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Analysis of Geothermal Storage of Water

R. K. Pal

Panjab University SSG Regional Centre, Department of Mechanical Engineering Hoshiarpur, Punjab, India

ravinder_75@yahoo.com

Abstract

Steady increase in the prices of fossil fuels and electricity has resulted in more and more use of alternate energy sources. Geothermal energy is one such option which can be used for heating and cooling of water. The present work was to see the usability of geothermal energy for cooling and heating of water. The geothermal system of cooling and heating water is very efficient. The energy saving for heating in winter season is 1569 kWh and that for cooling in summer season is 687 kWh. The corresponding savings in terms of value are Rs. 7841 for heating and Rs. 3433 for cooling for winter and summer seasons respectively. Savings are more in winter season than in summer season.

Keywords: Geothermal energy, cooling/heating load, energy, underground tank.

Introduction

Steady escalation in the cost of electricity and conventional fuels is leading the world to search for renewable forms of energy. Geothermal energy is one option which can be used for heating or cooling of water. Geothermal energy comes from the heat inside the earth retained since the formation of the planet, from solar radiations absorbed at the surface and from radioactive decay of the minerals. Ground temperature remains nearly constant from 10°C to 16°C below a depth of 6 ft. [1]. Daily and annual temperature variations have their effect up to a depth of 1, 20 m respectively [2, 3]. This fact can be used for geothermal heating or cooling of water. Underground storage tank can be used to keep the water at reasonable temperature. About 270 PJ of geothermal energy was utilized for direct heating by around seventy countries in 2004 [4]. Only a fraction of the electricity generation in the United States comes from geothermal energy and projections tells that it will increase marginally by 2035 [5]. Thermal efficiency of geothermal heating or cooling systems is high since no conversion of energy is needed. Paybacks period is two to less than five years. Low emissions lead to minimum greenhouse warming effect. Knowledge of heat transfer, the geology of the place and availability of space are some of the factors required for the design of geothermal cooling system [6]. Geothermal system can be used to cool buildings very successfully with savings of around 692 units of electricity and in terms of value around Rs. 3742 per month [7]. In India and especially in Punjab Summers are very hot and winters are very cold.

Therefore cooling and heating of water is a necessity in summers and winters respectively. The minimum temperature of rooftop tank water in winters is around 6°C and maximum temperature of water in summers is 48°C. The present work is to analyze the geothermal cooling and heating unit for a house situated in Punjab and to estimate the savings in terms of energy and value. Per capita water consumption was taken 40 liters/day from literature available [8]. The various other parameters like temperature of water in summers & winters, flow rate of water, volume of storage tank, savings in terms of energy and savings in terms of value were measured or computed.

Geothermal Storage Systems

The schematic sketch of the geothermal storage system for a house is shown in Fig.1. It comprises of GI pipes, small rooftop storage tank, underground storage tank, and hydraulic pump. The geothermal system exchanges heat with the earth through an underground heat exchanger made of GI sheets. The properties of the material used and the working fluid are given in Table 1.

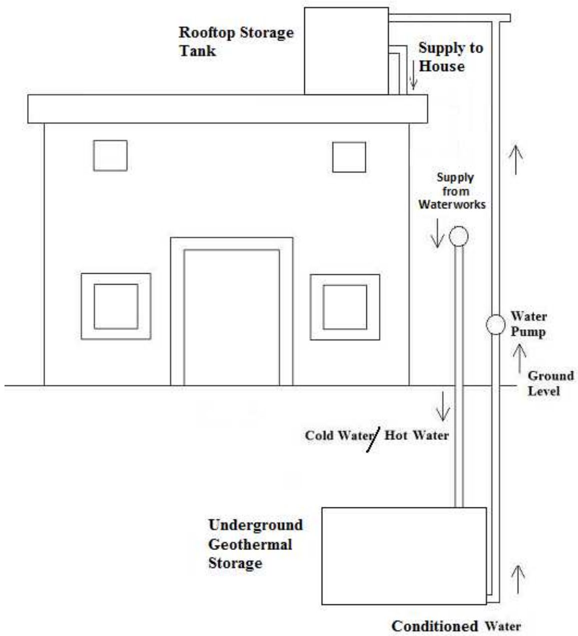

Fig. 1. Schematics of Geothermal Water Storage System

Table 1. Material and working fluid properties

Material of pipe	GI
Internal diameter of pipe (in)	1
Thermal conductivity of pipe (W/m-k)	75.31
Specific heat of water (MJ/m^{3}K)	4.1813
Density of water (kg/m^3)	1000

Methodology

As discussed earlier the water temperature in winters is as low as 6°C and in summers as high as 48°C in Punjab. So the water for normal use has to be brought to a normal temperature of 28°C (Groundwater temperature) by heating in winters and by cooling in summers. It can be done by using geothermal system shown in fig. 1. Water from the waterworks can be stored in a tank kept underground at a moderate temperature and can be used later on with the help of a small pump and a secondary small tank at the rooftop for uniform supply. The heating or cooling will be done with the help of geothermal heat of earth. In winter the earth will provide heat and in summer heat will be lost to the earth. The formulae for calculating various parameters are given below: -

Heat to be removed (Q) = $m_w*c_{pw}*(T_c- T_w)/\varepsilon_g$ kJ/s

Darcy friction factor (f) $1/\sqrt{f} = -1.8 \log10 ((\varepsilon/D)/3.7)1.1 + 6.9/Re$

Head loss due to friction (h_f) = $f * L * V^2/ (D*2g)$ m

Head (h) = $p_w/ (\rho_w*g) + V^2/2g+Z+ hf$ m

Power input (P) = $Qw*\rho w*g*h/ (3.6*106*\eta_{pump})$ kW

Electric energy input/day (E) = P * n kWh

Results and Discussions

Geothermal storage system consumes less energy as compared electric geyser in winters and as compared to vapour compression system for cooling water in summers (Fig. 2.) because the pump is used only for pumping and cooling & heating is done with the geothermal heat of the earth; 3 m deep storage tank below ground where the seasonal variations go[8] is sufficient to transfer the heat to the ground for all months. Geothermal cooling system is very efficient and economical method as compared to geyser or vapour compression system of cooling the water. Savings both in terms of energy and value are more in case of winters as compared to summers (Fig.3, Fig. 4) because of more COP in case of vapour compression cooling unit. Cumulative savings in terms of energy are 1569 kWh and 687 kWh (Fig. 5) for winters and summers respectively and in terms of value are Rs. 7841 and Rs. 3433 (Fig. 6).

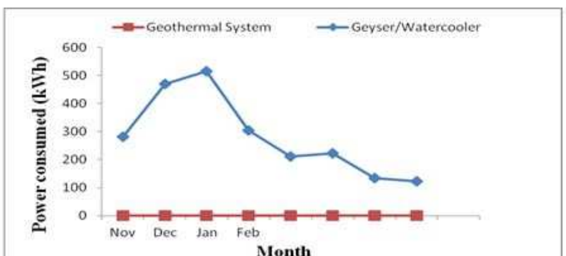

Fig. 2 Monthwise electricity consumption

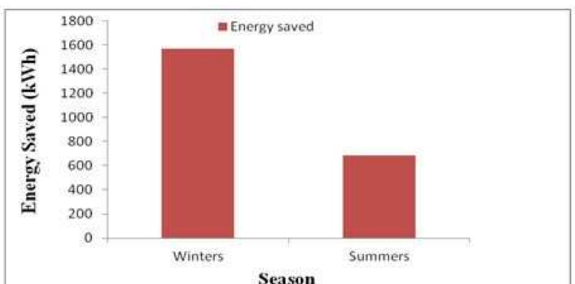

Fig. 3 Seasonwise energy saved

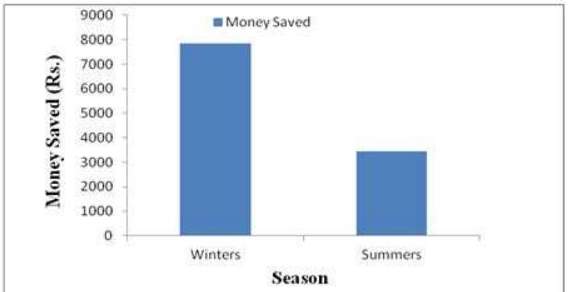

Fig. 4 Seasonwise money saved

Conclusions

Geothermal system of water cooling & heating is very efficient and economical technique. More savings can be obtained in winter season than in summer season. The energy saving for heating in winter season is 1569 kWh and that for cooling in summer season is 687 kWh. The corresponding savings in terms of value are Rs. 7841 for heating and Rs. 3433 for cooling for winter and summer seasons respectively.

Abbreviations

C_{pw} = Specific heat of water
T_c = Temperature of the fresh groundwater
T_w = Temperature of the water to be conditioned
ε_g = Heat exchanger efficiency in the ground
ε/D = Relative roughness
D = Internal diameter of the pipe
Re = Reynolds number
L = Length of the pipe
V = Velocity of water
ρ_w = Density of water
p_w = Pressure of water
Z = Datum head.
η_{pump} = Pump efficiency
n = Number of hours.

References

[1] Singh Jaswinder, "Experimental Evaluation of Heat Loss Characteristics of Buried Pipes of Geothermal Air Cooler", Proceedings first national conference on advances in Mech. Engg, 20-21, May UIET, Panjab University, Chandigarh, pp 359-362, 2011.
[2] Joss, G., "Theoretical Physics", Blakie and Sons, London, pp 748, 1934.
[3] Lettau, H., "Theory of surface temperature and heat-transfer oscillations near level ground surface", Eos 32 (2), 189–200, 1951.
[4] Fridleifsson, I.B., R. Bertani, E. Huenges, J. W. Lund, A. Ragnarsson, and L. Rybach, O. Hohmeyer and T. Trittin, ed., "The possible role and contribution of geothermal energy to the mitigation of climate change", IPCC scoping meeting on renewable energy sources, proceedings, Luebeck, Germany, pp. 59–80, 2008.
[5] Anon., "Annual Energy Outlook 2010 with projections to 2035", EIA (Energy Information Administration), Fig. 65, pp 68, 2010.
[6] Scanner B., Reuss M., "Design of closed loop heat exchangers", International summer school on direct application of geothermal energy, Energy, pp.147-156, 2000.
[7] R.K. Pal, "Analysis of Geothermal Cooling System For Buildings", Journal Of Engineering Sciences & Research Technology, http:// www.ijesrt.com, ISSN: 2277, 1(10): pp 569-572, 2012.
[8] Anon., 'Technical Manual" Punjab Rural Water Supply & Sanitation Programme (World Bank Assisted), Department of Water Supply & Sanitation, Govt. of Punjab, India. pp 4-5, 2006.