THE GEOTHERMAL HEATING PLANT AT WAREN-PAPENBERG

EXPERIENCE AND MODERNISATION

Frank Kabus[1] and Eckhart Jäntsch[2]

[1] Geothermie Neubrandenburg GmbH, Gerstenstraße 9,17034 Neubrandenburg

[2] Stadtwerke Waren GmbH, Ernst-Alban-Str. 2, 17192 Waren

KEY WORDS

low-temperature resource, direct use, district heating injection, materials selection, process control

ABSTRACT

In 1984 the Geothermal Heating Plant Waren - Papenberg was put into operation after the first drillings had been carried out in 1981.

Since then the research and production plant has been successfully providing heat for about 1,000 flats and social buildings.

Between 1993 - 1995 the plant has been completely modernised within the framework of the THERMIE- Programme of the European Union.

On the one hand this has been done to stop the ongoing wear, on the other hand the experience made during the past ten years of operation was to be used in the modernised plant.

Moreover, the new economic conditions in East Germany of 1993 had to be considered in order to prove the efficiency of the employment of a g e o t h d plant into the heat supplying system.

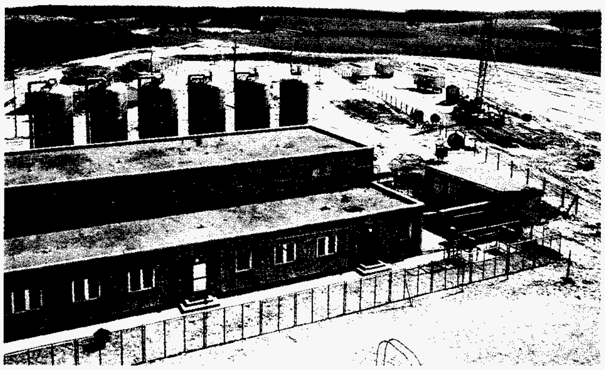

Figure 1 : Geothermal Heating Plant

1. INTRODUCTION

In the early eighties a new housing area with more then 1,000 flats was planned to be built in Waren, a town situated at the lake Müritz in the north east of Germany. Conventionally the heating system could only have been provided with brown coal due to a shortage in gas or oil in the former East Germany. Since pre-tests showed that the use of geothermal resources promised to be successful it was agreed to built a geothermal heating plant.

The plant itself had long been a subject to research. During the operation process various tests concerning especially the reinjection into sedimentary rocks, the choice of material as well as corrosion were carried out. The plant was also used as a test field for the latest special equipment.

Figure 2 : The Supply Area

1. 1. Geological Conditions

Two aquifers fit for exploitation of thermal water are available at the site in **Waren:**

- the Rätkeuper series (Contarta layer)
- Hettang (including Untersinemur).

A further aquifer, the Aalen, offers excellent conditions for injection within a two - aquifer - method

Table 1 : Aquifer Parameters

	Contarta	Hettang	Aalen
Bottom layer of the aquifer	1,566m	1,506m	1,159m
Effective sandstone thickness	24m	30m	30m
Effective porosity	29%	27%	28%
Permeability	2µm	1-2µm	0,5-2µm
Formation temperature	62°C	58°C	46°C
Total salinity	158g/l	149g/l	113g/l
of that mg/l			
Na+	57,825	54,342	41,584
Ca++	2,826	2,786	1,508
Mg++	781	779	623
Cl-	95,705	90,380	68,216
So4--	873	652	648
HCO3	129	116	184
Density	1,108kg/m3	1,099kg/m3	1,076kg/m3
ph - value	5.8		
Productivity index	120	80 - 160	30 - 60

1.3. Well Completion

The **opening** of the geothermal central heating system in **1984** went along with the employment of the two - aquifer - method. **At** the **site** of the plant Rätkeuper was exploited and injected into the **Aalen** within a well distance of 50 **m.** The wells were equipped with screens.

W e up to now no complications have occurred with the exploitation of 50 m^3/h **of thermal** water (the ground water level *sinks* by **20** m) the expectations raised for the injection well could not be fulfilled.

In **1985** a second injection **drilling** had been sunk with a distance of **1,300** m. Unfortunately, the Contorta layers used by the exploitation well did not prove fit for use. Thereupon, the Hettang

was explored **as** a possible horizon for use. Until today the present well arrangement **has** proved very reliable. The injection of **50** m^3/h of thermal water takes place Without the employment of the injection pumps.

1.1. Installations on the Consumers Side

The heat demand of the buildings supplied **amounts** to **250** $kWh/a/m^2$.

The heat is supplied by a double-pipe heating network. House substations **are** installed in every building. They operate with direct feeding and warm water supply by a storage charging system.

maximum heat demand	**5.2 MW**
temperature of the heating network	**65°C / 35°C**

The **heating** network is being operated with variable flow temperature. For customers are **being** supplied with warm water the flow temperature can **only** be reduced to **53°C** at a lowest.

1.5. Geothermal Heating Plant

Figure 1 and 2 show the central heating plant as it **has** been in operation since **1984.** For details of the flow scheme see Figure 3.

The heating network was operated by:

- direct heat transfer
- compression heat pumps
- electric boilers.

2. MODERNISATION OF THE COMPLETE HEATING PLANT

Figure 3 shows the state the plant was in before the modernisation. Figure **4** shows the appropriate energetic realisation. The circuit was adjusted according to the economic conditions in **East** Germany. Neither oil nor *gas* were available. Moreover, **the burning** of **brown** coal far a way **from** the deposits led to extremely **high** costs of transportation and caused serious damage to the environment. Electricity *on* the other hand was relatively cheap **as** long as it was obtained off peak.

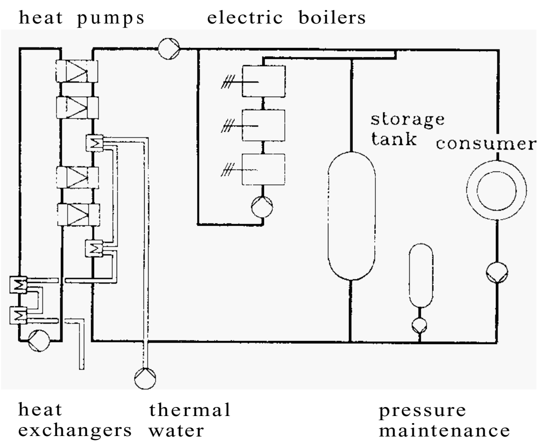

Figure 3 : Flow scheme of the geothermal heating plant before modernisation

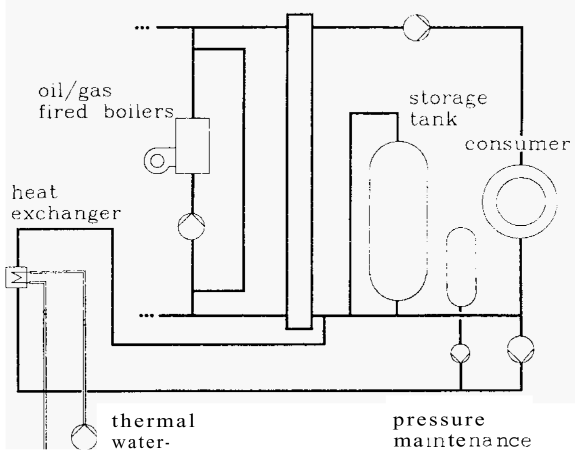

Figure 5 : Flow scheme of the geothermal heating plant after modernisation

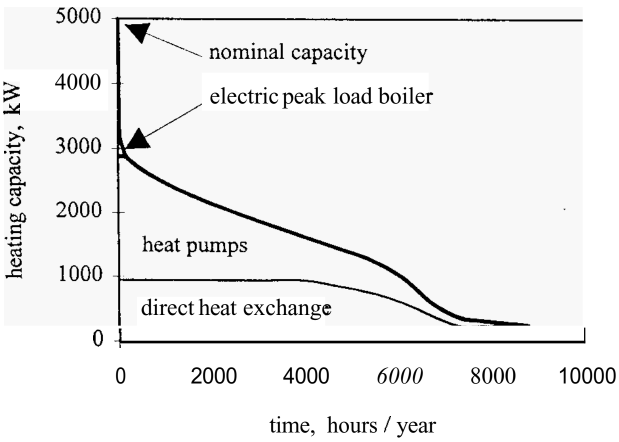

Figure 4 : Scheme of heat production before modernisation

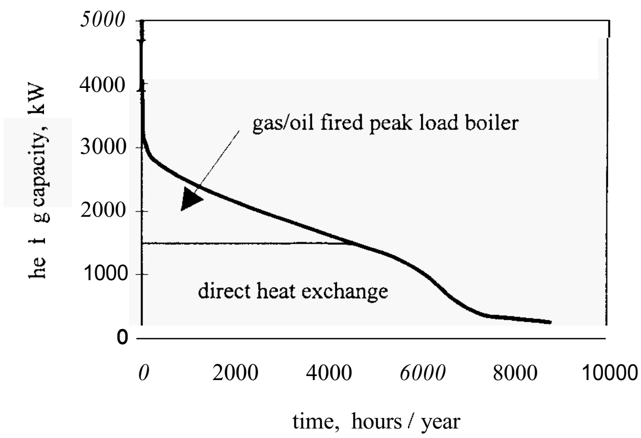

Figure 6 : Scheme of heat production after modemisation

The result was an extensivly dimensioned heat pump with an accordingly low number of full load hours and a storage system of a size of 230 m^3 that was charged by electric boilers at ntght time.

Studies on the profitability under the new economic conditions (ENERATO, 1992; Bachmann, Kabus, 1993) led to a realisation of the plant as it is shown in Figure 5.

The basic load is being covered with geothermal heat by direct heat transfer while the peak hours are covered by a boiler system.

The geothermal capacity could he increased in the modernised system. Firstly, the flow rate of thermal water could be increased to 60 m^3/h and secondly, the return flow temperature of the heating network could be reduced. For this reason the house substations were equipped with a modem control system as well as with efficient heat exchangers.

3. MODERNISATION OF THE THERMAL WATER CIRCUIT

The works at the thermal water circuit were the hear! of the modemisation of the system. The goals of the modemisation were:

- to guarantee the further operation of the system
- to exclude the possibility of the influence on the environment
- to reduce the probability of failure and break down of the system
- to allow the automatic operation of the system
- to improve the energy efficiency

Figure 7 and 8 illustrate the principal way that was to be done.

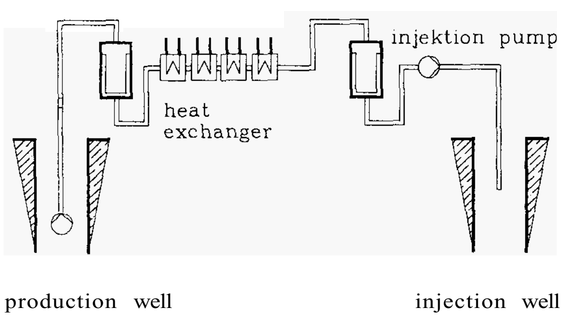

Figure 7: Thermal water circuit before the modemisation

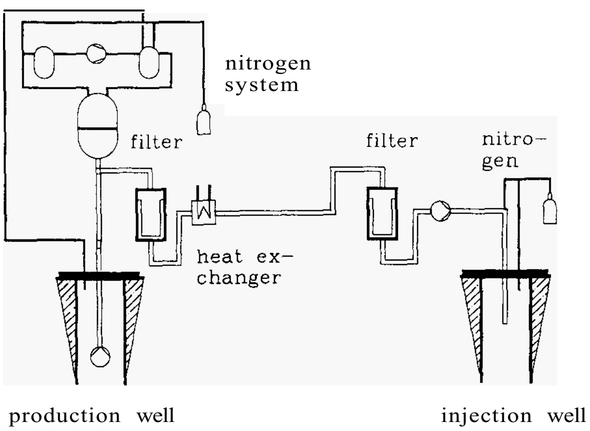

Figure 8: Thermal water circuit after the modemisation

The most important problems which occurred are explained in the following.

3.1. Production Well

The underground part of the system consists of an injection well and a production well which are sank in a distance 1,300 m. The latter is equipped with an underground screen while the injection well is perforated.

Within the modernisation an extensive injection and cleaning programme was carried out. As a result of this the corrosion resistance of the wells was to be improved. This led to the nitrogen-filling of the well heads; and the upper part of the production well was completely covered with plastic.

At the same time the submergible pump was to be sank in order to achieve higher flow rates; also a non-metallic pumping string was to be employed.

While the works at the injection well could be carried out to full satisfaction the works at the production well caused serious problems which could not be solved. Those parts of the well that came into contact with oxygen and were wet due to the deviation of the thermal water level were badly effected by corrosion. The corrosion products not only led to formation of tamps m the production pipes but also effected the screen.

Evaluation of the processes led to the decision to cany out a second production drilling close to the previous one that was also directed to the same aquifer.

3.2. Installation above the Surface

The aim of the modemisation was to develop a system of thermal water exploitation under vacuum conditions. The system was to serve the following purposes:

- the control of the pressure surges
- the compensation of the volume changes during the cooling down phase of the

  thermal water
- to guarantee over pressure in case the system comes to a tand still
- storage of thermal water in order to balance the flow into the wells during the shut down of the system

The system prevents the formation of solid particles to the highest possible degree. Moreover, what is most important it does not change the quality of the water. Thus, the water can be used as curative thermal water as it is planned with forthcoming projects.

While the pipelines to the tank are constructed as high pressure resistant steel pipelines and equipped with a special rubber coating further pipes can be made of polypropylene respectively fibre glass when laid underground. The heat exchanger was equipped with titanium plates.

The analysis of the storage rocks, the chemical analysis of the thermal water as well as the analysis of the of the processes during the injection of thermal water into the sandstone showed that particles of a size of less than 3μm diameter are relatively harmless as concerns the tamp of pore spaces.

The filtration method used up to now did not allow a selective separation of certain particle sizes as shown in Figure 9.

The cartridge filters which work according to the principles of surface filtration have been replaced by bag filters with coupled surface and deep filtration. The two-stage-method has proved very reliable no matter which filtration method had been used.

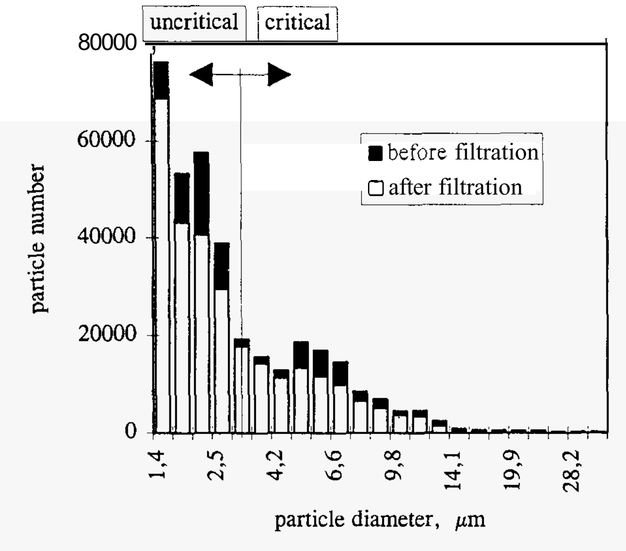

Figure 9: Efficiency of the filtration method used up to now.

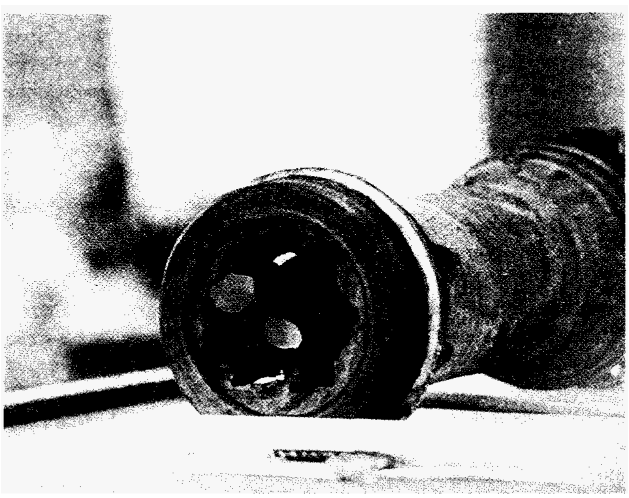

Figure 10: Component of the submergible pump of the plant in Waren after several years of operation.

3.3. Automation of the Plant

A modern DDC system has been installed with the following parts integrated into it.

- Process monitoring of submergible pumps (Harzfeld, 1992)

Because of the high complexity and the dynamics of the operating influences conventional methods for monitoring submergible pumps fall in the case of cavitation and bearing wear.

Figure 10 shows the effects such processes can have. The problems can be controlled by a new diagnosis procedure which contains elements of fuzzy logic and is based on the well proved vibration analysis. The application of pattern recognition for classification of large amounts of sensor information into 'normal' or 'dangerous' working conditions allows to influence the operation of the pump. Thus, the life span of the pump can be extended.

- Leakage detection system (Häusler, et. al, 1992)

The leakage detection system is based on the classic principles of dynamic balance. For this reason volume streams and / or pressures have to be recognised at the input and the output of the thermal water. Leaks bigger than 2% can easily be detected as the negative balance of the incoming and outgoing Row rates without extensive signal processing as long as the flow meters operate with the appropriate exactness. The relative error of the instruments is reached by leaks smaller than 1%. An identification function has been found by developing a suitable model which is able to detect smaller leaks. At the same time this model can be used at any location on the plant. The mathematic model describes both the hydraulic behaviour of the system and the behaviour of the sensors.

4. CONCLUSION

The further operation of the plant in Waren could be guaranteed by the modemisation. Research on the long term behaviour of mesozoic aquifers used for geothermal purposes can be continued out at a plant that has been in operation for many years. The experience made will flow into the planning and building of similar plants and enrich the basic knowledge on geothermal energy production.

ACKNOWLEDGEMENT

The modemisation described above is being supported by the Commission of the European Communities within the framework of a THERMIE-programme as well as by the Federal Ministry of Economics of Germany and the Ministry of Economics of Mecklenburg-Vorpommern.

REFERENCES

Bachmann,I.,Kabus,F.(1993). *Wirtschaftlichkeitsberechnung und Unternehmensplanung der geothermischen Wärmeversorgung.* Report (unpubl.) for the Stadtwerke Waren GmbH, 50 pp.

ENERATIO (1992). *Energiewirtschuftliche Untersuchung zur zukünftigen Wärmeversorgung des Versorgungsgebietes Waren-Papenberg.* Report (unpubl.) for the Stadtwerke Waren GmbH, 20 pp.

Harzfeld,E. (1 992). *Prozeß- und Zustandsüberwachung von Geothermie-Untenermotorpumpen - Ein Beitrag zur Früherkennung von Kavitation und Lagerverschleiß.* Doctor thesis, Technische Hochschule Zittau, 153 pp.

Häusler,F.,Rösel,G.-S. (1993). *Leckortungssystem für die Geothermieanlage Wuren-Papenberg.* Fraunhofer-Institut für Informations- und Datenverarbeitung (FhG-IITB), Report (unpubl.) for Geothermic Neubrandenburg GmbH, 18 pp.

Riedle,K. (1973). Die Technik der Mineralwasserförderung und Lagerung unter Luftabschluß bei Erhaltung der natürlichen Beschaffenheit. *Gesundheitsingenieur,* Vol. *94*(1), pp. 8-18.