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Handling of Microorganisms Growth and Sulfur Deposit in the Cooling Tower of Patuha Geothermal Power Plant (A Lesson Learned from Patuha Geothermal Power Plant, Indonesia)

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ABSTRACT

Geothermal fluids generally contain non condensable gas, especially H_2S. It will undergo an oxidation reaction with the air in the cooling tower forming a solid sulfur compound. Impurities other than sulfur mineral deposits are microbiological deposits in the form of algae, moss and slime which are formed due to the cooling water basin conditions are exposed to the sun's heat, humidity condition, acidity levels and the other conditions which support the growth of micro-organisms. The formation of this deposit can occur along the water flow pipe, nozzle, filler, thus inhibiting the process of heat exchange between the cooling media and the cooled fluid. Chemical treatment on a cooling water system is only focused on controlling the growth of microorganisms so that is not to exceed the required values. This biological treatment gives the results of the growth of low microorganisms. Maintenance teams cleaned them manually three times, as long as the operating period. A shutdown unit should be carried out which will cause derating and lost production. After repeated experimenting, it was decided to carry out a combination of chemical treatments for the cooling water. The first chemical treatment is routine dosing of non-oxidizing biocide to prevent the growth of micro-organisms in the cooling water and the second is slug dozing of the sulfur dispersant, to reduce not only sulfur deposition but also reduce other suspended solid deposit. These methods prove optimal and so effective that the heat transfer process runs better and is able to reduce the cooling water temperature, making the pressure of condenser better than before.

1. INTRODUCTION

PT Geodipa Energi (Persero) is a state-owned company engaged in the business of electricity sourced from geothermal. The fields that were already operated were Dieng Field (Central Java) and Patuha Field (West Java) with installed capacity of 1 x 60 MW respectively. Patuha Field is located in Patuha, District Bandung – West Java, Indonesia. The total potential of geothermal energy that can be produced around the area is estimated to reach 400 MW. From this potential, up to now 1 x 60 MW of utilization has been installed in September 2014. Patuha field typically is a vapour dominated geothermal field. The average system content from a production well reaches a dryness level of more than 98%. The average steam supply reaches 383 tons/hour and on average can generate power of 60 MW. Turbines can generate power with a Specific Steam Consumption (SSC) of 6.4 ton/MW. One of the most important parts of a Geothermal Power Plant is the cooling tower. It is an integrated part of any geothermal power plant because waste heat from turbine exhaust steam must be continuously rejected from the water discharged from the condenser so that the water can be discharged to the environment or recirculated and reused. Properly maintaining a cooling tower performance will increase the power plant efficiency.

2. SCALING PROBLEM

Geothermal, as one of the major renewable energy resources, is playing a greater role to support the world's energy demand. Geothermal power plants use heated geothermal fluid from wells thousands of feet deep as their heat source to generate electricity. If the brine has enough enthalpy, it can be flashed off to create steam, which is used to drive a turbine and spin a generator. Fluids produced from geothermal reservoirs include steam, brine and a variety of non-condensable gasses, NCG (CO_2, H_2S, CH_3, N_2, etc.). In water cooled systems with direct contact condensers, elemental sulfur fouling in the cooling system can be a significant problem.

A lot of sulfur rich scale accumulates in the cooling water system of geothermal power plants, which markedly lowers cooling system efficiency. An analysis of samples of scale deposits from some part of the cooling water system in the Geothermal Power Plant (GPP) Patuha Unit 1 indicated that the deposit was 12.70% sulfur.

Numerous sulfur bacteria were detected in the sulfur scale. It is thought that sulfur mainly originates from sulfur bacteria activity when oxidizing H2S (gas) to S (solid) in the circulating water (geothermal steam condensed water).

The following reactions are deemed to occur in the cooling water system and the formation of the sulfur supposedly depends on the balance between the reactions,

$$2H2S + O2 \rightarrow 2S \text{ (solid)} + 2H2O \quad (1)$$

$$2S + 3O2 + 2H2O \rightarrow 2H2SO4 \quad (2)$$

Chemical and biological origins are considered to be involved in the above reactions. The production of sulfur from the chemical origin is governed by the oxidation reduction potential and pH, while bacteria, such as Sulphate Reduction Bacteria (SRB), participate in the formation of sulfur from a biological origin.

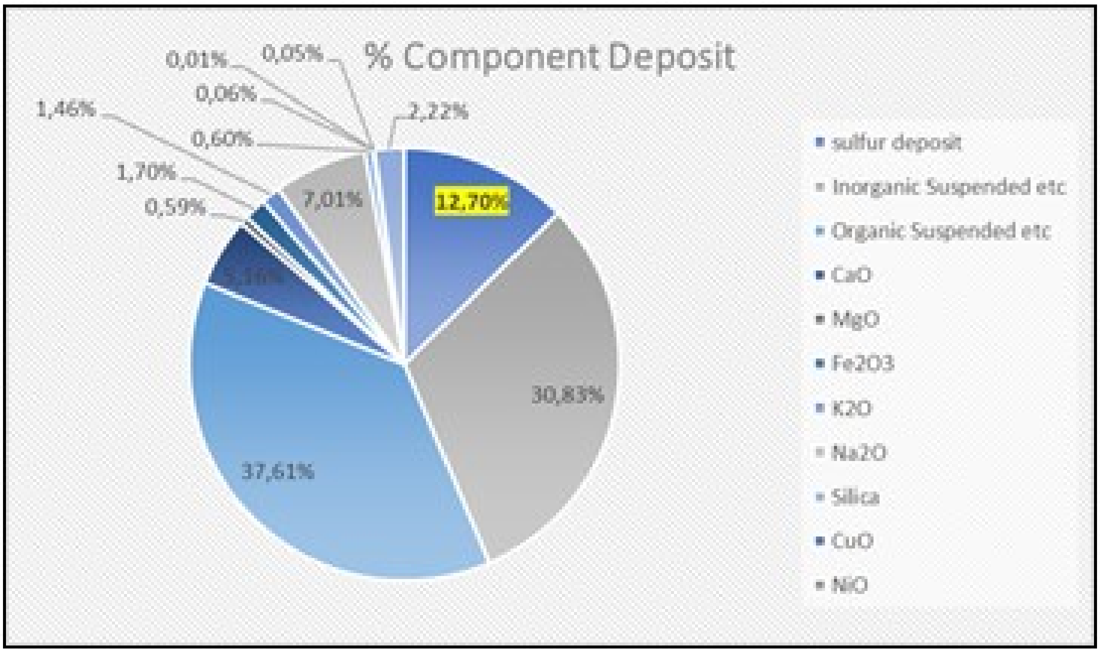

Figure 1. Deposit analysis before treatment

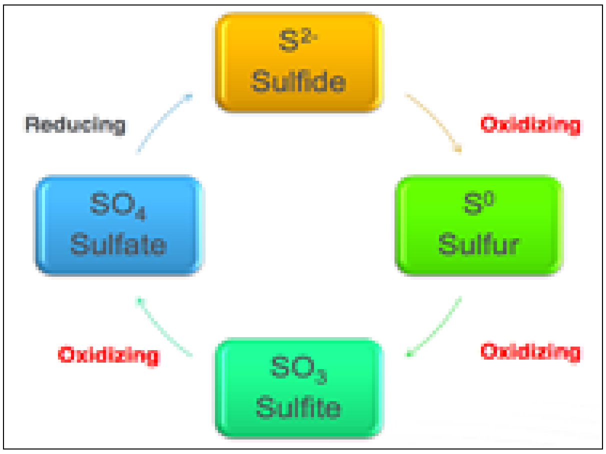

Figure 2. Sulfur Cycle

3. COOLING WATER TREATMENT

Since the end of October 2018, sulfur and microbial control has been conducted in the cooling water system at GPP Patuha Unit 1 by the combination application of Biocide and Sulfur Dispersant. Compared to the previous treatment, only the pH of water adjusted, this new application can inhibit the scale formation through 2 ways of prevention :

1. Biocide will control the SRB (Sulphate Reducing Bacteria) growth which could convert Sulphate to Elemental Sulphur.
2. Keep/Disperse sulfur elemental in molecular form by injection of sulfur dispersant

The combination of the two chemicals showed good results in decreasing the approach temperature of the cooling tower, shown in (Fig. 3) CT Performance graph.

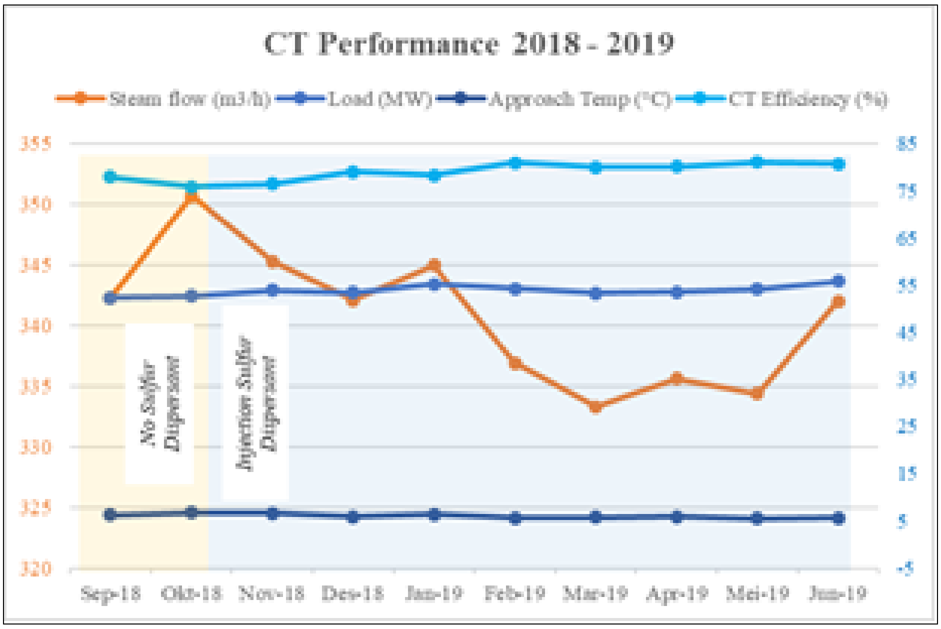

Figure 3. Cooling Tower performance

Approach Temperature is one of the cooling tower performance parameters, this value represents how close the cooling tower gets the water to the wet bulb temperature of the surrounding air. According to the graph in Fig. 3, the Approach Temp has gradually improved, this was also followed by the performance improvement of the power plant, where a higher load can be reached even with lower steam flow.

The main cooling tower variables that dictate approach are heat load, tower size, and airflow. Mechanical draft cooling towers have relatively constant airflow that is induced by a fan or centrifugal blower. In the case of induced draft cooling towers, cleanliness of distribution spray and tower fill pack play a role in determining the air flow. After 2 months application of slow killing biocide and sulfur dispersant, the approach temperature is slowly decreased (≤ 6ºC). It may indicate that cleanliness of the distribution spray and tower fill pack was improved; as evidenced by the following results of the Cooling Tower Inspection.

Figure 4. Distribution Spray – November 2018

Figure 5. Distribution Spray – 3 weeks after cleaning

Figure 6. Distribution Spray – April 2019

The initial condition of the distribution spray, as shown in Fig. 4, where the sulfur deposition in line has enough thickness to block the flow of water - as a result water droplet formation - is not optimal and heat rejection will be decreased. To avoid a worse impact, shock dosing of sulfur dispersant was conducted to disperse the sulfur deposit. Besides chemical applications, mechanical cleaning is also applied to speed up the cleaning process then monitoring is conducted regularly.
Three weeks and 4 months of monitoring after cleaning, shown in Fig.5 and Fig.6, prove that the thickness of sulfur did not increase since the last cleaning. This condition is achieved by maintaining the concentration of sulfur dispersant not less than 5 ppm. Deposit analysis (after application sulfur dispersant – Fig. 7) also shows that the % sulfur content reduced by 25% of weight compared to deposit analysis in November 2018 (Fig. 1).

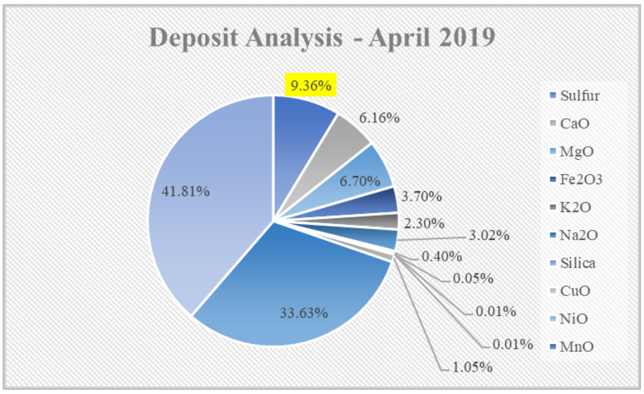

Figure 7. Deposit Analysis – April 2019

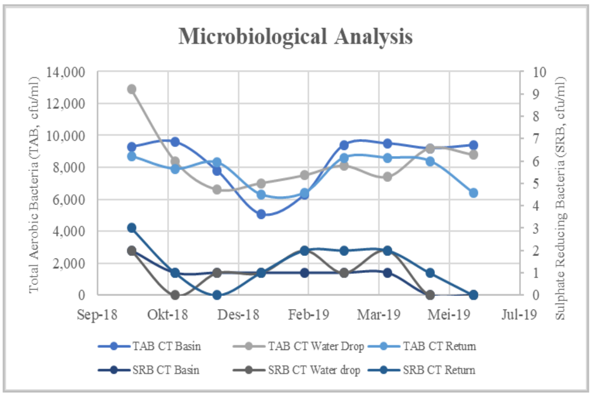

Figure 8. Monitoring Microbiological Parameter

Another parameter control that is always monitored is the number of bacteria. Total aerobic bacteria (TAB) should be no higher than 10,000 Cfu/ml and Sulphate Reducing Bacteria (SRB) were maintained within their standard range. Trends of microbio contents (TAB & SRB, Fig. 8) are decreasing since the application of slow killing biocide (N7330) on November 2018 until June 2019. Cleanliness of the Cooling Tower basin is also improving. The algae growth has been reduced and the cleaning screen became a less frequent maintenance issue (2-3 times/week →1 time/week).

By comparison to before the combination chemical treatment, the specific steam consumption was 6.9 Ton/hour steam/MW (1.91 kg/sec/ MW) and after the combine treatment it became 6.4 Ton/hr/MW (1.78 kg/sec/MW). There is a savings of 0.13 kg/sec steam / MW for electricity production, as a result.

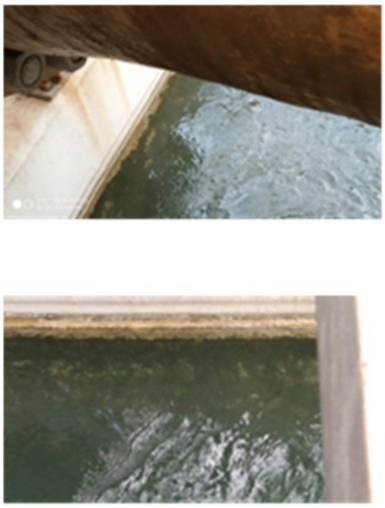

Figure 9. Before biocide injection

Figure 10. After Injection (1 week)

Figure 11. After Injection (3 weeks)

4. CONCLUSION

1. The combination of biocide and sulfur inhibitors can reduce optimally both the formation of sludge due to micro-organism activity and the deposition of sulfur (S) due to oxidation of H_2S gas originating from the well (NCG). This will have a direct impact on the condensation process inside the condenser so that the level of vacuum is getting better and the power generation will increase.

2. Before the combination chemical treatment the specific steam consumption was 6.9 Ton/hour steam/MW (1.91 kg/sec/ MW) and after the combination treatment it became 6.4 Ton/hr/MW (1.78 kg/sec/MW). There is saving of 0.13 kg/sec steam / MW for electricity production, as a result.

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