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DIRECT HEAT USE OF GEOTHERMAL ENERGY IN THE TAUPO AREA

K.J. KOOREY

Downer Energy Services Ltd., **Taupo, NZ**

SUMMARY-Geothermal energy is used in the Taupo township for domestic heating and hot water, greenhouses, swimming pools and aquaculture. This paper discusses the engineering aspects of the surface equipment used by a sample of these users.

1. INTRODUCTION

This paper discusses the engineering aspects of the surface equipment used by a sample of the direct uses of geothermal energy in and around the Taupo township.

The population of Taupo is approximately 18,000 and considerably more during vacation periods.

The township of Taupo is located over the south west corner of the Tauhara-Wairakei geothermal field. There are over 500 wells (Curtis, 1988) in and around the town drilled into the shallow part of the resource and deep wells used for power production at the Wairakei and Poihipi Road power stations to the north of the town.

The hot ground water under the town is largely infiltrated rainwater which has been heated by steam rising from the geothermal reservoir below. It has been estimated that the total energy used from the hot ground water is around 2.76 x 10^8 MJ/y, most of which is used by a small number of commercial users (Curtis, 1988).

2. AQUACULTURE

2.1 Prawn Park

The Prawn Park aquaculture pond complex is located on the banks of the Waikato river next to the Contact Energy Wairakei geothermal power station.

The farm grows Macrobrachium Rosenbergii fresh water prawns in 19 outdoor ponds (57000m^2 total area) and smaller covered nursery ponds. The pond water is maintained at 28°C. The estimated peak winter heat load required to maintain this temperature is 35 to 40MW thermal.

The farm uses separated geothermal water from the Wairakei power station through plate heat exchangers (HEX) to heat the pond water. Until recently the geothermal water was pumped from the Wairakei stream next to the farm. This water is now reinjected and the farm receives the water it requires from a branch off the reinjection pipeline. The water is received under gravity flow to the farm at 127°C and 4.5 bar.g. The flow is up to 450 t/h.

The two HEXs cool the geothermal water to 50-70°C. Pond water is pumped through the secondary side of the HEXs and is heated to 60-80°C. The farm operates with a high primary side discharge temperature and which saves on HEX size, cost and silica deposition. The used geothermal water is discharged to the Wairakei stream. The pond water temperature is maintained at 28°C.

PVC is used for the secondary piping from the **HEX** back to the ponds. The operating temperature limit of this material is 55°C, so some pond water by-passes the HEXs to maintain the temperature of the water returning to the ponds below 55°C. Secondary flow to the ponds can be up to 1100t/h.

A smaller HEX uses some of the larger HEXs primary discharge to heat river water, which is used in the nursery ponds. The layout of the pond heating system is shown in Figure 1.

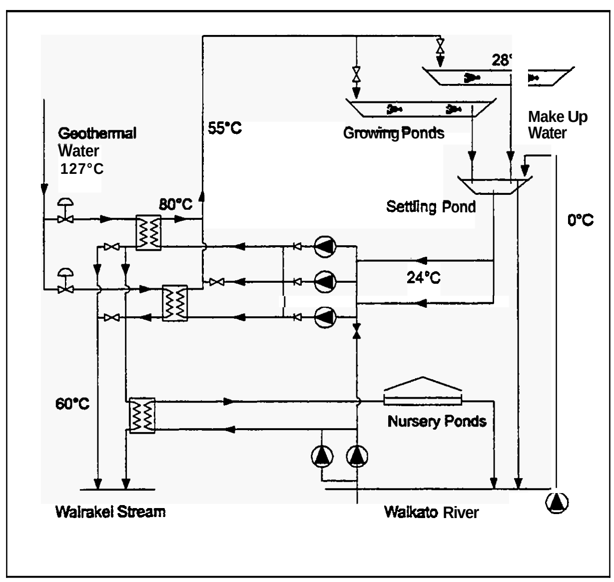

Figure 1. Prawn Farm Pond Heating System. Typical temperatures shown, see text for flows.

3. GREENHOUSES

3.1 Taupo Native Plant Nursery

The Taupo Native Plant Nursery has a number of green houses at a site over the western part of the Geothermal field. A deep investigation well TH2 is used for a small steam supply to the greenhouses for heating and soil sterilisation.

TH2 produces two phase fluid from the deep geothermal reservoir. Steam production equipment at the wellhead consists of a small (300mm) separator, water discharge silencer and manual control valves. Steam pressure at the separator is 11.5 barg. A 50mm steam line delivers steam to the greenhouse complex. The steam line is 600m long, half of which is installed in a buried conduit. The design flow of the system is 500 kg/h.

Originally the greenhouses used a **HEX** and hot water system but this has been scrapped. Bare steam piping is now run inside the green houses for heating. Pipe temperature is controlled by manually regulating the steam pressure with by-pass/dump valve. The steam lines are run between the greenhouses directly buried in the ground. Figure 2 shows the system layout.

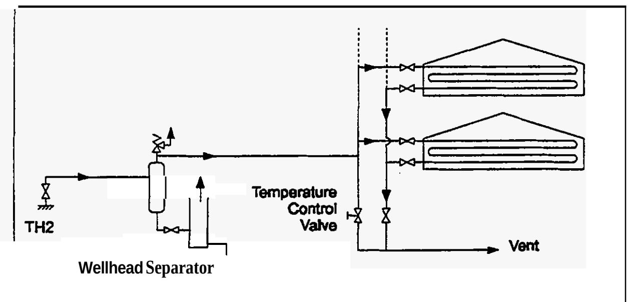

Figure 2 Taupo Native Plant Nursery

3.2 Geotherm Exports

Geotherm Exports operate a greenhouse complex for growing Phalaenopsis orchids for export. The greenhouse is close to the Poihipi Road power station dry steam production wells.

A 400m, 100mm diameter pipeline from one of the production wells supplies steam to the greenhouse. The steam is used in a shell and tube HEX to heat the green house with a pumped loop hot water system.

The total covered area is 8100m^2 and the growing temperature is 26°C. The peak winter heat load is approximately 700 kW. Steam supply pressure is nominally 6 to 10 barg depending on the production well operating status.

The steam is also used for heating the owners house.

4. SWIMMING POOLS

4.1 AC Baths

The Taupo District Council owned AC baths uses natural hot springs and a pumped well to heat three outside swimming pools, a number of small covered private pools and changing room showers. Total heat load is approximately 1.9 MW in winter.

Well AC2 is sited a few meters from the pool pump shed and is pumped from down hole with a shaft driven Mono moving void pump. AC2 was drilled to 150m. The static water level is 30m and the pump is set at 90m. The casing is 150mm. **Max** static temperature is 120°C and the discharge is 97°C.

The Kathleen Stream is fed by a number of hot springs. The stream runs next to the pool complex. A small dam allows stream water to be pumped to the pool pump/filter shed.

Stream and well water are mixed before being used in **HEXs** to heat the pool water. The secondary side of the **HEXs** are connected in series to the pool filtering systems. A **HEX** by-pass on the secondary side controls the pool heating.

The covered private *'soak'* pools are filled with geothermal water direct from the AC spring. The spring water is 79°C so is cooled via a spray cooling tower before going to the pools. During winter at peak heat demand uncooled AC spring water is used in addition to the water from AC2 and the stream to heat the main pools.

Typical flows and temperatures are shown in Figure 3.

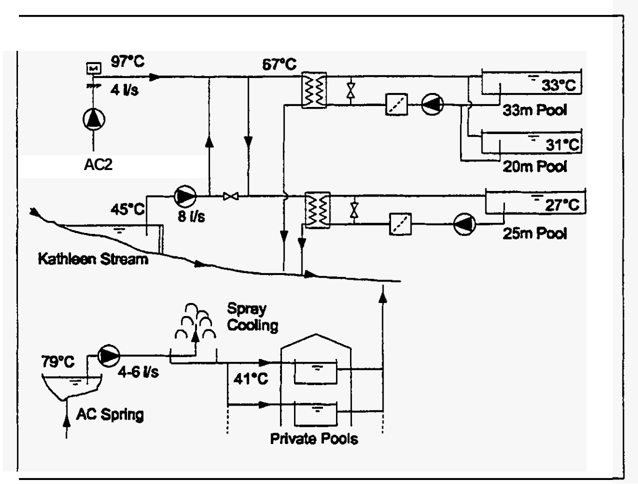

Figure 3 AC baths

4.2 SwimWell

SwimWell operate an indoor pool and heat this with a downhole **HEX**.

4.3 De Bretts Thermal Pools

De Bretts Thermal Pools are filled with geothermal hot water direct from a thermal stream. The pools are emptied each night and filled in the mornings. Spray cooling is used to lower the water temperature before the water is used in the pools.

5. SPACE AND WATER HEATING

Most of the wells in the Taupo area are used for domestic space and water heating. There are approximately equal numbers of downhole HEXs and wells used for hot water and steam extraction (Curtis 1998).

Large users of geothermal energy for heating include the Taupo hospital and the Wairakei Resort (hotel).

5.1 Tauhara College

Tauhara College is located on the east side of Taupo township, on the southern edge of the Tauhara geothermal resource.

Space heating for the college was provided by a gas fired water heater with hot water being circulated through a closed circuit heating system. A previous attempt to use geothermal heating with downhole heat-exchangers was unsuccessful as they were unable to maintain sufficient heating. The college decided to switch to geothermal heating, using two phase geothermal fluid to heat the circulating hot water through a plate heat-exchanger (HEX).

Well THM8, which is on the college grounds, was used for the down hole heat-exchangers system. The well was deepened from 204 to 330m to improve production. The maximum temperature in the deepened well was 140°C. A two hour discharge test established that, with the assistance of air lifting to start, the well would discharge 20t/hr of two phase fluid at 850kJ/kg and 134°C with a well head pressure of 4 barg. Further testing indicated that the minimum sustainable discharge flow was 7.5 t/hr.

The minimum sustainable flow of 7.5 t/hr posed several problems, disposal of this volume of fluid, and control of flow rate independent of the demand from the heating system. The fluid demand for heating the college, at start-up, was estimated at 2.5 t/hr (315kW), reducing to a steady demand of 0.8 t/hr (115kW) during normal operation.

The only viable option for disposal of the fluid was to reinject it into an adjacent well THM5. This was achieved using a helical rotor pump, selected for its low rotational speed, making the use of a simple packed gland possible. The pump was sized for the minimum sustainable flow from the well.

Surface equipment was installed that consisted of

- Piping from THM8 to the HEX.
- A by-pass upstream of the HEX to an atmospheric flash tank.
- Return line from the HEX to the tank
- The reinjection pump off the tank and piping to THM5
- Flow control valve on the by-pass

The pump operated continuously and the control valve maintained the water level in the tank. The flow from the well would always match the capacity of the pump, so the minimum sustainable flow from the well was maintained regardless of the flow to the HEX. (see Figure 4)

The system worked satisfactorily for 10 days, until the WHP declined. Well production ceased at a WHP of 0.8 barg. Further progress has been halted by the lack of a resource consent. The college now again using the gas fired heating system.

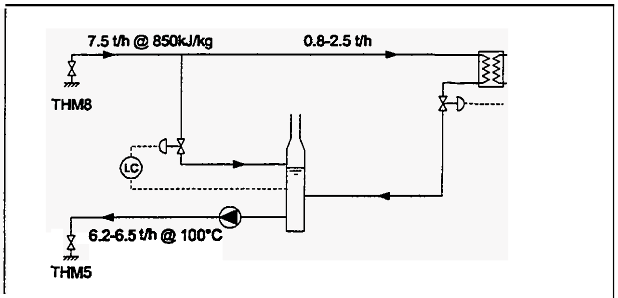

Figure 4 Tauhara College Heating System

5.2 Arthur Crescent.

The Watkins home and others in Arthur Crescent are typical of domestic space and water heating using a low pressure steam well. This property is located close to natural steaming ground. The well is approximately 30m deep and produces a small amount of steam with virtually no wellhead pressure. When there is high atmosphere pressure the well does not produce.

The steam is used for heating hot water, a small swimming pool (14,5001) and under floor heating. The estimated heat load is 5kW. The system layout is shown in Figure 5.

The pool system pumps water from the filter pump through a jacketed section steam pipe. When pool heating is not required the steam by-passes the jacketed section pipe.

The under floor heating uses a circulating pump and another section of jacketed pipe. Floor temperature is manually regulated with a valve on the steam pipe and a jacket by-pass.

The final section of jacketed pipe heats the household hot water. Hot water thermo siphons to the hot water cylinder installed on the first floor.

Each of the above systems uses a section of jacketed pipe as a HEX. The pool HEX is stainless steel and the other two are brass.

Un-condensed steam is vented from a pipe above the roof of the house while the condensate runs back against the steam flow and into the well.

This system requires little maintenance and is unobtrusive. The wellhead pipework and pool HEX are concealed under paving stones and the floor and water heating **HEXs** are within a closet space normally taken up with a conventional hot water cylinder. Obviously this home has no heating bills.

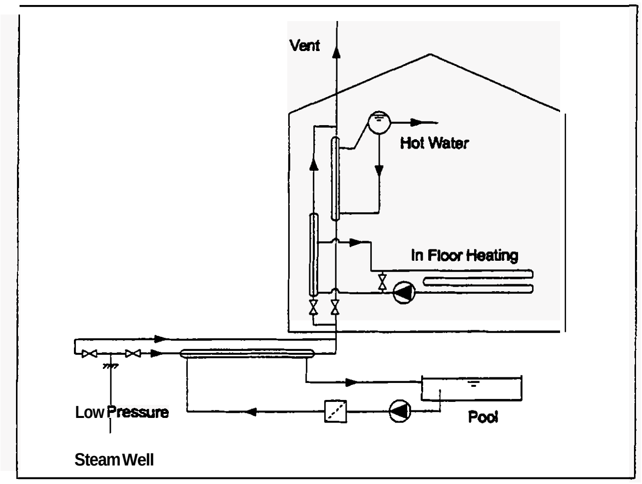

Figure 5 Arthur Crescent

6. DOWNHOLE HEAT EXCHANGER

Figure 6 shows a typical downhole HEX used for domestic space and water heating.

The well may be 50m deep cased 100NB to 18m with downhole temperatures around 80°C.

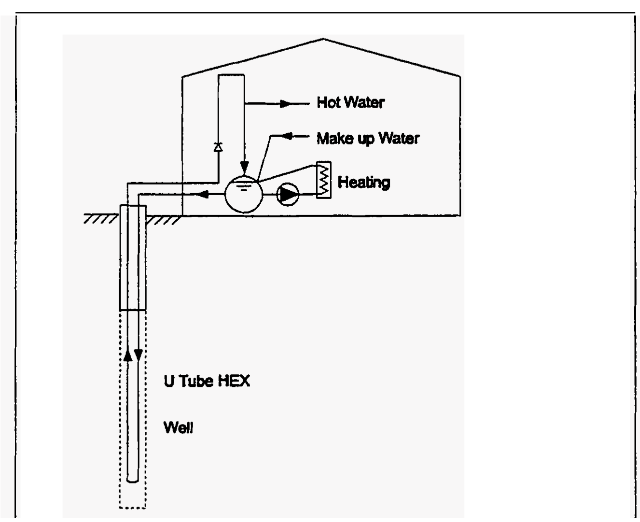

Figure 6 Typical Downhole Heat Exchanger

The example that the diagram was based on uses **20mm** stainless steel tubing for the U tube HEX. A loop in the return piping above the hot water tank assists the system to thermo siphon. A fan unit heater is used for space heating and hot water is drawn directly off the HEX circuit. This system is able to supply all the water heating and about 1/3 of the spacing heating for a large 3 bedroom home.

7. DISCUSSION

The location of a hot water and steam resource under the Taupo township has allowed many residents and businesses to obtain a low cost and reliable energy source.

The engineering of the surface systems has proven to be innovative, practical, reliable and easy to operate and manage.

The abundance or otherwise of the geothermal energy source effects how much effort has been put into making systems efficient. The Native Plant Nursery for example has the use of a high energy well and wastes energy with the low cost steam transport system. The AC baths often has a short fall of hot water and therefore has installed extra piping systems to scavenge hot water and recover more heat.

There are plans for developing industrial and power generation use of the deeper resource. There is the operating Wairakei power station (160MWe) and the soon to be commissioned Poihipi Road station (50MWe) and plans for up to 180MWe on the Tauhara part of the field. Plans have also developed for using the resource for timber treatment and drying, and wood panel board manufacture. The continued development of the geothermal resources at Wairakei and Tauhara will need to be properly co-ordinated to ensure that Taupo residents and businesses continue to benefit from this resource.

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- Michael Watkins, Arthur Crescent
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9. REFERENCES

Curtis, R.J, (1988). Use of the Shallow Hydrothermal Resource at Tauhara Geothermal Field, Taupo. Proceedings 10th New Zealand Geothermal Workshop *1988*, 31-35.