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A CHLORINE PRODUCTION IN A CHLORINE PLANT SYSTEM USING AC AND DC CURRENT AT THE PANGKALAN SUSU

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In a Steam Power Plant system. there are problems in the production process, requiring a cooling system that is used for work efficiency, namely circulation (steam recycling), and cooling the motor and pump using the natural temperature of sea water. In this research, we discuss the chlorine cooling system, so we need a system that can prevent marine biota from entering the cooling water circulation system, namely by providing high levels of chlorine liquid to the sea water intake (intake), which can expel biota . , and kill the moss. Therefore, it is necessary to create a Chlorination System Simulation at Steam Power Plants (PLTU), the aim of which is to maintain the efficiency of the system so that it works better.

1. INTRODUCTION

In line with the increasing need for electricity consumption in Indonesia, especially North Sumatra, PT PLN (PERSERO) is building a coal-fired steam power plant. With this PLTU, it will be able to help the country's electricity supply, especially in Sumatra.In the process of generating electricity, a tool is needed to support the reliable performance of the power plant. PLTU Pangkalan Susu with an installed capacity of 2x200 MW, is a type of power plant that uses sea water as the main cooling medium for the condenser. Sea water contains organisms such as; mussels, mussels, tripips, oysters, seaweed, algae bacteria and others, which flow and then stick to the condenser pipes can cause biofouling on the surface of the condenser pipes that are passed through. Biofouling is a colony or collection of organisms that stick and grow on the surface of an object, or in this case the surface of condenser pipes.

To avoid biofouling, the growth of marine organisms in seawater must be prevented or controlled. One way is to inject sodium hypochlorite (NaOCl) into seawater flowing through the condenser. Sodium hypochlorite (NaOCl) or commonly called chlorine is a type of disinfectant that is commonly used to inhibit the growth of organisms in water. The Chlorine Plant is used to produce sodium hypochlorite (NaOCl), the raw material for which comes from sea water.PLTU Pangkalan Susu each has 1 unit of chlorine plant system which functions as a transformer electrolysis processThe ectifier converts AC voltage into DC voltage which is then injected into the chlorine generator. In the chlorine generator, seawater is electrolyzed and converted into chlorine compounds (NaOCl).At the beginning of 2020, PLTU Pangkalan Susu experienced problems with its main cooling system, where a lot of biofouling was found in the condenser filter and resulted in unstable cooling of the power generating equipment, which made it questionable whether the chlorine plant system was operating effectively or not.

Chlorination plant at PLTU is a unit of auxiliary equipment in the generating system that functions to produce Sodium hypochlorite (NaOCl) which functions to inhibit the growth and development of animals - micro-organisms and micro-organisms, especially those that can stick to the walls of the cooling system pipes that can interfere with the operation of the cooling system in the PLTU Pangkalan Susu Generating Unit. The process is by decomposing seawater injected with DC current in the hypochlorite generator tube through an electrolysis process. Thus, the chloropac unit will be very helpful in keeping the power generation unit operating as efficiently as possible.

Chloropac in PLTU Pangkalan susu often experiences leaks on the outer and inner tubes with a service life of only about 5 - 10 months. Whereas the design life is 5 years. The material specifications used are Titanium tubes that work with a voltage of about 65 V, a current of 4000 A. When viewed from the life of the outer and inner tubes which are only around 5 months, of course this will require a backup tube to replace the leaking tube, besides that the Titanium tube is expensive

and not many are able to make it. With these considerations, PT Pangkalan Susu plans to analyze the factors that cause failure on the outer or inner tube, it is hoped that the right solution to the leak will be found.

Coal, which is an icon as a fuel for electricity, has various shortcomings both in terms of resources and the combustion process which causes pollution, basically this can be overcome with alternative energy sources that are renewable, environmentally friendly and easy to obtain. Solar energy is very potential to be developed because it is in peak conditions or perpendicular sun position Solar power plants that can usually be used for approximately 6 hours at night when the battery is fully charged must make us use the power provided by PLN when the power stored by the battery runs out, to maximize the installation of PLTS in households the solution used is to make PLTS still be able to produce electrical energy at night, namely using ultraviolet lights mounted on solar panels so that at night the lights can shine on solar panels and can produce energy again with this PLTS can produce more energy.

Previous research conducted by used MPPT to increase the effectiveness of solar cells, and research conducted using a prototype of sunlight tracking can increase the efficiency of the power that can be generated by solar cells but still has many shortcomings such as only being able to produce energy during the day, but at night PLTS cannot produce energy. In the concept of making, this renewable PLTS we use solar panels with a capacity of 100WP in this study, solar panels produce energy emitted by the sun during the day as usual, but at night the energy to be used from the battery to the inverter to be converted into DC then the voltage is divided into two namely to the load and to the ultraviolet lamp above the solar panel in order to generate electricity again.

Literature Review

Power Plant Steam

Steam Power Plant (PLTU) is an equipment installation owned by PT PLN Pangkalan Susu. Gresik in addition to PLTU and PLTG. PLTGU functions to convert heat energy, which comes from the combustion of fuel and air, into electrical energy that can be utilized for the community. Basically, the PLTGU working system utilizes a combined cycle system which is a combination of PLTG and PLTU. By utilizing heat energy and steam from the exhaust gas from combustion in the PLTG, which is then used to heat water in the HRSG (Heat Recovery Steam Genarator), thus producing dry saturated steam with high and low pressure. This dry saturated steam will be used to rotate the propeller so as to produce mechanical energy which is useful for rotating the turbine and then the generator which will convert it into electrical energy.

Figure 1. Electrolytic Cell Generator

Function: Producing NaOCl from seawater, especially NaCl through an electrolysis process with the help of AC current - direct electric current (DC).

Model: SC400/1
Quantity: 14 (1 set) x 2
Yield of effective chlorine: 100 kg/h (1 set) x 2
Flow of sea water: 68 m3/h (1 set) x 2
Anode material: titanium

Cathode material: Hastelloy alloy
Working voltage : ≤ 77 V
Working Current : 7200 A

Rectifier transformer

Function: converts input AC voltage and current into DC voltage and current which is used for the seawater electrolysis process.

Voltage: 6.3 kV AC, 50 Hz, 3 Phs
Power: 565 kVA

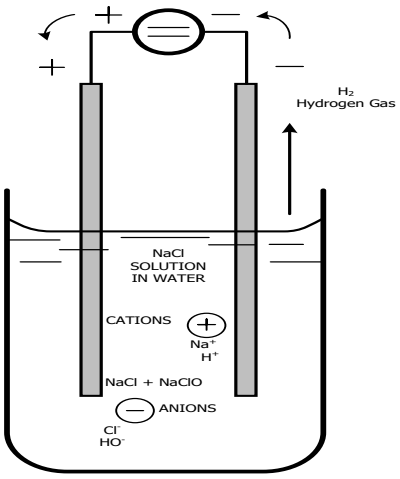

Figure 2. Rectifier.

Electrolysis Process

The Cl- ions will move towards the Anode and will undergo Oxidation and the Na+ ons will go to the Cathode and experience Reduction. Theoretically, electrolysis is a chemical process that converts electrical energy into chemical energy. Where the most important components in the electrolysis process are: electrode, electric current, and electrolyte solution. In the Chlorination Plant, this process is called Electrochlorination. In the Electrochlorination process, seawater is passed through an electrolysis cell so that the NaCl contained in the seawater turns into NaOCl and H2. The reactions that occur in an electrolysis cell are as follows:

Reaction at the anode:

$$2Cl^- \rightarrow Cl_2 + 2e$$

Reaction at the cathode:

$$2Na^+ + 2e^- \rightarrow 2Na$$
$$2Na + 2H_2O \rightarrow 2NaOH + H_2$$

Since the anode and cathode reaction products are not separated, the overall reaction is as follows:

$$2NaOH + Cl_2 \rightarrow NaOCl + NaCl + H_2$$

H2 gas as a by-product will then be released into the atmosphere because its concentration is relatively low. Apart from the reactions above, there are also side reactions that occur during the electrolysis process. Namely the formation of deposits that originate from the presence of Calcium and Magnesium ions. These deposits stick to the electrolysis cell and can result in reduced efficiency of the electrolysis process itself, so periodic cleaning is required. In its function, NaOCl dissolved in water will produce HOCl. This HOCl then acts as an effective disinfectant. The reaction is as follows:

$$NaOCl + H_2O \leftrightarrow HOCl + NaOH$$

HOCl (hypochlorous acid) formed can then dissociate to form OCl- (hypochlorite ion), as shown by the following reaction:

$$HOCl \leftrightarrow OCl^- + H^+$$

The dissociation reaction of HOCl to OCl- is an equilibrium reaction, where the reaction is influenced by the pH value. The higher the pH, the greater the HOCl that dissociates into OCl-, which will reduce the effectiveness of the biocide or disinfectant. At pH 7.4 the reaction is at the equilibrium point, where the concentration of HOCl is the same as OCl-. At pH 9.5 all HOCl changes to OCl.

2. METHOD

The principle of this electrochlorination process is as follows: The 6 kVAC voltage source is converted into DC voltage by a Transformer/Rectifier. DC current is then applied to the cathode and anode of the electrolysis cell to convert seawater (raw material) into the product NaOCl (sodium hypochlorite). NaOCl is then injected into the cooling water system for paralyze marine microorganisms from growing and multiplying in piping systems, condenser tubing, etc. which results in obstruction of the heat transfer process.

This Electrochloronation System consists of 2 sets of electrolysis cells with a capacity of 100 kg/hour NaOCl each. Each electrolysis cell can operate alternately (independently).

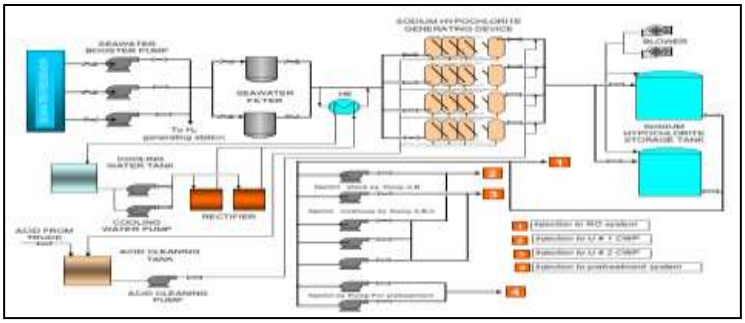

Figure 3. Process Flow Diagram

This Electrochloronation System consists of several parts, including: seawater conveying system, seawater filter, NaOCl production system, NAOCl Storage, NaOCl Dosing System, Acid Cleaning System, and also the Electric Control System.

The Seawater Conveying System consists of 3 Seawater Boosting Pumps, piping systems, valves, and supporting instrumentation equipment. Seawater filters consist of an Automatic Rinsing Filter and several supporting equipment. The NaOCl Production System consists of 2 sets of electrolysis cells and supporting equipment. NaOCl Storage consists of 2 storage tanks and equipment. NaOCl dosing system consists of 3 continuous dosing pumps, 2 shock dosing pumps, 2 pretreatment pumps dosing. The acid cleaning system consists of 1 acid storage tank.

In the flow diagram above you can see the overall process of the Electrochlorination System. Where the seawater booster pump functions to pump seawater from the seawater tank to the next system. Seawater filters function to filter impurity particles so they do not enter the electrolysis cell. The seawater will then be electrolyzed in an electrolyzer with DC current through the electrodes (anode and cathode) and produce sodium hypochlorite and H2 gas as by-products. NaOCl will be stored in the NaOCl storage tank while H2 gas will be removed into the atmosphere with the help of a blower. Chlorine function in PLTU Sodium Hypochlorite (NaOCl) is used to paralyze or prevent the reproduction of marine biota:

1. Condenser cooling water system
2. Water Treatment Unit (WTP)

Control Of Biological Fouling(In Cooling Water System) The Effect Of Microorganisms On The Cooling System:

- ✓ Proliferate on the surface of the Heat Exchanger (tube)
- ✓ Forms a thin layer on the surface of the Heat Exchanger
- ✓ Reduces heat transfer efficiency because it inhibits the flow of cooling water
- ✓ Reduces heat transfer efficiency due to lowering thermal conductance
- ✓ Creates turbulent currents which can result in erosion/corrosion of the HE tube

Chlorination Plant *Sodium hypochlorite*produced through the electrolysis reaction of sea water through electrolysis cells by flowing a direct electric current into it so that the salt solution will decompose to form a dilute solution of sodium hypochlorite.

Electrolyzer Process

- DC current passed through seawater produces Sodium Hypochlorite; Hydrogen in the solution is also produced as a byproduct. Electrocatalytic's generator works on the principle of constant flow where the concentration of NaOCl depends on the amount of current.
- The inlet and outlet flange of the cell are tied together and connected to earth (grounded) to prevent corrosion of external equipment caused by stray currents.
- Positive electric current is fed to the central Generating cell and negative electric current is drawn from the ends of the Generating Cell. Sufficient voltage is applied such that the potential increase in the solution produces cathodic and anodic areas. Namely the electrical connection between the bipolar elements which is made through electrolytes. This electrical arrangement will maintain a lower DC voltage requirement and prevent the possibility of corrosion due to stray electric currents, because the electrical potential at both the water inlet and outlet is maintained at ground potential. Functions as Cathodic Protection.

3. RESULTS AND DISCUSION

Chemical Composition Test Results

Chemical composition testing using the X – Ray Fluorescence tool was carried out at PT. PJB UP. Gresik to determine the suitability of the composition of the analyzed Titanium elements with the reference, namely ASTM B 338 Grade 2.

Table 1. Data System

Element	ASTM B 338 Grade 2	Test results Outer Tube
Nitrogen	0.03 (max)	(-)
Carbon	0.08 (max)	(-)
Hydrogen	0.015 (max)	(-)
Iron	0.20 (max)	0.073
Oxygen	0.18 (max)	(-)
Aluminum	(-)	1,036
Vanadium	(-)	0.788
Tin	(-)	(-)
Ruthenium	(-)	0.004
Palladium	(-)	0.002
Cobalt	(-)	0.045
Molybdenum	(-)	0.003
Chromium	(-)	0.190
Nickel	(-)	0.071
Niobium	(-)	0.004
Zirconium	(-)	0.004
Silicon	(-)	0.195
Titanium	Balance	99,950

The outer tube that was inspected was the inner part that was in direct contact with flowing sea water. In the results of this composition test, there is still the possibility of differences in numbers caused by "error" considering the position of the curved titanium. In the test results using XRF, the amount of Nitrogen, Oxygen, Carbon and Hydrogen detected is likely to be very small than the maximum allowed, so it cannot be read. In the results of this test it is also known that apart from Titanium as the base metal, there is Aluminum as an alpha stabilizer and Vanadium as a beta stabilizer.

Metallographic Test Results

This metallographic test aims to determine the effect of chlorination plant work activities which cause damage in the form of holes in the titanium tube on phase changes using an optical microscope to obtain a microstructure that has previously been etched with Kroll Reagent (ASTM E 407). Tools that used is the Olympus BX51M-RF which is located in the Metallurgical Laboratory in the ITS Department of Materials and Metallurgical Engineering. There are 2 points observed in

metallographic testing. The 2 points have different locations, namely the first point or point 1 is an area close to the hole, while point 2 is a piece far from the hole. The following is an illustration in Figure 1. This unit is prepared to control microorganisms that grow in the cooling water intake of the PLTU condenser.

Chlorination System is an equipment system found in the Pangkalan Susu PLTU which functions to produce NaOCl (Sodium Hypo Chlorite) which functions as protection for the Circulating Water System equipment, Heat Exchanger, and also in the Reverse Osmosis System and Waste Water Treatment System. Namely protecting against disturbance by living creatures/marine biota so that they do not live/breed in the equipment they pass through, from the intake to the condenser outlet and also on the Reverse Osmosis membrane.

This marine biota is a type of microorganism and a type of macroorganism, which if not injected with chlorine solution produced by the Sodium Hypochlorite Generator (in the Chlorination System), will be able to live and grow and develop to form coral or shellfish, thus disrupting the flow of sea water used. as cooling water, it may even cause blockage of the cooling water pipe holes in the Condenser and Heat Exchanger. Because this risk can be detrimental and can even speed up the life time of equipment, a chlorination system is very necessary for generating electricity.

The chlorination dose here is not meant to kill the biota that are carried away by the water flow into the Cooling Water system, but what is meant is only to be intoxicating, so that they cannot live and grow. So that the sustainability of the sea around the power plant is not damaged. Sea water contains a lot of sodium chloride (NaCl), magnesium chloride (MgCl2) and others. Because sea water contains a lot of salts, sea water also has electrolyte properties which have the property of conducting electric current. Because the salt content dissolved in it is quite large, the electrolyte properties are strong so the conductivity is large and the resistance is relatively smaller compared to water. bid. With these properties, it will make it easier to electrolyze sodium chloride salts dissolved in water to become sodium hypochlorite contained in sea water.

X – Ray Diffraction or what is often known as XRD aims to analyze whether there are compounds that enter titanium or act with titanium. XRD analysis was carried out using 2 points, namely points near the hole and far from the hole. From the XRD results, peaks with certain intensities were obtained. The peaks with the highest intensity are matched with a PDF card to find out what phase or compound is present in the sample.

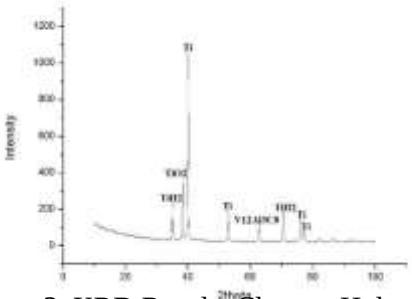

Figure 2. XRD Results Close to Hole

In Figure 2 the XRD results are presented with the highest peak at 2θ = 40.0705°with a peak height of 1118.90 cts owned by Titanium. The second highest peak with a peak height of 408.34 cts is located at 2θ = 38.3137°owned by TiO2and the third highest peak has a peak height of 245.43 cts at 2θ = 35.0041°owned by TiH2

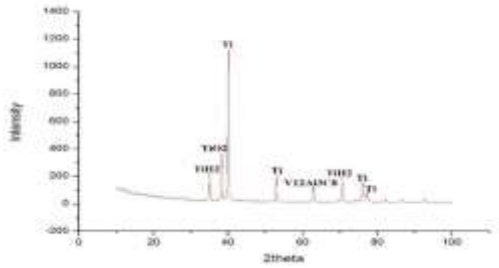

Figure 3. XRD Results Far from Holes

4. CONCLUSIONS

From the results of this research it can be concluded that: Factors that cause failure of titanium material in PT's outer tube pipe. PLN Pangkalan Susu is an increase in temperature Increase in temperature to above 70oC and seawater abrasion cause TiO layers2torn, protection is reduced. So hydrogen can enter and produce a hydrogen embrittlement reaction in the titanium pipe and produce Hydroid Needles which are brittle and cause holes. The composition of sea water has no effect on material failure. *Hydrogen embrittlement*which ends in fractures and holes, is indicated by the presence of Hydrid Needles, Slip Bands¸Voids, and vertical fault lines along the fault which indicate ductile fracture.

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