

An Analysis of Current Decrease in Generators at the Hydrogen Plant PLTU Pangkalan Susu

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ABSTRACT

The hydrogen generator is one of the devices used to cool the main generator. The hydrogen produced by the hydrogen generator is sent to the main generator to reduce the very high temperature. The hydrogen generator system is the hydrogen obtained from the electrolyte. After the electrolysis process, it flows into the generator to cool the main generator. The PLTU Pangkalan Susu hydrogen power plant was interrupted by a sudden power drop. As a result, the system tripped, cutting off the supply of hydrogen injected to the generator. According to the analysis, the reason for the current drop is that the electrolyte concentration value is low. in order to replace it in such a way that the current in the generator returns to normal.

Keywords : Current, Electrolyte Solution, Hydrogen

INTRODUCTION

The electricity needs in Indonesia is quiet significant, particularly in North Sumatera. The consumers have a very high consumption. Based on this reality found, PT. PLN established a coal-fired steam power plant (PLTU). The establishment of PLTU was expected to fulfill the electricity supply in Indonesia. In the process of generating electricity, a device that can convert mechanical energy into electrical energy (generator) is needed. Hydrogen Plant is one of the supporting units in PLTU unit 1 and 2 which have 1 generator for each. The generator has function to electrolyze demin water into hydrogen and oxygen gas with the help of an electrolyte solution and then a DC current is applied. At the end of 2020 until early 2021, the hydrogen plant at Pangkalan Susu PLTU was disrupted by a sudden drop in current.

When the current in the generator decreases, the production of hydrogen gas is not optimal. This situation caused the trip system and hydrogen injection supply to generator unit 1 and 2 are cut off. This phenomenon as a strong reasons related to the necessary of analyzing generator current decrease in the Hydrogen Plant. The analysis has been applied by finding the factors that cause the generator to trip. One of them was by replacing the electrolyte solution. This electrolyte solution serves as a catalyst that can reduce the electrical resistance of the electrolyzed water. The analysis implemented was expected that the current in the generator at the Hydrogen Plant will not drop suddenly.

LITERATURE REVIEW

Hydrogen

Hydrogen (Latin: hydrogenium, Greek: hydro: water; gen: form) is a chemical element in the Periodic Table 3, with the symbol H and atomic number 1. At normal temperature and pressure, hydrogen is colorless, odorless and non-toxic. highly flammable metal, monovalent and diatomic gases. Hydrogen with an atomic mass of 1.00794 amu is the lightest element on

earth. Hydrogen is also the most abundant element, accounting for about 75 percent of the total mass of elements in the universe. Most stars are formed from hydrogen in the plasma state. Hydrogen compounds are relatively rare and rarely found naturally on earth, produced industrially from various hydrocarbon compounds such as methane. Since hydrogen is a secondary energy, it needs to be increased from other energy sources such as natural gas, coal gasification, water electrolysis, methanol electrolysis which is relatively expensive, and conversion to biogas methane which requires heat energy. In industry, petroleum or coal and natural gas are used as a source of raw materials in most processes, but they still contain harmful by-products and pollute the environment. (Luhur Andana, 2016, pp. 9– 10)

Hydrogen Plant

Hydrogen plant is one of the complementary units in PLTU Unit 1 and 2 Pangkalan Susu which produces hydrogen gas. This hydrogen is used as a coolant in the generator. The use of hydrogen in the generator as a coolant was based on the following:

- a. Among other gases, hydrogen has the highest thermal conductivity.
- b. It does not make a noisy because it has a low molecular density.
- c. Low impurity components.

The hydrogen gas produced in the hydrogen plant comes from pure water which is electrolyzed using direct current. In the electrolysis process, the direct current used is supplied by the rectifier. The hydrogen generation system in the Pangkalan Susu PLTU consists of several main parts:

- a. 5 Nm³/hour *hydrogen equipment* (include *hydrogen purification equipment*). Consist of: Frame I (*hydrogen generation plant & the piping system*) and Frame III (*water & KOH tank, feed water pump*)
- b. *Hydrogen storage and distribution system* (Frame II) consist of *hydrogen distribution cabinet and hydrogen storage tank*.

Electrolysis Generator is the main component in a hydrogen plant. In this electrolysis generator, water (H₂O) is broken down into basic elements (H₂ and O₂). This generator consists of electrolytic multicells physically connected in series by two-pole plates. In each cell, hydrogen and oxygen are decomposed at separate electrodes. The electrodes are separated by a matrix that prevents the two gases from mixing. (Kang, 2013). Generator is an electrical energy converter that converts mechanical energy into electrical energy. Heat, water, steam, and other forms of mechanical energy can all be used to produce mechanical power. Generator electrical energy can be in the form of alternating current (alternating current) or direct current. This depends on the design of the generator used in the power plant. (Sunarlik, 2017)

Elektrolisis

Electrolysis is a chemical reaction in which electrical energy is converted into chemical energy. By passing an electric current to an electrode containing an electrolyte solution (water and catalyst), the electrolysis process separates water molecules into hydrogen and oxygen gas. Electrolysis is a non-spontaneous redox process that can occur due to the influence of electrical

energy. (Firnanda, 2020). The electrolysis efficiency of pure water itself is very low, because pure water has a low ionization constant and a large resistance. Therefore, to produce hydrogen from the electrolysis of water, KOH solution is used as the electrolyte. The main function of potassium hydroxide (KOH) electrolyte is to act as a catalyst. The presence of this electrolyte reduces the resistance of the electrolyzed water and does not decrease during the reaction. When a DC power source is connected to the electrodes in each cell, current will flow to the electrodes and the water will split into H₂ and O₂. The decomposition reaction or electrolysis of water on the generator is as follows:

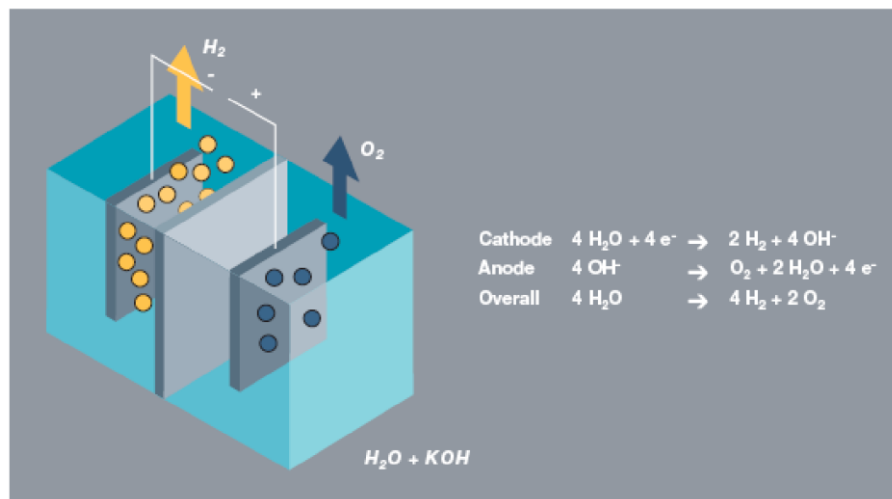
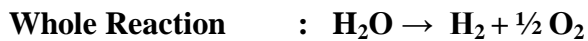


Figure 1. Water Electrolysis Process in Electrolysis Generator

The reaction rate above is proportional to the amount of current flowing at the electrodes. The H₂ gas production process requires the addition of V₂O₅ to the KOH solution to minimize the electrolytic voltage between the electrodes. The electricity consumption in this electrolysis process depends on the magnitude of the electrolysis voltage. The higher the generator temperature and the lower the voltage value, the more aggressive the asbestos matrix membrane. Therefore, it is necessary to adjust the generator working temperature at 80-90 °C.

The amount of hydrogen gas produced is directly proportional to the amount of current flowing between the electrodes. This is in accordance with Faraday's first law of electrolysis, namely:

“The mass of the substance formed at each electrode is proportional to the strength of the electric current that flows during the electrolysis process ”.

Hydrogen produced during electrolysis still contains impurities, especially moisture and oxygen, so it must be removed and having further processed. A deoxidizer (Ps-Pt) was used to reduce the oxygen content in the product. A separator/trap is used to separate hydrogen from the electrolyte solution. At the same time, to absorb moisture in hydrogen, a desiccant (molecular sieves 13X beads) was used to fill the drying tower. High purity hydrogen is then stored in storage tanks. (Kang, 2013).

METHODS

The steps that will be carried out are to analyze the current decrease in the generator at the hydrogen plant of the PLTU of Pangkalan Susu through a qualitative approach.

- Data Collection
 Data collection techniques in this study are by conducting observations, interviews and documentation studies.
 - a) Observation
 Observation made in this study were direct observation in the field
 - b) Interview
 Interviews were conducted to complete the data and obtain more accurate and precise data. In this study, the researcher interviewed colleagues related to the hydrogen plant.
 - c) Documentation studies
 Documentation studies in this research are needed to complete the research analysis related to the current decrease in the generator at the hydrogen plant.
- Analysis
 Analyzing the main problems that are the factors that cause a decrease in the current in the generator and apply the results of the analysis that have been researched.

RESULTS AND DISCUSSION

Result

At this stage it contains the results of research and implementation testing on generators at the hydrogen plant to minimize trip conditions that hamper the performance of the generator at (PLTU) unit 1 in Pangkalan Susu.

1. Disturbance Chronology and Problem Analysis

Table 2. Service Request for Hydrogen Plant Disturbance

No	DESCRIPTION	DATE	NO.SR
1	BOP/H2 Plant Generator 2 Trip	11/10/2020	2020172332
2	BOP/H2 Plant Unit 2 Current dan Voltage Hunting	10/02/2021	2021109190

Based on table 1, it can be concluded that the disturbance that generally occurs in the generator is a sudden drop in current. This disturbance can cause the generator to trip. As a result, the supply of hydrogen gas injection to the generator units 1 and 2 is disrupted. When the current decreases in the generator, it results in reduced production of hydrogen gas produced.

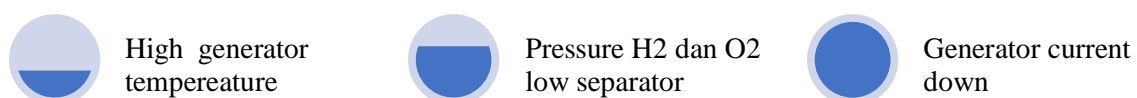


Figure 2. Root Cause Failure Analysis Generator Trip Fault

Discussion

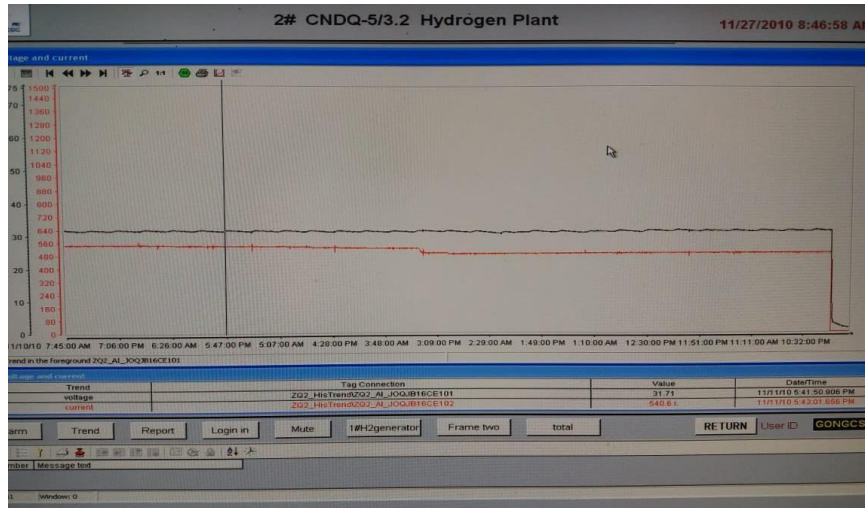


Figure 3. Current Drop Graph

Figure 2 shows the trend of decreasing current to 540.61 A with the normal operating value of the generator being 800 A until the current drops and causes the generator to trip. The reason for the current down in the generator was caused by the concentration of the electrolyte solution was not reached. In order for the current to return to normal, the electrolyte solution was replaced. The following is a comparison of the quality of the electrolyte solution:

Table 3. Comparison of the quality of the electrolyte solution

Parameter	Before	After		
		Research I	Research II	Research III
Concentration (kg/m ³)	1.697	1.549	1.320	1.209
Temperature (°C)	33	34.6	36.6	38.3



Figure 4. Electrolyte Replacement Process

After replacing the electrolyte solution, the current returns to normal in the generator. The concentration of alkali used was 1,209 kg/m³ after 3 times research. The graph of the current reading on the DCS after replacement can be seen in Figure 4.

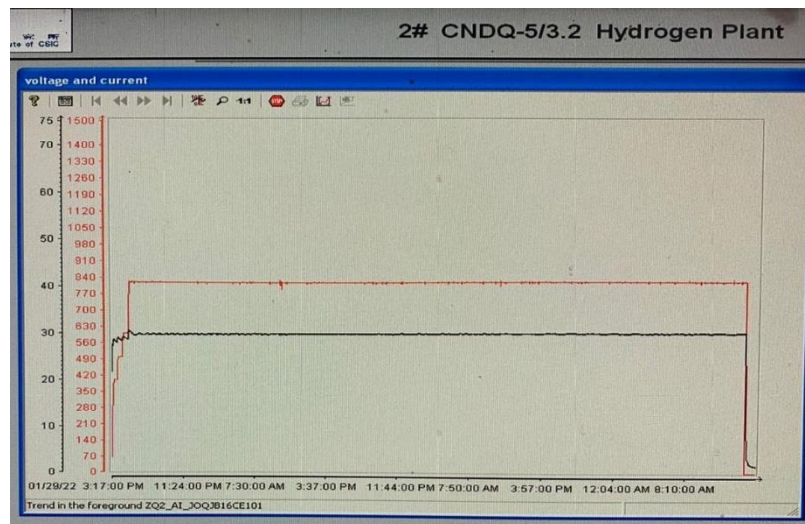


Figure 5. Current Graph after Electrolyte Solution Replacement

CONCLUSION

From the description above, it can be concluded that the Hydrogen Plant of PLTU Pangkalan Susu has 1 generator set and was used as a place for electrolysis of demin water into H₂ and O₂ gas with the help of electrolyte solution and injected DC current. The electrolysis efficiency of pure water itself was very low, because it had a low ionization constant and a large resistance. The main role of potassium hydroxide (KOH) electrolyte was as a catalyst, and the presence of this electrolyte can reduce the resistance of the electrolyzed water and not decrease during the reaction. From these data it can be concluded that the disturbance that usually occurs in the generator is a sudden decrease in current. To return the current to normal, the electrolyte solution was replaced.

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