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Evaluation of low temperature geothermal energy through the use of heat pump

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Abstract

A water-to-water geothermal heat pump (GHP) running on R-22 was designed to evaluate disposed geothermal water from geothermal health resort centres in Erzurum. The GHP uses geothermal water at 35°C temperature and provides clean water at 45°C for a floor heating network. The GHP heating capacity was around 7.2 kW, and an electric driven hermetic R-22 compressor was used. The overall coefficient of performance was determined as 2.8. © 2000 Elsevier Science Ltd. All rights reserved.

Keywords: Geothermal; Heat; Pump; R-22

1. Introduction

Despite Turkey having very rich geothermal resources corresponding to 350 MW electrical power or 2000 MW thermal energy, evaluation of the resources is poor. There is only one electrical power plant (20.4 MW) using geothermal energy and a few direct use district heating applications across the country [1]. For direct use of geothermal energy in space heating applications, the well temperature should be higher than 80°C. The temperature gradient of geothermal water will vary by location, however, some reasonable predictions of well temperature versus well depth can be made using the formula given by Niess [2].

$$T = 12.8 + 27.4(Z),$$

where T and Z stand for temperature in °C and depth in km, respectively. From this correlation, it can be concluded that for obtaining geothermal water at 80°C or higher, deeper wells are required.

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Nomenclature

η	efficiency
ω	rotational speed (rad/s)
COP	coefficient of performance
c_p	specific heat at constant pressure (kJ/kg K)
h	specific enthalpy (kJ/kg)
I	current (A)
m	mass flow rate (kg/s)
P	power (kW)
Q	Heat rate (kW)
T	temperature (°C)
v	specific volume (m^3/kg)
V	volt
V_d	compressor displacement volume (m^3)
W	work (kW)

Subscripts

r	refrigerant
cd	condenser
ev	evaporator
w	water
i	inlet
o	outlet
cm	compressor
s	suction
v	volumetric

For instance, to provide hot water at 80°C, the indicated well depth would be over 2400 m. The cost of drilling wells to these depths could be prohibitive, considering the present cost of conventional energy sources. On the other hand, according to the Turkish Mineral Research and Exploration Foundation (MTA), there are more than 70 drilled wells, varying over 100–750 m depths, with 1–300 l/s flow rates and 30–50°C temperatures. There are also more than 170 hot springs at 30–50°C temperature range across the country [1]. Most of the wells, even at high temperature, are used as health resort centres, and the geothermal water after the baths is discharged to the environment. For instance, there are three wells below 45°C temperature around Erzurum city, where Ataturk University is located. In the *Pasinler* location, there are two wells at 42°C temperature, 200 m depth and 75–95 l/s flow rates. Another well is available in the *Ilıca* location at 39°C and 605 m depth. The wells are used only for health care, and the temperature of the discharged geothermal water is around 30–35°C. This is a very appropriate source temperature for a heat pump. There are many BTUs that can still be extracted from the disposed geothermal water via a heat pump. The basic principles underlying heat pump technology have been