CALCITE REMOVAL FROM WELBORES AT KIZILDERE GEOThermal FIELD, TURKEY

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SUMMARY – The sole geothermal power plant of Turkey with a capacity of 17.5 Mwe has been established at Kizildere Geothermal Field. The plant is fed by 9 wells. The production wells have to be cleaned periodically because of high CaCO₃ scaling in the casings. Scale inhibitor injection, acidizing and mechanical reaming methods were tried to prevent scaling or to remove scaling from the wells. Mechanical reaming appeared as the most economical method with the effect at the cost of € 0.2/kWh. Using mud or water as circulation fluid at mechanical reaming caused formation damage in the reservoir. To eliminate this problem, the wells were reamed while the wells were flowing. The first meters of the wells where reaming while the well was flowing had not been possible, reamed with foam with success. Thus, the wells were reamed mechanically without any formation damage problem.

1. INTRODUCTION

Kizildere Geothermal Field is located in the western part of Turkey (Fig 1). It's a water dominated field with a reservoir temperature of 195-212°C at a depth of 500-600 m (Tan, 1985). The sole geothermal power plant of Turkey with a capacity of 17.5 MWe has been established in this field. It started electric power generation in 1984. In the beginning, the plant was fed by 6 wells. Three additional production wells (KD 20, KD 21 and KD 22) were drilled in 1986 due to lack of steam (Fig 2).

In this paper, these methods will be discussed shortly. Also the combination of mechanical reaming while the well is flowing with foam reaming which appears as the most economical method will be discussed in detail.

2. SCALING PROBLEM AND PREVIOUS CLEANING WORKS

Geothermal fluid at Kizildere Geothermal Field contains high CaCO₃ and 1-1,5 % dissolved CO₂ by weight.
(Simsek, 1985). The scale is caused by the CO₂ partial pressure drop that takes place during the upflow of geothermal fluid. The flashing point where the scaling starts is around 450-500 m.

Fig 3 shows the daily production rates among 1988-1993 (Aksoy et al., 1992, 1993). The production reaches the maximum value right after cleaning work; but it starts to decline immediately after a short production period and the slope of decline increase by time. Actually the slope is steeper than the slope on graph; because the optimum production well head pressure determined by scaling tests is 1.5 MPa. Also a production more than 700 t/h causes decline in the reservoir pressure and thus in production rate (Aksoy et al., 1992). Although the field reaches to a production capacity of about 1500 t/h at 1.5 MPa WHP after reaming work, it is kept at about 1000-1200 t/h by increasing WHP to 1.6-1.7 MPa. When the production falls below 1000 t/h, the WHPs also reduced to 1.5 MPa. After a 6-9 months’ production the WHPs are reduced to lower values for some wells to keep the Power Plant running efficiently. Because of high scaling rate, the wells have to be cleaned annually. In addition, the surface equipment is cleaned continuously.

![Graph showing daily production rates of Kizildere Geothermal Field (1988-1993)](image)

**Fig 3: Daily Production Rates of Kizildere Geothermal Field (1988-1993)**

### 2.1 Scale Inhibitor Injection

Scale inhibitor injection was tried in three wells (KD 6, KD 20 and KD 22) to prevent scaling. It was not successful because of breakdown of injection pipes due to high production rates and high vibration in the wells. It worked only in KD 6 without any problem for three years. It was also not economic because of high cost of chemicals (US $600,000/year / 9 wells).

### 2.2 Acidizing

The acidizing was tried in this field in 1988 for the first time. The result was satisfying and output values of some wells were even increased over their original values (Allegrini et al., 1989). The main reason of this phenomenon is stimulating wells by removing cuttings deposited in the fractures and cleaning the scaling in the reservoir. Acidizing was done with 40 m³ of 28% HCl. The wells had been reamed mechanically before acidizing. Although acidizing is a high cost operation ($20,000/well), it is the only way to remove calcite deposition from reservoir. The acidizing was done in 1992 for 5 production wells that had very low PI and high +S values. Recoveries in output values were observed (Aksoy et al., 1992).

### 2.3 Previous Cleaning Jobs

Table 1 and Fig 4 show the previous cleaning works and output values before and after cleaning. In 1984 and 1986, 6 production wells were on the line and they were reamed. In 1987/1988, 9 wells were reamed and 6 wells were acidized. Production rates before and after cleaning are at
1.5 MPa WHP. Production rate after cleaning (2405 t/h) was obtained by individual flow tests (one well was produced while the others were shut in) that give high values due to high interference between wells and to the reservoir's production capacity.

Table 1: Calcite Removing Methods and Productions Before and After Cleaning Works (Allegrini et al., 1989, Aksoy et al., 1991, 1992, 1993)

<table>
<thead>
<tr>
<th>YEAR</th>
<th>CALCITE REMOVING METHOD</th>
<th>PRODUCTION BEFORE CLEANING (t/h)</th>
<th>PRODUCTION AFTER CLEANING (t/h)</th>
<th>RECOVERY (%)</th>
<th>EXPLANATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1984</td>
<td>Mech. Reaming by Mud</td>
<td>1200</td>
<td>1210</td>
<td></td>
<td>6 wells on the line</td>
</tr>
<tr>
<td>1986</td>
<td>Mech. Reaming by Mud</td>
<td>706</td>
<td>1415</td>
<td>100</td>
<td>6 wells on the line</td>
</tr>
<tr>
<td>1987/1988</td>
<td>Mech. Reaming by Water + Acid</td>
<td>264</td>
<td>2405</td>
<td>810</td>
<td>9 wells on the line. 7 wells were acidified</td>
</tr>
<tr>
<td>1990</td>
<td>Mech. Reaming by Water + RCHP</td>
<td>507</td>
<td>1437</td>
<td>183</td>
<td>One of the wells was reamed by RCHP</td>
</tr>
<tr>
<td>1991</td>
<td>Mech. Reaming by RCHP</td>
<td>748</td>
<td>1475</td>
<td>97</td>
<td>All wells were reamed by RCHP</td>
</tr>
<tr>
<td>1992</td>
<td>Mech. Reaming by RCHP + Acid</td>
<td>649</td>
<td>1507</td>
<td>132</td>
<td>5 wells were acidized</td>
</tr>
<tr>
<td>1993</td>
<td>Mech. Reaming by RCHP</td>
<td>645</td>
<td>1317</td>
<td>104</td>
<td>8 wells were reamed</td>
</tr>
</tbody>
</table>

Fig 4: Production Before and After Cleaning Works.

3. Mechanical Reaming

Because of high costs of scale inhibitor injection and acidizing, mechanical reaming appeared as the most economical method to remove calcite off the wells. From the beginning, several mechanical reaming methods were used.

3.1. Mechanical Reaming by Mud as Circulation Fluid

The wells had been discharged for long term well tests before the power plant commissioned. In this period, scaling occurred and the wells were reamed mechanically by mud as circulation fluid. Although some of the cuttings were elevated to the surface by mud circulation, most of the cuttings went to the bottom of the well and into the fractures that were feeding well. Mud also caused formation damage in the reservoir due to mud caking. The recovery in the discharge of the wells was not satisfactory. The low PI and high +S values also indicated formation damage in the wellbores. Because of disadvantages of the mud mentioned above, this method was abandoned.

3.2. Mechanical Reaming by Water as Circulation Fluid

To prevent formation damage caused by mud caking, water was tried as circulation fluid for reaming the wells. Two different situations occurred during reaming by water. In the first case the cuttings plugged the well where the scaling rate was high and full circulation was obtained. Thus, the cuttings are carried to the surface. But the well was heated up below the plug and when the well was unplugged by bit, blow out occurred that might cause work hazards. In the second case, the well was not plugged and all cuttings went to the well bottom and into the fractures feeding well. It was almost impossible to remove cuttings from the well bottom since the carrying capability of water was not enough to carry cuttings from well bottom to the surface.

So, both of the, mechanical reaming by mud or by water yielded poor recovery in the output of the wells.

4. Mechanical Reaming While the Well is Flowing and Foam Reaming

Because of poor performance of mechanical reaming by
using water or mud, one of the wells (KD 7) was reamed while the well was flowing by using Rotating Control Head Preventer (RCHP) in 1990. For the last three years all wells were reamed by this method, since all problems encountered during reaming by mud or water were eliminated. The first meters of the wells where reaming while the well was flowing was not possible were reamed by foam. In this chapter the method consisted of the combination of reaming by foam and reaming while the well is flowing will be discussed.

4.1. Mechanical Reaming by Foam

The wells have to be killed by cold water before mechanical reaming. The piezometric level of the field is around 50-100 m from well heads. The water level drops to these meters when it is killed by cold water. The upper part of the well cannot be reamed while the well is flowing since the weight of the drill string is not enough to overcome well head pressure that is between 7-18 bar (Aksoy et al., 1992).

The reaming starts after the well is filled by foam obtained by mixing detergent from a tank and air from a compressor. The cuttings are carried to surface by the circulation of foam. Foam circulation continues until the well starts to flow when the bit reaches to the water level in the well.

4.2. Mechanical Reaming by RCHP

Mechanical reaming work continues while the well is flowing after foam reaming. The geothermal fluid is directed to the silencer by RCHP (Fig 5).

RCHP is consist of 5 main parts which are:
- Kelly Bushing
- Bearing Assembly
- Stripper Rubber
- Bowl
- Positive Pressure Lubrication System

The main objectives of these parts are:

Kelly Bushing transmits the rotating movement of kelly to the bearing assembly and to the stripper rubber that is connected to the bottom of the bearing assembly.

Bearing Assembly houses all the bearings and seals.

Bowl houses the bearing assembly and stripper rubber. It has an outlet to direct the geothermal fluid to the silencer and an inlet for cold water or mud. In our design the outlet is closed with a blind flange and geothermal fluid is directed to the silencer through adapter between RCHP and BOP to prevent excessive worn of stripper rubber from hot geothermal fluid and from cuttings in the fluid.

Stripper Rubber screws onto the bearing assembly via left hand threads and provides sealing on drill string while drilling and trip.

Positive Pressure Lubrication System lubricates the bearing assembly under constant pressure (0.2 MPa).

Care should be taken when using RCHP:
- Bearing assembly should be cooled down by fresh water.
- The RCHP should be as close as possible to the rotary table of the rig and aligned with drill string so that kelly driver will engage with the top of the bearing assembly.
- Lubrication oil pressure and lubricator should be checked to ensure that bearing assembly receives oil at all time.
- The conditions of the seals and bowl gasket should be checked and replaced when needed.

![Figure 5: Rotating Control Head Preventer](image)

The RCHP allows mechanical reaming while the well is flowing by directing geothermal fluid to the silencer. Thus, the cuttings come to the surface with geothermal fluid. The RCHP is placed onto the BOP (Fig 6). The total height of the well head rises to 2.60 m together with RCHP and adapters, so that the rig has to be mounted on a platform of a height of 1.50 m. The geothermal fluid is directed to the silencer through a 8" pipe; so that the crew can work on the deck without being effected from the hot geothermal fluid. The bearing assembly and stripper rubber are cooled down by fresh water through 2" inlet. Two check valves are placed into the drill string to prevent geothermal fluid upflow through the drill string. The WHPs and production rates of the wells vary from 0.7 to 1.8 MPa and from 30 to 120 t/h, respectively, depending on well characteristics.
The average cost of the mechanical reaming while the well is flowing is $150,000 for 9 wells ($35/m or €0.2/kwh). The well has to be shut in for 10 days (including disassembling, reaming, reassembling and cleaning of separator and surface facilities) for reaming. The production loss at that time is not included in the cost calculations. Because, the reaming starts at the same time with the annual maintenance of the Power Plant that takes almost 30 days. Also the production is already limited by the reservoir pressure; so any production loss caused by reaming can not be pronounced.

5. CONCLUSION

The production wells of the Kizildere Geothermal Field have to be cleaned annually because of high \(\text{CaCO}_3\) scaling in the casings. Scale inhibitor injection, acidizing and mechanical reaming methods were tried to prevent scaling or to remove scaling off the wells. Mechanical reaming appeared as the most economical method with the effect on cost of \(\leq 0.2\ \text{kWh}\). Using mud or water as circulation fluid caused formation damage in the wells. To eliminate this problem the wells were reamed while the wells were flowing. The first meters of the wells where this method could not be applied, foam reaming was tried. Thus, the wells were reamed mechanically without any formation damage problem in the reservoir. Reaming the wells without causing any formation damage and pollution in the well and in the fractures will help to extend the period between two acidizing operations.

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7. REFERENCES


