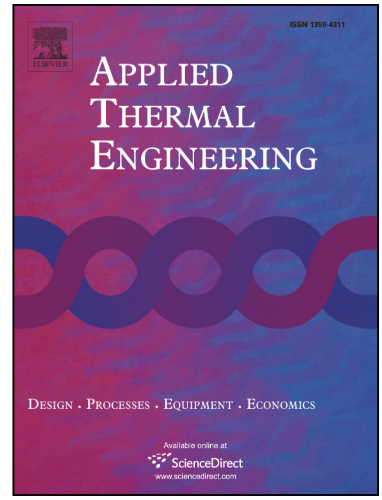
Accepted Manuscript



Exergo-economic analysis of a low-temperature geothermal-fed combined cooling and power system

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PII: S1359-4311(18)33299-X
DOI: https://doi.org/10.1016/j.applthermaleng.2018.09.072
Reference: ATE 12681

To appear in: *Applied Thermal Engineering*

Received Date: 27 May 2018
Revised Date: 4 September 2018
Accepted Date: 16 September 2018

Please cite this article as: Z. Seyfouri, M. Ameri, M. Ali Mehrabian, Exergo-economic analysis of a low-temperature geothermal-fed combined cooling and power system, *Applied Thermal Engineering* (2018), doi: https://doi.org/10.1016/j.applthermaleng.2018.09.072

Exergo-economic analysis of a low-temperature geothermal-fed combined cooling and power system

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Abstract

In this work, a novel cogeneration system is analyzed. The system consists of an organic Rankine cycle and a hybrid GAX cycle, and uses a source of 100 kg low-temperature geothermal water at 133.3 ℃ to produce power and cooling at -50℃. The ammonia-water mixture is used as the working fluid of the system. The "Parallel-Series" configuration of the system produces more power output, higher exergy efficiency, and lower unit product costs as compared to the "Parallel" configuration. For 1000 kW cooling load while other conditions are the same, the "Parallel-Series" configuration produces 1897 kW power with 42.8% exergy efficiency and 4.192 $/GJ total unit product cost. The exergo-economic analysis also shows that the boiler has the lowest exergetic factor, and the regenerator has the highest relative cost difference.

Keywords: Exergo-economic, geothermal, Rankine cycle, hybrid GAX cycle, cogeneration.

1. Introduction

Low grade heat sources such as solar, geothermal, biomass … can effectively be used to generate the required energy in residential and industrial processes. Geothermal energy is a suitable and accessible alternative source that has a huge potential for space cooling/heating and power generation. More efficient use of energy sources can help to overcome the energy crisis in the world and decrease the greenhouse emissions and air pollutions. Mid/low temperature geothermal heat sources are more suitable for direct uses, and high temperature geothermal sources are mostly used for power generation [1]. Organic Rankine Cycle (ORC) is a technology to generate power from low temperature heat sources. The ORC can be coupled with cooling/heating technologies to generate power, cooling and heating simultaneously. Combined power and heating/cooling systems are more efficient than single generation systems. The ORC can be used as the bottoming or topping cycle in the combined systems. Erdewegke et al. [2] proposed a Combined Heating and Power (CHP) configuration fed by geothermal energy. Their CHP system consists of an ORC and a thermal network. They compared three configurations of ORC and thermal networks namely "Preheat-Parallel", "Series" and "Parallel" arrangements. The results show that the power production and exergy efficiency of the "Preheat-Parallel" configuration are higher than those of the other two configurations. Sun et al. [3] integrated a two-stage ORC with a simple absorption refrigeration system to produce cooling, heating and power. The heat released from the absorption refrigeration cycle is serving as a supplement heat source for the low pressure evaporator of the ORC. They compared the system with a two-stage ORC and showed that the integrated system increases the power output, but decreases the thermal efficiency.

Thermo-economic analysis combines exergy analysis with economic principles to provide information about the system that cannot be achieved via conventional exergy and/or economic analyses [4]. Many researchers carried out thermo-economic analysis of combined generation of power and heating/cooling. For example: Nami et al. [5] made the exergo-economic and exergo-environmental analyses for a cogeneration system to produce power and steam. They calculated the payback period and the optimized economic condition for the system. Thermodynamic optimization of a cascade refrigeration system was done by Cismit et al. [6]. Their system consists of a compression and a simple absorption refrigeration cycle. They optimized the exergy efficiency and the total product cost of the system to present some important variables like generator, condenser and absorber temperatures of the vapor compression cycle. The minimum total cost and the

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