Available online at www.sciencedirect.com

ScienceDirect

International Journal of Refrigeration 30 (2007) 364–376

REVUE INTERNATIONALE DU FROID
INTERNATIONAL JOURNAL OF
refrigeration

www.elsevier.com/locate/ijrefrig

Numerical simulation of an advanced energy storage system using H_2O–LiBr as working fluid, Part 2: System simulation and analysis

S.M. Xu[a,*], C.H. Xu[a], L. Zhang[a], J. Liang[b], R. Du[b]

[a] *R & D Lab of Refrigeration and Heat Pump Technology, Department of Power Engineering,*
Dalian University of Technology, Liao Ning, 116024, China
[b] *Department of Automation and Computer-Aided Engineering, The Chinese University of Hong Kong,*
Shatin, N.T., Hong Kong, China

Received 21 November 2005; received in revised form 14 March 2006; accepted 14 March 2006

Abstract

This paper is the second part of our study on the advanced energy storage system using H_2O–LiBr as working fluid. In the first part, the system working principle has been introduced, and the system dynamic models in the operation process have also been developed. Based on the previous research, this paper focuses on the numerical simulation to investigate the system dynamic characteristics and performances when it works to provide combined air-conditioning and hot water supplying for a hotel located near by Yangzi River in China. The system operation conditions were set as follows: the outdoor temperature was between 29 °C and 38 °C, the maximum air-conditioning load was 1450 kW, the total air-conditioning capacity was 19,890 kWh and the 50 °C hot water capacity for showering was 20 tons which needed heat about 721 kWh on a given day. Under these conditions, the system operation characteristics were simulated under the full- and partial-storage strategies. The simulation results predicted the dynamic characteristics and performances of the system, including the temperature and concentration of the working fluid, the mass and energy in the storage tanks, the compressor intake mass or volume flow rate, discharge pressure, compression ratio, power and consumption work, the heat loads of heat exchanger devices in the system and so on. The results also showed that the integrated coefficient of performances (COP_{int}) of the system were 3.09 and 3.26, respectively, under the two storage strategies while the isentropic efficiency of water vapor compressor was 0.6. The simulation results are very helpful for understanding and evaluating the system as well as for system design, operation and control, and device design or selection in detail.

Keywords: Absorption system; Water-lithium bromide; Thermal storage; Energy storage; Simulation; Performance; COP

---

* Corresponding author.
E-mail address: xsming@dlut.edu.cn (S.M. Xu).

0140-7007/$35.00 © 2006 Elsevier Ltd and IIR. All rights reserved.
doi:10.1016/j.ijrefrig.2006.03.014

Simulation numérique d'un système d'accumulation thermique de pointe employant le H_2O-LiBr en tant que fluide actif. Partie 2: Simulation et analyse du système

Mots clés : Système à absorption ; Eau-bromure de lithium ; Accumulation thermique ; Stockage d'énergie ; Simulation ; Performance ; COP

Nomenclature

E	energy (kWh)
f	solution circulation ratio (kg kg^{-1})
h	specific enthalpy (kJ kg^{-1})
$\dot{m}$	mass flow rate (kg/s)
m, M	mass (kg)
m_1	mass sprayed into the moistener (kg)
N	power (kW)
Q	thermal energy or heat (kWh)
$\dot{Q}$	heat power or heat transfer rate (kW)
SD	energy storage density (kWh m^{-3})
t	time in the energy charging period (h)
T	temperature (°C or K)
W	work (kWh)
x	vapor quality of vapor–water mixture (kg kg^{-1})
Greeks	
η	efficiency (%)
ξ	LiBr mass fraction or mass concentration in working solution (kg kg^{-1})
ρ	density (kg m^{-3})
τ	time in the discharging period (h)
Γ	compression ratio

Subscripts	
1–13	status points in Fig. 1
ab	absorption or absorber
am	ambient
c	cooling
cw	cooling water
comp	compression or compressor
cond	condensation or condenser
cry	crystallization
e	evaporation or evaporator
ex	heat exchanger
g	generation or generator
h	heating
i	into
int	integrated
is	isentropic
o	out
pump	solution pump
re	recycle pump
stor	solution in its storage tank
w	water
ws	water in its storage tank
wv	water vapor

1. Introduction

This paper is the second part of our study on the advanced energy storage system using H_2O–LiBr as working fluid. The advanced energy storage system is also called the Variable Mass Energy Transformation and Storage (VMETS) system. As shown in Fig. 1, the VMETS system composes of several major components: (I)-solution pump, (II)-solution storage tank, (III)-heat exchanger, (IV)-generator/condenser, (V)-water vapor compressor set, (VI)-moistener, (VII)-auxiliary heater, (VIII)-water storage tank, (IX)-recycle pump, (X)-absorber, (XI)-evaporator, some control valves and throttles.

In the first part [1] of our study on the system, it was known that the VMETS system does not directly transform the electric energy in off-peak time into the cold or heat energy, but transforms the electric energy mostly into the chemical potential of the working solution and stored it in the system firstly. And then the potential is transformed into cold or heat energy by absorption refrigeration or heat pump mode when the consumers need the cold or heat energy. As a result, the energy transformation and storage can be carried out at the desirable time to shift electric load efficiently by the VMETS system for cooling, heating or combined cooling and heating. Since the concentration of the working solution in the VMETS cycle varies