



## ANALYSIS OF HANDLING HYDROGEN LEAKAGE ON LINE GENERATOR STATOR COOLING WATER

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### ABSTRACT

The stator is part of the generator that does not move, consisting of coils of conducting wire arranged in such a way and placed in the grooves of the iron core. In the conductor is the place where the induced emf is formed which is the result of the rotating magnetic field from the rotor which is the stator conducting coil. The amount of electrical voltage generated by a generator at a power plant is usually in the form of volts. When the generator operates there will be a short circuit in the form of heat that occurs in the rotor and stator of the generator. To reduce the heat that occurs, each generator has its own cooling system to get the appropriate temperature so that it can operate normally. Generators that have a large capacity (> 300 MVA) generally use hydrogen gas as a cooling medium.

**Keywords:** *Generator, Stator and Hydrogen Cooling*

### 1. INTRODUCTION.

PLTU Pangkalan Susu is a coal-fired power plant with an installed capacity of 4x200MW. Operate on Load Based Operation in Sumatra Electrical System North. Then Availability and reliability of generating machines is very important. When a generator fails or malfunctions, it will disrupt the process of converting mechanical energy into electrical energy, which can cause the unit to stop operating. If this happens other than a loss consequence loss of opportunity of operating unit to there is losses from repair costs and replacement material losses.

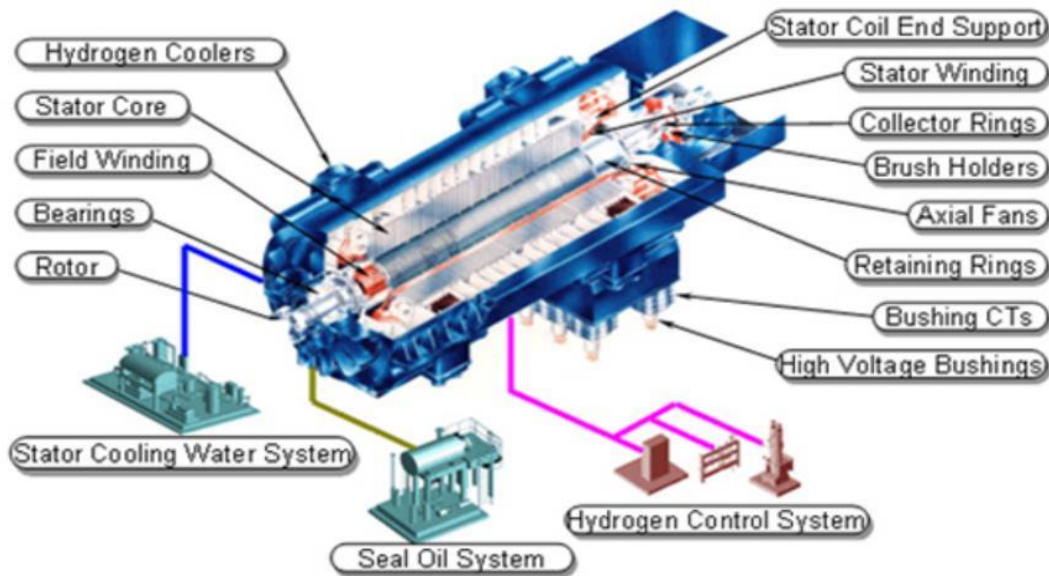
Generator is a device that functions to convert mechanical energy into electrical energy. The process of converting mechanical energy into electrical energy occurs with the help of style magnets. In the generator at PANGKALAN SUSU PLTU, mechanical energy comes from the rotor which coupling with turbine which coupled with steam. The rotor is injected with DC current to generate a magnetic field. Furthermore, the magnetic field on rotor that rotates will induce a voltage in the generator stator. Generator Unit Specifications 1 and 2 PANGKALAN SUSU UJP PLTU produces 200 MW of electrical power with a nominal voltage of 15.75KV on 3000 rpm rotation.

In 2021 occur problem on generator unit on system hydrogen in the generator. The hydrogen pressure in the generator drops very much fast, so decision taken for shut down unit. After inspection on area which allows there is hydrogen that leaking with H<sub>2</sub> leakage detector, the Stator Cooling water tank has hydrogen. Pressure H<sub>2</sub>-0.3Mpa Pressure cooling water= 0.147-0.196Mpa (In let Pressure of stator winding) 0.2-0.25Mpa (Pressure of in fluent water of hydrogen cooler) Looking at the data above and the results of the inspection, it can be concluded that the

biggest possibility is that there is a cooling water pipe that is leaking in the generator, so that hydrogen enter sand carried away on system GSCW. Before checking to in the generator do test Insulation tester with merger for ensure value prisoner generator winding insulation is in good condition

## 2. LITERATURE REVIEW.

### 2.1. Construction.



**Figure 1.** Synchronous Generator Construction

In general, the construction of a synchronous generator is the same as a synchronous motor, where the construction of a synchronous generator consists of a rotor, stator, and air gap. The rotor is the rotating part of a generator in which the field coil is supplied with direct current from the excitation. The stator is part of a stationary synchronous generator, which will produce an induced emf (electromotive force) in the conductors contained in the armature field. The air gap is the space between the rotor and the stator which functions as a place for the flux or induction of electrical energy to the stator and allows the armature to rotate in a magnetic field.

### 2.2. Generator Components

#### 1. Stator

The stator is a part of the generator that does not move or is stationary, consisting of coils of conducting wire arranged in such a way and placed in the grooves of the iron core. The conductor is where the induced emf is formed due to the rotating magnetic field of the rotor which cuts the stator conducting coil. The amount of electrical voltage produced by a generator at a power plant is usually in the thousands of volts. The stator parts of a generator include:

- a) Stator Frame



Is the outermost part of a generator that we usually see and even hold with open hands when the generator is operating. The stator frame is designed to be explosion safe, that is, the frame can survive an internal explosion due to the mixing of hydrogen and air, so that the explosion will not injure people, damage equipment or buildings.

b) Stator Core

The outermost part is the place where the stator winding (Stator Winding) is placed. Made of steel plates arranged in layers with a thickness of  $\pm 0.35$  mm to 0.5 mm.

c) Stator winding

The stator winding is made using a copper conductor that has special insulation and is evenly distributed on the stator core. In each slot there are two stator bars (upper and bottom coil).

The stator winding is divided into three phases and generally has a Wye connection where in the Wye connection there is a grounded neutral as protection from the stator winding.

## 2. Rotor

The rotor is a moving part which is part of the generator that serves to place the excitation magnetic field coil. Consists of magnetic field coils arranged in the iron core grooves of the rotor, so that if direct current (DC) is applied to the coil, it will form North and South magnetic poles.

a) Rotor Forging

Rotor Forging is a mechanical part of the rotor made of special material (permeable magnetic steel) which can function as a flux path generated by the rotor winding. The generator rotor is a dynamic component, operating at high rotations, the material must be able to withstand pressure and be shaped in such a way that it can function to place the rotor winding. The forging rotor must be able to operate at high mechanical and thermal loads

b) Rotor Winding

The rotor windings are installed in the generator rotor slots with an even distribution on the rotor body for both poles. The winding rotor is made of a number of windings of copper (copper) connected in series. All rotor winding designs made by many fabricants will have the same basic function, namely to produce flux for the generator stator. The thing that must be considered is how the cooling method of the winding rotor is when operating. For turbo generators generally use direct cooled by using air or hydrogen gas. Cooling air or hydrogen gas is passed through the rotor winding to reduce the temperature on the rotor winding including ground insulation so that the insulation life time is maintained.

### 2.3. Generator support components

#### 1. Generator Cooling System

Cooling System with Hydrogen (Hydrogen Cooled) Generators that have a large capacity (> 300 MVA) generally use hydrogen gas as a cooling medium. The advantage of hydrogen gas as a



coolant is that it has good heat transfer and relatively small friction so that the heat generated is small. The generator stator and rotor will be cleaner because there is no outside air entering the generator. One of the conditions for the operation of a hydrogen gas-cooled generator is purity hydrogen gas. in generators. The required purity is >95%, this value can be maintained during operation with the hydrogen pressure regulator and hydrogen seal oil system.

## **2. Hydrogen Cooler**

The hydrogen cooler is inside the generator which functions as a heat exchanger, where the hydrogen circulating in the generator has a high temperature will be passed to the cooler to transfer heat. The construction of the hydrogen cooler is adapted to each generator, there are vertical or horizontal ones. The hydrogen pressure in the generator is greater than the cooler pressure so that if a leak occurs in the cooler, hydrogen will enter the cooler. There is a hydrogen sensor on the system cooler to find out if there is a leak.

### **Generator Stator cooling water**

Cooling the generator that can be done in addition to the use of hydrogen gas in the generator room, at this time the stator bar can also be cooled using water. The cooling water for the stator bar certainly has certain requirements. Stator cooling water becomes very important when the generator is operating because if the required water quality is not met it will cause an alarm or a stator ground fault to occur. Here are some conditions that need to be considered in the operation of the stator cooling water generator, namely:

- Stator inlet temperature The temperature of the cooling water is set at 50°C, normally operating normally at a temperature of 35 to 40°C.
- Stator cooling water outlet temperature The temperature of the cooling water on the outlet side is set at a temperature of 75 to 90°C. If it is more than that temperature, boiling water will occur and evaporation will occur.
- The cooling water pressure in the stator cooling water is maintained at the design level of each fabricant, so that the cooling water is expected to flow throughout the stator bar.

The thing to note is that the cooling water pressure is lower than the hydrogen gas pressure in the generator (5 psi lower). This is so that if there is a leak in the stator, the cooling water does not come out but the hydrogen gas in the generator will enter the stator.

## **3. Seal Oil System**

As previously explained, almost all generators with large capacities use pressurized hydrogen gas for cooling of their internal components. The main function of the oil seal system is to maintain hydrogen pressure and prevent leakage of hydrogen gas in the journal shaft. Seal oil is found on the exciter side and turbine side where high pressure oil will be needed which is used as a seal on both sides which is flowed continuously so that the main function of the oil seal is achieved. Equipment consisting of oil seals, piping, oil pump seals and instrumentation is called



a hydrogen seal oil system. There are two types of oil seals, namely; Single flow and Double flow. Each type has equipment consisting of:

- Air Side Seal Oil Pump
- Hydrogen Side Seal Oil Pump

### 3. RESEARCH RESULTS.

In 2021 there was a problem with the generator unit on hydrogen system in generators. Pressure hydrogen in generator down to 5 kPa/hour the unit can still operate with a record of operating parameters such as the GSCW water pressure being maintained at 0.18 mpa, the pressure sealing oil being maintained at 0.8 mpa with flow and maintaining the stator winding temperature waiting for the results of the check from the electrical maintenance team within 3 days in fact the rate of decline is 30 kPa/hour so that decision was taken for shut down units.

The data was taken in 2021, which means that there was a leak problem in the Hydrogen system on the Generator which resulted in the hydrogen plant supply not being able to catch up with the hydrogen supply to the generator and the unit was required to shut down due to hydrogen leakage reaching 30 kPa/hour, this caused the stator ground alarm to appear fault. So with this the author tries to document everything that arises to facilitate troubleshooting, troubleshooting, and temporary handling to reduce a greater impact, in order to secure the equipment.

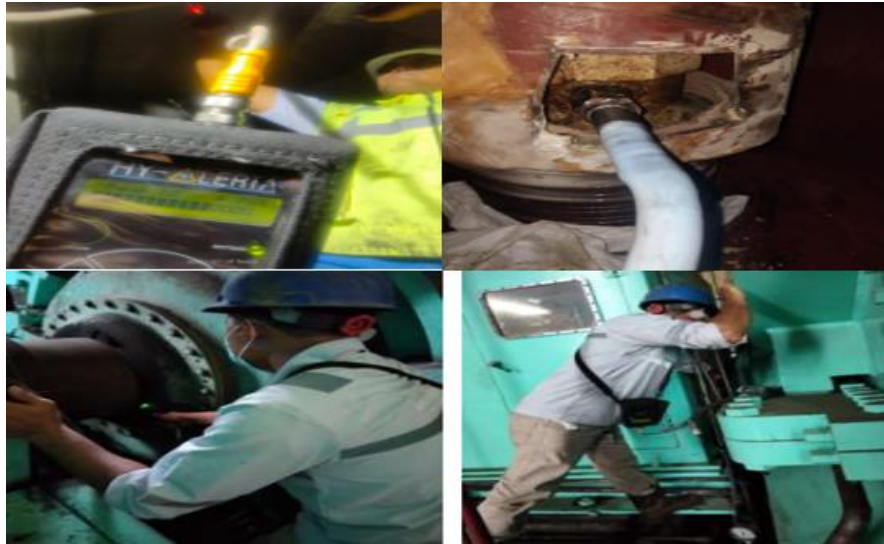
*case record* divided into two, namely light cases and heavy cases as follows:

1 . *Case* The first is a lightweight case

The trend finding on the dcs monitor is a decrease in Hydrogen Gas in the generator which causes the unit to be unable to increase its production power (MW). After a search was carried out which caused the rate of hydrogen gas to decrease rapidly, it was found that the hydrogen leak was as follows:

Equipment used:

- HY-ALERTA (H2 DETECTOR)
- SOAP WATER (SNOOPY) ATTACHMENT



**Figure 2.** Equipment

- Bearing 6 and 7 Generator (No leak found)
- Drain gene Leak on the high and low side (No leak found)
- H2 gen . pipe line (No leak found)
- H2 Dryer (No leak found)
- Venting H2 gen d above turbine house (Finding 6.2%)
- Venting H2 separator above turbine house (Finding 0.1%)
- H2 cooler generator (Not yet out serviced)
- Line Generator Stator Cooling Water (77% Finding)
- Bottom area of DE and NDE side generator (No leak found)
- Top H2 cooler/flange area no 1,2,3,4 (no leak found)

After checking the leaking hydrogen with H2 leakage detector It was found that the Stator Cooling water tank contained hydrogen.

2 . The second case is the heaviest case (Recovery Process)

### Stage 1 (Overhaul)

- 1 . Removing hydrogen by injection of Co2 by opening a small venting valve after getting <4% (16 bottles of Co2) H2 in Co2 then continuing to fill air into the generator
- 2 . Block Valve for flow from GSCW system
- 3 . Manhole opening on each side of the generator
- 4 . Remove the flow meter on the cooling water pipe
- 5 . Install Special Tools on the side of the flow meter for nitrogen and Freon injection



- 6 . Do the nitrogen injection again and add freon with a pressure of 0.3 Mpa and identify leaks in the GSCW pipe inside the generator using the H2 detector and the sense of hearing
- 7 . After getting the leaking pipe, isolate the leaking pipe section to give a sign
- 8 . After the inspection is complete, replace the leaking cooling pipe with a new one
- 9 . After the cooling pipe is installed with a new one, do a leakage test by injecting freon with nitrogen with a pressure of 0.4 Mpa. Check for leaks using an H2 detector and soapy water (Snoopy) and monitoring pressure for 1 hour
- 10 . After the leakage test results in step 9 are good, do the leakage test again on the cooling stator pipe using demin water through the special tools that have been installed
- 11 . Apply pressure to the pipe using 0.8 Mpa demin water and monitor it for 4 hours while checking for leakage in the cooling water pipe in the generator
- 12 . After the conditions are properly monitored, normalize the GSCW pipeline line. Run the GSCW system to fill the cooling water pipe with a pressure of 0.25 Mpa and a flow of +4.00 m<sup>3</sup>
- 13 . Check the flow in the cooling water pipe on the generator using ultrasonic flow meter tools
- 14 . Turn off the GSCW system

### **Stage 2 Gluing and Insulation Process**

- 1 . Prepare the resin material for gluing the cooling water stator pipe
- 2 . Mix mica gypsum powder to make a sealing dough on the winding pipe connector
- 3 . Mix the hardener in a glass container and add alcohol then stir until the solution blends so that the hardener becomes runny
- 4 . Do the same for the liquid resin like the liquid hardener
- 5 . After the liquid is ready, mix it into one container and mix it together for the serlak / glue
- 6 . Apply glue to the new cooling pipe connector, then wrap it with mica foil for the generator. At the end of the first dressing, give the glue that has been made in the first part and then wrap it again with the same insulating paper and repeat the same thing.
- 7 . After giving the mica foil, cover the bandage using the dough that has been made. When finished then give the glue back then wait for it to dry

### **Stage 3 Testing Process and Results**

- 1 . Disconnect the connection at the generator output to the Generator Transformer in the neutral grounding cubicle and disconnect the junction box header cooling water under the generator, each terminal in parallel with the cable and the output is connected to the grounding connection star generator
- 2 . Do a leakage test on the GSCW line using air to make sure there are no more leak

#### **Parameter**

Duration of test (H) $\Delta t= 12$

Initial barometric pressure (Mpa) $P_1= 0.2993$

Final barometric pressure (Mpa) $P_2= 0.2986$



Initial atmosphere test pressure (Mpa)B1= 0.1006

Final atmosphere test pressure (Mpa)B2= 0.1011

Initial average temperature of the test ( c )t1= 28.6 c

Final average temperature of the test ( c )t2= 28.6 c

Note: held on 8/9/2021 16:00 to 9/9/2021 04:00 (12 Hours)

### DEC Formulation

$$\square \text{pd} = \frac{24}{\Delta t} \{ (p_1 - p_2) + (B_1 - B_2)(p_1 + B_1) \} \times \frac{(t_2 - t_1)}{(273 + t_1)}$$

$$= \frac{\Delta \text{pd}}{p_1} \times 100\%$$

DEC standard= 1%

### Result

$$\square \text{pd} = 0.00040$$

$$\square = 0.134 \%$$

### Conclusion

### Leak Conduction: GOOD

3 . After the leak test has been carried out on the GSCW Line, measure the insulation resistance per winding R, S, T with a ground voltage of 10 kV

4 . Testing the winding resistance value using the Polarization Index, the resistance value must be above 1 to be said to be normal

After yesterday's incident, further inspection was carried out with a high voltage test (HV test), to determine the quality of the insulation & and the value of the leakage current in each winding. After getting good results, re-test the insulation tester to each winding to ensure the winding insulation conditions are good, at the last stage, normalize the generator

1. Star generator connection splicing
2. Installation of the typing an cable connection on the generator cooling stator panel
3. Installation of generator output to IPB
4. GSCW pipe normalization
5. Generator manhole closure
6. GSCW running system

### 5. CONCLUSION

To prevent the above problems from recurring, it is necessary to pay attention to the following operating limitations:

- After adding(gluing) pipe hydrogen and tested by applying pressure to the line pipe with result good
- The cooling water pressure in the stator cooling water is maintained at the design level of each fabricant, so that the cooling water is expected to flow throughout the stator bar. The thing to note is that the cooling water pressure is lower than the hydrogen gas pressure in the generator (5 psi lower). This is so that if there is a leak in the stator bar, the cooling water does not come out but the hydrogen gas in the generator will enter the stator bar.
- Maintain operating parameters in accordance with the manufacturer's requirements as follows: Maintain temperature conditions in the range of 40-50°C





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Water ph 7.0-9.0

Keeping GSCW Flow less than 45 liters/minute

Keep pressure less 0.18 mpa

- Hydrogen leaks must be treated quickly because hydrogen is explosive when mixed with air

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