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Research Paper

Experimental study of a graphite disk generator into an absorption heat transformer

A. Márquez-Nolasco[a,*], J. Delgado-Gonzaga[a], A. Huicochea[b,*], J. Torres-Merino[c], J. Siqueiros[d], J.A. Hernández[b]

[a] Posgrado En Ingeniería Y Ciencias Aplicadas, Centro de Investigación En Ingeniería Y Ciencias Aplicadas (CIICAp), Universidad Autónoma Del Estado De Morelos (UAEM), Av. Universidad 1001, Col. Chamilpa, Cuernavaca 62209, Morelos, Mexico

[b] Centro de Investigación En Ingeniería Y Ciencias Aplicadas, Universidad Autónoma Del Estado De Morelos, Av. Universidad 1001. Col. Chamilpa, C.P. 62209 Cuernavaca, Morelos, Mexico

[c] Facultad De Química, Universidad Nacional Autónoma De México, Circuito Interior, Ciudad Universitaria, Col. Copilco, Delegación Coyoacán C.P. 04510, Mexico

[d] Secretaria de Innovación, Ciencia Y Tecnología, Morelos, Av. Atlacomulco No. 13, Col. Acapantzingo, 62440 Cuernavaca, Morelos, Mexico

HIGHLIGHTS

- A graphite disks generator was studied experimentally inside an AHT.
- An overall heat transfer coefficient of 240 W/m^2 °C in the generator was obtained.
- The generator is to able to transfer up to 1832 W/m^2.
- A COP from 0.253 to 0.483 was reached in the AHT.

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ABSTRACT

Absorption heat pumps main consist of four heat exchangers: Generator, Absorber, Evaporator and Condenser. The heat transfer carried out in every process has a direct impact on the performance of the whole system. A weakness of heat pumps by absorption at low pressure is the leaks in the Generator because the lithium bromide-water working solution attacks the material and the thermodynamic cycle is broken. For this reason, an experimental study about a novel Generator with 18 disk of graphite is analyzed as a component for an Absorption Heat Transformer (AHT). Graphite is used because of its high resistance to corrosion, support thermal shocks and its similar thermal conductivity with respect to stainless steel. For this study, the thermodynamic analysis is carried out under the following scenario: the heat for the generator was supplied by heating water with volumetric flows of 1.6, 2.1, 2.6 and 3.6 LPM and temperatures of 70, 73, 76 and 79° C. This study consists of knowing the thermal capacity, heat transfer coefficients and experimental behavior of the generator to compare it with generators made of stainless steel, also know the complete performance of the AHT. As results, the overall heat transfer coefficient obtained was of 50–240 W/m^2 °C, similar values with generators made of stainless steel, while the coefficient of performance (COP), regarding external heats was from 0.253 to 0.483. The results about corrosion are notable due to the component has been working for 8 years without leaks problems.

1. Introduction

Energy inefficiency usage reflects a poor environmental culture and the lack of suitable technologies for the thermal processes. Currently, many residual heats at temperatures between 60 and 90 °C [1] are dissipated in the environment, which has irreversible damages. Several works published have demonstrated that an Absorption heat Transformer (AHT) is a promising device since this one can recover the residual heat for upgrading its thermal level in order to reuse it [2]. The thermodynamic cycle for the AHT requires a working solution and for heat exchanger, which operates at different saturated operating conditions. Every component can interchange heat as falling film, using horizontal and vertical tubes.

Based on the experimental results, the horizontal type has been

* Corresponding authors.
E-mail addresses: aldo.marquez@uaem.mx (A. Márquez-Nolasco), huico_chea@uaem.mx (A. Huicochea).

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Nomenclature

A	heat transfer area, m^2
AHT	absorption heat transformer
COP	coefficient of performance, dimensionless
Cp	specific heat, J/kgK
D_0	diameter of graphite disk wetted with LiBr-H_2O, m
F	volumetric flow, LPM
H	enthalpy specific, kJ/kg
h	convective coefficient of heat transfer, $W/m^2\,°C$
k	thermal conductivity, W/mK
LPM	liters per minute
$\dot{m}$	mass flow, kg/s
Nu	Nusselt number
P	pressure, kPa
Pr	Prandtl number, dimensionless
$\dot{Q}$	heat load, W
$\dot{q}$	heat flux, W/m^2
Re	Reynolds number, dimensionless
T	temperature, °C
U	overall coefficient of heat transfer, $W/m^2\,°C$
$\dot{W}$	mechanical work, W
X	concentration by weight of LiBr-H_2O solution, %wt.

Greek letters

μ	dynamic viscosity, kg/ms
Γ	mass flow of LiBr-H_2O solution per wetted perimeter unit, kg/sm
δ	film thickness, m
θ	angle
ρ	density, kg/m^3

Subscripts

1–8	internal currents
AB	absorber
A-B	external currents
AHT	absorption heat transformer
CO	condenser
EV	evaporator
GE	generator
hw	heating water
in	input
LiBr	solution of LiBr-H_2O
mlog	logarithmic mean
out	output
w	water

more used, while the vertical type is still been developed as a promising way [3].

The advantage over the use of falling film in a heat exchanger compared to a flooded one is that the overall heat transfer coefficient is higher; therefore less transfer area is required. Some researchers emphasize the importance of using vertical heat exchangers and downslope heaters. Shi et al., [4] carried out a study in a generator, in which they obtained global coefficients of heat transfer 4.37 times greater for falling film, compared to a flooded one, this indicates that the volume of the generator per descending film is only 52.1% of the total volume of the flooded generator. Genssle and Stephan [2] indicate in one study that the overall heat transfer coefficient is 30% greater than a vertical generator per descending film than a horizontal generator of tubes and shell, requiring only 70% of area, so that investment costs could be reduced by about 20%. Due to its high thermal conductivity and resistance to corrosion, several researchers have experimented with absorbers or generators made of stainless steel [4–7], which has a good operating performance due to the design. However, based on the literature, it is known that LiBr-H_2O causes great corrosion problems, causing problems of hermiticity and economic costs for corrective work, among others [8,22]. Therefore, the generator and the absorber are the most critical components in the heat pumps by absorption, due to their interaction with the LiBr-H_2O. The researchers [4,9–11] concluded that corrosion to stainless steel increases with increasing LiBr-H_2O solution concentration, having a greater impact at higher temperatures, and that the efficiency of the inhibitors used (Li_2CrO_4, 1Cr18Ni9Ti) is low to reduce the corrosion effect. Therefore, it is necessary to investigate materials resistant to corrosion, with the aim of extending the life of the heat exchanger, replacing stainless steel as a common construction material [12]. Polymers are an alternative as a

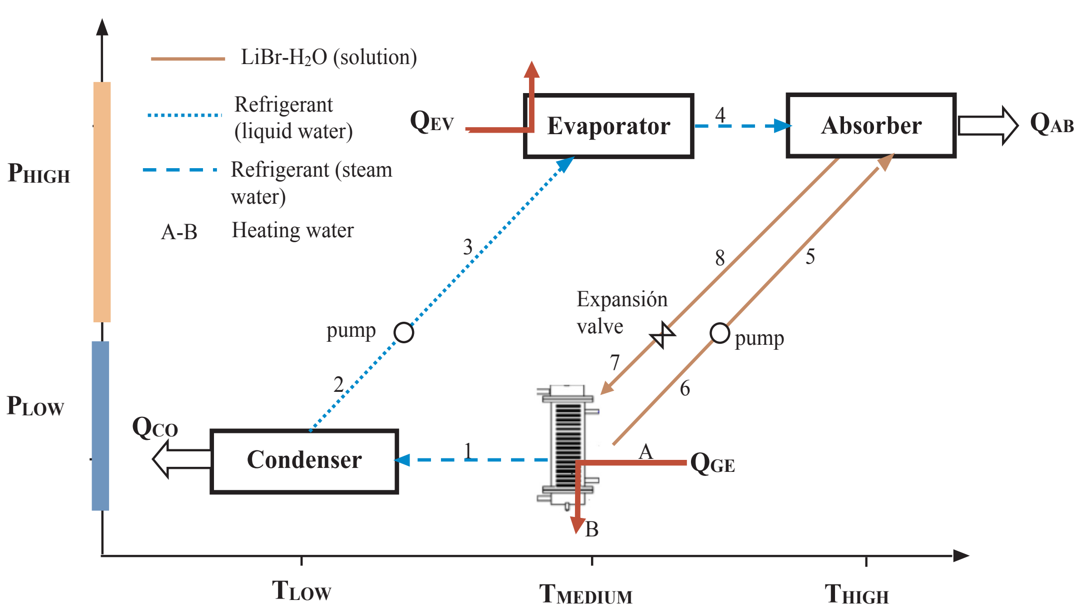

Fig. 1. Schematic diagram of a single stage AHT.