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GEOTHERMAL ENERGY APPLICATIONS AND CONVERSIONS

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ABSTRACT

Geothermal energy is a renewable and clean energy which is extracted heat from the earth's core. It is present in affluent amount in the earth's core and it can meet the energy requirement of the human being. The geothermal energy can be directly used for the heating and cooling of house in winter and summer respectively. The flooded mine water is a good source of geothermal energy. House heating using geothermal energy is efficient and economical. It can be used low annual average temperature. This paper reviews the application of geothermal energy in different systems. This paper also deals with the forms in which geothermal energy can directly be used and it can be converted in to electrical energy.

KEY WORDS: Geothermal energy, Flooded mine water, House heating, Electricity

INTRODUCTION

Geothermal energy, defined as heat from the Earth's core which is a renewable and clean source of energy. It is flexible and present in enormous amount. Geothermal energy can meet the energy requirement of human being all around the world. It has wide application in geothermal heat pumps that transfer heat to or from the ground and are the most energy efficient means of heating and cooling buildings. Due to this reason, geothermal heat pumps have been gaining more attention.

The mine water is generally considered as a waste water, therefore, the recyclable use of this water for transferring geothermal energy is sustainable. The mine water goes in the deeper locations of the Earth, where there is higher temperature as compared to the Earth surface. The volume of the mine water is generally very large as compared to the water flowing through pipes or present in soil pores. It provides better heat transfer (directly between the mine water and surrounding

The geothermal energy increases with increasing depth of the earth. For a depth of 3km, the total stored energy of known fields is around 8×10^{21} J and whereas for a depth of 10 km the total stored energy is about 4×10^{22} J. The energy present in hot spring is about 10% of the above quantities. If the energy present in the earth's core is extracted from a 3 km depth with 1% thermal energy recovery factor at a uniform rate of over a period of 50 years, thermal power of 50 GW is obtained whereas based on a 10 km depth an electric power of 50 KW is predicted. The U.S.A. has 5-10% geothermal fields and India has much less.

LITERATURE REVIEW

Ting Bao, et-al. (2019),[1] studied the recovery of geothermal energy from deep flooded mines for house heating. It also explains the advantages of extraction of the geothermal energy from flooded mines and provides a possibly practical high-tech way for recycling these flooded mines. This demonstration project has been running since 2009 to provide heating to a 15,000ft^2 (1394m^2) building. The heat pump system efficiency, installation cost, and water temperature stability are assessed. 380 million tons of copper ores were mined. copper mines are often deeper than other types of mine shafts in the U.S. It was estimated that about 43 million tons of copper ores, it has been mined from the Quincy mine. There were about 3 million tons of waste rocks (rock without copper) extracted from the mine. Most of the rocks are extracted on the ground surface in "poor rock piles" or hauled away for road constructions in the region. The above mined ores and rocks result in a potential underground mined volume of 1.55×107m^3. After the closure of the mine, groundwater started to fill its underground mining spaces. To date, the water level is stabilized on the 7th level, therefore, about 95% of under ground mining spaces of the mine is filled with water, leading to a great amount of mine water (around 1.47×107m3) stored in the mine.

E.Ura-Bińczyk, et-al (2018),[2] presented on-site monitoring and laboratory characterization of corrosion processes in the geo thermal water of Polish Lowland. The survey spectra and high resolution spectra were obtained by applying 150 and 40eV pass energy (the maximum energy resolution is 0.83eV). The XPS signal intensity was obtained using a linear or Shirley background subtraction method. The peaks were fixed using an asymmetric Gaussian/ Lorentzian mixed function. Binding energy, chemical states and percentage share of sulphur and carbon compounds was detected using XPS in the deposits collected at the geothermal plant in Pyrzyce. The chemical results reveal that the smooth part is probably a scale of iron oxide while, the more developed surface contains locally more carbon and Sulphur. It indicates that in this area the microbiological corrosion may occur.

A. Babaa, et-al (2019),[3] determined geological, tectonic and hydro geochemical properties of a geothermal system in the GAP region. The result showed that the surface temperatures of geothermal fluidsare from 20 to 84.5°C has a large number of abandoned oil wells, whose temperature reaches 140°C. Also, hydro geochemical results indicated that deep circulated geothermal fluids are enriched with Na-Cl and shallow geothermal system fluids have Na−HCO3 and Ca-SO4 characters because of cold water mixing and water-rock interaction. Cold waters are generally of Ca-Mg−HCO3 and Ca−HCO3 type. Cation geo-thermometers were employed to determine reservoir temperature of the geothermal resources in the region. They found that the reservoir temperature of these geothermal resources ranges from 50°C to 200°C.

Le Zhang, et-al. (2019),[4] presents the easy assessment way to estimate recoverable geothermal energy. Based on their previous hydrothermal heating projects in northern and eastern China, they concluded that the main formation for direct heating is Guantao formation. It is sandstone with nearly identical permeability and porosity. The highest temperature difference in the development is less than 9°C and it can be calculated by the temperature gradient. So the reservoir temperature can be obtained directly as the temperature in the middle of reservoir. The results indicate that the effect of heat from the underlying rock can be neglected on the temperature distribution under common flow rates in the heating projects. The assessment method based on above assumptions full fills the assessment requirement for irrecoverable geothermal resources for China's traditional hydro thermal heating project. They found this method unsuitable for calculating geothermal fluid exploitable reserve under reinjection conditions.

Hossein Yousefi, et-al (2019),[5] studied the importance of providing sustainable urban energy without the requirement of fossil fuels, and investigated the efficiency of geothermal systems. The study was done with reference to the importance of well head pressure. Four scenarios have been considered based on the geothermal flashing cycle and the use of direct geothermal applications. The first and the second scenarios are focused on electricity production in single and double flash geothermal system, while the third and fourth ones consider direct uses besides electricity production. The current design of the geothermal power plant does not include direct possible uses of geothermal energy. The efficiency of a double-flash condensing power plant (2nd scenario) is reported equal to 36.3% and is better than single-flash counterpart. Considering the pollution reduction made by a geothermal power plant, it can save 635,943 or 2′373,939 dollars each year by launching scenario 2 or 4.

Chao Zhang et al. [6] (2019) presented enhanced Geothermal System (EGS) approach to entrap heat from deep hot dry rock (HDR) which is a low-carbon renewable energy source. The Qiabuqia geothermal area, located in the northeastern margin of the Gonghe basin, Tibetan Plateau, is one of the areas that have the greatest HDR geothermal resources exploration and development potential in China has been considered for the study. Based on the geological data of the GR1 borehole at the Qiabuqia geothermal area, north east Tibetan plateau, a 3D thermo-hydraulic coupled numerical model is presented using finite element to assess the heat production potential. The mathematical model applied was validated by the analytical solution of a single fracture model. By varying several key reservoir parameters such as thermal conductivity, permeability, porosity, injection mass flow rate, injection fluid temperature, and lateral well spacing. The simulation results showed that in the basal granitic reservoir with a depth of 2900me3400m and a corresponding initial temperature of 160^0C -180^0C, the temperature produced and effective electric power can maintain at 173.4C and 2.48MW for the first 7 years of simulation under the combination of 50kg/s of injection flow rate, 60C of the injection fluid temperature and a 300m of lateral well spacing.

Vinay Kakkar, et-al (2012),[7], used a 3D thermo-hydraulic coupled numerical model with using finite element method to assess the heat production potential. The mathematical model considered was validated by the analytical solution of a single fracture model. By varying several key reservoir parameters such as thermal conductivity, permeability, porosity, injection mass flow rate, injection fluid temperature, and lateral well spacing; the sensitivity analysis of the long-term production temperature and electric power rate evolution was carried out. The simulation results confirmed that in the basal granitic reservoir with a depth of 2900 m - 3400 m and a corresponding initial temperature of 160^0C-180^0C, the temperature produced and effective electric power can maintain at 173.4^0C and 2.48MW for the first 7 years with 50kg/s of injection flow rate, 60^0C of the injection fluid temperature and a 300m of lateral well spacing.

Chandrasekharam, D and Varun Chandrasekhar (2015), [8] presented the data on the geothermal waters from Bihar, Jharkhand and west Bengal. These locations were selected due to the reason that the thermal gases in these sites are highly enriched in helium and the concentration varies from 1 to 3%. Since 80% of the electricity generated is spent for space cooling, a large amount of CO_2 can be saved using ground source heat pumps (GHP) and thus electricity saved can be supplied to rural population. They found that up to this date the geothermal heat is being utilized for bathing, and in certain cases as a source of energy for cooking. Total annually usage of geothermal energy for bathing, swimming and balneology has increased to 4,302 TJ from 2,545 TJ between the years 2010-2014.

M. Abdel Zaher a, et-al, (2018),[9] carried out investigation with an aim to develop a geothermal favourability map of Egypt, which may be considered as a screening tool for the assessment of optimal areas for geothermal development. Digital data layers and maps were used with GIS model to select the most promising areas for geothermal potentiality. The Arc GIS model consists of six thematic layers: distance to faults, Bougueranomaly, distance to seismic activity, Curie depth, heat flow, and temperatures at different depths. The validation of the generated geothermal favourability map was done by a comparison with thermal water wells and hot springs. The results showed that the most encouraging zones for geothermal probability in Egypt are located near the shore lines of the Gulf of Suez and the Red Sea.

Hafeza A, et-al (2018),[10] discussed the application of geothermal energy in our electrical power systems. This study emphasizes the resource in conjunction with the ways in which geothermal energy is converted into electrical energy. They also reviewed a few geothermal projects in world. Finally a comparative review of renewable energy sources is presented. They proposed several recommendations that can be performed to enhance renewable energy development. Firstly, Analyze widely about the potential of other renewable energy such as hydro, geothermal and etc. so that there will be a lot of data and information would be gathered for the future used. Finally, latest policies and funding mechanisms will be required to sustain and promote renewable energy investment.

C. Benighausa, A. Bleicherb (2019) [11] discussed different responses to innovative geothermal energy technologies at the local level. The study was carried out with assumption that these responses are rendered visible through different framings of the technology. The case study was conducted four focus groups in two German communities with a total of 27 participants. The case study results reveals that diversity of local understandings of geothermal energy, which differ within and between communities. The analysis identified arguments related to geothermal energy that were discussed in the focus groups. These arguments cover aspects such as the possible contribution of geothermal energy to the supply of renewable energy, its potential to provide base load energy, and its benefits for regional development and the environment. Their arguments concerned potential damage to buildings due to uplift, subsidence or seismic events, and groundwater pollution caused by radioactive elements, as well as the fact that the technology is new and still requires further development.

Tugberk Hakan Cetina, et-al, (2019),[12], presented the study on thermodynamic assessment of a cryogenic energy storage unit integrated to a single-flash geothermal power plant is performed and the effect of geothermal source temperature on the system performance is investigated using a resource that can supply geothermal water at 180°C at a rate of 100kg/s is considered. Power generated from the geothermal plant during off-peak hours is used to produce and store liquefied air. The results showed that the liquefaction unit consumes 4304kW power in order to liquefy air for a 6-h charging period. In the discharge mode, the CES unit can produce a net power output of 12,049kW for a 1-h operation. The flashing pressure is optimized at 255kPa for which the total power output is 16,100kW. The round-trip efficiency of the CES unit is determined to be

46.7% while the overall efficiency of the integrated system is 24%.

Guodong Cui, et-al, (2017), [13] presented a comprehensive numerical simulation model which can consider formation water evaporation, salt precipitation, CO_2-water-rock geochemical reactions, and the changes in reservoir porosity and permeability in the CO_2 plume geothermal (CPG) system. Using this model, the geochemical reactions and salt precipitation and their effects on the geothermal exploitation were analyzed, and some measures were proposed to reduce the influence of fluid-rock interactions on the heat mining rate. The simulation results show that the gravity and the negative gas-liquid capillary pressure gradient induced by evaporation can cause the formation water to flow toward the injector. The back flow of the formation water results in salt precipitation accumulation in the injection well region, which can cause severe reservoir damage and consequent reductions to the heat mining rate. The CO_2-water-rock geochemical reactions could result in the dissolution of certain minerals and precipitation of others, but its minimal influence on the heat mining rate can be ignored. However, salt precipitation can affect the geochemical reactions by influencing the CO_2 flow and distribution, which can reduce the heat mining rate up to 2/5 of the original. Sensitivity studies showed that the reservoir condition can affect the salt precipitation and heat mining rate, so a sedimentary reservoir with high temperature, high porosity and permeability, and low salinity should be selected for CPG application, with an appropriately high injection-production pressure difference. The injection of low salinity water before CO_2 injection and the combined injection of CO_2 and water vapor can be applied to reduce the salt precipitation and increase the heat mining rate in the CPG system.

R.Delhaye, et-al, (2019), [14] selected the magneto telluric (MT) method as the investigative geophysical tool as it is capable of sensing and defining electrically conductive porous sediments beneath over lying resistive strata, in this case flood basalt sequences. MT data were acquired on a rectangular grid of 39 sites across almost half of the onshore basin to investigate the composition and spatial variation of the basin's formations. Based upon new, high quality temperature data available in the Ball in lea 1 borehole, an approximate estimation of thermal energy in place as a function of final reservoir temperature has been performed for the interpreted MT resistivity model volume. A final minimum temperature of 25°C (being the temperature that comparable estimates have been made for adjacent geothermal prospects) results in a minimum estimated Indicated Geothermal Reserve (IGR) of 2.9×10^{18}J beneath the MT survey area. The modeling results suggest that exploitation of the maximum volume of sediments would occur for a final temperature of ≈55°C.

W.F. He, et-al, (2018),[15] presented a novel combined system, integrated with a flashing Ranking cycle and humidification de-humidification (HDH) desalination unit, is proposed to achieve the energy utilization from geothermal water. The flashed steam is used to generate power while the remaining water is applied to heat the seawater for water production. Based on the coupling relation between the power and desalination unit, conservation equations based on the thermodynamic laws are constituted. Energy and entropy analysis of the combined system are achieved for determining the power and water production. Furthermore, the influence principles from the spraying temperature and terminal temperature difference of the seawater heater on the overall performance of the combined system are also focused. The simulation results indicate that the maximal net power from the flashing Rankine cycle reaches

157.0kW when the flashing temperature is 375.15K. Due to the leading role to determine total efficiency of the combined system, maximum values of 711.85kgh−1 for the water production and 43.98% for the total efficiency are obtained when the flashing temperature is 378.15K.

Conclusion

From the review conducted, geothermal power plant technology and direct use applications are alternatives for decreasing worldwide fossil-fuel dependence and its environmental impacts. The world geothermal resource assessment estimated a lower limit of geothermal potential for electricity generation at 1.5 TW. It also suggests that approximately 68% of the total geothermal resources are temperatures lower than 130°C. Thus, Binary – Organic Ranking Cycle Power Plants might play a vital role in the exploitation of low temperature geothermal resources. On the other hand, direct applications of geothermal heat present good opportunities for increasing the revenue of a geothermal project. Depending of the geographic zone, multiple direct uses can be achieved. Cascade configurations contributes to maximise the use of geo-heat contributing to increase the standard of living of the communities around the geothermal resource.

REFRENCES

[1.]Ting Baoa, Jay Meldrumb, Christopher Greenb, Stanley Vittonc, Zhen Liud and Kelsey Birde, “Geothermal energy recovery from deep flooded copper mines for heating,” Energy Conversion and Management, vol. 183, pp. 604-616,2019.

[2.]E.Ura-Bińczyka,J.Banaśb, B.Mazurkiewiczb, W.Solarskib, M.Lewandowskaa, A.Roguskac, M.Andrzejczuka,M.Balcerd,S.Kulike,P.Żarnowiecf and W.Kacaf, “On-site monitoring and laboratory characterization of corrosion Processes in the geothermal water of Polish Lowland,” Geothermics, vol. 77,pp. 267-277,2019.

[3.] A. Babaa,⁎, F.Şaroğlub, I. Akkuşb, N. Özelc, M. İ. Ye şilnacard, M.T. Nalbantçılare, M.M. Demira, G. Gökçena, Ș. Arslane, N. Dursund, T. Uzellia and H. Yazdania, “Geological and hydro-geochemical properties of geothermal systems in the southeastern region of Turkey,” Geothermics, vol. 78, pp. 255-271,2019.

[4.]LeZhang, ChengGao, BingyuJi, RushengZhang and JunNiu, “A simplified assessment method forestimating recoverable geothermal resources,” Geothermics, vol. 79, pp. 145-151,2019.

[5.] Hossein Yousefia, Soheil Roumia, Halldór Ármannssonb and Younes Noorollahia, “Cascading uses of geothermal energy for a sustainable energy supply for Meshkinshahr City, Northwest, Iran,” Geothermics, vol. 79, pp. 152-163,2019.

[6.] Chao Zhang ,Guangzheng Jiang, Xiaofeng Jia d, Shengtao Li,Shengsheng Zhang, Di Hua, Shengbiao Hu and Yibo Wang, “Parametric study of the production performance of an enhanced geothermal system: A case study at the Qiabuqia geothermal area, northeast Tibetan plateau,” Renewable Energy, vol. 132, pp. 959-978,2019.

[7.] Vinay Kakkar, Nirmal. Kr. Agarwal and Narendra Kumar, Dept of Electrical Engg. IPEC, Ghaziabad, (UP), India Dept. of Electrical Engg. JSSATE, Noida, (UP), India Dept.of Electrical Engg , DCE Delhi, India, “GEOTHERMAL ENERGY: NEW PROSPECTS,” International

Journal of Advances in Engineering & Technology, Vol. 4, Issue 2, pp. 333-340,2012.

[8.] Chandrasekharam, D and Varun Chandrasekhar, "Geothermal Energy Resources, India: Country Update," Proceedings World Geothermal Congress 2015 Melbourne, Australia, 19-25 April 2015.

[9.] M. Abdel Zaher and S. Elbarbarya, A. El-Shahatb, H. Mesbaha and A. Embaby, "Geothermal resources in Egypt integrated with GIS-based analysis," Journal of Volcanology and Geothermal Research, Article in press, 2018.

[10.] Hafeza A. Bakara,b and Sadiq J. Zarrouka, "Transient pressure analysis of geothermal wells fractured during well testing," Geothermics, vol. 76, pp. 26-37,2018.

[11.] C. Benighausa and A. Bleicherb, "Neither risky technology nor renewable electricity: Contested frames in the development of geothermal energy in Germany," Energy Research & Social Science, vol. 47, pp. 46-55,2019.

[12.] Tugberk Hakan Cetina, Mehmet Kanoglub and Neslihan Yanikomera,"Cryogenic energy storage powered by geothermal energy," Geothermics, vol. 77, pp. 34-40,2019.

[13.] Guodong Cuia, Shaoran Rena, Zhenhua Ruib, Justin Ezekielc, Liang Zhanga and Hongsheng Wangd, "The influence of complicated fluid-rock interactions on the geothermal exploitation in the CO_2 plume geothermal system," Applied Energy, Article in process.

[14.] R.Delhayea, V.Ratha, A.G.Jonesa, M.R.Mullera and D.Reay, "Quantitative geothermal interpretation of electrical resistivity models of the Rathlin Basin, Northern Ireland," Geothermics, vol. 77, pp. 175-187,2019.

[15.] W.F. Hea,b, H.X. Yanga and D. Hanb, "Thermodynamic analysis of a power and water combined system with geothermal energy utilization ," Geothermics, vol. 76, pp. 106-115,2018.