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REPOWERING IN THE LOS AZUFRES GEOTHERMAL FIELD

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ABSTRACT

Two x 1.45 MW Organic Rankine Cycle Units (ORCU) began commercial operation during 1993 in the Los Azufres Geothermal Field Mexico, in order to increase the efficiency of two power stations where an important amount of waste water is discharged to the injection system. Three wells connected to the 50 MW condensing unit together, produced 75 T/H of brine collected at well Az-22. Well Az-26 is the location of one 5 MW backpressure turbine which was installed to produce electricity with the steam from 130 T/H of water. In both locations, CFE decided to utilize the otherwise wasted energy, by installing in each site a 1.45 MW Organic Rankine Cycle Unit. ORMAT Inc. supplied the units, and the general performance of both units are acceptable and have maintained an operational capacity for six months.

Introduction

The Los Azufres Geothermal Field, located in Michoacan State, Mexico, has an installed power capacity of 98 MW, with 9 x 5 MW backpressure wellhead portable units, 1 x 50 MW condensing unit, and 2 x 1.5 MW binary units.

Twenty-six wells supply more than ,1000 T/H of steam for the turbines. Two phase flow is produced by the wells, so the brine production rate in the field is approximately 1000 T/H. The operating pressure of the main separators is 9 Bars (Ts = 175°C). Let us suppose that the water temperature drops to 100°C in the power production process, then the energy liberated in this process is 87.5 MW— obviously, not all of this energy can be transformed to electricity, but using an organic Rankine Cycle it is possible to recover about 10 additional MW from the waste brine. This is one way to improve the thermal efficiency of the generation process, but it is limited by the topography of the field and the disposal of the waste water. Figure 1 shows this problem in the Los Azufres Geothermal Field, and we have identified six locations where more than 100 T/H of brine is collected on site, two were included in the repowering project using binary units furnished by Ormat., Figure 1

Description of the Repowering Project

Two binary units furnished by ORMAT Inc. were installed at well Az-26 (named U-11) and well Az-22, (named U-12) both with similar technical features:

- Brine flow per unit . . . . . 155 T/H
- Brine inlet temperature . . . . . 175°C
- Exhaust brine temperature . . . . . 110°C

Turbine: Single-flow, impulse stage and special design.

- Power Output . . . . . 1,450 kW
- Net power output . . . . . 1,250 kW
- Speed . . . . . 3,600 rpm
- Evaporator . . . . . Sheet and tubes of Stainless Steel

Generator:

- Tension . . . . . 4,160 V
- Frequency . . . . . 60 Hz
- Type . . . . . Sincronous, Brushless
- Speed . . . . . 1,800 rpm
- Cooling system . . . . . Air
- Condenser . . . . . Air cooled

Figure 2 shows the diagram of the generation system.

Unit 11

This unit was installed on well A-26 in 1993. Since 1992, a 5 MW backpressure turbine has operated with the steam produced by this well; however, the amount of production water of Az-26 is very large, more than 130 T/H of water was

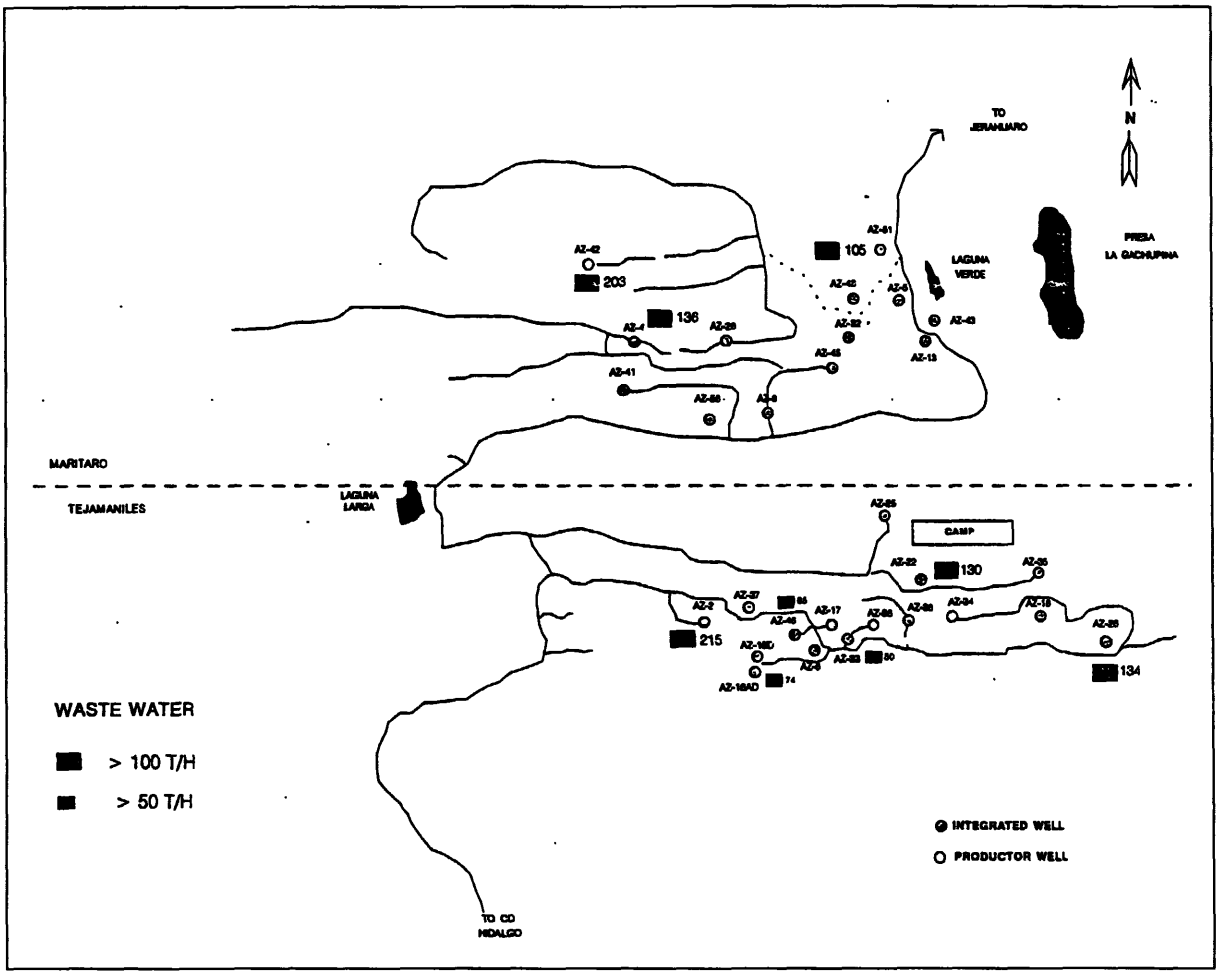

Figure 1. Dispersion of waste water in the Los Azufres Geothermal Field.

discharged to the injection system from the power plant. In order to increase the efficiency in the power system, CFE decided to install at well Az-26 one Ormat Energy Converter (OEC), to take advantage of water produced by the well. Also, it was decided to combine the electrical (switch yard) equipment of both units in order to simplify the generation scheme. Both units are connected to a low tension side of the same transformer. This transformer originally had a capacity of 6,250 KVA, using a free circulation air cooling system. In order to use the same transformer now with 6.5 MW, cooling of the transformer had to be modified by a forced circulation air cooling system. A complex protection system was installed in order to minimize any risk during the operation of the units.

The OEC unit works without any problem, except that production brine is not sufficient to operate the unit at full load (the power output of the OEC is 1.1 MW). ORMAT is studying this situation in order to propose small modifications of the heat exchangers, with the introduction of a small amount of steam for heat to increase the generation rate.

Unit 12 (U-12)

This unit is located 700 m away from the 50 MW condensing unit (U-7). In this case, production from two wells (Az-25 and Az-35) is transported in two phase and collected at the location for well Az-22. So the main separator installed at well Az-22 operates at 10 Bars pressure and produces 120 T/H of brine used to operate the OEC. In a short time well Az-55, which has mechanical problems, will be repaired and the steam will be diverted to U-7. The steam and water from this well will be collected at well Az-22, and the amount of brine will increase to 170 T/H. At this time, the OEC will operate at full load, 1.0 MW.

Generation History

Both units were built during 1993, and at the end of this year, U-11 and U-12 passed the acceptance tests and normal operation began in 1994. However, in both cases, there was not enough brine to run the units full load.

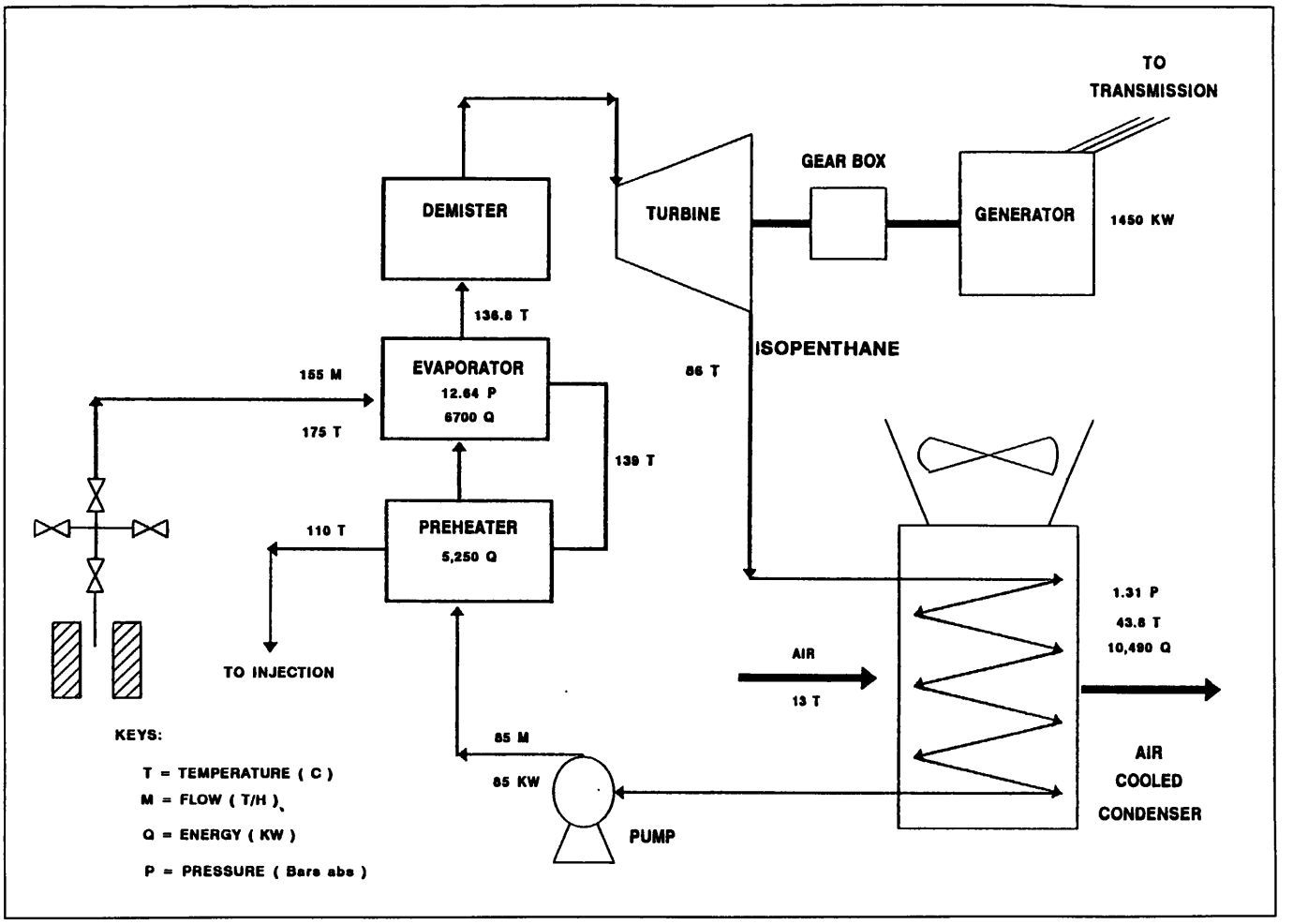

Figure 2. Schematic flow chart of the Los Azufres Ormat Binary Units.

General information on these units in 1994 are as following:

U-11 - Flow water . . . . . 130 T/H
- Generation (Jan/Apr) . . . . 2,540 MWH
- Load Factor (1) 66.5%
- Availability Factor 84.2%

U-12 - Flow water . . . . . 75 T/H
- Generation (Jan/Apr) . . . . 2,281 MWH
- Load Factor (1) 103.4%
- Availability Factor 100.0%

Load factor is calculated considering the available energy in the evaporator, and remaining constant efficiency.

The main reason to explain different behavior of the units is that unique transformer needs several protection devises, and some times a false alarm shuts the unit off, and careful procedures are necessary which consumes a large amount of time prior to starting the 5 MW and 1.45 MW units.

Economic Considerations

Several economic advantages can be mentioned in this repowering project using ORMAT Energy Converters:

- OEC converts waste energy into electricity, which increases the economic value attached to the brine, because this brine has no other alternative use in this field. The operational cost in this application is very low, with respect to conventional geothermal technologies.
- The OECs are built in a modular configuration; in the Los Azufres Geothermal Field the construction period took place in two months — adding additional economic benefits in construction costs and earlier electrical generation.
- Because the OECs recover energy from the discharged brine, they are located near the main separators, the easy pipeline design and hook up required allows more profit from this energy at lower construction costs.
- For well Az-26, where the OEC is connected to the same transformer with another 5 MW unit, this connection

saves the cost of another transformer and the auxiliary equipment. However, it is necessary to solve a few technical problems in order to improve the operation of the turbines.

- Air cooled condensers for the OECs were required because in this field it is not easy to use water in a cooling tower, and the cost to transport water is expensive. Obviously, the OEC cost increased because of the air cooled condensers, but in the long run, there will be more energy recovered because water was not used in the condenser operations.
- The required area for the OEC installation is 20 x 40 m; it was possible to install the unit inside the available location to avoid environmental effects during the construction.
- The OECs work unattended, no operators are required and periodic inspection is necessary only to check the main components of the OECs.

Conclusions

- The repowering project at two units in the Los Azufres Geothermal Field is a successful option for the recovery of energy from the waste brine.
- The technology developed by ORMAT in the Organic Rankine Cycle is a good option in this type of application.
- Important economic benefits were obtained in this repowering project.
- A one-half year experience with these units shows that scaling problems do not occur during the operation of the evaporators. However there is not enough brine to operate the units at full load. CFE and ORMAT are working to solve this problem.

References

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