Contents lists available at ScienceDirect



Energy Conversion and Management

journal homepage: www.elsevier.com/locate/enconman



Comparative performance study and advanced exergy analysis of novel vapor compression-absorption integrated refrigeration system



Vaibhav Jain^{a,*}, Gulshan Sachdeva^b, S.S. Kachhwaha^c

^a Department of Mechanical and Automation Engineering, MAIT, Delhi, India

^b Department of Mechanical Engineering, National Institute of Technology, Kurukshetra, India

^c Department of Mechanical Engineering, SOT, Pt. Deendayal Petroleum University, Gujarat, India

ARTICLE INFO

ABSTRACT

Keywords: Vapor compression Vapor absorption Novel integrated refrigeration system CSB analysis Advanced exergy analysis In present work, a novel configuration of vapor compression-absorption integrated refrigeration system (VCAIRS) is analyzed. Unlike previous vapor compression-absorption cascaded refrigeration system (VCACRS), proposed configuration works at lower generator temperature of 60 °C. Thus, allowing the use of low grade waste heat for its operation. The performance of VCAIRS is also compared with the equivalent vapor compression refrigeration system (VCRS) and VCACRS for the same cooling capacity of 100 kW. The comparative study result shows that electrical energy requirement in VCAIRS is 21.4% more as compared to VCACRS but it is still 63% less as compared to the equivalent VCRS. Further, the second law efficiency of VCAIRS, VCACRS and VCRS are determined to be 27.9%, 32.7% and 18.8%, respectively. Thus, both the VCAIRS and VCACRS are energy and exergy efficient configurations; but, VCACRS results in more energy efficient cooling technology in the foreseeable future as it utilizes heat at lower generator temperature as compared to VCACRS.

After the comparative performance study, the exergetic performance of VCAIRS is further explored based on the coefficient of structural bonds (CSB) and advanced exergy analysis methods. Highest CSB of 4.39 is obtained for high pressure solution heat exchanger but its overall contribution in total irreversibility rate is merely 0.2%; whereas, the highest contribution of 17.4% in total irreversibility rate is by compressor 1 but CSB value computed for it is merely 1.73. Further, advance exergy analysis results show that 35.2% of total irreversibility rate of VCAIRS can be avoided by improving the efficiency parameter of components of system.

1. Introduction

There are different applications which require refrigeration from near absolute temperature of 4 K to near atmospheric temperature (human comfort) of 300 K [1]. Hence, different refrigeration methods are suggested by the researchers to fulfill this requirement. The selection of refrigeration system also depends on cooling duty across it and its investment and running cost [2]. Around 80% of present day refrigeration systems (300–120 K range) work on electrically powered vapor compression refrigeration cycle; whereas, vapor absorption refrigeration cycle which requires heat energy as input, are the second most widely used refrigeration systems (280–243 K). Refrigerators which operate on other types of energy input are only used in niche applications [1].

Vapor compression refrigeration system (VCRS) is most widely used due to its high COP and smaller size for the same cooling capacity as compared to vapor absorption refrigeration system (VARS). The other advantage of VCRS includes attainment of lower refrigeration temperature as compared to VARS but it consumes large amount of electrical energy for its operation [3].

Researchers are constantly engaged in inventing new technologies to reduce the electricity consumption in VCRS. The proposal of integrating VCRS with VARS is considered as a probable alternative to the conventional VCRS and VARS by the research community since it economizes the usage of energy resources [4]. The integrated system entails the simultaneous usage of electricity and heat energy for refrigeration which can be furnished as waste energy from industrial processes, solar energy, geothermal energy, etc. Abundant configurations on the combined vapor compression and vapor absorption refrigeration systems have been proposed in the literature which leads to the development of energy efficient and environmental friendly cooling technologies.

Jain et al. [2] compared the performance of series, parallel and combined series-parallel configurations of vapor compression-

* Corresponding author.

E-mail address: vaibhavursaathi@gmail.com (V. Jain).

https://doi.org/10.1016/j.enconman.2018.06.116

Received 2 May 2018; Received in revised form 22 June 2018; Accepted 30 June 2018 0196-8904/ © 2018 Elsevier Ltd. All rights reserved.

P_{p} specific heat at constant pressure (kJ/kg K) HPG is high pressure solution heat exchanger COP coefficient of performanceininlet condition CSB coefficient of structural bondsidealideal K idealidealidealideal f circulation ratiokenisentropic f circulation ratiok k^{h} dement of system h specific enthalpy (kJ/kg)LPAlow pressure absorber 1 irreversibility rate (kW)LPClow pressure circuit m mass flow rate (kg/s)LPGlow pressure solution heat exchanger P pressure ratiooenvironment condition Q heat transfer rate (kW)outoutlet condition g pressure (kJ/kg K)outoutlet condition g specific entropy (kJ/kg K) P pump T temperature (k) P pump T tent of power input (kW) R rational x mass concentration of absorbent in the solution (%) R^{ef} retigerant r totalvapor absorption refrigeration system $VCARS$ vapor compression-absorption integrated refrigeration g efficiencyvapor dispection efficiency is vaporvapor dispection efficiency is vapor $VCARS$ vapor compression refrigeration system g efficiencyvapor absorption refrigeration system $VCARS$ vapor compression refrigeration system g efficiencyvapor compression refrig	Nomenclature		HPC	high pressure circuit	
cp specific heat at constant pressure (kJ/kg K) HPSHX high pressure solution heat exchanger COP coefficient of performance in inlet condition CB coefficient of structural bonds ideal istern E rate of exergy (kW) isen isentropic f circulation ratio k k ^h element of system h specific enthalpy (kJ/kg) LPA low pressure absorber I irreversibility rate (kW) LPC low pressure solution heat exchanger P pressure fato 0 environment condition sas flow rate (kg/s) LPSHX low pressure solution heat exchanger PR pressure ratio ou outlet condition sas specific entropy (kJ/kg K) out outlet condition sag specific entropy (kJ/kg K) out outlet condition sag specific entropy (kJ/kg K) R rational x mass concentration of absorbent in the solution (%) R rational x etemperature (K) VCARS vapor absorpt			HPG	high pressure generator	
COP coefficient of performance in inter condition CSB coefficient of structural bonds ideal ideal <t< td=""><td>c_{p}</td><td>specific heat at constant pressure (kJ/kg K)</td><td>HPSHX</td><td>high pressure solution heat exchanger</td></t<>	c_{p}	specific heat at constant pressure (kJ/kg K)	HPSHX	high pressure solution heat exchanger	
CSB Erate of exergy (kW)idealidealidealidesÉrate of exergy (kW)isenisentropicfcirculation ratiokk*ement of systemhspecific enthalpy (kJ/kg)LPAlow pressure absorberiirreversibility rate (kW)LPAlow pressure absorberfirreversibility rate (kW)LPClow pressure solution heat exchangerPpressure (kPa)LPGlow pressure solution heat exchangerQheat transfer rate (kW)outoutlet conditionsspecific entropy (kJ/kg K)outoutlet conditionsspecific entropy (kJ/kg K)outoutlet conditionsspecific entropy (kJ/kg K)ppumpTtemperature (K)PRVpressure reducing valveKrate of power input (kW)Rrationalxmass concentration of absorbent in the solution (%)Rrationalseffciencyvapor compression-absorption integrated refrigerationseffciencysystemsystemseffciencysystemsystemseffciencysystemsystemssystemtotalsystemssystemtotalsystemseffciencysystemsystemseffciencysystemsystemseffciencysystemsystemsosolution (kg/m ³)systemsystemssystemsyst	COP	coefficient of performance	in	inlet condition	
L^{c} isenisenisenisen f circulation ratiokk th element of system f specific enthalpy (kJ/kg)LPAlow pressure absorber l irreversibility rate (kW)LPClow pressure generator p pressure (kpa)LPSLlow pressure solution heat exchanger R pressure ratiooenvironment condition Q heat transfer rate (kW)outoutlet condition g specific entropy (kJ/kg K)overlapdegree of overlap g_{pan} entropy generation rate (kW/K)ppump T temperature (K)Rrational x mass concentration of absorbent in the solution (%) ref rational x mass concentration of absorbent in the solution (%) ref rational η efficiency $Vapor compression absorption integrated refrigerationgefficiencysystemVCARSvapor compression-absorption cascaded refrigerationgefficiencysystemVCARSvapor compression absorption cascaded refrigerationgescade condenserx_isystem efficiency parameterx_icondcondenserx_isystem fifticency parametergexpansion valveAVavidableevapaevaporatorAVavidablepevaporatorAVavidablegevaporatorAVavidablegevaporatorAVavidable$	CSB	coefficient of structural bonds	ideal	ideal system	
fcirculation ratiokk*<	Ė	rate of exergy (kW)	isen	isentropic	
h specific enthalpy (k1/kg) LPA low pressure absorber i inversessuility rate (kW) LPC low pressure circuit mass flow rate (kg/s) LPG low pressure solution heat exchanger P pressure ratio o environment condition Q heat transfer rate (kW) out outle condition s specific entropy (kJ/kg K) out outle condition s specific entropy (kJ/kg K) out outle condition s specific entropy (kJ/kg K) p pump r temperature (K) PR pressure reducing valve kin ass concentration of absorbent in the solution (%) ref refigerant T temperature (K) PR vapor compression-absorption integrated refrigeration s effectiveness vapor compression-absorption integrated refrigeration g effectiveness vapor compression-absorption cascaded refrigeration g system system cascade condenser ka system cascade condenser system efficiency parameter cascade condenser ka evapansion valve AV avoidable evapanstor valve AV exogenous <td>f</td> <td>circulation ratio</td> <td>k</td> <td>kth element of system</td>	f	circulation ratio	k	k th element of system	
i irreversibility rate (kW)LPClow pressure circuit m mass flow rate (kg/s)LPClow pressure generator P pressure (kPa)LPGlow pressure generator Q heat transfer rate (kW) LPG low pressure solution heat exchanger Q heat transfer rate (kW) out outlet condition s specific entropy (kJ/kg K) out outlet condition \hat{S}_{gen} entropy generation rate (kW/K) p pump T temperature (K) PRV pressure reducing valve k mass concentration of absorbent in the solution (%) R rational x mass concentration of absorbent in the solution (%) R rational $referrefigerantTtotalGreek symbolseffectivenessVCARSvapor compression-absorption integrated refrigeration\rhoeffectivenessVCARSvapor compression-absorption cascaded refrigeration\rhoeffectivenessVCARSvapor compression refrigeration system\rhoeffectivenessVCARSvapor compression refrigeration system$	h	specific enthalpy (kJ/kg)	LPA	low pressure absorber	
m m mass flow rate (kg/s)LPGlow pressure generatorPpressure (kPa)LPGHlow pressure solution heat exchangerPpressure ratiooenvironment conditionQheat transfer rate (kW)outoutel conditionsspecific entropy (kJ/kg K)overlapdegree of overlapSspecific entropy (kJ/kg K)PpumpTtemperature (K)PpumpWrate of power input (kW)Rrationalxmass concentration of absorbent in the solution (%)TtotalrefrefrigerantTtotalrefefficiencyspacesystemeefficiencysystemVCARSeefficiencysystemsystemftotal solution (kg/m³)systemsystemracacadeensity of solution (kg/m³)VCARSvapor compression-absorption integrated refrigeration systemcensity of solution (kg/m³)systemsystemsystemcexacade condenserXisystem efficiency parametersystemconqcondenserXisystem efficiency parametersiteconqexternal fluidsupersitesitesiteeventexternal fluidsitesitesiteeventexternal fluidEXexogenoussiteeventexternal fluidEXexogenoussiteeventsupersiteEXexogenoussiteevent <td>İ</td> <td>irreversibility rate (kW)</td> <td>LPC</td> <td>low pressure circuit</td>	İ	irreversibility rate (kW)	LPC	low pressure circuit	
P P PR PR PR Pressure ratioLPSHXlow pressure solution heat exchangerPR PR Pressure ratiooenvironment conditionsspecific entropy (kJ/kg K)outle conditionsspecific entropy (kJ/kg K)overlapdegree of overlapppumpTtemperature (K)PRVpressure reducing valveKrate of power input (kW)Rrationalxmass concentration of absorbent in the solution (%)refrefrigerantrtotalVARSvapor compression-absorption integrated refrigeration systemffefficiencyvapor compression-absorption integrated refrigeration systemsefficiencyVCARSvapor compression-absorption cascaded refrigeration systemsefficiencesVCARSvapor compression-refrigeration system weakfexacade condenserxisystem efficiency parameterccascade condenserxisystem efficiency parametercompressorxisystem efficiency parametercompressorxisystem efficiency parametercompcompressorsystem efficiency parametercompevaporator valveAVavoidableevaporator valveAVavoidableevaporator valveENexogenousfelment or subsystemENexogenousevaporator valveEXexogenousfelment or subsystemEXexogenousevaporator subsystemEXe	'n	mass flow rate (kg/s)	LPG	low pressure generator	
PR P pressure ratiopressure ratiooenvironment condition Q heat transfer rate (kW)outoutlet conditions specific entropy (kJ/kg K)outlet condition \hat{S}_{gen} entropy generation rate (kW/K) p pumpTtemperature (K) PRV pressure reducing valve \hat{W} rate of power input (kW) R rational x mass concentration of absorbent in the solution (%) R' rational $rate of power input (kW)Rrationalxmass concentration of absorbent in the solution (%)R'rationalrate of power input (kW)Rrationalrate of power input (kW)Rrationalrate of power input (kW)R'rationalrate of power input (kW)R'R'rate of power input (kW)R'rationalrate of power input (kW)R'R'rate of power input (kW)R''R'''''''''''''$	Р	pressure (kPa)	LPSHX	low pressure solution heat exchanger	
$ \begin{array}{cccc} \dot{Q} & heat transfer rate (kW) & out outlet condition \\ s & specific entropy (kJ/kg K) & overlap \\ degree of everlap \\ degree of overlap \\ degree of everlap \\ degree of degree \\ degree of degree \\ degree of degree \\ degree of degree \\ degree of degree \\ degree of degree \\ degree of degree \\ degree of degree \\ degree of degree \\ degree of degree \\ degr$	PR	pressure ratio	0	environment condition	
sspecific entropy (kJ/kg K)overlapdegree of overlap \hat{S}_{gen} entropy generation rate (kW/K)ppumpTtemperature (k)PKpressure reducing valveTrate of power input (kW)Rrationalxmass concentration of absorbent in the solution (%)RrationalTtotalTtotalGreek SVARSvapor absorption refrigeration systemV χ efficiencysystemsystem ξ effectivenessVARSvapor compression-absorption integrated refrigeration system gen ensity of solution (kg/m³)systemsystem gen compression refrigeration systemvapor compression refrigeration system systemsystem gen compression refrigeration systemsystemsystem gen compression valvesustemsystem gen compression valvesustemsustem gen comparison valvesustemsustem gen sustemsustemsustem gen comparison valvesustemsustem gen sustemsustemsuste	Q	heat transfer rate (kW)	out	outlet condition	
$\begin{array}{cccc} S_{\text{gen}} & \text{entropy generation rate (kW/K)} & p & pump \\ T & \text{temperature (K)} & PRV & \text{pressure reducing valve} \\ \hline T & \text{temperature (K)} & R & \text{rational} \\ \hline x & \text{mass concentration of absorbent in the solution (%)} & R & \text{rational} \\ \hline x & \text{mass concentration of absorbent in the solution (%)} & ref & \text{refrigerant} \\ \hline T & \text{total} \\ \hline Greek symbols & VARS & vapor absorption refrigeration system \\ \hline V ARS & vapor compression-absorption integrated refrigeration \\ \rho & \text{efficiency} & system \\ \hline \varepsilon & \text{efficitiveness} & VCAIRS & vapor compression-absorption cascaded refrigeration \\ \rho & \text{density of solution (kg/m^3)} & VCACRS & vapor compression-absorption cascaded refrigeration \\ \hline system & system \\ \hline Subscripts & cascade condenser & x_i & system efficiency parameter \\ cascade & cascade condenser & x_i & system efficiency parameter \\ comp & compressor & x_i & system efficiency parameter \\ cond & condenser & x_i & system efficiency parameter \\ ev & expansion valve & AV & avoidable \\ evap & evaporator & EN & endogenous \\ EQS & element or subsystem & EN & endogenous \\ EQS & element or subsystem & EX & exogenous \\ EQS & element or subsystem & EX & exogenous \\ EVAR & high pressure absorber & VIN & unavoidable \\ HPA & high pressure absorber & VIN & unavoidable \\ \end{array}$	S	specific entropy (kJ/kg K)	overlap	degree of overlap	
Ttemperature (K)PRVpressure reducing valve \dot{W} rate of power input (kW)Rrationalxmass concentration of absorbent in the solution (%) ref refrigerantTtotalTtotalGreek symbolsVARSvapor absorption refrigeration system γ efficiencyvapor compression-absorption integrated refrigeration ρ density of solution (kg/m ³)VCARSvapor compression-absorption cascaded refrigeration systemSubscriptsweak veak solutionvapor compression refrigeration system $cascade$ cascade condenser x_i system efficiency parameter $condenser$ cascade condenser x_i system efficiency parameter ev expansion valve AV avoidable ev evaporator AV avoidable eva evaporator EN endogenous EQS element or subsystem EX exogenous HPA high pressure absorber UN unavoidable	Śgen	entropy generation rate (kW/K)	р	pump	
\vec{W} rate of power input (kW) R rational x mass concentration of absorbent in the solution (%) ref refrigerant ref refrigerant T total $Greek symbols$ $VARS$ vapor absorption refrigeration system γ efficiency $VARS$ vapor compression-absorption integrated refrigeration ε effectiveness $VCARS$ vapor compression-absorption cascaded refrigeration ρ density of solution (kg/m ³) $VCACRS$ vapor compression refrigeration system $Subscripts$ $VCRS$ vapor compression refrigeration system $condenser$ x_i system $condenser$ $1, 2, 3, \cdots$ state points $condenser$ x_i system ev expansion valve AV $evap$ evaporator AV $evaporator$ EN endogenous EQS element or subsystem EN HPA high pressure absorber UN	Т	temperature (K)	PRV	pressure reducing valve	
xmass concentration of absorbent in the solution (%)refrefrigerantT T T Greek structureVARS $VaCAIRS$ $VaCAIRS$ $VaCAIRS$ $VaCAIRS$ $VaCAIRS$ $VaCAIRS$ $VaCAIRS$ $VaCAIRS$ $VaCAIRS$ $VaCAIRS$ $VaCAIRS$ $VaCAIRS$ $VaCAIRS$ $VacaIRS$ V	Ŵ	rate of power input (kW)	R	rational	
Greek symbolTtotal η efficiencyVARSvapor absorption refrigeration system η efficiencyvapor compression-absorption integrated refrigeration ε effectivenessVCAIRSvapor compression-absorption cascaded ρ density of solution (kg/m ³)VCRSvapor compression refrigeration systemSubscriptsVCRSvapor compression refrigeration system $cascade$ cascade condenserVCRSvapor compression refrigeration system $conq$ condenser x_i system efficiency parameter $cond$ condenser x_i system efficiency parameter $cond$ condenser x_i system efficiency parameter $cond$ condenser x_i system efficiency parameter eva external fluid x_i solutiable eva external fluid x_i avoidable eva element or subsystem x_i endogenous EQS element or subsystem EX exogenous GH hot surface EX exogenous HPA high pressure absorber X_i	x	mass concentration of absorbent in the solution (%)	ref	refrigerant	
Greek symbolVARSvapor absorption refrigeration system η efficiencyVCARSvapor compression-absorption integrated refrigeration ε effectivenessVCARSvapor compression-absorption cascaded refrigeration ρ density of solution (kg/m ³)VCARSvapor compression-absorption cascaded refrigeration ρ density of solution (kg/m ³)VCRSvapor compression refrigeration system ρ subscriptioncascade condenserVCRSvapor compression refrigeration system $cascade$ condenser $vapor compression refrigeration systemvapor compression refrigeration systemcondcondenservapor compression refrigeration systemvapor compression refrigeration systemevexternal fluidvapor compression refrigeration systemvapor compression refrigeration systemevapevaporatorvapor compression refrigeration systemvapor compression refrigeration systemevapexternal fluidvapor compression refrigeration systemvapor compression refrigeration systemevapevapor compressorvapor compression refrigeration systemvapor compression refrigeration systemevapexternal fluidvapor compression refrigeration systemvapor compression refrigeration systemevapevaporatorvapor compression refrigeration systemvapor compression refrigeration systemevapevaporatorvapor compression refrigeration systemvapor compression refrigeration systemevapevaporatorvapor compression refri$			Ť	total	
$ \begin{array}{cccc} & \label{eq:product} & VCAIRS & vapor compression-absorption integrated refrigeration \\ & & & & & & & & & & & & & & & & & & $	Greek symbols		VARS	vapor absorption refrigeration system	
$\begin{array}{cccc} \eta & \mbox{efficiency} & \mbox{system} \\ \varepsilon & \mbox{effectiveness} \\ \rho & \mbox{density of solution (kg/m^3)} \\ \end{array} & \begin{tabular}{lllllllllllllllllllllllllllllllllll$			VCAIRS	vapor compression-absorption integrated refrigeration	
ε effectivenessVCACRSvaporcompression-absorptioncascaderefrigeration ρ density of solution (kg/m³) $VCACRS$ vaporcompression-absorptioncascaderefrigerationSubscripts $VCRS$ vaporvaporcompression refrigeration systemweakweakweak $cascade$ cascade condenser $vaporvaporcompression refrigeration systemweak<$	η	efficiency		system	
$ \rho \text{density of solution (kg/m^3)} \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad$	ε	effectiveness	VCACRS	vapor compression-absorption cascaded refrigeration	
SubscriptsVCRSvapor compression refrigeration system weakcascadecascade condenserxisystem efficiency parametercompcompressor1, 2, 3, state pointscondcondensersuperscriptsefexternal fluidsuperscriptsevexpansion valveAVevapor atorENendogenousEQSelement or subsystemENendogenousGHhot surfaceUNunavoidableHPAhigh pressure absorberUNunavoidable	ρ	density of solution (kg/m ³)		system	
Subscriptsweakweak solutioncascadecascade condenser x_i system efficiency parametercompcompressor1, 2, 3, \cdots state pointscondcondenser x_i superscriptsefexternal fluid x_i avoidableevexpansion valve AV avoidableevapevaporatorENendogenousEQSelement or subsystemEXexogenousGHhot surfaceUNunavoidableHPAhigh pressure absorber $unavoidable$			VCRS	vapor compression refrigeration system	
cascadecascade condenser x_i system efficiency parametercompcompressor1, 2, 3, \cdots state pointscondcondensercondenserefexternal fluidcondenserevexpansion valveAVevaporevaporatorENevaporatorendogenousEQSelement or subsystemEXGHhot surfaceUNHPAhigh pressure absorber	Subscripts		weak	weak solution	
cascadecascade condenser1, 2, 3, state pointscompcompressor1, 2, 3, state pointscondcondenserSuperscriptsefexternal fluidAVevexpansion valveAVevapevaporatorENendogenousEXexogenousGHhot surfaceUNHPAhigh pressure absorber			X_i	system efficiency parameter	
compcompressorcompressorcondcondenserSuperscriptsefexternal fluidAVevexpansion valveAVevapevaporatorENendogenousEXexogenousGHhot surfaceUNunavoidable	cascade	cascade condenser	1, 2, 3,	• state points	
condcondenserSuperscriptsefexternal fluid AV evexpansion valve AV evapevaporator EN endogenous EX EQSelement or subsystem EX GHhot surface UN HPAhigh pressure absorber	сотр	compressor		1	
efexternal fluidAVevexpansion valveAVavoidableevapevaporatorENendogenousEQSelement or subsystemEXexogenousGHhot surfaceUNunavoidable	cond	cond condenser		Superscripts	
evexpansion valveAVavoidableevapevaporatorENendogenousEQSelement or subsystemEXexogenousGHhot surfaceUNunavoidable	ef	external fluid	1 1		
evapevaporatorENendogenousEQSelement or subsystemEXexogenousGHhot surfaceUNunavoidableHPAhigh pressure absorberUNunavoidable	ev	expansion valve	AV	avoidable	
EQSelement or subsystemEXexogenousGHhot surfaceUNunavoidableHPAhigh pressure absorberUNunavoidable	evap	evaporator	EN	endogenous	
GHhot surfaceUNunavoidableHPAhigh pressure absorberUN	EQS	element or subsystem	EX	exogenous	
HPA high pressure absorber	GH	hot surface	UN	unavoidable	
	HPA	high pressure absorber			

absorption cascaded refrigeration system (VCACRS) with an equivalent vapor compression chiller of 170 kW cooling capacity. As compared to equivalent vapor compression chiller, the electricity consumption in the compressor of vapor compression section is reduced by 76.8%, 50%, and 88.3% for series, parallel and combined series-parallel configurations, respectively. It is to be noted here that the heat is supplied in the generator of vapor absorption section at the source temperature of 100 °C for all the three configurations. Bhavesh et al. [5] estimated the energetic and rational efficiencies of VCACRS powered by organic rankine cycle as 79.02% and 46.7%, respectively; with the source temperature, which increases the temperature of the pressurized water upto 151.5 °C. Li et al. [6] estimated exegetic efficiency of 23% for solar absorption-subcooled compression hybrid cooling system, with inlet temperature of hot water as 100 °C. Wang et al. [7] studied absorptioncompression hybrid refrigeration system; wherein, all the heat lost in condensation is used for the generation purpose. It was resulted 70-80% reduction in the generation heat and 97.1% improvement in primary energy efficiency of proposed system as compared to conventional VARS. Vasta et al. [8] presented experimental investigation of cascade chiller consisting of an adsorption and vapor compression units. Electrical COP up to 5.7 was recorded for 95 °C driving temperature in adsober. Chen et al. [9] proposed absorption/absorptioncompression refrigeration system which consists of a conventional single-effect VARS and an absorption-compression refrigeration system. With the source temperature of 200 °C, the cooling capacity per unit mass of flue gas for the proposed system was 28.2% higher than equivalent VARS; whereas, the exergy efficiency was reported to be

25.9%. Su and Zhang [10] proposed a hybrid compression-absorption refrigeration air-conditioning system combined with liquid desiccant dehumidification. The heat rejected from the condenser of absorption section is used to regenerate the diluted liquid desiccant solution. Besides, the evaporator temperature is increased as the latent heat is handled by diluted liquid desiccant solution. It increases the primary energy efficiency of the system by 34.9% as compared to traditional VARS; whereas, the generator temperature is decreased from 100 °C to $60\ensuremath{\,^\circ C}$ due to the presence of the compressor at the exit of generator. Ayou et al. [11] improved the performance of VARS by placing a compression booster in between the absorber and the evaporator. The energy and exergy efficiency of the proposed system are reported to be 12.2% and 60.7%, respectively with the generator source temperature of 130 °C. Xu et al. [12] compared the performance of vapor compression-absorption cascaded refrigeration system with an evaporator condenser and with an evaporator-subcooler based on their COP. The COP of vapor compression-absorption cascaded refrigeration system with an evaporator condenser is 7.6% higher as compared to evaporator-subcooler system with generator temperature in the range of 90 to 120 °C.

In addition to the above mentioned systems, researchers [13–15] proposed several other different possible configurations of vapor compression-absorption integrated refrigeration systems. Each configuration has its own pros and cons. In present work, a novel configuration of vapor compression-absorption integrated refrigeration system (VCAIRS) is presented for low temperature application. The proposed integrated system utilizes both the low grade as well as high grade

Download English Version:

https://daneshyari.com/en/article/7157898

Download Persian Version:

https://daneshyari.com/article/7157898

Daneshyari.com