

Assessment and Chemical Prevention of Scales

Oana Stanasel^{*}, Alina Caraban^{*}, Mioara Sebesan^{*}, Aurel Iovi^{**}

^{*} University of Oradea, Department of Chemistry, Oradea, Armatei Române 5, Romania, e-mail: stanasel@uoradea.ro

^{**} Faculty of Industrial Chemistry and Environmental Engineering, University "Politehnica" Timișoara, Victoriei Square no.2, Romania

Abstract: Felix geothermal resort located at about 6 km to Oradea is a useful place for balneological treatment in Romania. Geothermal waters from well 4003 Felix have been direct used in a hospital, where are treated rheumatic diseases. The main aim when exploiting a production well is to have continuous operation. Corrosion and scaling on the equipments surfaces is one of the biggest problem during geothermal water utilization. The chemical composition of the geothermal waters from well 4003 was established by the use of analytical procedures. Based on the chemical data, a simulation computer program was used to assess the possibility of scale formations. Scale depositions, caused by corrosion and mineral precipitation from the water, were thermic and XRD analysed and the results were compared to the predicted ones. In order to prevent the scales it was made a test by the use of chemical additives, in static conditions. The results indicated the good efficiency of the used inhibitor.

Keywords: Felix Spa, depositions, corrosion, additives.

1. Introduction

In the west part of the country, geothermal water is used as industrial water for hemp and ceramic factories. It is also used for domestic use and for heating swimming pools. In some resorts, like Felix Spa, geothermal water is used for heating hotels and recreation houses as well as for balneology. In the Felix Spa resort there are natural hot springs with temperatures between 35 and 50 C. The waters which spring up at Felix come from the lower cretaceous system. Located close to Oradea, Felix is a nice place, a flower very rare in Europe, *Nymphaea Lotus Thermalis* being a definite tourist attraction.

2. Studies on chemical composition of geothermal water from Felix

Considering the outstanding special therapeutic properties of the geothermal water from Felix Spa this thermomineral water was taken for analysis. Geothermal waters from Felix were analysed [1] in the chemical laboratory from Orkustofnun, Iceland. The results of the laboratory analysis are summarized in Table 1. The wellhead temperature measured during sampling was 42 C at Felix. As seen from the Table 1, geothermal waters from Felix are slightly basic. The mineralisation of water is low. The chloride content is low and the sulphate is higher.

The water is carbonated-calcium-sulphate type.

TABLE 1. Chemical composition of geothermal water, in mg/L

Component	Well Felix	Component	Well Felix
pH	8	Ca	120.4
CO ₂	280.55	F	0.465
B	0.18	Cl	9.8
SiO ₂	21.6	SO ₄	92
Na	15.44	Al	0.001
K	4.45	Fe	0.013
Mg	19.53	TDS	452

3. Prediction of depositions

The Watch program [2] was used to model what happens in geothermal fluids under different conditions, first at reservoir temperature and then during water influx into the distribution system during production.

The diagram for Felix (Figure 1) indicates a supersaturation with calcite, talc, microcline and quartz at the wellhead temperature. There is an equilibrium with chalcedony at any temperatures which were used, assuming a conductive cooling during utilization. There is undersaturation in respect with the other minerals.

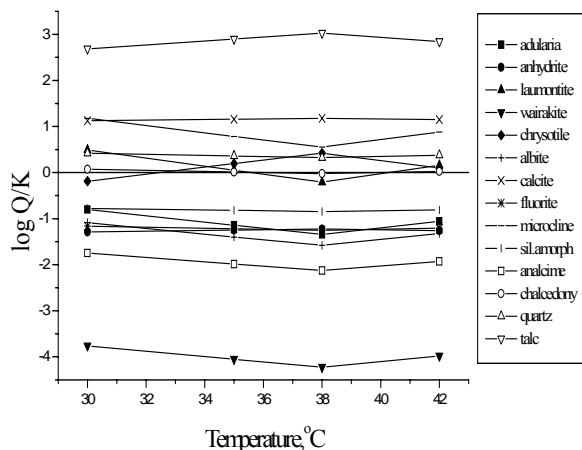


Fig. 1. Log Q/K vs. temperature for geothermal water from Felix

During the exploitation of the well from Felix scales have been encountered inside the well and in the surface construction. The solid depositions were sampled and analysed by the chemical methods briefly described in Table 2. The sample was first disintegrated. The results of the chemical analysis of the solid depositions are presented in Table 3.

The structural analysis [3] (Figure 2) was made by X-Ray diffraction by using a PHILIPS PW 1400 X-ray spectrometer with $K\alpha$ Cu radiations.

They resulted calcite crystals and the elevated baseline is due to a high iron content as a corrosion product.

TABLE 2. Analysis of depositions

Component	Methodology
CaO	Complexonometric determination
MgO	Complexonometric determination
Fe ₂ O ₃	Titration with potassium bichromate, by using phenilanthranilic acid as indicator
Total of Al ₂ O ₃ & Fe ₂ O ₃	Gravimetric analysis
Na ₂ O	Gravimetric analysis
Loss	Calcination at 1000 C

TABLE 3. Chemical composition of the scale depositions, in %

Al ₂ O ₃	CaO	MgO	Fe ₂ O ₃	Na ₂ O	Calcinated loss
0.3	53	1.2	2.2	0.8	42.4

The solid sample was then thermic-differential analysed, by using a Derivatograph Q-1500D equipment. The sample was grounded very fine and it was heated up to 1000 °C with 10°/minute. The obtained diagram (Figure 3) shows that at 690 °C starts a slow and continue decomposition process, which has a maximum at 940 °C. The mass loss is about 43.8 % in the range of temperatures 690 - 1000 °C, that means that all depositions sample consists of CaCO₃ as main, the loss being CO₂.

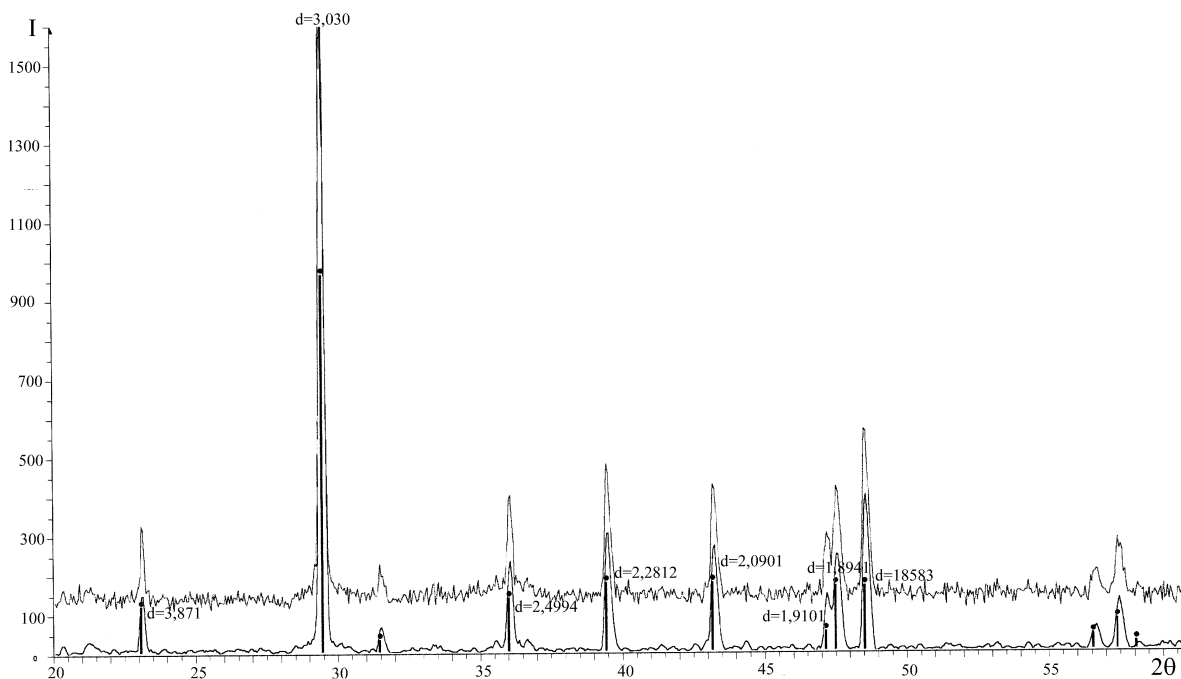


Fig. 2. The XRD diagram for depositions from Felix

4. Control of scales by additives

Geothermal water from the studied well from Felix, containing $120.4 \text{ mgCa}^{2+}/\text{L}$ was placed in a water bath at $42 \text{ }^\circ\text{C}$ (which was the measured temperature during sampling), for duration of one hour. Calcium carbonate was found to be separated from this water. In the next runs there were tried additives: a tripolyphosphate and a polyacrilate in order to control the deposition of calcium carbonate. The experimental results (Figure 4) indicate that the tripolyphosphate additive can be useful to prevent the precipitation of calcium carbonate from water with a minimum dosage of 8 mg/L . As compared, the polyacrilate additive can give good results in preventing precipitation with a lower concentration of 4 mg/L .

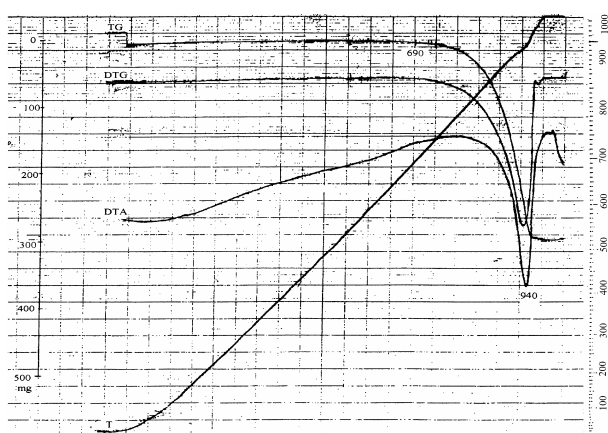


Fig. 3. The thermogravimetric diagram of solid depositions.

In order to control the scale formation, a chemical additive can be injected into the well in dynamic conditions. The Figure 5 shows the equipments needed for treating with inhibitor in a low temperature geothermal well. This leads to an efficient production, avoiding any encountered deposition. A chemical inhibition system is a promising method to combat scaling both technically and economically as compared to mechanical methods.

It is better to counteract scaling and corrosion problems before they occur. For monitoring of the field and possible scaling and corrosion, it is recommended to take samples for complete analysis and also to use a special device for testing any scales which have formed. The proposed device (Figure 6) allows the coupons to the geothermal water without interrupting the flow, which is important when an uninterrupted supply of water is required.

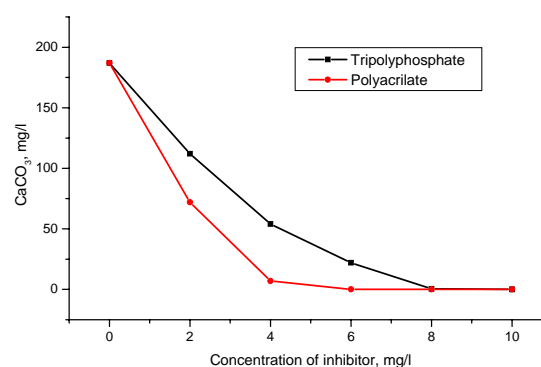


Fig. 4. Calcium carbonate control with inhibitors

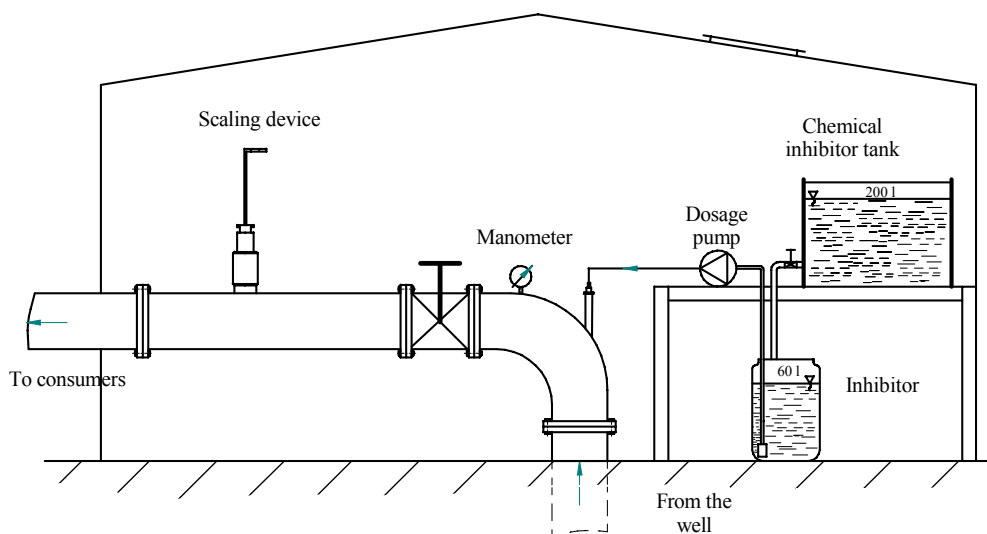


Fig. 5. Equipment for injection of inhibitor

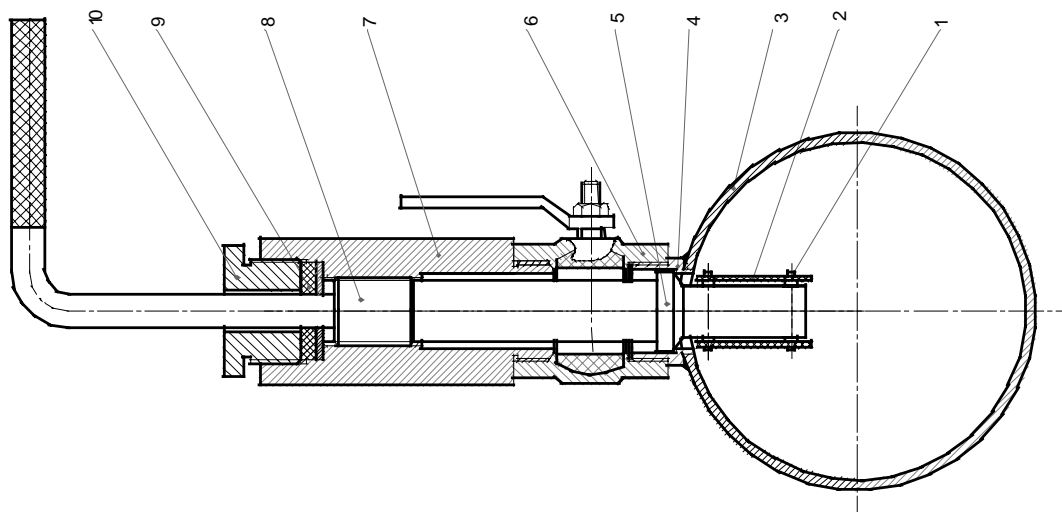


Fig. 6. Scaling device

1-nylon screw; 2-scaling/corrosion coupon; 3-pipeline of geothermal water;
4-nipple; 5-safety valve; 6-globe valve; 7-body; 8-stem; 9-packing gland; 10-gland

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.

If theoretical studies and modelling of the system show that there might be any potential danger of scaling or corrosion such monitoring device is useful.

5. Conclusions

Taking into account the results of water analysis from Felix, due to high CO₂ content, a chloride concentration around 10 ppm, a corrosion process can be estimated. It would be accelerated if some traces of oxygen are presented into the water or enter the water due to some leakages of the pipes. Also the precipitation of calcium carbonate can be predicted due to high carbon dioxide and rather high calcium concentration. The simulation program assessed calcium carbonate scale at the measured temperature and at lower temperatures reached during water utilization.

The analysis of the solid scale from the pipes confirmed the predictions mentioned before. The scale consists mainly of calcium carbonate as calcite crystals and of products of corrosion proved by the iron content of the sample.

The tests with chemical inhibitors made in static conditions for geothermal water from Felix indicated a good performance both of the tripolyphosphate and of the polyacrilate, being efficient in low concentrations. For monitoring of scales, a special scaling device should be installed in many sites of the network.

References

1. Stănășel, O., UNU G.T.P. Iceland, **1996**, 16, 363.
2. Bjarnason, J.O., The speciation program Watch, version 2.1. Reykjavik, **1994**, 1-7.
3. Stănășel, O., Assessment of scaling problems, Proceedings of the 27th Annual Congress of the American Romanian Academy of Arts and Sciences (ARA), Oradea, **2002**, II, 1385.