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Thermodynamic performances using energy-exergy analysis of NH_3H_2O vapor absorption refrigeration system cascaded with vapor compression refrigeration systems using ecofriendly refrigerants

R.S. Mishra

Department of Mechanical and Production Industrial and Automobiles Engineering, Delhi Technological University, Delhi, India

Abstract

The main aim of the study is to locate for components in the system for maximum irreversibility and to find ways to improve the system. The overall objective is to accomplish the thermodynamic analysis of the refrigeration systems and study their thermodynamic viability. Fourth generation refrigerants i.e. R-1234yf and R1234ze) are needed because the high GWP of the R134A that are used in existing refrigeration and air conditioning systems. The hydro fluoro olefins (HFOs) known as fourth generation refrigerants are available in limited quantities and also their thermodynamic performance on cascaded vapor absorption- compression refrigeration systems are not completely tested in different applications by the various investigators. . The thermodynamic performance of fourth generation refrigerants in terms of their first low efficiency termed as coefficient of performance (COP, second law efficiency termed as exergetic efficiency and exergy destruction ratio for a specified cooling load and compared with the third generation HFC-134a refrigerant. It is found that fourth generation HFO-1234yf refrigerant have slightly low(around 1.477% first law efficiency (COP) and exergetic efficiency and reduction in exergy destruction ratio of at -53^{o}C of low temperature evaporator. However, HFO1234ze can replace R134a as its thermodynamic performance is almost similar to R134a for -30^{o}C of low temperature evaporator temperature due to low GWP (around. The effect of performance parameters such as temperature over lapping (approach), generator temperature, high pressure absorber temperature, low pressure absorber temperature, condenser temperature of vapor absorption on thermodynamic performances (such as first and second law efficiencies , exergy destruction ratio have been presented.

Keywords: Thermodynamic performances, cascaded vapor compression-absorption refrigeration systems, ecofriendly refrigerants

1. Introduction

A refrigeration system utilized high grade energy in terms of work supplied by an electric motor to transfer heat from a space to be cooled. Low temperature boiling fluids called refrigerants which absorbed thermal energy to get vaporized in the evaporator causing a cooling effect in the region being to be cooled. Even though comparing the advantages and disadvantages of various refrigeration systems, two most important parameters i.e. the operating temperature and refrigerating capacity are of vital importance in these systems. These systems can be evaluated using energy and exergy analyses which are based on first and second law of thermodynamics to compute and the coefficient of performance, exergy destruction ratio and exergetic efficiency respectively.

An extensive review of the literature has been done on different refrigeration and air conditioning systems by the various investigators which has been classified as

(i) Vapor Absorption Refrigeration Systems.
(ii) Vapor Compression Refrigeration Systems.
(iii) Vapor-compression-absorption refrigeration systems.

Vapor Absorption system is an attractive method for utilizing low grade energy directly for cooling. This is an important advantage as against the conventional vapor compression system which operates on high grade energy. Another important feature of these systems is that it does not use any

Corresponding author: Prof. R.S. Mishra
Email Address: hod.mechanical.rsm@dtu.ac.in

moving component except a very small liquid pump. Vapor absorption system consists of four basic components viz. an evaporator, an absorber (located on low pressure side), a generator and a compressor (located on high pressure side). A refrigerant flows from the condenser to the evaporator, then via absorber to the generator and back to condenser, while the absorbent passes from absorber to the generator and back to absorber. For maximum efficiency, the pressure difference between the low pressure side and high pressure side is maintained as small as possible. Although, the initial cost of these systems is at present higher but their operating expenses are often appreciably lower, which can further be reduced if efficient absorption and distillation can be achieved. Since, the efficiency of these processes is determined largely by thermodynamic properties of the refrigerant absorbent combination, an extensive study of these properties is of utmost importance in the development of an efficient absorption refrigeration cycle. A large number of researchers have carried out research in the field of vapor absorption refrigeration using different working pairs and the most common working pairs are LiBr-H2O and NH3-H2O. Alizadeh et al [1] carried out theoretical study on design and optimization of water – lithium bromide refrigeration cycle and determined that for a given refrigerating capacity higher generator temperature causes high cooling ratio with smaller heat exchange surface at a low cost. In vapor compression system there are four major components: evaporator, compressor, condenser and expansion device. Power is supplied to the compressor and heat is added to the system in the evaporator, whereas in the condenser heat rejection occurs. Heat rejection and heat addition are dissimilar to different refrigerants. A standard vapor compression cycle consists of four processes viz. a 28 reversible adiabatic compression from the saturated vapor to the compressor pressure followed by a reversible heat rejection at constant pressure causing de-superheating and condensation. This is further extended to an irreversible expansion at constant enthalpy from saturated liquid to evaporator pressure and there after a reversible heat addition at constant pressure causing evaporation to saturated vapor. Keshwani and Rastogi [2] studied a two stage VCR system for refrigerant CFC12 and determined the optimum inter-stage pressure in in two stage VCRS for minimization of overall compressor work. Zubair et al [3-4] showed that the optimum inter stage pressure for a two stage refrigeration system and found that optimum inter stage pressure for refrigerant R-134a for maximum COP of the system which was closed to the saturation pressure corresponding to the arithmetic mean of the refrigerant condensation and evaporation temperatures. And found that the system irreversible losses are lowest at an intermediate saturation temperature near to arithmetic mean of the condensation and evaporation temperatures. Aprea et al [5] studied that vapor compression refrigeration systems using refrigerant R-502 which is an azeotropic mixture of refrigerants R-22 and R-115. are widely used for cold storage refrigeration. Doring et al [6] carried out an experimental study of R-507 and developed mathematical correlations using measured thermodynamic data and found that the compressor discharge temperature for R-507 was approximately 8K below in comparison to R-402. Sami and Desjardins [7] carried out performance evaluation of R-407B, R-507, R-408A and R-404A as substitutes to R-502. And found that the R408A blend has a higher performance than R-502. Nikolaidis and Probert [8] used exergy analysis to investigate the behaviour of two stage compound compression cycle with flash intercooling using R-22 as refrigerant by varying the condenser saturation temperature and evaporator saturation temperature from 298 to 308 K and 238 to 228 K respectively. They determined the effect of temperature change in condenser and evaporator on plants irreversibility rate. They concluded that the changes in the temperatures of condenser and evaporator significantly effecting the overall irreversibility of the plants and concluded that the two stage compound compression system with flash intercooling using R-22 as refrigerant needs optimization.

Dopazo et al [9] analyzed performance parameters of a CO_2/NH_3 cascade cooling system and their effect on system COP and exergetic efficiency using general mathematical model which was validated using experimental results and concluded that the isentropic efficiency for each compressor in cascade system should be determined for the optimum CO2 condensing temperature and maximum COP.

Miguel Padilla et. al. [10] developed analysis model by carried out energy-exergy analysis of the impact of direct replacement of R-12 by zeotropic mixture R-413A on the performance of a domestic vapor compression refrigeration system and concluded that the overall energy and exergy performance of system working with R-413A is better than R-12. Qureshi and Zubair [11] developed first and second law analysis for investigating thermodynamic performance degradation due to fouling in a vapor compression cycle for various applications. Using refrigerants R-134a, R-410A and R-407C. The first law analysis indicates that R-134a always performs better unless only the evaporator is being fouled. However, the second law shows that R-134a performs the best in all cases. The second-law efficiency indicates that R-717 performs the best in all cases. Volumetric efficiency of R-410A and R-717 remained the highest under the respective conditions studied. Furthermore, performance degradation of the evaporator often has a larger effect on compressor power requirement while that of the condenser has an overall larger effect on the COP.

2. Cascade Refrigeration System

A cascade system consists of two independently operated single-stage refrigeration systems: a lower system that maintains a lower evaporating temperature and produces a refrigeration effect and a higher system that operates at a higher evaporating temperature. These two separate systems are connected by a cascade condenser in which the heat released by the condenser in the lower system is extracted by the evaporator in the higher system. Reduces irreversibility during heat exchange process between working fluids and results in improved system performance. Cascade vapor refrigeration system comprises two separate single stage

NH_3H_2O absorption refrigeration cycle and cascaded vapor compression cycle with a different refrigerants, best suited for the working conditions. It is necessary to use a cascade vapor compression system when the difference between the temperature at which heat is rejected and the temperature at which refrigeration is required is so large that a single refrigerant with suitable properties cannot be found. In low-temperature applications, including rapid freezing and the storage of frozen food, the required evaporating temperature of the refrigeration system ranges from –40°C to –55°C, therefore, single-stage vapor-compression refrigeration system is insufficient, while two-stage or cascade refrigeration systems are used for low-temperature applications. The high- and low-pressure sides of a two-stage refrigeration system are charged with the same refrigerant, whereas the high and low-temperature circuits in a cascade system are filled separately with appropriate refrigerants. Therefore, using HFO refrigerants in both two-stage and cascade refrigeration system helps to meet the requirements of environmental regulations [12-13] Mishra [13] described. Cascade refrigeration systems which are where the evaporating temperature of frozen-food cabinets ranges from –30°C to –50°C. In these units, two single-stage systems are thermally coupled through a cascade condenser. The high-temperature stage of a cascade refrigeration system usually uses HFO -1234ze, whereas the low-temperature circuit of the refrigeration system can be charged with HFO-1234yf and HFC-134a and carbon dioxide (R744).

2.1 Vapor Compression-Absorption System

Vapor Compression-absorption heat pump/refrigeration cycle represents a cycle in which vapor is mechanically compressed, absorbed and then desorbed using a liquid solution cycle. These systems may be considered as hybrid systems between conventional vapor compression and vapor absorption systems. The hybrid vapor compression/absorption heat pump cycle combines two well-known heat pump concepts, the compression heat pump and the absorption heat pump. It uses a mixture of refrigerants as the working fluid, one as the absorbent and the other as the desorbent. A key advantage of the hybrid heat pump is the extended range of temperatures available for a mixture compared to pure refrigerants. This is the effect of the reduced vapor pressure obtained for a refrigerant in a mixture with less volatile component. Another advantage is the gliding temperature obtained in the absorber and desorbed. Fernandez-Seara et al [14] investigated a compression absorption cascade refrigeration system. The results were computed for refrigerants carbon-dioxide and ammonia in the compression stage and ammonia water in absorption stage. It is shown that the intermediate temperature level is an important design parameter that causes an opposite effect on the COP of the compression and absorption systems. Kairouani and Nahdi [15] developed a novel combined refrigeration system using geothermal energy for hybrid system and carried out thermodynamic analysis of the cycle. The possibility of selected three working fluids R-717, R-22 and R-134a for the conventional and ammonia–water Pair for the absorption system at the geothermal temperature source is in the range of 343-349K and the results show that the COP of a combined system is significantly higher than that of a single stage refrigeration system to reduce the continuously increasing electrical energy consumption. Garimella et al [16] analyzed a novel cascaded absorption/vapor-compression cycle with a high temperature lift for a naval ship application. A single-effect LiBr–H2O absorption cycle and a subcritical CO_2 vapor-compression cycle were coupled together to provide low-temperature refrigerant −40°C and developed a thermodynamic model to analyze the performance of the cascaded system, and parametric analyses were conducted to estimate the performance of the system over a range of operating conditions. The performance of the cascaded system was also compared with an equivalent two-stage vapor-compression cycle and found to exhibit very high COPs over a wide range of operating conditions and when compared to an equivalent vapor-compression system, was found to avoid up to 31% electricity demand. Yari et al [17] studied and compared the GAX and GAX hybrid absorption refrigeration cycles using first and second law of thermodynamics. They performed the exergy analyses in order to calculate the total exergy destruction rate within the cycles and also reveal the contribution of different components to the destructions and concluded that in both cycles the generator temperature (Tgen) has more influence on the second law efficiency whereas, the coefficient of performance (COP) of the cycles are comparatively less affected by this temperature. An increase of about 75% in the second law efficiency of the GAX cycle was found as the generator temperature was varied from 400 to 440 K. With this variation of the generator temperature, the increase in the corresponding COP was around 5%.

Zheng and Meng [18] studied the thermodynamic performances of the hybrid refrigeration cycle and proposed the fundamental concept in terms of ultimate refrigerating temperature and investigated the impact of compressor pressure increasing on the thermodynamic performances and also observed that the refrigeration cycle performance varies with the change of compressor outlet pressure and depends on the absorption sub-system or the compression sub-system. Mishra and Ankit Dewedi [19] also described methods for improving thermal performances of vapor absorption system using heat pipes. Comprehensive review of the literature on Vapor Absorption Systems, Compression-Absorption System and Vapor Compression System has been carried out on various aspects of energy-exergy analysis and the type of cycles analyzed, working pairs used and using entropy generation principle. With regards to vapor absorption cycles, it is found that mostly the studies are carried out on large capacity systems and the investigation had been carried out with in a limited range of system design parameters. The literature on small vapor absorption systems is limited and very few studies have been done on smaller systems. The above studies are simulation studies. About compression absorption systems studies have been carried out by many investigators mostly analytically and experimentally. The investigations have been done on wet compression cycles which eliminated the need of the solution pump. However the literature on exergy analysis of such systems is limited and NH3-H_2O is the most suitable working fluid due to its high latent heat and excellent heat and mass transfer properties. Literature review revealed that thermodynamic optimization on compressor-absorption system was carried out to find optimum working condition for a given external condition. The temperature gradient in the absorber is optimized. The literature reveals that cost optimization of the system is essential to minimize the cost as this system is more capital intensive than the conventional compression refrigeration system and cascaded absorption-compression refrigeration system. With respect to vapor compression systems, literature review revealed that natural refrigerants such as ammonia, propane, propylene are halogen free and are safe for the environment. Many investigators have carried out theoretical and experimental investigations on alternative refrigerants. Considerable talked about the replacement of R-134a by using HFO refrigerants of low GWP less than 7. In view of the increase in the cost of our existing resources, the advantage of minimizing losses in the use of this energy is very important and essential. Exergy analysis is a prime area for effective improvement of the systems. In the present work energy and exergy analysis of the refrigeration systems is done in order to improve the system thermodynamically. The main idea was to have possible future direction of research is to search the HFO refrigerants (such as low GWP of R1234yf and R1234ze) to replace HFC refrigerant (i.e. R134a).

3. Results and Discussions

Following two cascade system have been chosen for numerical computation and input data is also given below of each system.

System1: NH_3H_2O vapor absorption refrigeration system cascaded with vapor compression refrigeration system using HFC-134a ecofriendly refrigerant.

- Temperature of Absorber=35°C.
- Temperature of Condenser=35°C
- Temperature of Generator=80°C to 115°C
- Evaporator temperature of vapor compression refrigeration system= 5 °C
- Evaporator temperature of vapor compression refrigeration system= -53 °C
- Compressor efficiency=0.8
- Heat exchanger effectiveness =0.5
- Refrigeration effect =29.09“kW”
- Temperature overlapping(Approach) =10 °C

System2: NH_3H_2O vapor absorption refrigeration system cascaded with vapor compression refrigeration system using HFO-1234yf ecofriendly refrigerant.

- Temperature of Absorber=35°C.
- Temperature of Condenser=35°C
- Temperature of Generator=80°C to 115°C
- Evaporator temperature of vapor compression refrigeration system= 5 °C
- Evaporator temperature of vapor compression refrigeration system= -53 °C
- Compressor efficiency=0.8
- Heat exchanger effectiveness =0.5
- Refrigeration effect =29.09“kW”
- Temperature overlapping(Approach) =10 °C

Input variables used in the for numerical computation of NH_3H_2O vapor absorption refrigeration system cascaded with vapor compression refrigeration systems using HFC-134a (system-1) and HFO-1234yf (system-2) refrigerants following ranges

- Effect of temperature overlapping (Approach= Temperature of cascade condenser vapor compression refrigeration cycle- cascade evaporator temperature of vapor absorption refrigeration cycle) variation from 0 to 20 using HFC-134a and HFO-1234yf refrigerants
- Generator temperature variation NH_3H_2O vapor absorption refrigeration from 65 °C to 115 °C,
- Evaporator temperature vapor compression refrigeration system from $T_{\_EVA\_VCRS}$ = -30 to - 53°C.
- Evaporator temperature vapor absorption refrigeration system $T_{\_EVA\_VARS}$= 30 °C to 45°C,
- Absorber temperature vapor absorption refrigeration system $T_{\_EVA\_VARS}$= 30 °C to 45°C.

3.1 *Effect of of low temperature evaporator temperature of vapor compression refrigeration cycle on thermal performances of NH_3H_2O vapor absorption refrigeration cascaded with vapor compression refrigeration system*

Table-1 (a) shows the variation of low temperature evaporator circuit temperature with variation of thermal performances such as first law efficiency (coefficient of performance (COP) of cascaded vapor absorption system) & second law efficiency in terms of exergetic efficiency and exergy destruction ratio based on exergy of fuel of NH_3H_2O vapor absorption refrigeration system cascaded with vapor compression refrigeration using HFC-134a refrigerant and it is found that when low temperature evaporator circuit temperature of vapor absorption refrigeration system is increasing, the thermodynamic performances in terms of ($COP_{\_Cascad}$,) is decreasing and exergetic efficiency $_{Cascade\ System}$ is also decreasing and EDR is increasing . Similarly exergy destruction ratio based on the exergy of product ($EDR_{\_Cascade}$) is also decreasing and exergetic efficiency is increasing. The optimum values of single effect vapor absorption refrigeration cycle cascaded with vapor compression cycle for generator temperature of 80°C and condenser temperature and absorber temperature of 35°C by using HFO-1234yf refrigerant (system-2) has 1.477% lower COP than System-1 using HFC-134a

Table-1(a): Effect of evaporator temperature on thermal performances of NH_3H_2O vapor absorption refrigeration cascaded with vapor compression refrigeration system using R134a ecofriendly refrigerant (COP_NH_3H_2O= 0.322, Rational EDR_$_{VARS}$=0.8683, EDR_$_{VARS}$=6.594, Exergetic Efficiency_$_{NH3H2O}$=0.1317) for ,T_$_{EVA}$=-1ºC, Absorber temperature=35ºC, generator temperature=80ºC, Condenser temperature_$_{VARS}$=35ºC, Collector Area= 31.65 m^2), Compressor efficiency=0.80, T_$_{EVA}$=-53ºC and Approach (temperature overlapping) =10, {SYSTEM-1}

T_EVA (ºC)	COP_$_{Cascade}$	EDR_$_{Cascade}$	Exergetic Efficiency$_{cascade}$
-53	0.5339	1.549	0.3924
-52	0.5364	1.553	0.3917
-51	0.5390	1.558	0.3910
-50	0.5416	1.583	0.3902
- 45	0.5545	1.593	0.3856
- 40	0.5673	1.633	0.3798
-35	0.5802	1.683	0.3727
-30	0.5931	1.745	0.3643

Table-1(b): Effect of evaporator temperature on thermal performances of NH_3H_2O vapor absorption refrigeration cascaded with vapor compression refrigeration system using R1234yf ecofriendly refrigerant (COP_NH_3H_2O= 0.322, Rational EDR_$_{VARS}$=0.8683, EDR_$_{VARS}$=6.594, Exergetic Efficiency_$_{NH3H2O}$=0.1317) for ,T_$_{EVA}$=-1ºC, Absorber temperature=35ºC, generator temperature=80ºC, Condenser temperature_$_{VARS}$=35ºC, Collector Area= 31.65 m^2), Compressor efficiency=0.80, T_$_{EVA}$=-53ºC and Approach (temperature overlapping) =10, {SYSTEM-2}

T_EVA (ºC)	COP_$_{Cascade}$	EDR_$_{Cascade}$	Exergetic Efficiency$_{cascade}$
-53	0.5336	1.552	0.3918
-52	0.5361	1.556	0.3912
-51	0.5387	1.561	0.3904
-50	0.5413	1.566	0.3897
--45	0.5541	1.597	0.3851
-40	0.5670	1.637	0.3793
-35	0.5799	1.687	0.3722
-30	0.5928	1.748	0.3638

The variation of thermal performances such as coefficient of performance (COP) of cascaded vapor absorption system & second law efficiency in terms of exergetic efficiency and exergy destruction ratio based on exergy of fuel of NH_3H_2O vapor absorption refrigeration system cascaded with vapor compression refrigeration using HFO-1234yf refrigerant in table-1-(b) because HFO has GWP is four as compared to HFC-134a which has GWP of 1360 it is found that when low temperature evaporator circuit temperature of vapor absorption refrigeration system is increasing**,** the thermodynamic performances in terms of (COP_$_{Cascad}$,) is decreasing and exergetic efficiency_$_{Cascade\ System}$ is also decreasing and EDR_$_{Rational}$ is increasing . Similarly exergy destruction ratio based on the exergy of product (EDR_$_{Cascade}$) is also decreasing and exergetic efficiency is increasing. The optimum values of single effect vapor absorption refrigeration cycle cascaded with vapor compression cycle for generator temperature of 80ºC and condenser temperature and absorber temperature of 35ºC by using HFO-1234yf refrigerant (system-2) has lower COP & lower exergetic efficiency and higher EDR than System-1 using HFC-134a

Table-1(c): Effect of evaporator temperature on thermal performances of NH_3H_2O vapor absorption refrigeration cascaded with vapor compression refrigeration system using R134a ecofriendly refrigerant (COP_NH_3H_2O= 0.322, Rational EDR_$_{VARS}$=0.8683, EDR_$_{VARS}$=6.594, Exergetic Efficiency_$_{NH3H2O}$=0.1317) for ,T_$_{EVA}$=-1ºC, Absorber temperature=35ºC, generator temperature=80ºC, Condenser temperature_$_{VARS}$=35ºC, Collector Area= 31.65 m^2), Compressor efficiency=0.80, T_$_{EVA}$=-53ºC and Approach (temperature overlapping) =10, {SYSTEM-1}

T_EVA (ºC)	COP_$_{Cascade}$	Rational EDR_$_{Cascade}$	Exergetic Efficiency$_{cascade}$
-53	0.5339	0.6076	0.3924
-52	0.5364	0.6083	0.3917
-51	0.5390	0.6090	0.3910
-50	0.5416	0.6098	0.3902
- 45	0.5545	0.6144	0.3856
- 40	0.5673	0.6202	0.3798
-35	0.5802	0.6273	0.3727
-30	0.5931	0.6347	0.3643

Table-1 (c) shows the variation of low temperature evaporator circuit temperature with variation of thermal performances such as first law efficiency in terms of coefficient of performance (COP) of cascaded vapor absorption system & second law efficiency in terms of exergetic efficiency and exergy destruction ratio based on exergy of fuel of NH_3H_2O

vapor absorption refrigeration system cascaded with vapor compression refrigeration using HFC-134a refrigerant (system-1) and it is found that when low temperature evaporator circuit temperature of vapor absorption refrigeration system is increasing , the rational EDR based on exergy of fuel is increasing .

Table-1(d): Effect of evaporator temperature on thermal performances of NH_3H_2O vapor absorption refrigeration cascaded with vapor compression refrigeration system using R1234yf ecofriendly refrigerant (COP_NH_3H_2O= 0.322, Rational EDR_$_{VARS}$=0.8683, EDR_$_{VARS}$=6.594, Exergetic Efficiency_$_{NH3H2O}$=0.1317) for ,T_$_{EVA}$=-1°C, Absorber temperature=35°C, generator temperature=80°C, Condenser temperature_$_{VARS}$=35°C, Collector Area= 31.65 m^2), Compressor efficiency=0.80, T_$_{EVA}$=-53°C and Approach (temperature overlapping) =10, {SYSTEM-2}

T_EVA (°C)	COP_$_{Cascade}$	Rational EDR_$_{Cascade}$	Exergetic Efficiency$_{cascade}$
-53	0.5336	0.6082	0.3918
-52	0.5361	0.6088	0.3912
-51	0.5387	0.6096	0.3904
-50	0.5413	0.6103	0.3897
--45	0.5541	0.6149	0.3851
-40	0.5670	0.6207	0.3793
-35	0.5799	0.6278	0.3722
-30	0.5928	0.6362	0.3638

Table-1 (d) The variation of thermal performances s coefficient of performance (COP) of cascaded vapor absorption system & second law efficiency in terms of exergetic efficiency and exergy destruction ratio based on exergy of fuel of NH_3H_2O vapor absorption refrigeration system cascaded with vapor compression refrigeration using HFO-1234yf refrigerant (System-2) shown in Table-1(d) with the the variation of low temperature evaporator circuit temperature of cascade vapour absorption refrigeration systems and it is found that when low temperature evaporator circuit temperature of vapor absorption refrigeration system is increasing , the rational EDR based on exergy of fuel is increasing. Table-1 (e) & Table-1 (f) show the variation of low temperature evaporator circuit temperature with variation of thermal performances such as first law efficiency in terms of coefficient of performance (COP) of cascaded vapor absorption system & second law efficiency in terms of exergetic efficiency and exergy destruction ratio based on exergy of fuel of NH_3H_2O vapor absorption refrigeration system cascaded with vapor compression refrigeration using HFC-134a refrigerant (System-1) and it is found that when low temperature evaporator circuit temperature of vapor absorption refrigeration system is increasing , coefficient of performance (COP_$_{VCRS}$) is increasing & the rational EDR based on exergy of fuel of cascaded vapor compression refrigeration system is decreasing. Also second law efficiency (exergetic efficiency_$_{VCRS}$) of cascaded vapor compression system is also increasing

Table-1(e): Effect of evaporator temperature on thermal performances of NH_3H_2O vapor absorption refrigeration cascaded with vapor compression refrigeration system using R1234yf ecofriendly refrigerant (COP_NH_3H_2O= 0.322, Rational EDR_$_{VARS}$=0.8683, EDR_$_{VARS}$=6.594, Exergetic Efficiency_$_{NH3H2O}$=0.1317) for ,T_$_{EVA}$=-1°C, Absorber temperature=35°C, generator temperature=80°C, Condenser temperature_$_{VARS}$=35°C, Collector Area= 31.65 m^2), Compressor efficiency=0.80, T_$_{EVA}$=-53°C and Approach (temperature overlapping) =10, {SYSTEM-1}

T_EVA (°C)	COP_$_{Cascade}$	Rational EDR_$_{Cascade}$	Exergetic Efficiency$_{cascade}$
-53	3.486	2.427	0.2918
-52	3.601	2.442	0.2905
-51	3.721	2.458	0.2892
-50	3.848	2.475	0.2878
- 45	4.592	2.571	0.2801
-40	5.587	2.69	0.2710
-35	6.986	0.2839	0.2605
-30	9.093	3.023	0.2485

Table-1(f): Effect of evaporator temperature on thermal performances of NH_3H_2O vapor absorption refrigeration cascaded with vapor compression refrigeration system using R1234yf ecofriendly refrigerant (COP_NH_3H_2O= 0.322, Rational EDR_$_{VARS}$=0.8683, EDR_$_{VARS}$=6.594, Exergetic Efficiency_$_{NH3H2O}$=0.1317) for ,T_$_{EVA}$=-1°C, Absorber temperature=35°C, generator temperature=80°C, Condenser temperature_$_{VARS}$=35°C, Collector Area= 31.65 m^2), Compressor efficiency=0.80, T_$_{EVA}$=-53°C and Approach (temperature overlapping) =10, {SYSTEM-2}

T_EVA (°C)	COP_$_{Cascade}$	Rational EDR_$_{Cascade}$	Exergetic Efficiency$_{cascade}$
-53	3.486	0.6082	0.2918
-52	3.601	0.6195	0.2905
-51	3.721	0.6108	0.2892
-50	3.848	0.6122	0.2878
- 45	4.592	0.6199	0.2801

-40	5.587	0.6290	0.2710
-35	6.986	0.6395	0.2605
-30	9.093	0.6515	0.2485

Table-1 (g) The variation of low temperature evaporator circuit temperature with variation of thermal performances such as first law efficiency in terms of exergy destruction ratio based on exergy of fuel of NH_3H_2O vapor absorption refrigeration system cascaded with vapor compression refrigeration using HFO-1234yf refrigerant (System-1) is shown in Table-1(g) and it is found that when low temperature evaporator circuit temperature of vapor absorption refrigeration system is increasing , coefficient of performance (COP_VCRS) is increasing

Table-1(g): Effect of evaporator temperature on thermal performances of NH_3H_2O vapor absorption refrigeration cascaded with vapor compression refrigeration system using R1234yf ecofriendly refrigerant (COP_NH_3H_2O= 0.322, Rational EDR_$_{VARS}$=0.8683, EDR_$_{VARS}$=6.594, Exergetic Efficiency_$_{NH3H2O}$=0.1317) for ,T_$_{EVA}$=-1°C, Absorber temperature=35°C, generator temperature=80°C, Condenser temperature_$_{VARS}$=35°C, Collector Area= 31.65 m^2), Compressor efficiency=0.80, T_$_{EVA}$=-53°C and Approach (temperature overlapping) =10, {SYSTEM-2}

T_EVA (°C)	COP_$_{Cascade}$	Rational EDR_$_{Cascade}$	Exergetic Efficiency$_{cascade}$
-53	3.473	2.433	0.2913
-52	3.587	2.448	0.290
-51	3.707	2.464	0.2887
-50	3.832	2.480	0.2873
- 45	4.571	2.576	0.2796
-40	5.558	2.696	0.2706
-35	6.943	2.845	0.2601
-30	9.025	3.030	0.2482

3.2 Effect of ecofriendly refrigerants in low temperature evaporator t of vapor compression refrigeration cycle on thermal performances of NH_3H_2O vapor absorption refrigeration cascaded with vapor compression refrigeration system

Table-2(a-b) show, the effect of ecofriendly refrigerants in low temperature circuit with variation of thermal performances such as first law efficiency in terms of coefficient of performance (COP) of cascaded vapor absorption system & second law efficiency in terms of exergetic efficiency and exergy destruction ratio based on exergy of fuel of single effect Li/Br-H_2O vapor absorption refrigeration system cascaded with vapor compression refrigeration at 5°c and at 8°C of cascaded vapor absorption refrigeration system evaporator temperature and vapor compression evaporator temperature of -30°C and it is found that the performance of HFC-134a. Similarly Table-2(c). It was also observed that by changing evaporator temperature from 1°C to 6°C the thermodynamic performances enhanced significantly

Table-2(a): performance comparison of thermal performances of NH_3H_2O vapor absorption refrigeration cascaded with vapor compression refrigeration system using ecofriendly refrigerants (COP_NH_3H_2O= 0.322, Rational EDR_$_{VARS}$=0.8683, EDR_$_{VARS}$=6.594, Exergetic Efficiency_$_{NH3H2O}$=0.1317) for ,T_$_{EVA}$=-1°C, Absorber temperature=35°C, generator temperature=80°C, Condenser temperature_$_{VARS}$=35°C, Collector Area= 31.65 m^2), Compressor efficiency=0.80, T_$_{EVA}$=-53°C and Approach (temperature overlapping) =10,

Refrigerant	COP_$_{Cascade}$	EDR_$_{Cascade}$	Exergetic Efficiency$_{cascade}$
R134a	0.5335	1.552	0.3918
R1234yf	0.5323	1.597	0.3892
R152a	0.5346	1.541	0.3936
R290	0.5336	1.552	0.3919
R600a	0.5344	1.543	0.3933
R600	0.5349	1.537	0.3942

Table2 (b): performance comparison of thermal performances of NH_3H_2O vapor absorption refrigeration cascaded with vapor compression refrigeration system using ecofriendly refrigerants (COP_NH_3H_2O= 0.322, Rational EDR_$_{VARS}$=0.8683, EDR_$_{VARS}$ =6.594, ExergeticEfficiency_$_{NH3H2O}$=0.1317) for T_$_{EVA}$=-1°C, Absorber temperature=35°C,generator temperature=80°C, Condenser temperature_$_{VARS}$=35°C, Compressor efficiency =0.80, T_$_{EVA}$=-53°C and Approach (temperature overlapping) =10,

Refrigerant	COP_$_{VCRS}$	EDR_$_{VCRS}$	Exergetic Efficiency_$_{VCRS}$
R134a	3.472	2.433	0.2913
R1234yf	3.406	2.460	0.2890
R152a	3.516	2.415	0.2928
R290	3.475	2.432	0.2914
R600a	3.509	2.418	0.2925
R600	3.533	2.408	0.2933

Table-2(c): performance comparison of thermal performances of NH_3H_2O vapor absorption refrigeration cascaded with vapor compression refrigeration system using ecofriendly refrigerants ($COP\_NH_3H_2O$= 0.322, Rational EDR_{VARS}=0.8683, EDR_{VARS}=6.594, Exergetic $Efficiency\_{NH3H2O}$=0.1317) for ,T_{EVA}=-1ºC, Absorber temperature=35ºC, generator temperature=80ºC, Condenser $temperature\_{VARS}$=35ºC, Collector Area= 31.65 m^2), Compressor efficiency=0.80, T_{EVA}=-53ºC and Approach (temperature overlapping) =10,

Refrigerant	$COP\_{Cascade}$	$EDR\_{Cascade}$	Exergetic $Efficiency_{cascade}$
R134a	0.5335	1.552	0.3918
R1234yf	0.5323	1.597	0.3892
R152a	0.5346	1.541	0.3936
R290	0.5336	1.552	0.3919
R600a	0.5344	1.543	0.3933
R600	0.5349	1.537	0.3942

Table2 (d): performance comparison of thermal performances of NH_3H_2O vapor absorption refrigeration cascaded with vapor compression refrigeration system using ecofriendly refrigerants ($COP\_NH_3H_2O$= 0.322, Rational EDR_{VARS}=0.8683, EDR_{VARS} =6.594, $ExergeticEfficiency\_{NH3H2O}$=0.1317) for T_{EVA}=-1ºC, Absorber temperature=35ºC, generator temperature=80ºC, Condenser $temperature\_{VARS}$=35ºC, Compressor efficiency =0.80, T_{EVA}=-53ºC and Approach (temperature overlapping) =10,

Refrigerant	$COP\_{Cascade}$	$EDR\_{Cascade}$	Exergetic $Efficiency_{cascade}$
R134a	3.472	2.433	0.2913
R1234yf	3.406	2.460	0.2890
R152a	3.516	2.415	0.2928
R290	3.475	2.432	0.2914
R600a	3.509	2.418	0.2925
R600	3.533	2.408	0.2933

Table-2(a) shows, the effect of ecofriendly refrigerants in low temperature circuit with variation of thermal performances such as first law efficiency in terms of coefficient of performance (COP) of cascaded vapor absorption system & second law efficiency in terms of exergetic efficiency and exergy destruction ratio based on exergy of fuel of NH_3H_2O vapor absorption refrigeration system cascaded with vapor compression refrigeration at 5ºC of cascaded vapor absorption refrigeration system evaporator temperature and vapor compression evaporator temperature of -30ºC and it is found that the performance of HFC-134a.is higher than R1234yf. Similarly Table-2(b) shows, the effect of ecofriendly refrigerants in low temperature circuit with variation of thermal performances such as first law efficiency in terms of coefficient of performance (COP) of cascaded vapor absorption system & second law efficiency in terms of exergetic efficiency and exergy destruction ratio based on exergy of fuel of NH_3H_2O vapor absorption refrigeration system cascaded with vapor compression refrigeration at 8ºc of cascaded vapor absorption refrigeration system evaporator temperature and vapor compression evaporator temperature of -30ºC and it is found that the performance of HFO-1234yf . It was also observed that by changing evaporator temperature from 5ºC to 10ºC the thermodynamic performances enhanced.

3.3 *Variation of temperature overlapping of* NH_3H_2O *vapor absorption system with thermal performances of cascaded vapor absorption compression refrigeration system*

Table-3 (a) and (d) shows the variation of approach with variation of thermal performances such as first law efficiency in terms of coefficient of performance (COP) of cascaded vapor absorption system & second law efficiency in terms of exergetic efficiency and exergy destruction ratio based on exergy of fuel of NH_3H_2O vapor absorption refrigeration system cascaded with vapor compression refrigeration using HFC-134a refrigerant and it is found that when temperature overlapping in terms of approach (means condenser temperature of vapor compression refrigeration minus evaporator temperature of vapor absorption refrigeration system) is increasing , the thermodynamic performances in terms of $COP\_{Cascade}$, exergetic $efficiency\_{Cascade\ System}$ is decreasing and EDR_ is increasing

Table-3(a) Thermal performances comparison of thermal performances of NH_3H_2O vapor absorption refrigeration cascaded with vapor compression refrigeration system using R134a ecofriendly refrigerant ($COP\_NH_3H_2O$= 0.322, Rational EDR_{VARS}=0.8683, EDR_{VARS} =6.594, $ExergeticEfficiency\_{NH3H2O}$=0.1317) for T_{EVA}=-1ºC, Absorber temperature=35ºC, generator temperature=80ºC, Condenser $temperature\_{VARS}$=35ºC, Compressor efficiency =0.80, T_{EVA}=-53ºC and Approach (temperature overlapping) =10,
(Approach =T_{Cond_VCRS} -T_{Eva_VARS}) using R134a

Approach (ºC)	$COP\_{Cascade}$	$EDR\_{Cascade}$	Exergetic $Efficiency_{cascade}$
0	0.5569	1.307	0.4334
2	0.5522	1.354	0.4248
4	0.5475	1.402	0.4164
5	0.5452	1.426	0.4122
6	0.5429	1.450	0.4082

8	0.5384	1.499	0.4002
10	0.5339	1.549	0.3924
12	0.5294	1.599	0.3848
14	0.5250	1.650	0.3773
15	0.5228	1.676	0.3737
16	0.5206	1.702	0.3701
18	0.5162	1.755	0.3629
20	0.5119	1.809	0.3560

Table-3(b) *Thermal performances comparison of thermal performances of NH_3H_2O vapor absorption refrigeration cascaded with vapor compression refrigeration system using* R1234yf *ecofriendly refrigerant (COP_NH_3H_2O= 0.322, Rational EDR_$_{VARS}$=0.8683, EDR_$_{VARS}$ =6.594, ExergeticEfficiency_$_{NH3H2O}$=0.1317) for T_$_{EVA}$=-1ºC, Absorber temperature=35ºC, generator temperature=80ºC, Condenser temperature_$_{VARS}$=35ºC, Compressor efficiency =0.80, T_$_{EVA}$=-53ºC and Approach (temperature overlapping) =10,*

Approach (ºC)	COP_$_{Cascade}$	EDR_$_{Cascade}$	Exergetic Efficiency$_{cascade}$
0	0.5563	1.313	0.4324
2	0.5515	1.361	0.4236
4	0.5468	1.410	0.4150
5	0.5444	1.435	0.4107
6	0.5420	1.460	0.4066
8	0.5373	1.511	0.3983
10	0.5326	1.562	0.3903
12	0.5280	1.615	0.3824
14	0.5233	1.669	0.3746
15	0.5210	1.697	0.3708
16	0.5187	1.725	0.3670
18	0.5141	1.781	0.3595
20	0.5095	1.839	0.3522

Similarly exergy destruction ratio based on the exergy of product (EDR_Cascade) is also decreasing, Table-3 (b) shows the variation of approach with variation of thermal performances such as first law efficiency in terms of coefficient of performance (COP) of cascaded single effect vapor absorption system & second law efficiency in terms of exergetic efficiency and exergy destruction ratio based on exergy of fuel of NH_3H_2O vapor absorption refrigeration system cascaded with vapor compression refrigeration using HFO-1234yf refrigerant and it is found that when temperature overlapping in terms of approach (means condenser temperature of vapor compression refrigeration minus evaporator temperature of vapor absorption refrigeration system) is increasing , the thermodynamic performances in terms of (COP_$_{Cascade}$, Exergetic efficiency_$_{Cascade\ System}$) is decreasing and EDR_$_{Rational}$ is increasing. Similarly exergy destruction ratio based on the exergy of product (EDR_$_{Cascade}$) is also decreasing. The performance of NH_3H_2O vapor absorption system cascaded with vapor compression system using HFC-134a and HFO-1234yf for low temperature circuit evaporator at -53ºC and generator temperature at 80ºC have been compared and also shown in Tables-1(a) & Tables-1(b) respectively and it is found that thermodynamic performances using HFO-1234yf in NH_3H_2O cascaded vapor absorption system (system-2) in terms of COP is 1.354% lower and exergetic efficiency is 3.5543% lower than using HFC-134a For increment in EDR is 6.1144% as temperature overlapping approach at 10ºC.

Table-3(c) Thermal performances comparison of thermal performances of NH_3H_2O vapor absorption refrigeration cascaded with vapor compression refrigeration system using R134a ecofriendly refrigerant (COP_NH_3H_2O= 0.322, Rational EDR_$_{VARS}$=0.8683, EDR_$_{VARS}$ =6.594, ExergeticEfficiency_$_{NH3H2O}$=0.1317) for T_$_{EVA}$=-1ºC, Absorber temperature=35ºC,generator temperature=80ºC, Condenser temperature_$_{VARS}$=35ºC, Compressor efficiency =0.80, T_$_{EVA}$=-53ºC and Approach (temperature overlapping) =10, (Approach =T_$_{Cond_VCRS}$ -T_$_{Eva_VARS}$) using R134a

Approach (ºC)	COP_$_{Cascade}$	Rational EDR_$_{Cascade}$	Exergetic Efficiency$_{cascade}$
0	0.5569	0.5666	0.4334
2	0.5522	0.5752	0.4248
4	0.5475	0.5836	0.4164
5	0.5452	0.5878	0.4122
6	0.5429	0.5918	0.4082
8	0.5384	0.5998	0.4002
10	0.5339	0.6076	0.3924
12	0.5294	0.6152	0.3848
14	0.5250	0.6227	0.3773
15	0.5228	0.6263	0.3737

16	0.5206	0.6299	0.3701
18	0.5162	0.6471	0.3629
20	0.5119	0.6440	0.3560

Table-3 (c) shows the variation of approach with variation of thermal performances such as first law efficiency in terms of coefficient of performance (COP) of NH_3H_2Ocascaded vapor absorption system & second law efficiency in terms of exergetic efficiency and exergy destruction ratio based on exergy of fuel of NH_3H_2O vapor absorption refrigeration system cascaded with vapor compression refrigeration using HFC-134a refrigerant and it is found that when temperature overlapping in terms of approach (means condenser temperature of vapor compression refrigeration minus evaporator temperature of vapor absorption refrigeration system) is increasing, the EDR_ is increasing. Similarly rational exergy destruction ratio based on the exergy of fuel ($EDR\__{Cascade}$) is increasing.

Table-3(d) *Thermal performances comparison of thermal performances of NH_3H_2O vapor absorption refrigeration cascaded with vapor compression refrigeration system using* R134a *ecofriendly refrigerant ($COP\_NH_3H_2O$= 0.322, Rational $EDR\__{VARS}$=0.8683, $EDR\__{VARS}$ =6.594, $ExergeticEfficiency\__{NH3H2O}$=0.1317) for $T\__{EVA}$=-1°C, Absorber temperature=35°C,generator temperature=80°C, Condenser $temperature\__{VARS}$=35°C, Compressor efficiency =0.80, $T\__{EVA}$=-53°C and Approach (temperature overlapping) =10 (System-1)*

Approach (°C)	$COP\__{Cascade}$	Rational $EDR\__{Cascade}$	Exergetic $Efficiency_{cascade}$
0	0.5563	0.5676	0.4324
2	0.5515	0.5766	0.4236
4	0.5468	0.5850	0.4150
5	0.5444	0.5893	0.4107
6	0.5420	0.5934	0.4066
8	0.5373	0.6017	0.3983
10	0.5326	0.6097	0.3903
12	0.5280	0.6176	0.3824
14	0.5233	0.6254	0.3746
15	0.5210	0.6302	0.3708
16	0.5187	0.6330	0.3670
18	0.5141	0.6405	0.3595
20	0.5095	0.6478	0.3522

Table-3(e) *Thermal performances comparison of thermal performances of NH_3H_2O vapor absorption refrigeration cascaded with vapor compression refrigeration system using* R1234yf *ecofriendly refrigerant ($COP\_NH_3H_2O$= 0.322, Rational $EDR\__{VARS}$=0.8683, $EDR\__{VARS}$ =6.594, $ExergeticEfficiency\__{NH3H2O}$=0.1317) for $T\__{EVA}$=-1°C, Absorber temperature=35°C,generator temperature=80°C, Condenser $temperature\__{VARS}$=35°C, Compressor efficiency =0.80, $T\__{EVA}$=-53°C and Approach (temperature overlapping) =10, (System-1)*

Approach (°C)	$COP\__{VCRS}$	$EDR\__{VCRS}$	$ExergeticEfficiency\__{VCRS}$
0	4.756	2.055	0.3273
2	4.445	2.127	0.3198
4	4.167	2.20	0.3125
5	4.039	2.237	0.3090
6	3.917	2.274	0.3054
8	3.691	2.350	0.2985
10	3.486	2.427	0.2918
12	3.299	2.506	0.2852
14	3.127	2.587	0.2788
15	3.046	2.629	0.2756
16	2.968	2.670	0.2725
18	2.822	2.755	0.2663
20	2.686	2.842	0.2603

Table-3(f) Thermal performances comparison of thermal performances of NH_3H_2O vapor absorption refrigeration cascaded with vapor compression refrigeration system using R1234yf *ecofriendly refrigerant (COP_NH_3H_2O= 0.322, Rational EDR_$_{VARS}$=0.8683, EDR_$_{VARS}$ =6.594, ExergeticEfficiency_$_{NH3H2O}$=0.1317) for T_$_{EVA}$=-1ºC, Absorber temperature=35ºC,generator temperature=80ºC, Condenser temperature_$_{VARS}$=35ºC, Compressor efficiency =0.80, T_$_{EVA}$=-53ºC and Approach (temperature overlapping) =10, (System-1)*

Approach (ºC)	COP_$_{VCRS}$	Rational EDR_$_{VCRS}$	Exergetic Efficiency_$_{VCRS}$
0	4.756	0.6727	0.3273
2	4.445	0.6802	0.3198
4	4.167	0.6875	0.3125
5	4.039	0.6910	0.3090
6	3.917	0.6946	0.3054
8	3.691	0.7015	0.2985
10	3.486	0.7082	0.2918
12	3.299	0.7148	0.2852
14	3.127	0.7212	0.2788
15	3.046	0.7244	0.2756
16	2.968	0.7275	0.2725
18	2.822	0.7337	0.2663
20	2.686	0.7397	0.2603

Table-3(g) Thermal performances comparison of thermal performances of NH_3H_2O vapor absorption refrigeration cascaded with vapor compression refrigeration system using R1234yf *ecofriendly refrigerant (COP_NH_3H_2O= 0.322, Rational EDR_$_{VARS}$=0.8683, EDR_$_{VARS}$ =6.594, ExergeticEfficiency_$_{NH3H2O}$=0.1317) for T_$_{EVA}$=-1ºC, Absorber temperature=35ºC,generator temperature=80ºC, Condenser temperature_$_{VARS}$=35ºC, Compressor efficiency =0.80, T_$_{EVA}$=-53ºC and Approach (temperature overlapping) =10,*

Approach (ºC)	COP_$_{VCRS}$	EDR_$_{VCRS}$	Exergetic Efficiency_$_{VCRS}$
0	4.719	2.063	0.3264
2	4.404	2.137	0.3188
4	4.123	2.212	0.3113
5	3.994	2.250	0.3077
6	3.870	2.289	0.3041
8	3.641	2.368	0.2969
10	3.433	2.449	0.2899
12	3.242	2.532	0.2831
14	3.067	2.618	0.2764
15	2.984	2.662	0.2731
16	2.905	2.706	0.2698
18	2.755	2.797	0.2634
20	2.615	2.891	0.2570

Table-3(h) *Thermal performances comparison of thermal performances of NH_3H_2O vapor absorption refrigeration cascaded with vapor compression refrigeration system using* R1234yf *ecofriendly refrigerant (COP_NH_3H_2O= 0.322, Rational EDR_$_{VARS}$=0.8683, EDR_$_{VARS}$ =6.594, ExergeticEfficiency_$_{NH3H2O}$=0.1317) for T_$_{EVA}$=-1ºC, Absorber temperature=35ºC, generator temperature=80ºC, Condenser temperature_$_{VARS}$=35ºC, Compressor efficiency =0.80, T_$_{EVA}$=-53ºC and Approach (temperature overlapping) =10,*

Approach (ºC)	COP_$_{VCRS}$	Rational EDR_$_{VCRS}$	Exergetic Efficiency_$_{VCRS}$
0	4.719	0.6136	0.3264
2	4.404	0.6812	0.3188
4	4.123	0.6887	0.3113
5	3.994	0.6923	0.3077
6	3.870	0.6959	0.3041
8	3.641	0.7031	0.2969
10	3.433	0.7111	0.2899
12	3.242	0.7169	0.2831
14	3.067	0.7236	0.2764
15	2.984	0.7269	0.2731
16	2.905	0.7302	0.2698
18	2.755	0.7366	0.2634
20	2.615	0.7530	0.2570

Table-3 (g) & Table-3(h) show the variation of approach with variation of thermal performances such as first law efficiency in terms of coefficient of performance (COP) of cascaded vapor absorption system & second law efficiency in terms of exergetic efficiency and exergy destruction ratio based on exergy of fuel of NH_3H_2O vapor absorption refrigeration system cascaded with vapor compression refrigeration using HFC-1234yf refrigerant and it is found that when temperature overlapping in terms of approach (means condenser temperature of vapor compression refrigeration minus evaporator temperature of vapor absorption refrigeration system) is increasing, first law efficiency ($COP_{\_VCRS}$) and second law efficiency of cascaded vapor compression system are decreasing.. Similarly Exergy destruction Ratio based on exergy of product and Rational exergy destruction ratio based on the exergy of fuel ($EDR_{\_VCRS}$) are also increasing

4. Conclusions

The following conclusions were drawn from present investigations.

(i) The thermal performance of single NH_3H_2O vapour absorption refrigeration system cascaded with vapour compression system using HFO -1234yf refrigerant is always than the NH_3 H_2O vapour absorption refrigeration system cascaded with vapour compression system (system-1)using HFC -134a refrigerants. The thermodynamic performances using HFO-1234yf (system-2) in cascaded vapour absorption system in terms of COP is 1.477% % lower and exergetic efficiency is slightly lower than using HFC-134a in the vapour compression refrigeration system.

(ii) In the NH_3H_2O vapour absorption refrigeration system cascaded with vapour compression refrigeration using HFC-134a refrigerant and it is found that absorber temperature of NH_3H_2O vapour absorption refrigeration system is increasing , the thermodynamic performances in terms of ($COP_{\_Cascade}$,) is decreasing and Exergetic efficiency$_{_Cascade\ System}$ is increasing and EDR_ is decreasing.

(iii) In the NH_3H_2O vapour absorption refrigeration system cascaded with vapour compression refrigeration using HFC-134a refrigerant and it is found that when condenser temperature of vapour absorption refrigeration system is increasing, the thermodynamic performances in terms of ($COP_{\_Cascad}$,) and Exergetic efficiency$_{_Cascade\ System}$ both are decreasing and $EDR_{\_Rational}$ is increasing.

(iv) In the NH_3H_2O vapour absorption refrigeration system cascaded with vapour compression refrigeration using HFC-134a refrigerant and it is found that when generator temperature of vapour absorption refrigeration system is increasing , the thermodynamic performances in terms of ($COP_{\_Cascad}$,) is decreasing and Exergetic efficiency$_{_Cascade\ System}$ is increasing and $EDR_{\_Rational}$ is decreasing

(v) In the NH_3H_2O vapour absorption refrigeration system cascaded with vapour compression refrigeration using HFC-134a refrigerant and it is found that when Vapour absorption system evaporator temperature ($T_{\_evaporator}$)of NH_3-H_2O vapour absorption refrigeration system is increasing , the thermodynamic performances in terms of ($COP_{\_Cascad}$,) is decreasing and Exergetic efficiency$_{_Cascade\ System}$ is increasing and $EDR_{\_Rational}$ is decreasing . Similarly exergy destruction ratio based on the exergy of product ($EDR_{\_Cascade}$) is also decreasing and exergetic efficiency is increasing.

(vi) In the NH_3H_2O vapour absorption refrigeration system cascaded with vapour compression refrigeration using HFC-134a refrigerant and it is found that when heat exchanger effectiveness of vapour absorption refrigeration system) is increasing, the thermodynamic performances in terms of ($COP_{\_Cascade}$) & exergetic efficiency$_{_Cascade\ System}$) is increasing and $EDR_{\_cascade}$ is decreasing when heat exchanger effectiveness is increasing.

(vii) In the NH_3H_2O vapour absorption refrigeration system cascaded with vapour compression refrigeration using HFC-134a refrigerant and it is found that when temperature overlapping in terms of approach (means condenser temperature of vapour compression refrigeration minus evaporator temperature of vapour absorption refrigeration system) is increasing, the thermodynamic performances in terms of ($COP_{\_Cascade}$, Exergetic efficiency$_{_Cascade\ System}$) is decreasing and $EDR_{\_Rational}$ is increasing.

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