CALCITE REMOVAL FROM WELLBORES 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 $CaCO_3$ 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).

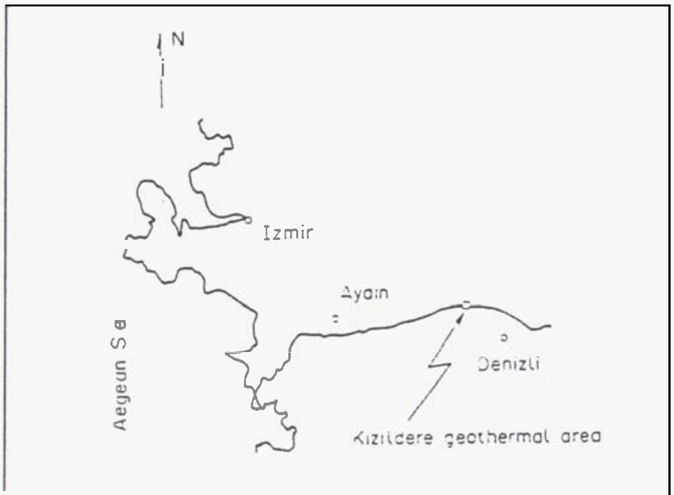
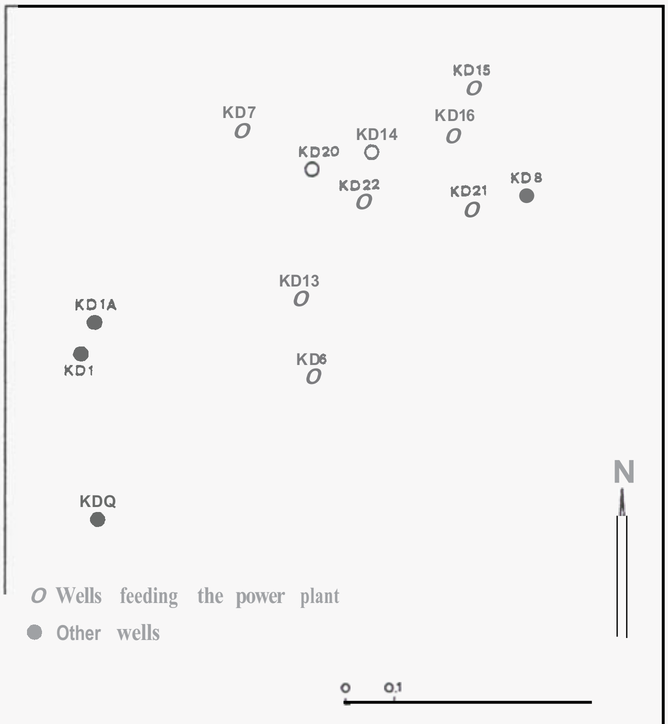


Fig 1: Location Map of Kizildere Geothermal Field

The main problem of the field is the enormous $CaCO_3$ scaling in the casings and the surface facilities that causes dramatic decline in the discharge of the wells. Periodic cleaning of surface facilities and wells has thus been necessary. Mechanical reaming, scale inhibitor injection and acid (HCl) injection methods were tried to prevent scaling or remove scaling off the wells.



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 $CaCO_3$ and 1-1,5 % dissolved CO_2 by weight

(Simsek, **1985).** The scale is caused by the CO_2 partial pressure drop that takes place during the upflow of geothermal fluid. The flashing point where the scaling *start* is around 450-500 m.

Fig **3** shows the daily production rates among **1988-1993** (Aksoy *et al.*, **1992, 1993).** The production reaches to 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.

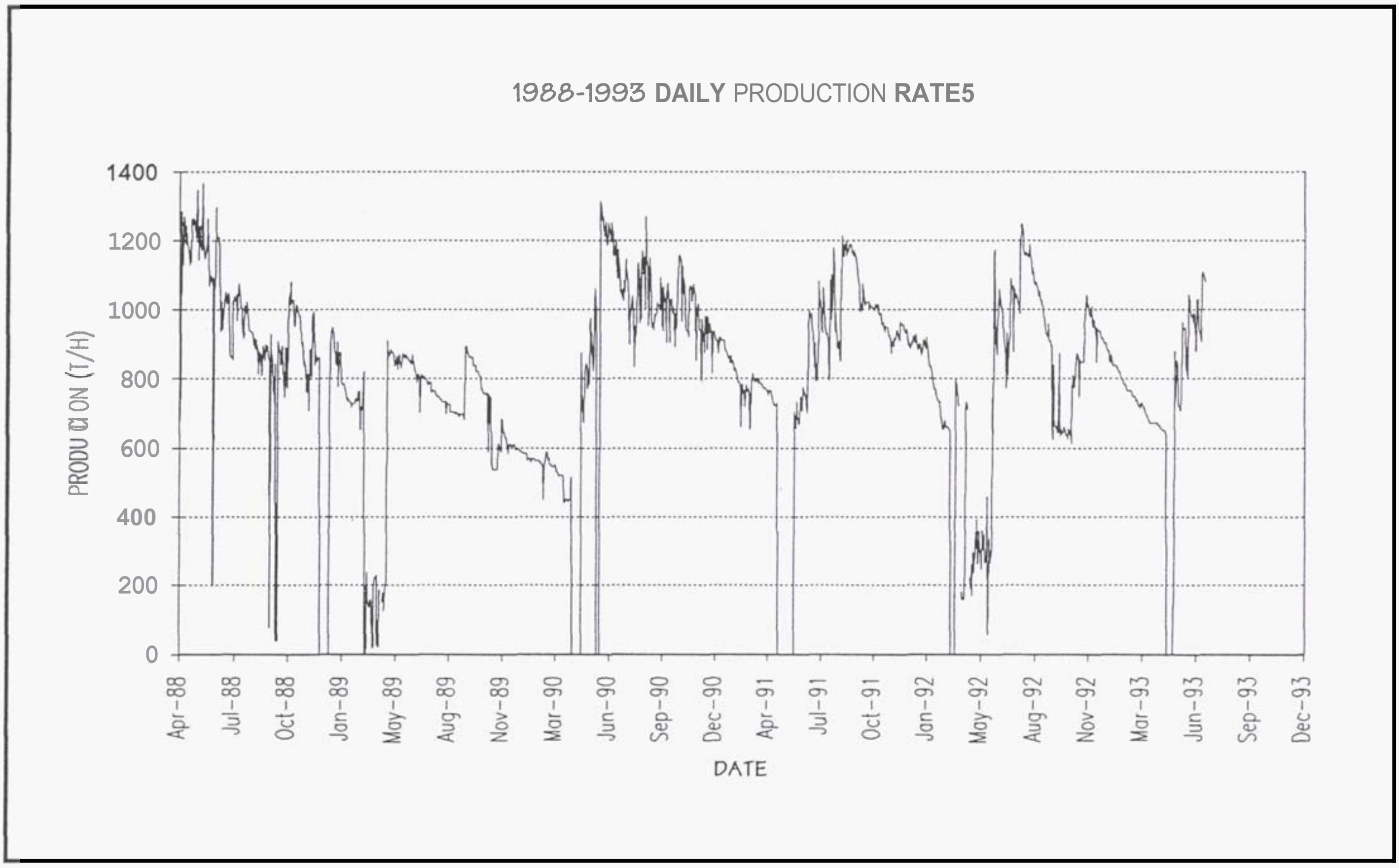


Fig 3: Daily Production Rates of Kizildere Geothermal Field **(1988-1993)**

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 m^3 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)

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

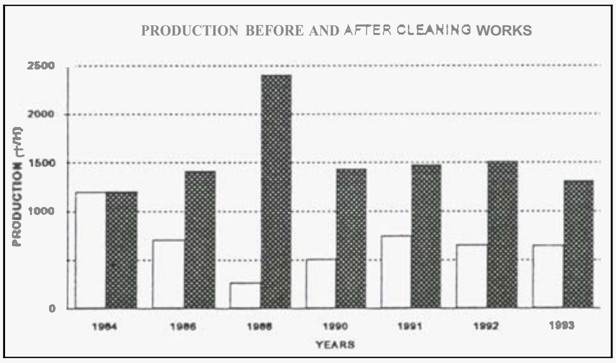


Fig 4: Production Before and After Cleaning Works.

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 satisfying. The low PI and high +S values also indicated to 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 occured 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 g (Aksoy *et al.*,1992).

The reaming starts after the well is filled by foam obtained by mixing detergent from a tank and air fiom a compressor. The cuttings are carried to surface by the circulation of foam. Foam circulation continues until the well start 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.

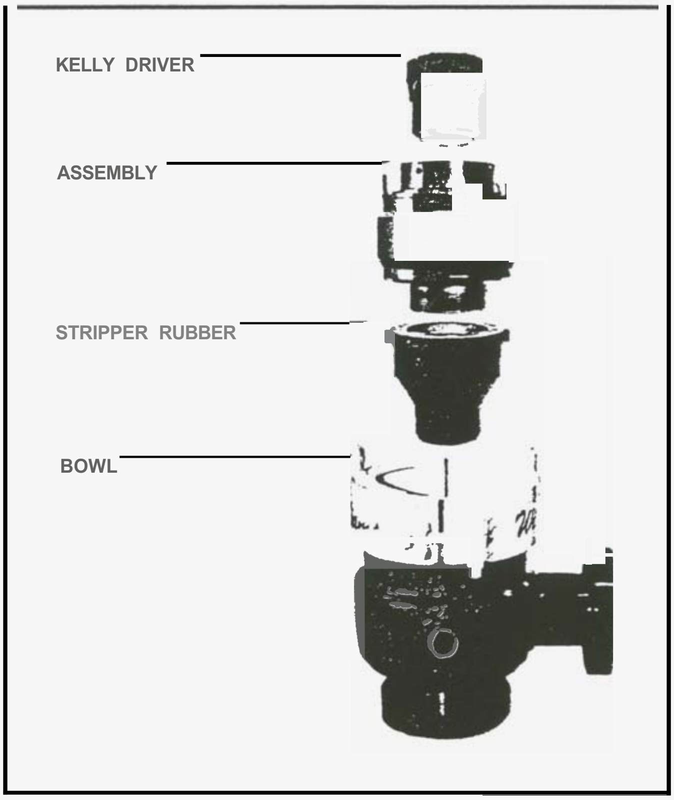
Bowl houses the bearing assembly and stripper rubber. It has an outlet to direct the geothermal fluid to the silencer and an inlet for cold water or mud. In our design the outlet is closed with a blind flange and geothermal fluid is directed to the silencer through adapter between RCHP and BOP to prevent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

Stripper Rubber screws onto the bearing assembly via left hand threats 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.



ׂigure 5: Rotating Control Head Preventer

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 fiom the hot geothermal fluid. The bearing assembly and stripper rubber are cooled down by fresh wafer 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 seperator 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.

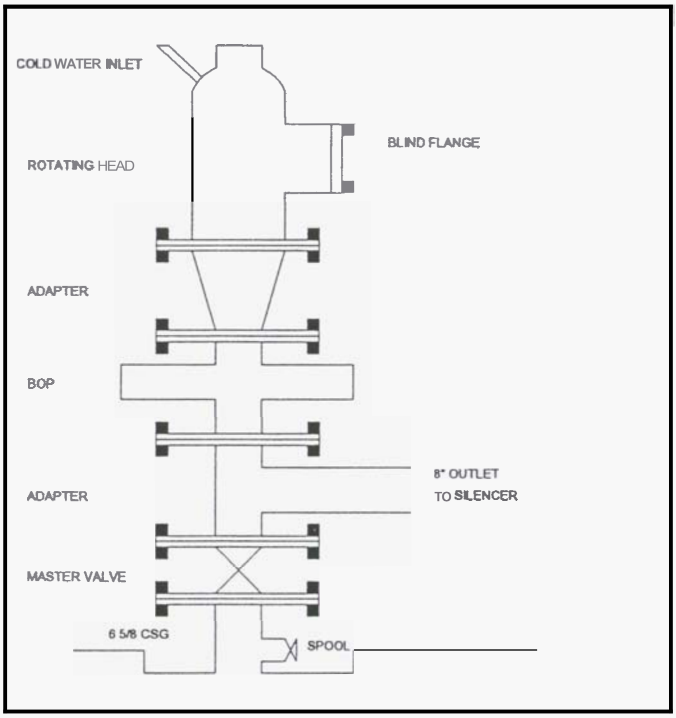


Fig 6: The Wellhead

5. CONCLUSION

The production wells of the Kizildere Geothermal Field have to be cleaned annually because of high $CaCO_3$ 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 ¢ 0.2 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

Aksoy, N., Durak, S., Erkan, B. **(1991).** *Calcite Removing and Well Tests Report for Kizildere Geothermal Field* Report of **MTA** Drilling Department for **TEK** (Turkish Electric Authority). Ankara, Turkey. (In Turkish, Unpub.)

Aksoy, N., Durak, **S.,** Erkan, B. **(1992).** *Calcite Removing Acidizing and Well Tests Report for Kizildere Geothemal Field* Report of **MTA** Drilling Department for **TEK** (Turkish Electric Authority). Ankara, Turkey. (In Turkish, Unpub.)

Aksoy, N., Durak, S., Erkan, B. **(1993).** *Calcite Removing and Well Tests Report for Kizildere Geothemal Field* Report of MTA Drilling Department for **TEK** (Turkish Electric Authority). Ankara, Turkey. (in prep.).

Allegrini, G., Barelli, A., Guven, Y., Özkaya, M. **(1989).** Results of the Italo-Turkish Cooperation in Reservoir Engineering at Kizildere, Turkey. *Seminar on New Developments in Geothemal Energy. Ankara, Turkey.* United Nations Economic Commission for Europe.

Simsek, S. **(1985).** Geothermal Model of Denizli, Saraykoy - Buldan Area. *Geothermics*, Vol. **14,** No, **2/3,** pp. 393-417.

Tan, E. **(1985).** Reservoir Characteristics of the Kizildere Geothermal Field. *Geothermics*, Vol. **14,** No, **2/3, pp. 419-428**