Modification of the control electrical circuit in the Hydrogen system at the Pelabuhan Ratu Power Plant to Maintain Generator Reliability

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***Abstract* - The hydrogen plant control system experienced six trips within a two-month period. This resulted in the cessation of hydrogen gas (H2) production and posed several potential risks to the generator, including: first, the potential overheating of the generator rotor, which could reduce the isolator's lifetime. Second, it could potentially lead to a unit trip due to a cooling failure in the generator rotor. Based on the analysis of the above issues, it was found that the control wiring for H2-A and H2-B was merged into a single 220-volt phase voltage source. In the event of a short-circuit fault, this simultaneously caused hydrogen generators A and B to stop production. To address these trip faults in the hydrogen generator, wiring modifications were made to the Process Control Cabinet (PCC) panel by drawing power control cables of 220 volts for each hydrogen generator (Parallel Power). This modification included the installation of fuses and indicator lights. As a result, the 220-volt power source was divided into two: first, power control for hydrogen A, and second, power control for hydrogen B. After the wiring modifications were implemented, it prevented simultaneous trip failures in hydrogen generators A and B. To date, if a short-circuit occurs in one of the hydrogen generators, the other hydrogen control system can still operate and produce H2 gas. Additionally, this modification was made to assist the operations team in notifying the maintenance team of any abnormal H2 system conditions.**

Keywords- Hydrogen, Wiring, Panel

I. INTRODUCTION

A hydrogen plant is a system for producing hydrogen gas (H2) which is used as a cooling medium for the generator rotor. In the main circulating water (MCW) of PLTU Pelabuhan Ratu PGU, there are two hydrogen plants, namely A and B. When one of the hydrogen plants is disrupted, it can cause all the hydrogen generators to stop operating. There are several consequences for generating units when hydrogen plants stop operating: First, the production of H2 gas stops. Second, it has the potential to cause excessive heat on the generator rotor, which can reduce the life of the insulator. And the third, potentially causing unit trips.

In 2017, the hydrogen plant experienced repeated disruptions with a duration of six trips in two months. The maintenance team has carried out panel checks, including checking the wiring, control cable insulation resistance, and control cable resistance, as well as replacing new fuses. But the maintenance team has not found the problem point. This is because the time needed to check the panel takes a long time. Based on the results of discussions that have been carried out by the maintenance team with the electrical system owner (SO), it was found that there was an abnormality in the source of the control voltage. The finding is that there is a 220-volt voltage source in the control circuit to support hydrogen generators A and B. From the results of the analysis, when a short circuit occurs, the cycle will break and cause the hydrogen generator to stop production.
Therefore, to reduce hydrogen plant interference, modifications to the process control cabinet (PCC) panel are needed by utilizing existing human resources (HR) and equipment.

II. METHODOLOGY

The writing methodology is as follows:

1 Problem identification
2 Problem Analysis
3 Design innovation in determining requirements, material specifications, and drawings
4 Implementation
5 Monitoring and Evaluation

III. RESEARCH FOUNDATION

A. Understanding Hydrogen Plant

A hydrogen plant is an installation to produce H2 (hydrogen) gas. H2 is used as a cooling medium for power generators by absorbing and dissipating heat (dissipation) arising in the power generator when operating. Heat occurs due to changes in electrical energy that turn into heat energy in the alternator. Electrical energy that is lost or turned into heat is called loss. There are two losses of electrical energy in the alternator:

1. Copper loss is a loss of electrical energy that turns into heat due to the loading current flowing through the copper conductor stator and rotor. The amount of energy lost is calculated according to the formula I2. R = electric current; I = copper resistance.

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2. Iron loss is the loss of electrical energy that turns into heat due to the umbilical current (eddy current) that occurs in the stator core and generator rotor.

In addition to heat from the two losses mentioned above, heat is also caused by friction with wind (windage). Excessive heat is caused by the power generator; it needs to be prevented from causing damage to the conducting insulation or burning, so the generator needs cooling. Hydrogen is a generator cooling medium that is commonly used in power plants because it has several advantages over other media, including:

1. Has good cooling heat capacity
2. Free from moisture and contaminants so as to reduce the risk of corrosion
3. It has a small atomic size so it does not interfere with the rotation of the generator.

B. Hydrogen storage tank

Hydrogen storage tanks are used to accommodate H2 production. There are four hydrogen storage tanks with a capacity of 13.9 m3 each. Operating pressure 3.2 MPa and operating temperature (-10)-70 C If the pressure in the tank decreases, the operator will run the hydrogen plant as needed to increase.

C. Panel process control cabinet

The control cabinet functions to control the work of the hydrogen plant, make settings, and display alarms and interlocks. In addition, it can carry out long-distance transmission to be displayed in the Central Control Room and BOP Control Room. The process control cabinet consists of a programmable logic controller (PLC), safety barrier, analyzer, solenoid valve, converter, and others.

D. Profile of Research Place Institutions

Indonesia Power is one of the subsidiaries of PT PLN (Persero), which was established on October 3, 1995, under the name PT PLN Pembangkitan Jawa Bali I (PT PJB I). On October 8, 2000, PT PJB I changed its name to Indonesia Power as an affirmation of the company's goal to become an independent power generation company with a pure business orientation. The company's current main business activities are focused as a power provider through power generation and as a provider of power plant operation and maintenance services, operating plants spread across Indonesia.

PLTU Palabuhanratu PGU is a steam power plant (PLTU) located on Jalan Raya Cipatuguran Jayanti Village, Citarik, Pelabuhan Ratu District, Sukabumi Regency, West Java, Indonesia. This power plant has a total capacity of about 3 x 350 megawatts (MW), which is one of the important sources of electrical energy in Java and Bali. As a coal-fired power plant, PLTU Palabuhan ratu PGU uses coal as its main fuel to produce electrical energy. The process begins with the burning of coal inside the boiler to generate heat. The heat is then used to convert water into steam in the boiler. The steam generated is pumped into a steam turbine, which will drive a generator to generate electricity.

IV. DISCUSSION

A. Identify the Problem

Based on work order 201715164 with chronological attachments from operators in two months, there have been six trips. Here's a detailed table of H2 generator interference:

No	date	description of the disorder	findings	consequence	handling
1	27-Jan-17	lost power indication	fuse broke	H2 generator -	fuse
2	13-Mar-17	trip indication	fuse broke	H2 generator -	fuse
3	25-Mar-17	lost power indication	fuse broke	H2 generator -	fuse
4	26-Mar-17	lost power indication	fuse broke	H2 generator -	fuse
5	26-Mar-17	lost power indication	fuse broke	H2 generator -	fuse
6	26-Mar-17	1. Amperes won't increase (Generator H2 - A) 2. The fuse blows when the generator is operating (Generator	fuse broke	H2 generator -	fuse

Table 1: Interference H2 Generator

The identification results on the H2 wiring panel of Plants A and B indicate installed control systems equipped with one overcurrent safety or fuse on the 220-volt phase line. It is known that circuits like this cause problems that cause hydrogen production to be disrupted. In addition, the level of difficulty in troubleshooting is inefficient because it must be checked on all control circuits, so it takes a long time.

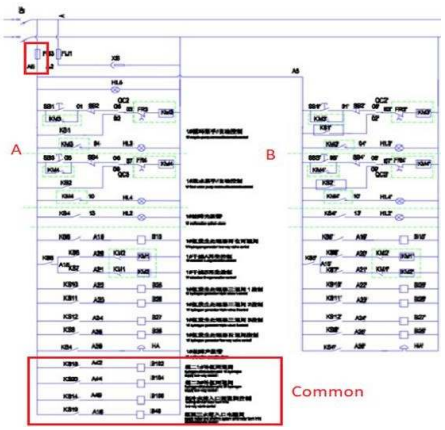

Figure 1: Wiring before modification

Based on the picture above, the function does not support the control system because the cycle or fuse is not attached to each control. When the second H2 generator plant is produced, if there is one weak system, such as a short circuit, it will stop other control systems that are in healthy condition.

B. Design of Innovation Works

By separating the power control for each hydrogen, it is expected to solve the problem efficiently. Here's the new wiring control design:

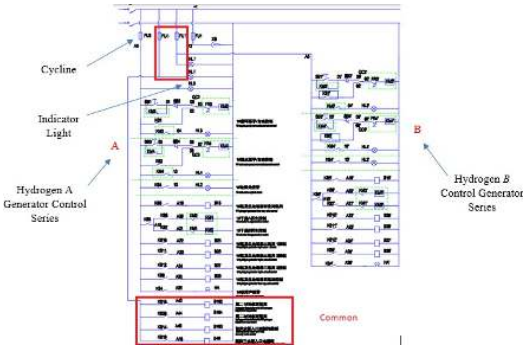

Figure 2: Wiring after Modification

Based on the picture above, the addition of h2 control cycles or fuses for A and B generators and common loads such as hydrogen distribution skids, cooling devices, supply water, and alkaline systems has been done.

C. Implementation

The implementation of rewiring panels on hydrogen has been carried out since April 5, 2017, by the JPR PGU electrical maintenance team. The parts that need to be prepared for this wiring control modification work are:

1 Fuse ceramics: 3 pieces
2 Indicator Light: 2 pieces
3 Cable NYAF: 1x1 mm
4 Terminal Strip: 5 pieces
5 Fuse Holder: 2 pieces
6 Cable lug 1 mm: 15 pieces
7 Multimeter: 1 piece
8 Cut pliers: 1 piece
9 Crimping pliers: 1 piece
10 Insulation tester: 1 piece
11 Cable ties: 1 pack

requires three people, consisting of one technician and two helpers,

The wiring modification process is not difficult, just by adding two fuses and holders to the PCC panel. By connecting a 220-volt phase voltage source to the top or input holder, the bottom or output is connected to the hydrogen generator control circuit. As shown in figure 3 below,

Figure 3: Adding Fuse and Holder

While the indicator light lights up as shown in Figure 4,it serves to signal when the voltage source is 220-volt standby. And vice versa, if the indicator light turns off, it indicates a short circuit in the control circuit due to interference with the hydrogen plant.

Figure 4: Adding indicator lights

Since the rewiring of the PCC panel, the level of interference that occurred in hydrogen plants until now is no longer repeated. Here is a graph of the decline in the number of disruptions that occurred from 2017 to 2022:

Figure 5: Graph of Hydrogen Plant Trip Decline

Based on the results of the chart above, there was a decrease; originally, in two months there had been six disruptions, but after innovation until now, in October 2022, there have been no similar disturbances.

V. CONCLUSION AND ADVICE

A. Implementation

1. After modification, it can maintain the reliability of the hydrogen generation system because it is able to produce hydrogen gas when one of the systems is maintained.
2. After the modification, the interference level decreased, and now there is no more recurring interference caused by broken fuses.
3. Partial maintenance can be performed on abnormal assets without shutting down the entire hydrogen system in the PCC panel.
4. Assist operations in determining abnormal assets when carrying out service requests (SR) to inform the system owner of asset health data.

B. Suggestions

It is necessary to add trip signals and alarms to the control room in the event of a disturbance to assist operators in monitoring hydrogen production.

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