

MONITORING OF GEOTHERMAL SYSTEMS

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Keywords: corrosion/scaling coupons, supersaturation

ABSTRACT

Reviewing data from a few Romanian geothermal fields and their production characteristics, there were encountered scaling and corrosion problems in the exploitation equipments. Regular chemical monitoring is suggested to be able to see, as soon as possible, chemical changes that may later lead to scaling or corrosion. An installation of scaling/corrosion device was projected in order to monitor the corrosion and scaling during production.

1. INTRODUCTION

The main aim of this study was to appreciate the need for chemical monitoring and predict possible corrosion and scaling during production in Romanian geothermal fields. Calcium carbonate is the most common scaling in geothermal production systems utilizing water of low and medium temperature, but silicates and metallic sulphides and oxides may also be precipitated [1]. The potential scaling problems of a geothermal utilization depend both on the type of water and the treatment of the water. Therefore, a reliable analysis of the water and a simulation of the changes occurring during the intended utilization are needed to predict possible scaling. Dissolved oxygen and free CO₂ in geothermal water is extremely corrosive to steel pipes. The corroded pipe surfaces will also accelerate the precipitation of calcium carbonate from the water. Geothermal waters frequently contain hydrogen sulfide, which will react with any oxygen taken up in storage tanks rod through plastic pipes and, thus, act as an inbuilt inhibitor for the corrosion of steel equipment. Some of the waters are free of hydrogen sulfide and any oxygen taken up will remain in the water. A very slight increase in salinity will increase the oxygen corrosion rate considerably. A minor inflow of seawater or any cold water into a geothermal system could make the water unsuitable for direct use. When the hot water is deaerated of acidic gases, the pH is elevated, which may lead to subsequent supersaturation and precipitation of carbonate in water of high ionic strength. Mixing will, in many instances, lead to instant supersaturation. Deposition may be accelerated by salinity or other catalysing effects such as rough surfaces or suspended materials. The main types of scales encountered in geothermal installations for low-temperature fluids are summarized in table 1 [2].

Table 1. Main types of scales

Types of scales	Location of scale	
	Inside well	In surface construction
Calcium carbonate (Calcite aragonite)	X	X
Magnesium silicate		X
Zinc silicate		X
FeS	X	X
Fe ₂ O ₃		X

2. MONITORING OF SCALING AND CORROSION

During the exploitation of geothermal fields the energy extracted normally draws greatly on their natural power, and field response to exploitation may create problems during long-term utilization. When drawdown or pressure drop follows the pumping of water wells, there is a potential danger of inflow of cold ground water or seawater into the field [3]. This can produce cooling and changes of production characteristics. A change in the chemical composition of the geothermal water will often precede cooling of the field, and data obtained by chemical monitoring of the fluids may, therefore, give a warning in time for preventive action. As chemical changes will often precede changes in temperature and pressure, it is always recommended to monitor the chemical composition of the fluids in a geothermal system.

The infiltration of seawater into a fresh water geothermal system is relatively easily traced and will be detected early on by simple chemical monitoring. The inflow of cold fresh water into a geothermal system is often difficult to detect at an early stage and its detection requires a much more elaborate monitoring system than seawater infiltration.

Wells with inflow from two or more aquifers, each with its characteristic temperature and chemistry, are commonly exploited in Iceland and probably elsewhere also. Changes in the mixing ratio of water from different aquifers resulting from changes in pressure may affect production characteristics drastically.

In exploited low-temperature systems it is common practice to collect a sample for analysis of all main constituents (pH, volatiles, silica, Na, K, Mg, Ca, Al, Fe, Mn, Cl, Br, B, SO₄, F, NO₃, TDS) at least once a year from all fields and more frequently from fields where the water is slightly mineralized and there is fear of fresh water inflow. Occasionally samples for analysis of selected trace elements (Li, Sr, Cd, I, Zn, Hg, Pb, As) are collected. Where the geothermal water is highly mineralized or where seawater infiltration is expected, additional samples for chloride and sulfate analysis and possibly also selected cation, silica and even stable isotope analyses, are collected. The samples are often collected six times a year, but the frequency varies from one field to another and according to the state of development of the field.

The monitoring programmes applied may differ significantly for the various types of geothermal fields [4], and they have to be carefully outlined from the start and continuously adapted to new developments and experience during exploitation.

Monitoring, both of production and chemical properties, has proved to be an important tool in the management of geothermal production in low-temperature geothermal fields. The results have been used to forecast imminent cooling of geothermal fields or changes in their production characteristics. When scaling or corrosion is expected or is considered possible, test plates are installed into the well for monitoring. Even though theoretical studies and modelling of the system do not predict any corrosion and scaling, it is advisable to insert test plates into the system at critical points such as at wellhead, after mixing and deaeration in tanks and out in the distribution system. If modelling shows that there might be any potential danger of scaling or corrosion, such monitoring is absolutely required [5].

In order to expose corrosion/scaling coupons to the geothermal water for testing, a special device has been designed (Figure 1) that allows the coupons to be entered and withdrawn without interrupting the flow. This is important in commercial installations where an uninterrupted supply of water is required.

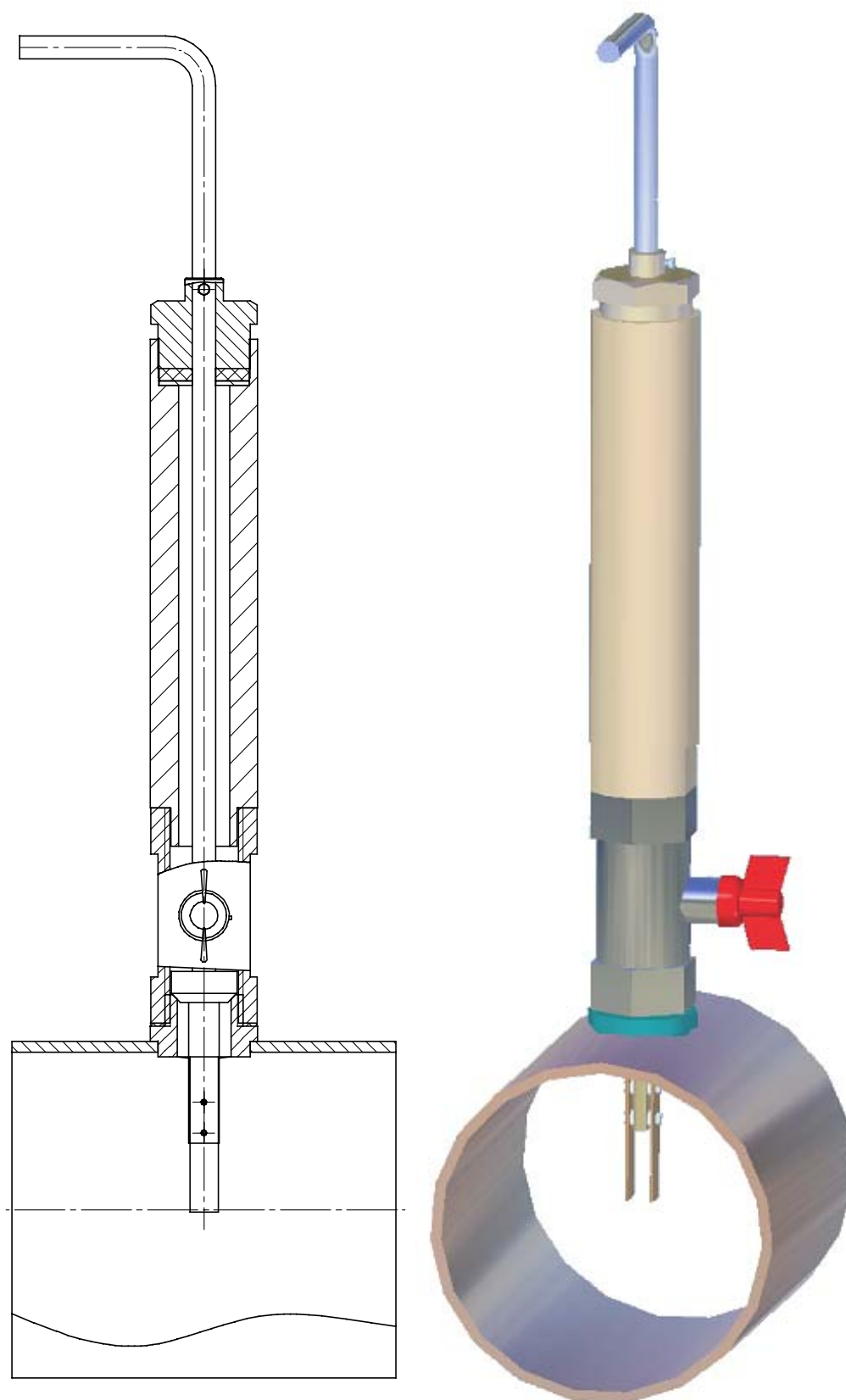


Figure 1. Scaling monitoring device.

The coupons are held by two nylon screws to a long stainless steel stem. It is important to isolate the coupons from the stem using nylon washers to prevent galvanic corrosion. A gland, similar to that on a gate valve, seals against leaks by the stem. The pressure chamber is made from solid stainless steel, drilled out to accommodate the coupons, with 1 1/4" pipe threads to attach to a valve. The procedure to expose the coupons to the water is then simply to:

- attach the coupons to the stem with nylon screws and use washers between coupons and stem;
- withdraw the coupons into the pressure chamber;
- attach the pressure chamber to the valve;
- after opening the valve the stem is pushed in, exposing the coupons to the flow; this requires moderate pressure to overcome the pipeline pressure;
- after the coupons are in place inside the pipe the gland nut is tightened and handle secured so that the sample will stay in place during the testing period.

When the sample is withdrawn from the pipeline for inspection or removal, the reverse procedure is applied. First pull out the stem, close the valve and unscrew the pressure chamber. Remove the coupons for evaluation. The coupons are cleaned with acetone and weighed both before insertion and after inspection to evaluate weight loss or gain. The evaluation consists in removing solids from the coupons and analysing them first by microscope and then by X-ray diffraction and X-ray fluorescence methods. For more accuracy the solids can be analysed with a scanning electron microscope.

3. CONCLUSIONS

For monitoring of scaling and corrosion, a scaling device (corrosion coupons) was projected. It is recommended to be installed in the distribution pipe, at about 1-1.5 meters to the wellhead, where are no turbulences of the fluid and it attained an equilibrium. This device has the advantage of being used without interrupting the flowrate, so it can monitor any scale during well production.

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