeolite crystals will form cavities that can be interconnected and form 1-3 directions so that it will look like a cage. This unique crystal structure makes zeolites have the ability as absorbents.

Another characteristic is to have abilities as a very selectively ion exchanging material for caesium ions and other radioactive elements. Zeolites are hydrated aluminosilicate crystals containing cations alkaline or soil alkaline in a three-dimensional framework. The basic framework of the zeolite structure consists of tetrahedral units of AlO_2 and SiO_2 which are interconnected through O atoms, so that the zeolite has the following empirical formula x/n M^{n+} $[(AlO_2)_x (SiO_2)_y]\ zH_2O$. The first component of M^{n+} is a source of cations that can move freely and can be partially or completely exchanged by other cations, so it is very good when used as an ion exchanging material.

2.7.3 Ion Exchanger Process

Ion exchange is a process in which ions that are adsorbed on a filter media surface exchanged with other ions in the water. This process is made possible through a phenomenon of attraction between the surface of the charged medium and the polar molecules.

When a charged molecule touches a surface that has an opposite charge, then the molecule will be chemically bonded to that surface. Under certain conditions these molecules can be exchanged with other molecules in the water which have a higher tendency to bind. Thus, the exchange process can occur. Media that can carry out such an exchange process include zeolites (either natural or artificial) and resins.

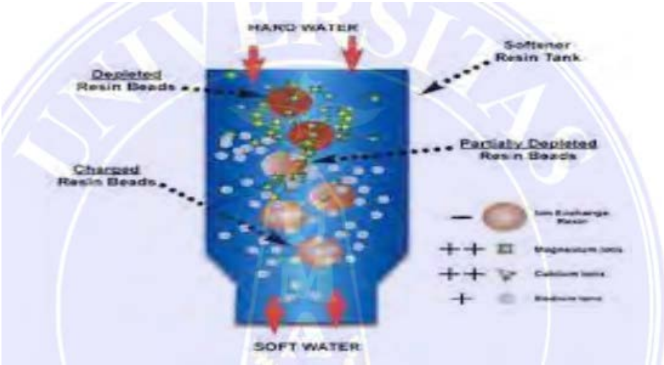

Figure 4. 5 Ion Exchangers

The exchange process that takes place generally follows the certain rules. that is:

1. First, the cations with the larger valence will be exchanged first before the cations with the smaller valence. For example, if in our aquarium there is iron (valence 3), calcium (valence 2) and ammonium (valence 1) in the same amount, then the iron will be adsorbed first by the zeolite, followed by calcium and finally ammonium.
2. Second, the cations with the highest concentration in the aquarium will be absorbed first even though the valence is lower. For example, in the above case, if the concentration (amount) of ammonium is much higher than that of iron and calcium, then according to rule 2, ammonium will tend to be absorbed first.

With the above processes, chemical filters can be applied to "clear" water from molecular-sized particles that cannot be processed mechanically or biologically. Some things can be removed with chemical filters include the effects of toxins, hardness, colour and dissolved organic particles.

From the data above, we will calculate the needs for cation resin if the active time target of the resin is planned every four days by referring to the results of the existing raw water quality test.

The test results show that raw water from well water contains a total hardness of 20 ppm, while for the boiler needs it must be free of hardness. So, the calculation is as follows.

1. Treated water (Q) = 3,500 l/hour
2. Total hardness (TDS) = 20 ppm
3. Target time (t) = 4 days
4. Exchanger capacity (R) = 10 %
5. Required resin volume (Vr)

$$\text{Vr} = \frac{QXtxTDS}{RX80\%}$$

$$\text{Vr} = \frac{3500x96x20}{10\%x80\%}$$

$$\text{Vr} = \frac{6.72}{0,08} = 84 \text{ L Resin cation.}$$

2.8 Blowdown

Blowdown is the partial discharge of the water in the boiler that has a high TDS concentration and replaces it with new boiler feed water so that it will reduce the concentration of suspended or dissolved solid water from the boiler. Usually expressed in percent.

If water is boiled and steam is generated, the dissolved solids present in the water will stay in the kettle. If a lot of solids are present in the feed water, they will be concentrated and will eventually reach a level where their solubility in water will be exceeded and will precipitate out of solution. Above a certain concentration level. These solids encourage the formation of foam and cause water to be carried into the steam. Sediment also causes scale to be formed inside the boiler wall, resulting in excessive local heating and eventually causing boiler pipe failure, steam traps, and even failure on operation of other equipment, especially on turbines. As for the increase in concentrate in the form of mud (sludge) will affect the efficiency of the boiler and the head transfer process. To overcome the above problems, the water in the boiler needs to be cleaned or blow down the surface of the boiler water (surface water blowdown) is usually carried out periodically to reduce the number of dissolved solids in the boiler water. The blowdown at the bottom of the boiler (bottom blowdown) serves to remove dirt in the form of mud (sludge) that settles in the boiler.

Water parameters that need to be considered to do blowdown is as follows.

1. Totally solid

   From a technical point of view, gravimetric measurement is an appropriate method for determining the total solids of boiler water, but this method is rarely used because the analysis is time consuming and too difficult for routine control. Also, the ratio of the total solids content of the boiler water to the total solids content of the feed water does not always provide an accurate measure of the feed water concentration in the boiler, due to the following:

a. Water samples may not show the true suspended solids content because solids tend to form precipitates.
b. Internal treatment can add solids to boiler water.
c. The content of bicarbonate and carbonate may free carbon dioxide gas and reduce total solids in boiler water.

2. Dissolved Solids

The specific conductance of boiler water is an indirect measure of dissolved solids and can usually be used to control blowdown. However, setting the blowdown rate on the basis of the relative specific conductivity of the feed water and boiler water does not provide a direct measure of the concentrations in boiler feed water. The specific conductance is affected by the loss of carbon dioxide with steam and the introduction of solids as an internal treatment. In addition, the particular feedwater conductance (dilute solution) and boiler water (concentrated solution) cannot be directly compared.

3. Silica, Alkalinity, Sodium, Lithium, and Molybdate.

In certain circumstances, measurements of silica content and boiler water alkalinity can be used to control blowdown. Sodium, lithium and molybdate have been used for accurate calculation of blowdown rate in high pressure units where demineralized water is used as feed water.

4. Chloride

If the chloride concentration in the feed water is high enough to measure accurately, it can be used to control blowdown and to calculate the blowdown rate. Since there is no chloride deposition in the boiler water, the relative chloride concentrations in the feed and boiler water provide an objective basis for calculating the blowdown rate.

The chloride test is not suitable for calculations when the feedwater chloride is too low to determine accurately. A slight analytical error in deciding the feedwater chloride content will cause considerable error in calculating the blowdown rate.

The following is a calculation of the amount of water that must be disposed through blowdown.

$$\text{Blowdown rate} = \frac{F.S}{B-F}$$

Where: F = Feed water TDS

S = Boiler capacity

B = Boiler target TDS

From the above formula used to calculate the blowdown rate, it produces the following numbers.

F = 20 ppm

S = 10,000 kg/hour

B = 1340 ppm

$$\text{Blowdown rate} = \frac{20x10.000}{1340-20}$$

$$= \frac{20x10.000}{1320-20}$$

$$= \frac{200.000}{1300} = 153{,}84$$ L/hour

Blowdown rate = 3,692.16 L/

CHAPTER III

RESEARCH METHODS

In carrying out this test the author uses the testing method and testing procedures. So that the steps and objectives of the tests carried out can be done in accordance with what is expected.

3.1 Time and Place of Research

a. Research place

The implementation and the testing place are carried out at the PT. Perkebunan Lembah Bhakti Astra Agro Lestari, aceh singkil.

b. Research time

The time of the research was carried out for 2 weeks, started from May, the 14^{th} of May until the end of the 28^{th} of May 2018.

The research time starts from the approval of the thesis title given by the head of the study program, data collection, data processing, until the preparation of the thesis is declared complete.

Table 3.1 Research Activity Schedule

No	Activity	MAY			
		Week I	Week II	Week III	Week IV
1	Literature Study				
2	Tool introduction				
3	Data Analysis				
4	Discussion				
5	Report Generation				

In the design of this plant, a water treatment system is formed which will be used for operational and utility purposes. The stages of water treatment are shown in Figure 3.1

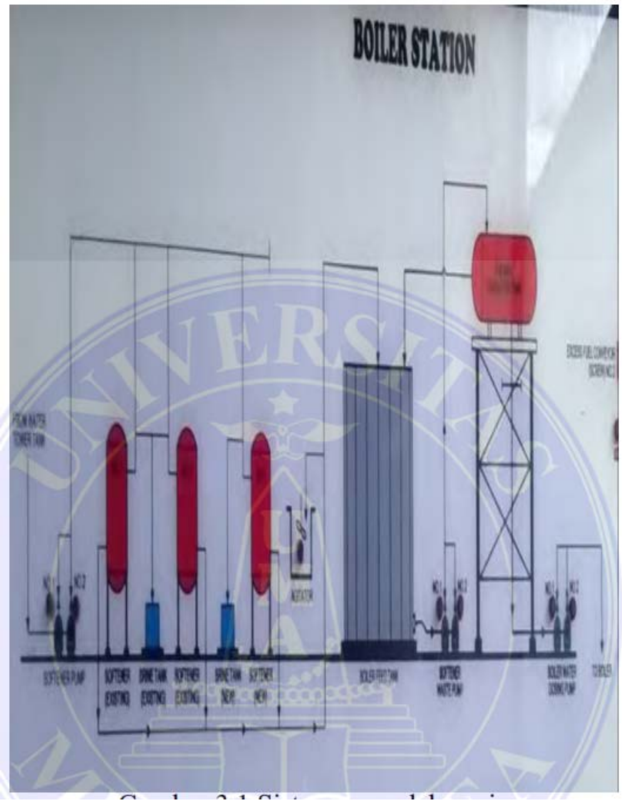

Figure 3.1 Water treatment system

3.2 Water Treatment Unit

This water treatment unit is described as follows:

a. Screening

Screening serves to prevent large dirt comes into the initial settling basin (Hanum, 2002.

b. Early Settlement

The initial deposition serves to settle the dirt that in the form of mud and sand (Hanum 2002). The sedimentation tank has a residence time of 2-4 hours (Powell, 1954).

c. Coagulation

The water from the settling tank flows into the coagulation tank. The coagulation process is a process of separating fine particles that can puddle the water. This process is done by adding a coagulating agent to the water. (Said and Ruliarsih, 2011).

With the addition of coagulant will cause the formation of lumps of impurities in the water. After that the water is allowed to stand for a while so that the floc will enlarge and settle quickly.

In water treatment at the propylene glycol plant, agglomerates are selected Alum as coagulants. Because alum is the best coagulant among other coagulants, the price is relatively cheap and easy to obtain in the market.

If the water turbidity is high, the addition of alum will be also more increasingly, and if the turbidity of the water is lower than the addition of alum is relatively small. Thus, the addition of coagulant depends on the level of turbidity of the water.

If the alkalinity of the water is not balanced with the alum dose, then alkalinity need to be added. The alkalinity commonly used is a solution of lime ($Ca (OH)_2$) or soda ash (Na_2CO3) (Hanum, 2002).

d. Clarifier

Clarifiers are commonly used for floc formation. On clarifier, separation occurs between clean water and dirty water. Dirty water will be deposited in the blow down while clean water will be channelled into the filter tank through pipes.

e. Filtration

The filter used in this process is a rapid filter (Rapid Sand Filter). This filter is in the form of a tank containing quartz sand which functions to filter fine floc and other impurities that escape from the clarifier.

Manufacture of filter media is usually made of more than one layer of quartz sand with a certain mesh. The water that flows down through the media will be filtered by the quartz sand. For substances that are not soluble in water, quartz sand will be retained, while clean water will collect at the bottom and then be released into a temporary reservoir (Hanum, 2002).

f. Water treatment units for housing and offices

This water is used to meet daily needs. Water that originated from the filter tank, it flows into a temporary reservoir, then flows into the chlorinator tank to add chlorine.

After that, the water is put in the activated carbon tank for carbonation process. The goal is that the water does not smell when consumed and removes the chlorine content in the water.

g. Water treatment unit for boiler feed

For this boiler feed water treatment using a demineralization system. This process is very supportive for river water treatment, because the salt content in river water is relatively low. In addition, the reasons for choosing an ion exchanging system are:

1. Volume and composition of water

2. The quality requirements of the processing results are in accordance with the its use objectives.
3. Capital costs and operations are required demineralization due to BFW (Boiler feed water) requires the following conditions:
    a) No scale at desired steam conditions if used as a heater. Scale can cause decrease in operating efficiency, and may result in not being able to operate at all.
    b) Free from O_2 and CO_2 gases which can cause corrosion.

Demineralization consists of exchange cations that take up positive ions and exchange anions that take up negative ions. The exchange material used in the form of resin, this resin when it is in a saturated condition can be activated again by being regenerated with H_2SO_4 for cation exchange and for anion exchanger using NaOH.

1. Cation exchangers

This cation exchange resin can be either a weak acid or a strong acid.

And the function of the cation exchanger is as follows:

a. Reducing the content of calcium and magnesium salts that can cause hardness.
b. Reducing total dissolved solids (TDS)
c. Reducing Alkalinity of alkaline and acid salts which is weak.

Exchange of calcium, magnesium ions with hydrogen ions in the cation exchanger causes the bicarbonate, sulphate, chloride and silica salts turn into silicic acid, carbonic acid, hydrochloric acid and sulfuric acid which are soluble in water.

2. Anion exchangers

It is flowed through the cations, the next step the water flowed in the tank anion that already contains a resin has a strong base anion or a weak base anion. And the material commonly used is NaOH.

Some of the functions of the ion exchanger:

a. Absorbs carbonic acid, sulfuric acid, hydrochloric and silicic acid produced by the cation exchanger
b. Reduce mineral salts

To support industrial processes, the water that comes out of the anion exchanger needs to be flowed into the process water tank. However, it should be noted that for boiler feed water, the water from the anion exchanger should be poured into the deaerator first to avoid the possibility of the cation and anions residues escaping. It is expected that the water coming out of this unit has a pH in the range of 6.1- 6.2 for further flow as boiler feed.

3.2 Steam Table

TABLE A-2

Pressure Conversions:
1 bar = 0.1 MPa
= 10² kPa

Properties of Saturated Water (Liquid–Vapor): Temperature Table

Temp. °C	Press. bar	Specific Volume m³/kg Sat. Liquid $v_f \times 10^3$	Sat. Vapor v_g	Internal Energy kJ/kg Sat. Liquid u_f	Sat. Vapor u_g	Enthalpy kJ/kg Sat. Liquid h_f	Evap. h_{fg}	Sat. Vapor h_g	Entropy kJ/kg · K Sat. Liquid s_f	Sat. Vapor s_g	Temp. °C
.01	0.00611	1.0002	206.136	0.00	2375.3	0.01	2501.3	2501.4	0.0000	9.1562	.01
4	0.00813	1.0001	157.232	16.77	2380.9	16.78	2491.9	2508.7	0.0610	9.0514	4
5	0.00872	1.0001	147.120	20.97	2382.3	20.98	2489.6	2510.6	0.0761	9.0257	5
6	0.00935	1.0001	137.734	25.19	2383.6	25.20	2487.2	2512.4	0.0912	9.0003	6
8	0.01072	1.0002	120.917	33.59	2386.4	33.60	2482.5	2516.1	0.1212	8.9501	8
10	0.01228	1.0004	106.379	42.00	2389.2	42.01	2477.7	2519.8	0.1510	8.9008	10
11	0.01312	1.0004	99.857	46.20	2390.5	46.20	2475.4	2521.6	0.1658	8.8765	11
12	0.01402	1.0005	93.784	50.41	2391.9	50.41	2473.0	2523.4	0.1806	8.8524	12
13	0.01497	1.0007	88.124	54.60	2393.3	54.60	2470.7	2525.3	0.1953	8.8285	13
14	0.01598	1.0008	82.848	58.79	2394.7	58.80	2468.3	2527.1	0.2099	8.8048	14
15	0.01705	1.0009	77.926	62.99	2396.1	62.99	2465.9	2528.9	0.2245	8.7814	15
16	0.01818	1.0011	73.333	67.18	2397.4	67.19	2463.6	2530.8	0.2390	8.7582	16
17	0.01938	1.0012	69.044	71.38	2398.8	71.38	2461.2	2532.6	0.2535	8.7351	17
18	0.02064	1.0014	65.038	75.57	2400.2	75.58	2458.8	2534.4	0.2679	8.7123	18
19	0.02198	1.0016	61.293	79.76	2401.6	79.77	2456.5	2536.2	0.2823	8.6897	19
20	0.02339	1.0018	57.791	83.95	2402.9	83.96	2454.1	2538.1	0.2966	8.6672	20
21	0.02487	1.0020	54.514	88.14	2404.3	88.14	2451.8	2539.9	0.3109	8.6450	21
22	0.02645	1.0022	51.447	92.32	2405.7	92.33	2449.4	2541.7	0.3251	8.6229	22
23	0.02810	1.0024	48.574	96.51	2407.0	96.52	2447.0	2543.5	0.3393	8.6011	23
24	0.02985	1.0027	45.883	100.70	2408.4	100.70	2444.7	2545.4	0.3534	8.5794	24
25	0.03169	1.0029	43.360	104.88	2409.8	104.89	2442.3	2547.2	0.3674	8.5580	25
26	0.03363	1.0032	40.994	109.06	2411.1	109.07	2439.9	2549.0	0.3814	8.5367	26
27	0.03567	1.0035	38.774	113.25	2412.5	113.25	2437.6	2550.8	0.3954	8.5156	27
28	0.03782	1.0037	36.690	117.42	2413.9	117.43	2435.2	2552.6	0.4093	8.4946	28
29	0.04008	1.0040	34.733	121.60	2415.2	121.61	2432.8	2554.5	0.4231	8.4739	29
30	0.04246	1.0043	32.894	125.78	2416.6	125.79	2430.5	2556.3	0.4369	8.4533	30
31	0.04496	1.0046	31.165	129.96	2418.0	129.97	2428.1	2558.1	0.4507	8.4329	31
32	0.04759	1.0050	29.540	134.14	2419.3	134.15	2425.7	2559.9	0.4644	8.4127	32
33	0.05034	1.0053	28.011	138.32	2420.7	138.33	2423.4	2561.7	0.4781	8.3927	33
34	0.05324	1.0056	26.571	142.50	2422.0	142.50	2421.0	2563.5	0.4917	8.3728	34
35	0.05628	1.0060	25.216	146.67	2423.4	146.68	2418.6	2565.3	0.5053	8.3531	35
36	0.05947	1.0063	23.940	150.85	2424.7	150.86	2416.2	2567.1	0.5188	8.3336	36
38	0.06632	1.0071	21.602	159.20	2427.4	159.21	2411.5	2570.7	0.5458	8.2950	38
40	0.07384	1.0078	19.523	167.56	2430.1	167.57	2406.7	2574.3	0.5725	8.2570	40
45	0.09593	1.0099	15.258	188.44	2436.8	188.45	2394.8	2583.2	0.6387	8.1648	45

H_2O

H_2O

TABLE A-2

(Continued)

		Specific Volume m^3/kg		Internal Energy kJ/kg		Enthalpy kJ/kg			Entropy kJ/kg · K		
Temp. °C	Press. bar	Sat. Liquid $v_f \times 10^3$	Sat. Vapor v_g	Sat. Liquid u_f	Sat. Vapor u_g	Sat. Liquid h_f	Evap. h_{fg}	Sat. Vapor h_g	Sat. Liquid s_f	Sat. Vapor s_g	Temp. °C
50	.1235	1.0121	12.032	209.32	2443.5	209.33	2382.7	2592.1	.7038	8.0763	50
55	.1576	1.0146	9.568	230.21	2450.1	230.23	2370.7	2600.9	.7679	7.9913	55
60	.1994	1.0172	7.671	251.11	2456.6	251.13	2358.5	2609.6	.8312	7.9096	60
65	.2503	1.0199	6.197	272.02	2463.1	272.06	2346.2	2618.3	.8935	7.8310	65
70	.3119	1.0228	5.042	292.95	2469.6	292.98	2333.8	2626.8	.9549	7.7553	70
75	.3858	1.0259	4.131	313.90	2475.9	313.93	2321.4	2635.3	1.0155	7.6824	75
80	.4739	1.0291	3.407	334.86	2482.2	334.91	2308.8	2643.7	1.0753	7.6122	80
85	.5783	1.0325	2.828	355.84	2488.4	355.90	2296.0	2651.9	1.1343	7.5445	85
90	.7014	1.0360	2.361	376.85	2494.5	376.92	2283.2	2660.1	1.1925	7.4791	90
95	.8455	1.0397	1.982	397.88	2500.6	397.96	2270.2	2668.1	1.2500	7.4159	95
100	1.014	1.0435	1.673	418.94	2506.5	419.04	2257.0	2676.1	1.3069	7.3549	100
110	1.433	1.0516	1.210	461.14	2518.1	461.30	2230.2	2691.5	1.4185	7.2387	110
120	1.985	1.0603	0.8919	503.50	2529.3	503.71	2202.6	2706.3	1.5276	7.1296	120
130	2.701	1.0697	0.6685	546.02	2539.9	546.31	2174.2	2720.5	1.6344	7.0269	130
140	3.613	1.0797	0.5089	588.74	2550.0	589.13	2144.7	2733.9	1.7391	6.9299	140
150	4.758	1.0905	0.3928	631.68	2559.5	632.20	2114.3	2746.5	1.8418	6.8379	150
160	6.178	1.1020	0.3071	674.86	2568.4	675.55	2082.6	2758.1	1.9427	6.7502	160
170	7.917	1.1143	0.2428	718.33	2576.5	719.21	2049.5	2768.7	2.0419	6.6663	170
180	10.02	1.1274	0.1941	762.09	2583.7	763.22	2015.0	2778.2	2.1396	6.5857	180
190	12.54	1.1414	0.1565	806.19	2590.0	807.62	1978.8	2786.4	2.2359	6.5079	190
200	15.54	1.1565	0.1274	850.65	2595.3	852.45	1940.7	2793.2	2.3309	6.4323	200
210	19.06	1.1726	0.1044	895.53	2599.5	897.76	1900.7	2798.5	2.4248	6.3585	210
220	23.18	1.1900	0.08619	940.87	2602.4	943.62	1858.5	2802.1	2.5178	6.2861	220
230	27.95	1.2088	0.07158	986.74	2603.9	990.12	1813.8	2804.0	2.6099	6.2146	230
240	33.44	1.2291	0.05976	1033.2	2604.0	1037.3	1766.5	2803.8	2.7015	6.1437	240
250	39.73	1.2512	0.05013	1080.4	2602.4	1085.4	1716.2	2801.5	2.7927	6.0730	250
260	46.88	1.2755	0.04221	1128.4	2599.0	1134.4	1662.5	2796.6	2.8838	6.0019	260
270	54.99	1.3023	0.03564	1177.4	2593.7	1184.5	1605.2	2789.7	2.9751	5.9301	270
280	64.12	1.3321	0.03017	1227.5	2586.1	1236.0	1543.6	2779.6	3.0668	5.8571	280
290	74.36	1.3656	0.02557	1278.9	2576.0	1289.1	1477.1	2766.2	3.1594	5.7821	290
300	85.81	1.4036	0.02167	1332.0	2563.0	1344.0	1404.9	2749.0	3.2534	5.7045	300
320	112.7	1.4988	0.01549	1444.6	2525.5	1461.5	1238.6	2700.1	3.4480	5.5362	320
340	145.9	1.6379	0.01080	1570.3	2464.6	1594.2	1027.9	2622.0	3.6594	5.3357	340
360	186.5	1.8925	0.006945	1725.2	2351.5	1760.5	720.5	2481.0	3.9147	5.0526	360
374.14	220.9	3.155	0.003155	2029.6	2029.6	2099.3	0	2099.3	4.4298	4.4298	374.14

Source: Tables A-2 through A-5 are extracted from J. H. Keenan, F. G. Keyes, P. G. Hill, and J. G. Moore, *Steam Tables*, Wiley, New York, 1969.

1.3 Research Flowchart

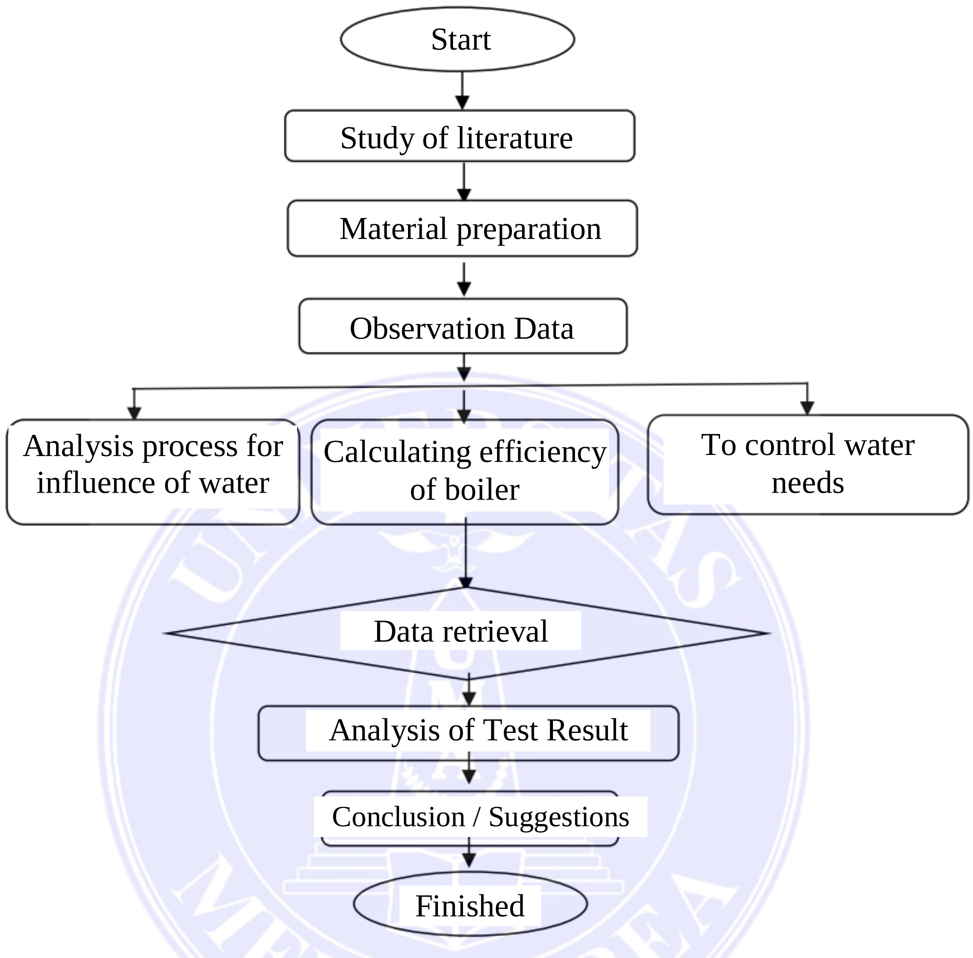

Figure 3.1 Research Flowchart

Figure 3.2 boiler at PT. Valley Bhakti Plantation, Agro Lestari Aceh Singkil.

CHAPTER V

CONCLUSION

In general, boiler problems related to water conditions and quality can be summarized as follows.

1. The water is fed to the boiler must meet the specifications given by the manufacturer. The water should be clean, colourless and free from suspended impurities.
2. Ph 8 to 10 slows down action or corrosion. Ph less than 7 accelerates corrosion due to the action of acids.
3. The water must be free of oil–this will cause priming (corrugated boiler water surface)
4. The total solids must be kept below the value at which water contamination in the boiler becomes excessive, results in the formation of deposits and scale and may be carried away by steam.
5. Appropriate water treatment plants should be installed to ensure water purity, and a certain amount of chemicals must be added to further control of boiler feed water quality.
6. Blowdown must be reset if there is an increase in concentration exceeding the allowable limit as set by the manufacturer.
7. Alkalinity should not exceed 20% of the total concentration.

8. The boiler water level must be appropriately maintained. Usually provided 2 pieces of monitoring glass to ensure this.
9. Operators must blowdown regularly and quickly, or at least once per day if the boiler is operated less than 24 hours a day.
10. Operators must make a checklist of periodic checklists (worksheets) which function to ensure routine checks are carried out regularly and consistently.
11. Avoid all possibilities that could result in the occurrence of the slightest occupational accident.

PROOFREADING

1.	cause the failure mentioned	:	cause the collapse mentioned
2.	The influence of the low quality	:	The impact of the low quality
3.	The limitations of the problem in this	:	The limitations of the situation in this
4.	burn certain areas	:	burn specific areas
5.	make a major contribution	:	make a significant contribution
6.	the nuclear reactor	:	the atomic reactor
7.	as well as provisions regarding	:	as well as conditions regarding
8.	This regulation contains technical	:	This regulation includes technical
9.	used system of the boiler	:	used technique of the boiler
10.	affecting various efficiency	:	affecting different efficiency
11.	contain elements that can cause	:	contain ingredients that can cause
12.	oxygen, greatly increase	:	oxygen, significantly increase
13.	specific conductance of feedwater	:	particular feedwater conductance
14.	provide an accurate basis	:	provide an objective basis
15.	error in determining the feedwater	:	error in deciding the feedwater
16.	must be maintained properly	:	must be appropriately maintained
17.	water used as following	:	water is used as following
18.	should be flowed into	:	should be poured into
19.	boiler in an industry	:	boiler in industry
20.	boiler which results	:	boiler that results
21.	problem, so that it will facilitate	:	problem to facilitate
22.	Able to understand and knowing factors that cause the process of scaling	:	Able to understand and know factors that cause scaling
23.	steam which has a certain	:	steam with a certain
24.	process, of course, it is necessary	:	process, it is necessary
25.	The working principle of this eolipile machine was consisting of a boiler tube	:	This eolipile machine's working principle consisted of a boiler tube
26.	discovery-by-discovery grown more which starting from Geovanni	:	discovery-by-discovery grew more, starting from Geovanni
27.	developments at this time, the boiler	:	developments, the boiler
28.	prior to	:	before
29.	need to gain attention	:	need attention
30.	boiler. Broadly speaking, water	:	boiler. Water