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Thermodynamic analysis of the absorption refrigeration system with geothermal energy: an experimental study

Abdullah Keçeciler, H. İbrahim Acar*, Ayla Doğan

Department of Mechanical Engineering, Faculty of Engineering, Cumhuriyet University, 58140, Sivas, Turkey

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Abstract

In the present study, an absorption refrigeration system, which is alternative to the ordinary mechanical refrigeration system, is designed. For this purpose, an experiment using geothermal energy in the Hot Spring in Sivas is set up in the lab conditions, and a thermodynamic analysis of the Absorption Refrigeration System (ARS) operating on water–lithium bromide is performed. The change in the coefficient of performance of the ARS has been graphically investigated with the various parameters and the results are tabulated. These results show that geothermal energy in the Hot Spring in Sivas cannot be used efficiently in electricity generation. However, taking into account the need of storing at 4–10°C, this geothermal resource can be used especially for refrigeration, and it will provide a considerable economical gain.

Keywords: Refrigeration; Geothermal; Absorption

1. Introduction

Absorption Refrigeration Systems (ARSs) become economically attractive when there is a source of inexpensive heat energy at a temperature of 50–200°C. Some examples of inexpensive heat energy sources include geothermal energy, solar energy and waste heat from cogeneration or process steam plants, that is, heat energy that otherwise would be wasted.

* Corresponding author. Fax: +90-346-2261-545.
E-mail address: iacar@cumhuriyet.edu.tr (H.İ. Acar)

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Nomenclature

COP	coefficient of performance
ARS	absorption refrigeration system
f	circulation ratio
h	specific enthalpy (kJ/kg)
m	mass flow rate (kg/s)
P	pressure (Pa)
T	temperature (K)
X	mass concentration (kg LiBr/kg Solution)
η	effectiveness
Q	heat flow (kW)
Δ	difference
W	Work

Subscripts

ab	absorber
co	condenser
ev	evaporator
ge	generator
o	state of surroundings
f	weak solution
z	rich solution
w	work
k	loss
p	pump

ARSs involve the absorption of a refrigerant by a transport medium. The most widely used ARS is the ammonia–water system, where ammonia (NH_3) serves as the refrigerant and water (H_2O) as the transport medium. Other ARSs include water–lithium chloride and water–lithium bromide systems, where water serves as the refrigerant.

In the present study, the lithium–bromide system, which uses geothermal energy, was designed in lab conditions with the aim of refrigeration. As shown in Fig. 1, the ARS looks very much like the vapour compression system, except that the compressor has been replaced by a complex absorption mechanism consisting of an absorber, a pump, a generator, a heat exchanger and a valve. Once the pressure of the H_2O is raised by the components in the absorption mechanism, it is cooled and condensed in the condenser by rejecting heat to the surroundings, throttled to the evaporator pressure and receives heat from the refrigerated space as it flows through the evaporator.

The water vapour leaves the evaporator and enters the absorber, where it chemically reacts with the lithium bromide to form $H_2O{\cdot}LiBr$. This is an exothermic reaction, thus heat is released during this process. The amount of H_2O that can be dissolved in LiBr is inversely