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Performance analysis of a novel integrated geothermal-based system for multi-generation applications

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ABSTRACT

In this paper, we propose a novel integrated, geothermal-based double flash power generating, ammonia-water quadruple effect absorption, and electrolyzer system for cooling, heating, power, hot water and hydrogen production. Detailed energy and exergy analyses are carried out, and the effects of geothermal source temperature, geothermal source mass flow rate, geothermal source pressure, effect of ambient temperature are then studied parametrically. It is found that increasing geothermal source temperature, pressure and mass flow rate results in increasing power and rate of hydrogen produced. The amount of hydrogen produced is found to be increasing from 1.85 kg/day to 11.67 kg/day with rise in geothermal source temperature from 440 K to 500 K respectively, and from 7.9 kg/day to 9.6 kg/day with increase in geothermal source pressure from 3000 kPa to 5000 kPa, respectively. However, increase in geothermal source temperature, pressure, and mass flow rate has negative effects on cooling production. Moreover, a rise in ambient temperature results in better exergetic efficiency of the system.

1. Introduction

Geothermal is considered to be one of the most reliable renewable energy source options. It is known as the energy which is stored under the crust of the earth. The major benefit of using geothermal is that it is renewable and that there are vast resources to use. It is a source of energy which is easy to adopt and can provide power, cooling, heating, and hot water, all in an efficient manner. One of the highly respected agencies the International Energy Agency (IEA) defined renewable energy as: "Renewable energy is energy that is derived from natural processes that are replenished constantly. In its various forms, it derives directly from the sun, or from heat generated deep within the earth. Included in the definition is electricity and heat generated from solar, wind, ocean, hydropower, biomass, geothermal resources, and biofuels and hydrogen derived from renewable resources" [1]. This definition from IEA proves that geothermal is a renewable source of energy.

With ever increasing concerns over global warming and energy issues, geothermal is the source of energy which cannot only provide cheap energy but it also provides pollution free energy. Since the price of oil has reached its peak and extensive efforts are necessary to find alternative energy resources, geothermal energy is more competitive when compared to conventional fossil fuel systems and direct use of geothermal energy has increased approximately twofold in the last five years [2–4].

The utilization of geothermal source either for power generation, cooling or heating applications depends mainly on the source temperature. High temperature geothermal resources above 150 °C are generally used for power generation. Moderate-temperature (between 90 and 150 °C) and low temperature (below 90 °C) geothermal resources are best suited for direct applications such as space and process heating, cooling, aquaculture, and fish farming [5,6]. It is obviously better to use high temperature geothermal source for multi-generation purposes. Generating multiple outputs from one source will not only increase the efficiency of the system but will also make more cost effective. The multi-generation capacity of geothermal has recently attracted attention from many researchers around the world [7,8].

Basic use of geothermal source at higher temperature is that of power production. Today, world installed electrical generation capacity is more than 10 GW [9]. There are many geothermal-based power production systems available in practice. For high temperature geothermal source the suitable technologies are single and double flash power plants [10–12]. These plants may use geothermal water directly to produce power. For geothermal source having medium temperature, it is better to use binary power plants

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