LARGE DOWNHOLE HEAT EXCHANGER IN TURKEY AND OREGON

John W. Lund
Geo-Heat Center

TURKEY

Downhole heat exchangers have been used extensively in Turkey from 1981 to 1990. One of these installations is part of the geothermal district heating system in the city of Balçova near Izmir on the west coast of Turkey. These downhole heat exchangers are some of the largest in the world in terms of energy output. During the period 1981 to 1997, there were 11 DHE installations in Turkey, but now there are only five - two in Simav and three in Balçova. These five sets consist of multiple bundles of pipes in a well (Fig. 1). Typically, two to four sets of reverse bend loops are installed in each well, and these loops are then attached to a common header to supply heat to the building (Fig. 2).

Figure 1. Downhole heat exchanger being removed from a well at Balçova.

Figure 2. Details of header pipe attached to the top of the DHE in Balçova.

The wells in Balçova are 100 m (330 feet) deep and the heat exchanger pipes are about 10 m (33 feet) long (Fig. 3). Since the beginning of 1998, the three DHE in Balçova have the following characteristics:

Well No.	Output	Bottomhole Temp. °C	Cyclic Temp. °C	Flow Velocity in the Loop (m/s)	No. Loops
B-1	1 million kcal/hr 4 million Btu/hr 1.16 MWt (13.8 kg/s -219 gpm)	114 (237°F)	70/50 (158/122°F)	3.5 m/s (11.5 ft/s)	2
B-5	0.56 million kcal/hr 2.2 million Btu/hr 0.65 MWt (7.7 kg/s - 122 gpm)	124 (255°F)	70/50 (158/122°F)	1.9 m/s (6.2 ft/s)	2
B-7	0.40 million kcal/hr 1.6 million Btu/hr 0.46 MWt (5.5 kg/s - 87 gpm)	114 (237°F)	70/50 (158/122°F)	1.4 m/s (4.6 ft/s)	2

The well shown in Figures 1 through 3, had three loops of DHEs and could produce as much as 2 million kcal/hr (8 million Btu/hr) or 2.3 MWt at a flow rate of 2.0 m/s (6.6 ft/s).

Figure 3. **Downhole heat exchanger pipes used for one well at Balçova.**

At Seferhisar, a self flowing well produced 200 ton/hr, but sealed itself due to carbonate scaling in a short time. In order to avoid the scaling, a DHE was installed and tested. With a bleed rate of approximately 5 L/sec (79 gpm), the well produced 5 MWt. The DHE flow rate was adjust to maintain 70 to 80°C (158 to 176°F) water for use in heating greenhouses. The characteristics of the well was as follows (it is no longer being utilized) (Culver, 1990):

Depth:	250 m (820 ft)
Casing:	30 cm to 200 m (11 3/4 inch to 660 ft) 22 cm (8 5/8 inch) open hole to total depth slotted 60 to 200 m (196 to 660 ft)
Bottom Hole Temp:	153°C (307°F)
Shut-In Pressure:	2.5 bars (36 psi)
DHE:	4 loops 5 cm diameter to 187 m (2 inch diameter to 614 ft)

After 1990, other developments in geothermal energy utilization reduced the use of the DHEs. The main reasons were: (1) the availability of downhole pumps for high temperature, (2) the use of chemicals to prevent scaling and corrosion, and (3) based on tests, the output capacity of a DHE is only 1/7 compared to an artesian well or a well with a downhole pump.

OREGON

A model of DHE using multi-tube pipes feeding into a common header was tested in Klamath Falls. The four loops of 2.5-cm (1 inch) diameter pipes were 6.8 meters (22 feet) in length (Figs. 4 and 5) and had a flow volume of 1.7 L/s (27 gpm) through the DHEs. With a 13 L/s (205 gpm) of convection cell circulation, the output was 380 kW. As can be seen from the photographs the multiple tube unit was attached in a circular header which in turn was attached to two 5 cm (2 inch) diameter pipes. The circular header was smaller in diameter than the well casing; thus, it could be lowered in the well to below the upper set of casing perforations and the water line (Culver and Reistad, undated)(Figure 6).

Figure 4. **Details of the multiple loop installation with circular header.**

Figure 5. **Test project using multiple loops being lowered in the well.**

The largest DHE installation in Klamath Falls, supplies space heat and domestic hot water for a middle school. The well is 152 m (500 ft.) deep, 36 cm (14 in.) in diameter with 92°C (198°F) water. Two 5.6-kW (7.5-hp) pumps circulate 33 L/s through a 122-m long, 7.5 cm diameter (3 inch) and two 5-cm diameter (2-inch) DHEs (Fig. 7). The system will provide 1.2 MWt output.

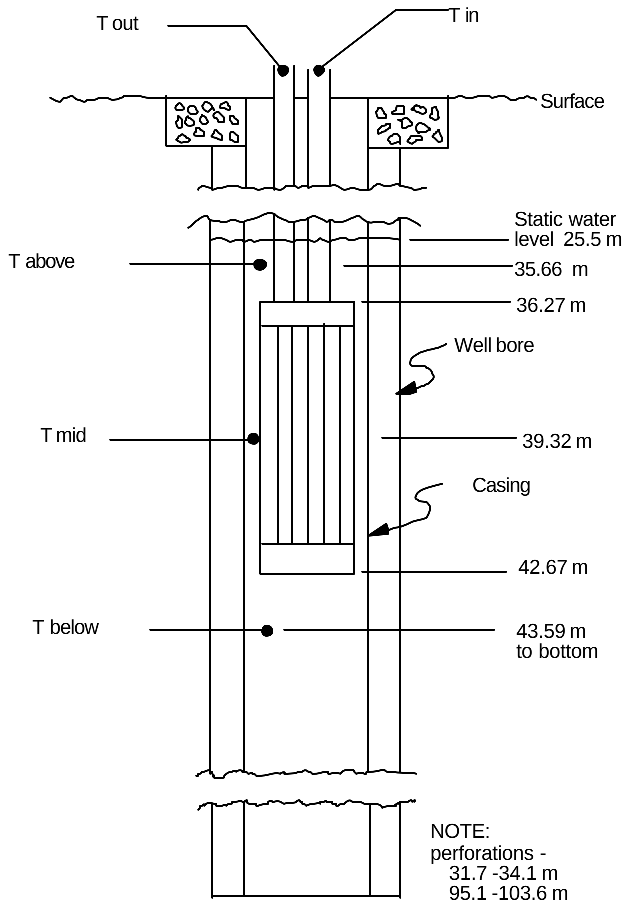

Figure 6. **Diagram of the multi-tube DHE installation in Klamath Falls (T = temperature measuring points).**

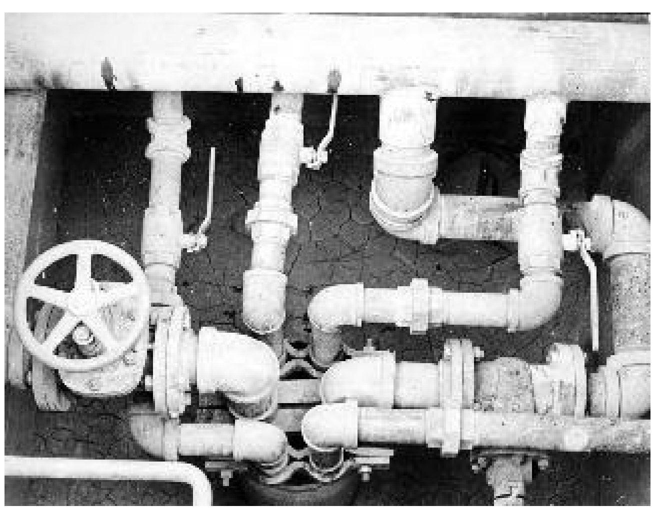

Figure 7. **Ponderosa middle school multiple DHE installation.**

CONCLUSIONS

The multi-tube DHE is more economical to install in shallow wells with high-static water levels; since, it can be installed with lighter equipment and has a high output for its short length, so does not require drilling beyond the hot aquifer when the aquifer is near the surface. The vertical convection in the well must also be high to provide adequate heat transfer to the loops. For energy outputs for large demands, the DHE is normally not adequate and thus, some form of pumping with a surface heat exchanger is necessary.

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