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FIELD DEVELOPMENT AND POWER GENERATION IN KIZILDERE, TURKEY

E. Okandan*
T. Polat **

* Middle East Technical University
** Turkish Electric Authority, Geothermal Division

ABSTRACT

Turkey is classified among countries which have high geothermal energy potential.[1] Geological and geophysical explorations are continuing in promising areas. However primary emphasis was given to Western Anatolia during the last decade. As a result of these efforts Kizildere field was developed and power plant was put into operation in February 14, 1984.

This paper summarizes the power plant, production problems encountered in wells during the last nine amonths and future field development plans.

INTRODUCTION

Kizildere field which is a hot-water type geothermal reservoir is producing through six wells. The steam is separated from the mixture at the surface and utilized in the 20.4MW power plant. 2.6MW of the gross capacity is used by the gas-compressor-extractors coupled directly to the turbine, which results in 17.8MW net energy input into the national interconnected power system.

Although detailed regional resource assessment study for the area is not available, the early geophysical and geological data indicate the capacity of the field to be higher than 20MW. Because Kizildere power plant was the first experience with geothermal power plants in Turkey and also larger discharge of power plant waste waters will couse a serious environmental problems in Menderes river and adjacent soil due to high boron content, the 20MW capacity was found feasible.

BRIEF DESCRIPTION OF THE RESERVOIR

Kizildere field is located at the junction of Büyük Menderes and Gediz graben, which is in the Western Anatolia (Fig.1.).

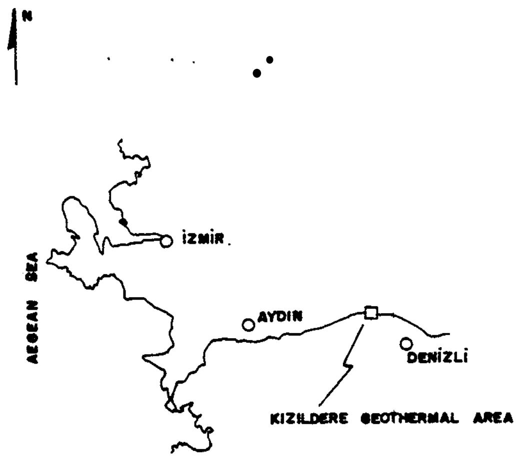

Figure 1 - Location of Kizildere Geothermal Field.

14 wells were drilled in this area by MTA and two reservoirs were encountered. First one being at an average depth of 300 meters and at 198°C, was tapped with 6 wells. The deeper reservoir at 600-850 meters with an average temperature of 200°C is the producing zone.6 wells were drilled to this reservoir and they are the ones connected to the power plant. Table 1 gives data of the 6 producing wells.

The producing reservoir is a marble-quartzite-schist[2] formation. The recharge area is believed to be in the B. Menderes river in the south. B,F and NH, content of geothermal waters decrease towards south and reservoir temperature is lower in this direction. Fig.2 shows the well locations and power plant in the field.

The early well test data showed that the wells had encountered productive fractures[3,4] however the data is not precise enough to apply new interpretation methods of well testing.

TABLE 1. Producing Wells of Kizildere

Well No.	Depth, m	BHP (bar)	Reservoir Temp. °C	Steam quality at 4.92 bar separator pressure	CO_2 content of Steam, wt %
KD-6	851.0	83.75	201	9.47	15
KD-7	667.5	64.29	205	10.75	12
KD-13	760.0	75.11	201	9.47	12
KD-14	603.5	61.02	210	11.18	11
KD-15	506.0	49.73	209	11.40	10
KD-16	666.5	65.14	212	11.82	13

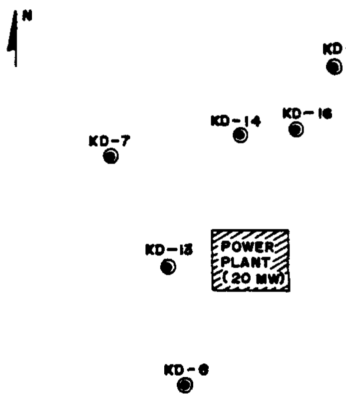

Figure 2. Well Locations in Kizildere Field.

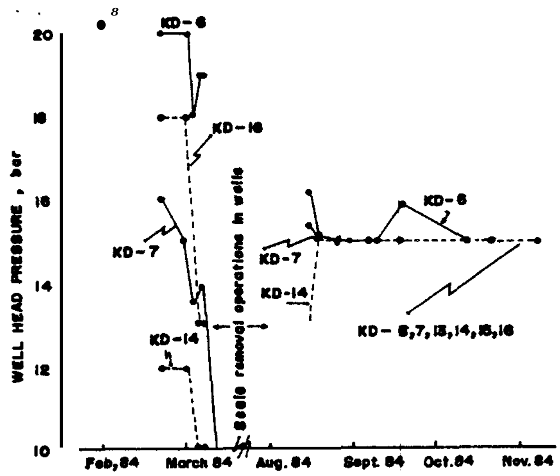

Figure 3. Change in well head pressure during power plant operation.

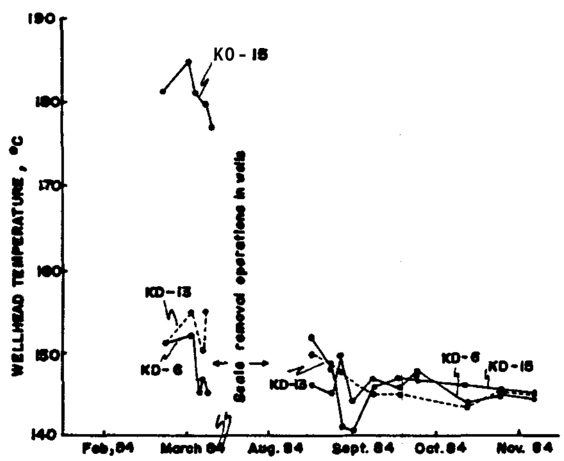

Figure 4. Change in well head temperatures during power plant operation

SCALING

One of the important problems which was foreseen as a drawback during the operation of powerplant is $CaCO_3$ scaling in wells. Presently the scales are removed by reaming the well periodically.

The optimum well head pressure was specified as 15 bars, inorder to have the wells producing for longer periods with less scaling. The wells had shown a decline in well head pressure as well as temperature (Fig.3,4) and this caused the cleaning operation to be performed after three months. However, even after cleaning there is still a decline in the production of the power plant (Table 2, Fig.5)

Well No.	Flow rate of steam on 11.February 1984 (Kg./hr)	Flow rate of steam on 25.September 1984 (Kg./hr.)
Total	180.211 Kg./hr	89.373 Kg./hr

OUTLINE OF POWER PLANT

Two phase steam and water mixture produced from 6 wells at 15kg/cm² wellhead pressure and 196–207°C temperature is separated in wellhead separators. The water separated is drained and used for heating the buildings and climating the green house constructed near the field. The silencer is of vertical type and made of steel. The operators are also vertical type and Water-steam separation takes place by combined effects of gravity and centrifugal force. Steam resulting from separation passes through two suitable ball valves (one for each separator) and conveyed to the power plant through the steam pipes having a total length of 1400m. Steam transmitted from each well is collected and admitted in main pipe which feeds the steam to the main separator placed near to the turbine hall. Main separator separates final liquid drops suspended in steam and send the completely dry steam to the turbine at 180.211 Kg /hr flow rate, 4.5 Kg /Cm² absolute pressure and 147.2°C temperature. Turbine is symmetrical expansion type from its central section where the steam is admitted through two safety valves and two control valves, placed two-by-two at each side, and is eppanded in seven reaction stages (for each half of the turbine). Specific steam consumption rate of turbine is 10.1 Kg./KW-hr.

Turbine output capacity is 20.4 MW. and it is directly coupled to the generator by a rigid coupling, whereas at the other end it is coupled to the gas compressor-extractors, by rigid type of coupling. Extracted non-condensable gases are given to a dry-ice plant which is constructed and integrated to the power plant.

Generator with a power factor of 0.85, rotating at 3000 rpm., generates 17.8 MW net electric power. The condenser which is connected to the turbine at the bottom is composed of a horizontal conduit where steam from turbine meets cooling water orthogonally and by a vertical chamber where cooling of gases extracted from the top takes place, while steam condensation occurs at the bottom.

Hot water extraction is carried out by pumps sucking it with a total rated flow of 8530 m³/hr directly from the chamber and directing it to cooling towers, while its return is obtained by exploiting the vacuum existing in the condenser. Cooling water circuit also provides necessary water for cooling the non-condensible gases extracted from the geothermal fluid by two stage gas-compressor-extractors.

Hot well water is fractioned and cooled in the cooling towers by means of a countercurrent stream of air from 4 power fans. The water falls in the cooling tower tank and the excess water formed from indigeneous steam is drained off through overflow pipe.

The electricity obtained at the generator terminals at a rated voltage of 10.5KV , is given to the 154 KV national network system by means of 20/25 MVA main transformer.

PRODUCTION HISTORY OF POWER PLANT

Figure 5 shows the generated electric power variation during the last 8 months. As it is known, calcite deposition rate in geothermal wells is related not only to the calcium but also to carbondioxide content of the geothermal fluid. Hence, high percentage of carbondioxide in geothermal fluid of Kizildere (Table 1,3) gives rise to the build-up of hard-deposits in wells and in wellhead equipment.

Table 3. Composition of non-condensible gases.

Gases	Amount (%)
CO_2	99.9
H_2S	0.1

The proportion of the non-condensible gases vary widely from field to field ranging from 0.1 to 25% by weight of the produced steam. Table 4 gives data from other fields for comparison

Table 4. Variation of non-condensible gases in different fields[5]

Field Name	Percentage of non-condensible gases (%)
Wairakei	0.35 - 0.50
The Geysers	0.60 - 1.00
Cerro Prieta	1.25
Larderello	4.50 - 5.00
Matsukawa	1.10
Monte Amiata	10 - 25
Kizildere	11 - 15

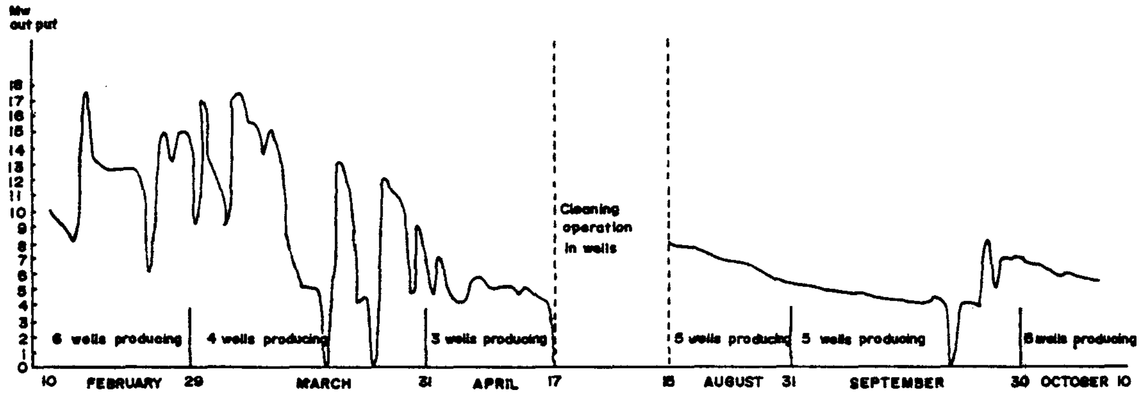

Figure 5. Power Output from Kizildere Since its Starting Date

During 8 months since the start of operation power plant produced total 19,161,600 KW-hr of electrical energy.

CONCLUSION

The real potential of the Kizildere Field for electricity production was determined as 150MW. but the capacity of the constructed power-plant was limited to 20,4 MW due to high concentration of boron (~ 25ppm.) in the discharge water. Being the first pilot plant was also an important factor limiting the capacity. Elimination of the waste water by means of re-injection is being investigated and pre-feasibility studies in this respect is being continued. Utilization of total potential capabilities of the field is directly dependent on solving the boron problem.

The next Gecthermal Power Plants which are being planned to be constructed in this field will be double-flash cycle with 55MW capacities, since 55 MW double-flash-cycle Geothermal Power Plants are the optimum ones considering bot the cost and specific steam consumption. Comparison figures are;

- Kizildere Power Plant(20MW.) .... 10.1 Kg /KW-hr
- 55 MW. Double Flash Cycle .... 5.6 Kg /KW.hr

The production wells in Kizildere field are being seriously affected by calcite incrustations which are related to the carbonate equilibrium in the fluid. Elimination of calcium carbonate by chemical means is being searched. After accomplishing this, the time for well cleaning will be decreased thus the annual operation period will be increased.

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