Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 109 (2017) 487 – 496

Energy Procedia

International Conference on Recent Advancement in Air Conditioning and Refrigeration, RAAR 2016, 10-12 November 2016, Bhubaneswar, India

"Theoretical Analysis of Hybrid Chiller"

Anil Kumbhar[a], Nitin Gulhane[b], Sachin Pandure[a,b,*]

"aResearch & Development Center, Voltas Limited, Thane 400 601, India"
"bDepartment of Mechanical Engineering, Veermata Jijabai Technological Institute, H. R. Mahajani Marg, Matunga, Mumbai 400 019, India"

Abstract

The present work aims to find out the performance parameter of hybrid chiller (combination of vapour absorption cycle and vapour compression cycle) of 351.7 kW capacity for working temperature of 5°C as evaporating temperature and 40°C as condensing temperature. The investigation uses R22 and DMA as working pair where, R22 (chlorodifluoromethane) is a refrigerant and DMA (dimethylacetamide) is absorbent. The theoretical results show that, with the hybrid chiller system the electrical power consumption of vapour compression system is reduced and the coefficient of performance (COP) of vapour absorption system improves by almost 23.05% for same temperature limits and capacity as compared to independent operation of the cycle at same operating temperature and capacity. Also, in hybrid system absorber heat capacity, heat rejected in condenser and the heat supplied to generator is reduced as compared to independent operation of vapour absorption cycle.

Peer-review under responsibility of the organizing committee of RAAR 2016.

Keywords: cooling system; compression-absorption (hybrid) cycle; R22-DMA pair

1. Introduction

In vapour absorption refrigeration cycle, the refrigerant-absorbent working pair vary according to the refrigerating temperature requirement. NH_3-H_2O is more complicated system than H_2O-LiBr because there is

* Corresponding author. Tel.: +91 9967231356
E-mail address: sachinpandure513@gmail.com

Peer-review under responsibility of the organizing committee of RAAR 2016.
doi:10.1016/j.egypro.2017.03.082

requirement of rectifying column so that pure refrigerant enters the evaporator and it requires a higher generating temperature than H_2O-LiBr system. For temperature below 0°C NH_3-H_2O is used as working pair because water will freeze at 0°C for H_2O-LiBr working pair. Few patented design in Voltas limited Thane, India with H_2O-LiBr are designed to give -5°C output temperature of chilled water. For NH_3-H_2O single effect system COP range is 0.6-0.7 whereas for H_2O-LiBr COP is 0.6-0.8 [1]. Besides, study on some new working pairs is also going on.

Hybrid refrigeration system consist of a vapour absorption cycle and a compressor. Vapour absorption system is driven by low grade heat and compressor is driven by electricity. He et al. [2] carried out thermodynamic analysis of R134a+DMF, R22+DMF and R32+DMF as working pair and concluded that R134a+DMF gives better results as compared to other two pair. Meng et al. [3] have analyzed energy saving mechanism in hybrid refrigeration cycle. Ramesh Kumar and Udayakumar [4,5] have found out the compressor pressure ratio for optimum COP using NH_3-H_2O as working fluid. The theoretical investigation of two stage absorption-transcritical hybrid system is carried out and it is observed that COP of hybrid system is more than the normal two-stage absorption system [6]. Considerable amount of increase in COP and primary energy ratio is observed using methanol-tetraethyleneglycol dimethylether (TEGDME) and trifluoroethanol (TFE)-TEGDME as working pair [7]. Significant amount of decrease in compressor work as compared to vapour compression cycle and reduction in thermal energy consumption in cascade system is observed using different pairs of refrigerant and absorbent in vapour absorption system and different refrigerant in vapour compression cycle [8]. Study of refrigerant R22 and six absorbent is made by Fatouh and Murthy [9]. 10% increase in refrigeration is observed using ammonia/lithium nitrate solution in hybrid system [10]. Kairouani & Nehdi [11] studied the compression-absorption refrigeration system and concluded that COP of cascade cycle is more than independent operation of conventional cycle.

Based on the above literature survey it has been observed that the performance of hybrid system is better than individual working of vapour compression cycle and vapour absorption cycle. In present work we have developed a theoretical model of hybrid system and added one external heat exchanger after compressor which will reduce the heat supplied to generator and instead of placing compressor in between evaporator and absorber we have placed it in between evaporator and generator which will reduce energy consumption and found the optimum mass flow rate compression so as to have COP more than COP of vapour absorption cycle. It also reduces condenser heat rejection. Using this hybrid cycle absorber size is reduced and also heat supplied to generator is less.

Nomenclature

COP	coefficient of performance	
EHX	external heat exchanger	
h	specific enthalpy	$(kJ\cdot kg^{-1})$
$\dot{m}_{ra}$	mass flow rate of refrigerant in absorber	$(kg\cdot s^{-1})$
$\dot{m}_{rc}$	mass flow rate of refrigerant in compressor	$(kg\cdot s^{-1})$
$\dot{m}_{ss}$	mass flow rate of strong solution	$(kg\cdot s^{-1})$
$\dot{m}_{ws}$	mass flow rate of weak solution	$(kg\cdot s^{-1})$
$\dot{m}_r$	$\dot{m}_{ra} + \dot{m}_{rc}$	