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The Importance of Processing Geothermal Fluids for Sustainability of Geothermal Power Plants: with Kizildere (Turkey) Geothermal Field Case

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ABSTRACT

A geothermal power plant is needed continuous geothermal fluids production to provide uninterrupted power generation. The plant is also needed continuous reinjection of brine to protect system pressure, environment and providing sustainability of geothermal systems. Although uninterrupted power generation is quite important for geothermal companies or associations; highly mineralized and corrosive geothermal fluids can easily affect production, reinjection wells and surface equipments at geothermal power plants. Depend on geochemistry of the fluids, various types scales can be occurred inside of wells, along reinjection lines, cooling tower and other surface equipments such as seperators, different walves which indicate pressure drop points at the system and even on blades of steam turbine. To provide continuous power generation and protection of the metal materials from corrosion and scaling effects, geothermal fluids must be processed in a geothermal power plant. The chemical conditioning studies, which consist of scale inhibitors and different dispersant chemicals, at different parts of the plant are quite important for sustainability of the system. In most geothermal systems; calcium carbonates can be seen all part of the systems such as; widely in production wells, surface equipments while silica scaling can be observed along reinjection lines and reinjection wells. Sulphure deposits can be also seen at surface and reinjection lines at the system. Except from these parts; the cooling tower which provides to emit of the non condensible gases from the system, must be under control and with this reason, chemical conditioning must be performed to prevent effects of corrosive gases; to control occurrences of scaling, sludging at the bottom and bacteria, algae in the cooling tower. Working of a geothermal power plant at optimum level during the projected license period, the systems must be reviewed as a whole such as from production wells to turbine, reinjection lines and cooling tower and to prevent the possible problems continuously monitoring and control studies must be performed together by reservoir, geochemistry and mechanical teams in the power plant. In Kizildere geothermal field, there are two different types geothermal power plants and conditioning studies of these power plants have been realized to Kizildere Phase I since 2009 and Kizildere Phase II since 2013. During 2009-2014 period, with the help of chemical processing of geothermal fluids, work over study is not required in production wells and significant performance loss of power plant is not observed in Kizildere Phase I Geothermal Power Plant.

1. IMPORTANCE OF SUSTAINABILITY IN GEOTHERMAL POWER PLANTS

The term, sustainability is ability to maintain of a system or process in existing system for a power plant. Sustainability is extremely important to produce continuous energy in geothermal systems, because there are many processes to need control for power production in the system.

These processes can be declared as sustainability of geothermal reservoirs, sustainability of fluid production, sustainability of turbine performance that includes equipment selection, noncondensible gas (ncg) system and cooling water system for a geothermal power plant.

2. PROVIDING SUSTAINABILITY OF A GEOTHERMAL POWER PLANT

2.1 Sustainability of Geothermal Reservoirs

The reservoirs of a geothermal system (also a geothermal power plant) can be compered to gasoline tank of a car. As long as there is fuel in the tank, a car starts to move and keeps continue on the way. When the fuel shortages in the tank, the car will also stop in a time. With this reason, to ensure continuous production from geothermal reservoirs, the balance must be provided underground and the system must be feed by water (Figure 1) (Haklidir et al 2014).

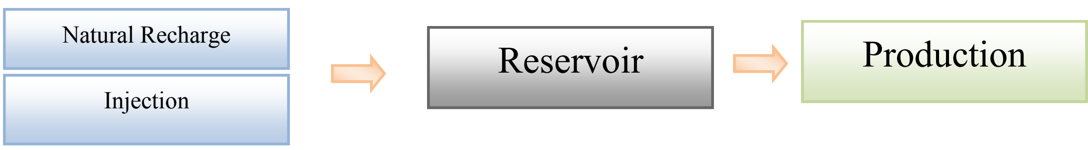

Figure 1: Sustainability of a geothermal reservoir

Geothermal reservoirs in which the system is dominated by fractures and cracks were formed in a very long time. Natural recharge will not be enough for identified flow rates at geothermal power plant designs. The fluid is not infinite source while production keeps going in a geothermal system. Thus, there is an additional recharge is necessary in a geothermal system. On the other hand, the fluids, which need to be injected to reinjection area after the steam production to provide sustainability in a water or/steam dominated geothermal systems (Figure 2). Therefore, the reinjection conditions such as temperature and pressure should be determined based on permeability of reinjection area. At the beginning of the system design study, production conditions must be evaluated together with injection conditions in a system. For this purpose, data collection from a geothermal field is extremely important during well tests/ geochemical studies. After these studies, it is expected that injection plan supports the pressure and temperature of production rates in a system.

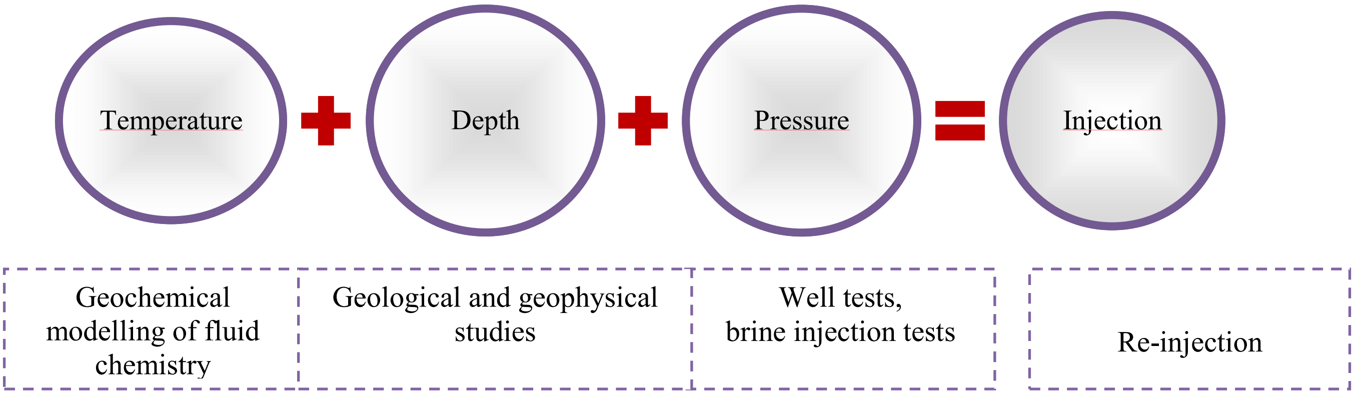

Figure 2: Importance of reinjection conditions to geothermal production

2.2 Sustainability of Geothermal Fluid Production

In a geothermal field, the system can be observed as two conditions; water-dominated or steam-dominated. The famous steam dominated systems take place in Geyzer (USA) or in Larderello (Italy) to produce electricity. Meanwhile water-dominated systems can be observed widely in the world. For instance, the most of geothermal systems are water-dominated in Turkey (such as Kizildere, Germencik, Salavatli, Pamukoren fields; Haklidir Tut et al, 2012). Because of high gas content, such CO_2, H_2S corrosion is a problem in geothermal wells in steam-dominated systems, while water-dominated systems have more complex conditions because of gas breakout conditions in borehole, thermodynamic changing inside surface equipment (such as separators, pipes) and reinjection lines. There are different types scaling can be occurred in boreholes and reinjection lines depending P, T conditions in a geothermal system (Haklidir Tut et al, 2011).

In geothermal reservoirs, gas breakout or two-phase (water – steam/gas) conditions occurs at the depth at which the gas pressure is added the water pressure exceeds the total pressure (at bubble point depth). Under these dynamic conditions, the depth when the measured total pressure, P_{tot} < gas pressure, P_{gas} + liquid water pressure, P_{liq} = bubble point depth (Haizlip Robinson et al, 2012). In the system, calcite scaling dominantly occurs at flash point means under gas breakout depths (Figure 3a), while silica scaling dominantly occurs in reinjection lines, because of temperature effects (Figure 3b). Calcite and silica solubilities are working incompatible in a geothermal system. When the fluid temperature increases calcite mineral starts to precipitate, while silica solubility increases with temperature in the system. With this solubility characteristic, the silica can be used as geothermometer to assume reservoir temperature in the system.

Figure 3a: Calcite scaling in Kizildere (Turkey) production wells in 2008

Figure 3b: Silica scaling in reinjection lines Iceland (Turkey)

Calcite scaling in production wells causes to decrease flow rates and it directly affects electricity production in the power plant. It may also affect performance of separator and other surface equipment. Silica scaling can be seen reinjection lines and reinjection wells and it can be observed increasing wellhead pressure of reinjection well that means fracture zones are contaminated by silica and may be low calcite minerals and permeability of the reservoir is affected by this contamination and it needs to clean to take more brine into well again.

To prevent scaling occurrences, scale mitigation in the wellbore requires that the inhibitor is injected into the flowing well through capillary tubing at depths 10-50 m below the estimated gas breakout depth preferably within the casing in production wells. Inhibitor systems consist of inhibitor tank, inhibitor pumps and lubricator systems and tubing and installed at the wellhead for production wells. For protection of reinjection lines, the system can be designed based on power cycle. For example, if it is flash cycle, the chemical dosage system must be installed after low-pressure separator or near brine tank before reinjection pumps. Control coupons (Figure 4a) and sampling ports (Figure 4b) on the lines provide to understand silica scaling condition (or calcite also) by chemical analysis in the system.

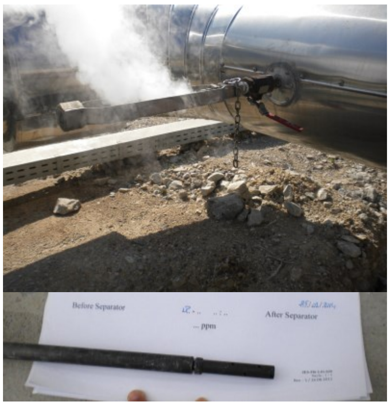

Figure 4a: Scale control coupons

Figure 4b: Sampling port on a line (Kizildere GPP-TR)

2.3 Sustainability of Turbine Performance

The steam quality directly affects performance of turbine. In a flash system, to produce pure steam scrubbers use after the separators. The rotating blades of turbine sometimes expose to bit of scales and it caused damages of blades. Corrosion is another dangerous factor for turbine blades.

2.3.1 Equipment Selection

The equipment selection is determined after the preparing design criteria of the power generation system. The design criteria include geothermal fluid characteristics for steam, gas and brine. Physical parameters (such ph, T) and chemical compositions are extremely important to equipment selection for different process of the system. The gas composition has great important at this stage and for example if there is high amount corrosive gases (such as H_2S) in the system, the equipment materials must be selected to high quality metal or polyurethane etc. In this kind of system, the materials don't use except from stainless steel.

2.3.2 NCG System

Unused steam (dead steam) and non condensable gases are thrown from turbine by compressor and these gases and steam (plus air) go to condenser in the power generation system. At this stage compressor and condenser performance will be important to increase turbine performance. These gases cannot use in turbine and needs to exhaust from this tool before electricity production. Generally these components are cooled by spray wash from cooling tower and directly go to cooling tower for degassing.

2.3.3 Cooling Water System

Cooling towers are divided at two groups in geothermal systems. For binary and flash systems are installed in warm/cold places can be cooled by air, while others use water to cooling the system. Cooling water systems needs conditioning because of dark, wet and different gas compositions, whose supports to grow of some algae or bacteria or cause corrosion inside the system. For the conditioning of the system; scale preventer, bio dispersant, hypo can be used (Figure 5a, 5b). The system conditions should be monitored by chemically and visual at periodically.

Figure 5a: Chemical conditioning of the water-cooling system

Figure 5b: Bacteria grow in cooling tower

3.CONCLUSION

Geothermal energy is renewable and sustainable energy source in the world. Although energy efficiency is very high of geothermal energy systems, the fuel is water and steam at different temperature and pressure condition. The geothermal fluids follow long way from deep depths of earth to reinjection wells and it means so many thermodynamically changing especially in water phase. To provide sustainable conditions for geothermal power plants, some conditioning conditions also must be installed in geothermal power plants. Scale inhibitor systems, reinjection systems, cooling tower systems, NCG systems and equipment selections are great importance for provide sustainability in geothermal power systems.

REFERENCES

Haizlip Robinson, J. Güney, A., Haklıdır Tut, F.S., Garg, K. S: The impact of High Noncondensible Gas Concentrations on Well Performance Kızıldere Geothermal Reservoir, Turkey. *Proceedings, Thirty-Seventh Workshop on Geothermal Reservoir Engineering Stanford University*, *(2012),* CA, USA.

Haklidir Tut, F.S., Akın, T., Parlaktuna, Ç., Turk, D., Savas., T: Scaling Types and Prevention and Control of Scaling in the Operation Stage in Geothermal Fields: Kızıldere Geothermal Field Case Study. *64th Turkey Geological Congress, (2011),* Ankara-TR.

Haklidir Tut, F.S., Sengun R., Kilicarslan S., Uzun, A: The Importance of Sustainability in Geothermal Power Plants. *67th Turkey Geological Congress, (2014),* Ankara-TR.

Haklidir Tut, F.S., Uzun, A., Sengun, R: Investigation of Reservoir Characteristics of High Enthalpy Geothermal Fields on Buyuk Menderes Graben and Sulphate Variations of Geothermal Fluids in the Graben. *Proceedings of International Earth Science Colloquium on the Aegean Region (IESCA), Dokuz Eylul University*, *(2012),* Izmir, Turkey.