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Exergy Based Analysis of LiCl-H_2O Absorption Cooling System

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Abstract

A thermodynamic analysis of single effect LiCl-H_2O vapour absorption cooling system of 1 TR capacity is conducted based on first and second laws. Mathematical models derived from thermodynamics theory, are employed in engineering equation solver to perform the calculations. It is found that maximum exergy destruction in system occurs in the absorber and generator while the pump and the expansion valve have the lowest. A performance comparison between LiCl-H_2O and LiBr-H_2O absorption system is also evaluated under identical operating conditions. It is found that LiCl-H_2O working pair performs thermodynamically better compared to LiBr-H_2O in vapour absorption cooling system.

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Keywords: VARS, LiCl-H_2O, LiBr-H_2O, Exergy, Exergetic efficiency

1. Introduction

Absorption system is becoming more popular nowadays because it is heat driven system instead of conventional compressing chillers which are work driven. Vapour absorption refrigeration system (VARS) is the optimum alternative for vapour compression chiller. VARS can also utilize non-conventional energy i.e. solar energy, biomass, geothermal energy etc. VARS performance is affected by the type of absorbent-refrigerant pair that has been chosen. There are limited pairs available for VARS, in which generally used pairs are LiBr-H_2O and NH_3-H_2O [1]. NH_3-H_2O

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absorption system is more complicated as it requires separate rectifier mechanism to remove water vapour from refrigerant vapour, whereas main problem occurs in LiBr-H_2O system is the crystallization [1]. Current research work focuses the potential refrigerant-absorbent pair for VARS. LiCl-H_2O pair is one of the good options for VARS working pair as it has advantages of triple state point, long term stability and cost, compared to LiBr-H_2O [2]. There is a study available for thermodynamic design data for double effect LiCl-H_2O absorption system and comparison for the performance of LiCl-H_2O and LiBr-H_2O absorption system and it is found that COP with LiCl-H_2O is better than that of LiBr-H_2O system [3]. Feasible range for each operating parameters and possible combination of operating temperature for LiCl-H_2O system has been also evaluated [4]. Experimental investigation of intermittent LiCl-H_2O absorption cycle has been performed and it is found that that LiCl-H_2O system can operate with low temperature heat source [5]. There has been recently developed novel absorption system with LiCl-H_2O pair in the high pressure cycle and LiBr-H_2O pair in the low pressure cycle [6]. In this study three different heat source utilization mode has been considered i.e. two parallel modes and one series mode and it is concluded that intermediate pressure has a large influence upon system performance. Many literatures are available for second law analysis for LiBr-H_2O absorption system [7-11] and NH_3-H_2O [12-13] VARS. Very few literatures are available on second law analysis of LiCl-H_2O absorption system [14-15]. Crystallization is the major issue in any salt based aqueous solution, so to prevent this phenomenon; LiCl-H_2O pair operator has to choose operating parameters in optimistic range. The detailed exergy analysis is carried out in the present work and the optimized operating parameters are suggested for LiCL-H_2O VARS.

Nomenclature

COP	coefficient of performance	E	evaporator
e	Specific exergy (kJ/kg)	G	Generator
h	specific enthalpy (kJ/kg)	in	inlet stream
$\dot{m}$	mass flow rate (kg/s)	out	outlet stream
$\dot{Q}$	heat load (kW)	o	dead state (ambient)
s	specific entropy (kJ/kg K)	P	pump
T	temperature (K)	r	refrigerant
$\dot{W}$	pump work (kW)	$REXP$	refrigerant expansion valve
η	efficiency	$SEXP$	solution expansion valve
$\Delta\dot{\psi}$	exergy destruction (kW)	SHX	solution heat exchanger
Subscripts		ss	strong solution
A	Absorber	sys	system
C	Condenser	ws	weak solution

2. System Description

The schematic diagram of the LiCl-Water vapour absorption cooling system is shown in Fig. 1. Main components of the system are generator, evaporator, condenser, absorber, solution pump, solution heat exchanger and expansion valve. It uses water as refrigerant and LiCl solution as absorbent. As shown in Fig. 1, at absorber outlet (1), the solution is rich in refrigerant and pump forces the liquid through a solution heat exchanger to the generator (3). The temperature of the solution in the heat exchanger increases. In the generator thermal energy is added and refrigerant escape from the solution. The refrigerant vapour (7) flows to the condenser, where the refrigerant gets condensed. The condensed refrigerant (8) flows through expansion valve to the evaporator (9). In the evaporator, the heat from the load evaporates the refrigerant, which flows back to the absorber (10). At the generator exit (4), the steam consists of absorbent-refrigerant solution, which is cooled in the heat exchanger. From points (6) to (1), the solution absorbs refrigerant vapour from the evaporator and rejects heat through a heat exchanger.