Proceedings World Geothermal Congress 2005
Antalya, Turkey, 24-29 April 2005

Total Reinjection Project in Ahuachapán Power Station (El Salvador)

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Keywords: Reinjection, environmental project, pumping station, Ahuachapán Power Station.

ABSTRACT

Starting in 1976, Ahuachapán Geothermal Power Station had been managing its residual geothermal fluids through a long open channel from the field to the Pacific Ocean. This open channel has caused different environment impacts such as damage in some neighbor-cultivated areas, river pollution and even some burns to people.

With the development of "Ahuachapán Total Reinjection", in 1998 all the geothermal fluids are reinjected to the field, stopping all discharges to the sea and surround surfaces. The Project consisted of the design and construction of a Reinjection Pumping Station, which is divided in three main systems: Hot brine pumping reinjection, Condensate pumping reinjection and Occasional and Emergency pumping reinjection.

Using modern technology and taking into account all the environmental, safety and functional considerations to assure an adequate performance, Ahuachapán Geothermal Power Station has a cleaner and environmentally friendly production and also guarantees its field sustainability with the total geothermal fluid reinjection.

1. INTRODUCTION

Ahuachapán Geothermal Power Station has been in operation since 1976. The original design concept of the power station considered to dispose of separated water and remaining condensate into the Pacific ocean through an 80 km long open channel. This notable civil work took around eight years construction and crosses many different lands, small towns and rivers until reach the seashore. Nevertheless, the utilization of this channel has caused different environmental impacts such as high temperature water and mineral deposition into the sea and, some accidental overflows along the channel have caused damages in some neighbor cultivated areas, rivers pollution and has even burned people. Moreover, this long channel has represented a high maintenance costs and elevated operation risks.

In 1998 a 5 km long reinjection pipeline was built to carry by simple gravity the remaining brine after the second flash process toward three reinjection wells located at the northeastern area of Ahuachapán geothermal field. Due to hydraulic restrictions, the pipeline could not carry all the brine by simple gravity and just two of the three wells have been utilized. Around 44% of the total brine was still discharged to the sea.

Since a couple of years ago, engineers from *LaGeo S.A. de C.V.* have developed the project called "Ahuachapán Total Reinjection", working on the design and construction of a Reinjection Pumping Station which has two main objectives: First, to bring to an end the utilization of the open channel toward the Pacific ocean as a mean of geothermal waste water disposal and second, to help reservoir sustainability with the total geothermal fluid reinjection.

2. CURRENT WASTE WATER SOURCES IN AHUACHAPAN GEOTHERMAL POWER STATION

2.1 Ahuachapán Power Station General Configuration

Ahuachapán Power Station is a double flash type. Medium pressure (MP) steam is mainly separated close to the wellheads at 5-7 bar g. Almost all of the separated water is piped from the pad to two Low Pressure (LP) vaporizers (Called "*flashers*") where saturated LP steam is generated at around 0.7 bar g.

Ahuachapán Power Station has three condensing type turbine units. Units 1 and 2 have a capacity of 30 MWe each and operate just with MP steam. Unit 3 is a mixed flow type with capacity of 35 MWe. The third unit operates with a mixture of MP and LP steam.

At the present time, just two of the three units operate at nominal capacity due to MP steam deficit. Current power production is around 60-65 MWe.

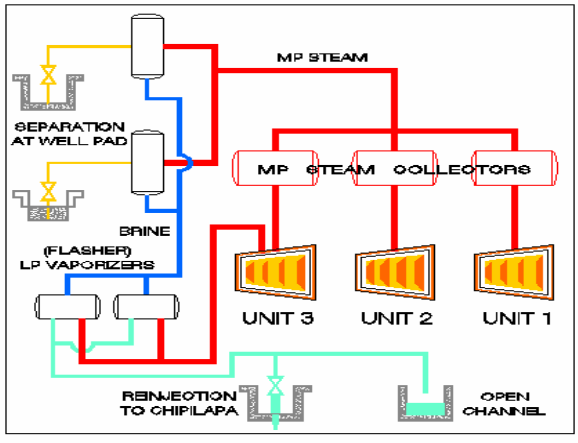

Figure 1: Simple diagram of Ahuachapán power station.

2.2 Separated brine

The remaining brine at the LP vaporizers is around 410 kg/s. This brine was partially reinjected at two reinjection wells (CH-7Bis and CH-9) by simple gravity through a 24" pipeline of 5 km long. Due to high well pad elevations and pipeline pressure drop, gravity flow presents some hydraulic limitations; the pipeline managed just 230 kg/s. So far, one of the reinjection wells is not utilized (CH-7)

Approximately 180 kg/s of separated brine is discharged into the open channel and conveyed to the Pacific Ocean.

2.3 Cooling towers blow-down

Cooling towers at Ahuachapán Power Station are of the cross-flow type. Cooling tower blow-down is currently discharged to the open channel or to a small neighboring river called *"Los Ausoles"*. The measured blow-down mass flow from cooling towers is around 40 kg/s. This amount varies along dry and wet seasons. Blow-down temperature is around 40 ˚C.

2.4 Occasional or Emergency Geothermal Water Discharges

The following geothermal discharges are considered as small and/or occasional discharges:

- Accidental or occasional discharges due to bursting disks rupture or control valves opening,
- Well tests operations,
- Condensate drained from steam collectors and pipelines.
- Discharges during pipe and vessels heat-up and maintenance operations.

All of these discharges are conveyed to an open channel network along the field and power station. Then, they are collected into a silica deposition tank and disposed into the open channel to the sea.

3. AHUACHAPAN TOTAL REINJECTION PROJECT

3.1 Project Objectives

The project "Ahuachapán Total Reinjection" was created with the following two main objectives: First, to bring to an end the utilization of the open channel toward the Pacific ocean as a means of geothermal waste water disposal and second, to help reservoir sustainability with the total geothermal brine reinjection.

The project consisted of the design and construction of a reinjection pumping station to dispose all the residual geothermal fluid into three wells (CH-7, CH-7Bis and CH-9) located at *Chipilapa* region to the northeast of Ahuachapán Geothermal Field. The geothermal fluid will be piped through an existent pipeline, which currently works by conveying part of the remaining brine by simple gravity.

The pumping station is divided into three different reinjection systems: Hot brine reinjection, Condensate reinjection and, occasionally and emergency reinjection. These systems are explained below.

The project was initiated in November 2002 and it was commissioned in May 2004.

3.2 Hot Brine Reinjection Pumping System

An estimated mass flow of 410 kg/s of brine at 114°C is pumped by a set of three centrifugal pumps (One in stand-by) These pumps have the following technical data:

Type: Horizontal shaft - Centrifugal Pump

Nominal capacity: 220 kg/s

Driver Power: 300 kW

Dynamic Head: 94 m

The brine is at saturation conditions, consequently the pump's Net Positive Suction Head (NPSH) definition was a thorough process during the design project stage.

Hot brine is supplied directly from the two LP vaporizers. This is a critical operation condition because the water level inside the tanks must be controlled to avoid entrance of liquid to the turbine and to avoid LP steam to escape through the reinjection pipe. The system design planned to operate this set of pumps by Variable Frequency Drivers (VFD), which regulate the motors speed according to the water level variations. The pumps speed control is totally automatic.

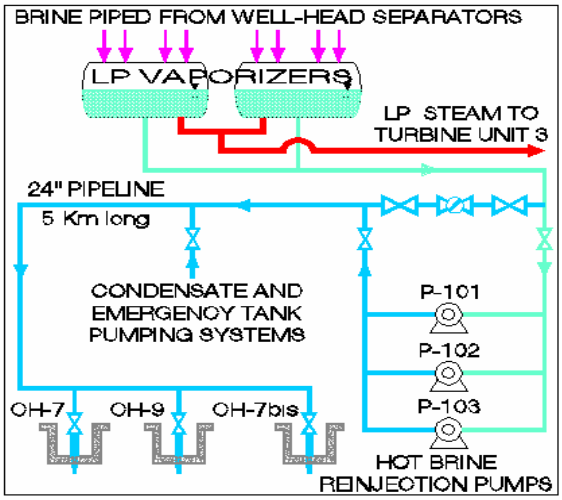

Figure 2: Diagram of Hot Brine Reinjection pumping system.

3.3 Blow-down Reinjection Pumping System

Cooling tower blow-down is pumped directly by the cooling water pumps located at the hot well of each turbine unit toward a 300m^3 storage tank. Water is taken from this tank and pumped again to the reinjection pipeline by a set of two centrifugal pumps (one in stand-by).

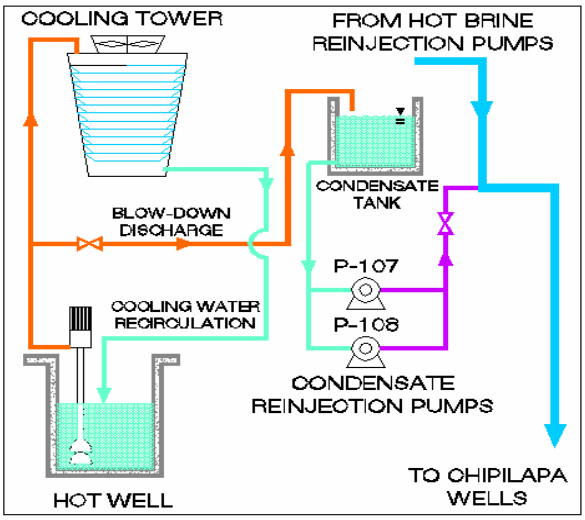

Figure 3: Diagram of Condensate Reinjection Pumping system.

The condensate pumps have the following technical data:

Type: Horizontal shaft - Centrifugal Pump

Nominal capacity: 50 kg/s

Driver Power: 110 kW

Dynamic Head: 108 m

The pumped condensate is integrated directly into the Hot Reinjection system.

3.4 Occasional and emergency Reinjection Pumping System

An 8,000 m^3 emergency tank was constructed close to the hot brine and condensate pumping station (see Fig 5). The main purpose of this tank is to collect all the occasional and emergency geothermal fluid discharges and then to reinject them by a set of two additional pumps (one in stand-by) These pumps have the following technical data:

Type: Vertical shaft - Centrifugal Pump

Nominal capacity: 280 kg/s

Driver Power: 500 kW

Dynamic Head: 120 m

In case the Hot Reinjection Pumping System fails or a Blackout happens, all the Hot Brine and Condensate Pumping Reinjection systems are immediately disabled and fluid is discharged to the emergency tank, after that, the reinjection by simple gravity is established again until the problem is solved and pumping systems restart operation over again. In these conditions, the emergency tank can sustain the urgent situation for approximatly eight hours. Additionally, the Emergency Tank Pumping System can replace the others two systems working as backup for a short period of time.

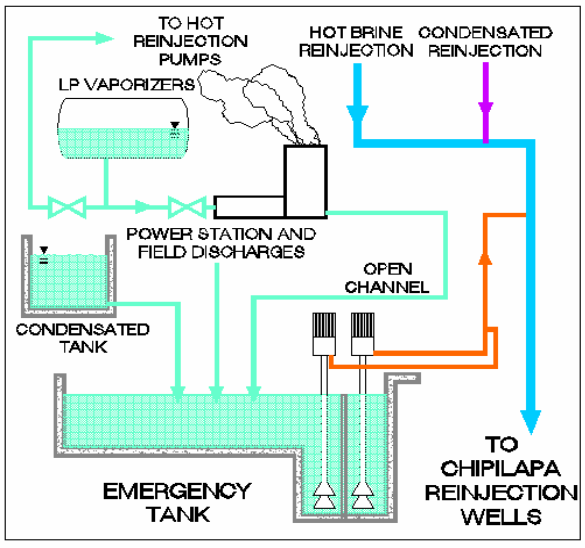

Figure 4: Diagram of Emergency Reinjection pumping system.

3. FUTURE IMPROVEMENTS AND ACTIVITIES

In the future, a new goal for LaGeo might be to reinforce the reinjection system with some additional projects such as the construction of a second reinjection pipeline and drilling new reinjection wells. Furthermore, some feasibility studies are in development toward extra power generation with the utilization of remaining brine temperature. Finally, research is in progress to look for new uses for the long open channel that so far does not have any important function. A good idea is to utilize the channel to conduct fresh water to some remote cultivated lands that lack of such a vital element.

4. CONCLUSIONS

With the "Ahuachapán Total Reinjection" project, the discharge of geothermal fluids to the Pacific Ocean has come to a halt. The reinjection of total residual geothermal fluids is part of the normal energy production with a friendly environmental process and helping to assure reservoir sustainability.

Figure 5: A general view of the Emergency Tank.

Figure 6: Hot brine and Condensate Reinjection Pumps.

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