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Performance Evaluation of Solar Assisted Half Effect Li/Br Vapour Absorption Refrigeration System Cascaded with Vapour Compression Refrigeration System Using Eco-friendly Refrigerants

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ABSTRACT

In the most of industrial process the waste heat energy increases the production cost. Using this waste heat to produce power or cooling can decrease the costs and increases the thermal efficiency of the systems. A growing need for refrigeration in industry and for building cooling is well known due to the main cause of growing the demands of higher living standards , by the increasing requirements for comfort, by increasing thermal load of buildings. Using LiBr-H2O solution in the vapour absorption refrigeration systems offers very good thermodynamic efficiency for cooling at over 0 0C temperature than the other solutions. In this paper, we analyzed solar assisted half effect vapour absorption refrigeration system cascaded by vapour compression refrigeration system using ecofriendly refrigerants and developed thermodynamic model to predict the variation of generator , absorber , condenser temperatures on first and second law efficiencies and to predict the solar collector area required.

Keywords: *Thermodynamic Analysis; Half Effect Cascaded Vapour Compression-Absorption System; Performance Prediction.*

1.0 Introduction

Absorption cooling cycles are environmental, clean and economically driven cycles. By consuming very small electric power, they can use waste heat or solar energy for cooling. The half effect absorption systems have the advantage of using low temperature heat energy for cooling. Karaali [1] presented exergy analysis of a half effect absorption system developed computer program in FORTRAN codes for the thermodynamic properties of lithium bromide-water solutions effect absorption system. he numerical computation was carried out for developed model for computing exergy losses in each component of the system.

The computed coefficient performance (COP) of the half effect absorption system is 0.45 and the exergetic coefficient performance (ECOP) is 0.24. and concluded that most of the irreversibilities are in the evaporator and in the absorbers. Kaushik and Arrora A [2] carried out energy and exergy analysis of single effect and series flow double effect water–lithium bromide absorption systems and developed computational model for the parametric investigation of these systems. The performance parameters computed such as coefficient of performance, exergy destruction, efficiency defects and exergetic efficiency which take into account , the effects of pressure drop between evaporator and absorber, and effectiveness of heat exchangers, effects of generator, absorber and evaporator temperatures.

The first law efficiency in terms of coefficient of performance of the single effect system ranges from 0.6–0.75 and double effect system coefficient of performance for the series flow ranges from 1–1.28 have been predicted and found the highest irreversibility is in the absorber in both refrigeration systems.

Kaushik et.al [3] carried out thermodynamic analysis of a parallel flow double effect absorption refrigeration system maximum COP and maximum exergetic efficiency and developed model for double effect parallel flow LiBr/H2O absorption refrigeration system.

This model takes into account of the effect of generator, absorber and evaporator temperatures the maximum COP and maximum exergetic efficiency. Inzunza et.al [4] compared performance of four vapour absorption refrigeration systems and found that the highest coefficient of performance of double effect vapour absorption refrigeration system ranging between 1.1 and 1.75 followed by the

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generator temperature above 150°C and generators are connected in series combination while lowest COP are found using half effect vapour absorption refrigeration systems between 0.32 to 0.45 for generator temperature 60°C to 80°C while COP of single effect vapour absorption system is found between 0.65 to 0.92 while single effect vapour absorption system, the generator temperature between 80°C to 110°C and suggested that series combination in double effect vapour absorption system is more efficient than parallel combination double effect vapour absorption system is that the utility of half effect Li/Br that the system required low temperature in generator can operate in the hot climate and also found that in all four combinations of vapour absorption refrigeration systems, the single effect vapour absorption system is simple because this system required minimum number of components to operate and has less expensive. Gomri and Hakimi [5] carried out second law analysis of double effect vapor absorption cooler system and found that by increasing low pressure generator temperature increases the performance of the system and the highest exergy losses occurs in high pressure generator and absorber.

Wang and Zheng [6] studied the performance of one and half effect absorption cooling cycle of H_2O/LiBr system and found that the 1.5-effect cycles gives better performance due to the advantages of the single-effect and half-effect absorption cooling cycles.

Colorado and Rivera [7] have obtained the performance comparison between a conventional vapor compression and compression-absorption single-stage and double-stage systems used for refrigeration and concluded that the compression power of the cascade cycles was 45 % lower than in compression cycles.

Jain [8] carried out the performance of a four types of vapour compression–absorption cascaded refrigeration system (CRS) under fouled conditions and found that the main effect of fouling is to decrease the effectiveness of the heat exchanger.

The solar assisted half effect vapour absorption refrigerationsystem cascaded with vapour compression refrigeration system using ecofriendly refrigerants have not been studied in detail.

In this paper we investigate the performance of above system along with variation of performance parameters and its effect on system performances in terms of exergetic efficiency, coefficient of performance aalong with exergy destruction ratio based on exergy of product.

2.0 Results and Discussions

Following input variables have been chosen for validation of model Evaporator Temperature of Half effect Li/Br vapour absorption refrigeration system= 8°C , Generator temperature=80°C.

Evaporator Temperature of vapour compression refrigeration system= -50°C , Temperature overlapping (Approach)=10

Refrigerating Capacity=29.09 “kW”

Condenser temperature =35°C,

Absorber Temperature=35°C, Compressor_Efficiency=0.80,

Thermal performance of half effect vapourabsorption refrigeration systemwas computed by developed model is given below.

i. First law efficiency of vapour absorption refrigeration system is (COP_VARS) =0.4255,
ii. The second law efficiency of vapour absorption refrigeration system is the exergetic_efficiency= 0.1558.
iii. The exergy destruction ratio based on out put
iv. (exergy of product) is EDR_Output= 5.419
v. The exergy destruction ratio based on input
vi. (exergy of exergy of fuel) is EDR_Input= 0.8442.
vii. The solar Collector/absorber area required to run that system is 89.37 m^2

Fig-1(a) shows the variation of approach of Combined Half effect LiBrVapour absorption refrigeration system cascaded with Vapour compression refrigeration system using R134a eco-friendly refrigerant and it was observed that as temperature overlapping in increasing, the first law efficiency (COP) and second law efficiency (exergetic efficiency) Cascade system of cascaded system are decreasing as temperature overlapping is increasing. Similarly exergy destruction ratio based on exergy of product is also decreasing as temperature overlapping is increased.

Fig-1(b) shows the variation of approach of CombinedHalf effect Li/BrVapour absorption refrigeration system cascaded with Vapour compression refrigeration system using R134a eco-friendly refrigerant and it was observed that as temperature overlapping in increasing, the first law efficiency (COP) and second law efficiency (exergetic efficiency) VCRS of cascaded system are decreasing as temperature overlapping is increasing. Similarly exergy destruction ratio based on exergy of product is also decreasing astemperature overlapping (approach) is increased.

Table 1(a): Performance Variation with Temperature Over Lapping of Half Effect LiBrVapour Absorption Refrigeration System Cascaded with Vapour Compression Refrigeration System Using R134a Eco-friendly Refrigerant

Effect of Approach (°C)	COP_Cascade-Cascade COP_R134a	EDR_Cascade	Exergetic Efficiency
0	0.6452	1.976	0.3361
5	0.6303	2.262	0.3065
10	0.6155	2.581	0.2793
15	0.6009	2.938	0.2540

Table 1(b:) Performance Variation with Temperature Over Lapping of Half Effect LiBrVapour Absorption Refrigeration System Cascaded with Vapour Compression Refrigeration System Using R134a Eco-friendly Refrigerant

Effect of Approach (°C)	COP_R134a_VCRS	EDR_VCR	Exergetic Efficiency
0	2.402	0.2376	0.8080
5	2.144	0.3871	0.721
10	1.92	0.5487	0.6457
15	1.734	0.7250	0.5797

Fig-2(a) shows the variation of absorber temperature of Combined Half effect LiBrVapour absorption refrigeration system cascaded with Vapour compression refrigeration system using R134a eco-friendly refrigerant and it was observed that as absorber temperature increasing, the first law efficiency (COP) and second law efficiency (exergetic efficiency) VCRS of cascaded system are decreasing as absorber temperature is increasing. Similarly exergy destruction ratio based on exergy of productis also increasing as absorber temperature is increased. Similarly solar collector area is also increasing as absorber temperature is increasing.

Table 2(a): Effect of Thermodynamic Performances (First Law Performance (COP_Cascade), Second Law Performance (Exergetic Efficiency) and System Exergy Destruction Ratio with Absorber Temperature of Vapour Compression Refrigeration System Coupled with Single Effect VapourAbsorption Refrigeration LiBrSystem Using 134a Ecofriendly Refrigerant

Absorber Temperature (°C)	COP_Cascade	EDR_Cascade	Exergetic Efficiency _Cascade	Solar collector area (m2)
30	0.6309	2.54	0.2825	86.88
35	0. 6155	2.581	0.2793	89.57
40	0.6038	2.613	0.2768	91.36
45	0.5942	2.64	0.2747	93.05
50	0.5860	2.644	0.2729	94.53

Table 2(b): Effect of Thermodynamic Performances (First Law Performance (COP_VARS), Second Law Performance (Exergetic Efficiency) and System Exergy Destruction Ratio with Absorber Temperature of Vapour Compression Refrigeration System Coupled with Single Effect Vapour Absorption Refrigeration LiBr System Using 134a Ecofriendly Refrigerant

Absorber Temperature (°C)	COP_VARS	EDR_VARS	Exergetic Efficiency	Solar collector area (m2)
30	0.4377	5.24	0.1603	86.88
35	0.4255	5.419	0.1558	89.57
40	0.4162	5.562	0.1524	91.36
45	0.4087	5.683	0.1496	93.05
50	0.4023	5.789	0.1473	94.53

Fig-2(b) shows the variation of absorber temperature of Combined Half effect LiBrVapour absorption refrigeration system cascaded with Vapour compression refrigeration system using R134a eco-friendly refrigerant and it was observed that as absorber temperature increasing, the first law efficiency (COP) and second law efficiency (exergetic efficiency) VARS system are decreasing as absorber temperature is increasing. solar collector area is also increasing as absorber temperature is increasing Similarly exergy destruction ratio based on exergy of product is also increasing as absorber temperature is increased.

Table 3(a): Effect of Thermodynamic Performances (First Law Performance (COP_Cascade), Second Law Performance (Exergetic Efficiency) and System Exergy Destruction Ratio with Condenser Temperature of Vapour Compression Refrigeration System Coupled with Single Effect VapourAbsorption Refrigeration LiBrSystem Using 134a Ecofriendly Refrigerant

Condenser Temperature (°C)	COP_Cascade	EDR_Cascade	Exergetic Efficiency	Solar collector area (m2)
30	0.6176	2.575	0.2797	89.04
35	0.6155	2.581	0.2793	89.37
40	0.6136	2.586	0.2789	89.7
45	0.6116	2.591	0.2784	90.03
50	0.6096	2.597	0.2780	90.37

Fig-3(a) shows the variation of condenser temperature of Combined Half effect LiBrVapour absorption refrigeration system cascaded with Vapour compression refrigeration system using R134a eco-friendly refrigerant and it was observed that as condensertemperature increasing, the first law efficiency (COP) and second law efficiency (exergetic efficiency) of combined system is decreasing as absorber temperature is increasing. solar collector area is also increasing as condenser temperature is increasing Similarly exergy destruction ratio based on exergy of product is also increasing as condenser temperature is increased.

Fig-3(b) shows the variation of condenser temperature of Combined Half effect LiBrVapour absorption refrigeration system cascaded with Vapour compression refrigeration system using R134a eco-friendly refrigerant and it was observed that as condenser temperature increasing, the first law efficiency (COP) and second law efficiency (exergetic efficiency) of half effect vapour absorption refrigeration system is decreasing as absorber temperature is increasing. Similarly exergy destruction ratio based on exergy of product is also increasing as condenser temperature is increased

Table 3(b): Effect of Thermodynamic Performances (First Law Performance (COP_VCRS), Second Law Performance (Exergetic Efficiency) and System Exergy Destruction Ratio with Condenser Temperature of Vapour Compression Refrigeration System Coupled with Single Effect Vapour Absorption Refrigeration LiBrSystem Using 134a Ecofriendly Refrigerant

Condenser Temperature (°C)	COP_VARS	EDR_VARS	Exergetic Efficiency	Solar collector area (m2)
30	0.4271	5.395	0.1564	89.04
35	0.4255	5.419	0.1558	89.37
40	0.4239	5.433	0.1552	89.7
45	0.4224	5.467	0.1546	90.03
50	0.4208	5.491	0.1541	90.37

Table 4(a): Effect of Thermodynamic Performances (First Law Performance (COP_VCRS), Second Law Performance (Exergetic Efficiency) and System Exergy Destruction Ratio with Generator Temperature of Vapour Compression Refrigeration System Coupled with Single Effect Vapour Absorption Refrigeration LiBrSystem Using 134a Ecofriendly Refrigerant

Generator Temperature (°C)	COP_Cascade	EDR_Cascade	Exergetic Efficiency _ Cascade	Solar collector area (m2)
60	0.6335	1.751	0.3636	86.47
65	0.6283	1.965	0.3373	87.29
70	0.6236	2.175	0.3149	88.05
75	0.6194	2.381	0.2958	88.74
80	0.6155	2.581	0.2793	89.37
85	0.6121	2.773	0.2650	89.94
90	0.6091	2.959	0.2526	90.45

Fig-4(a) shows the variation of generator temperature of CombinedHalf effect LiBrVapour absorption refrigeration system cascaded with Vapour compression refrigeration system using R134a eco-friendly refrigerant and it was observed that as generator temperature increasing, the first law efficiency (COP) and second law efficiency (exergetic efficiency) of combined vapour absorption cascaded refrigeration system is decreasing as generator temperature is increasing. solar collector area is also increasing as generator temperature is increasing. Similarly exergy destruction ratio based on exergy of product is also increasing as condenser temperature is increased.

Table -4(b): Effect of Thermodynamic Performances (First Law Performance (COP_VCRS), Second Law Performance (Exergetic Efficiency) and System Exergy Destruction Ratio with Generator Temperature of Vapour Compression Refrigeration System Coupled with Single Effect Vapour Absorption Refrigeration LiBrSystem Using 134a Ecofriendly Refrigerant

Generator Temperature (0C)	COP_VARS	EDR_VARS	Exergetic Efficiency	Solar collector area (m2)
60	0.4397	3.190	0.2387	86.47
65	0.4356	3.762	0.210	87.29
70	0.4319	4.325	0.1878	88.05
75	0.4285	4.876	0.1701	88.74
80	0.4255	5.419	0.1558	89.37
85	0.4228	5.949	0.1439	89.94
90	0.4204	6.467	0.1339	90.45

Fig-4(b) shows the variation of generator temperature of CombinedHalf effect LiBrVapour absorption refrigeration system cascaded with Vapour compression refrigeration system using R134a eco-friendly refrigerant and it was observed that as generator temperature increasing, the first law efficiency (COP) and second law efficiency (exergetic efficiency) of half effect vapour absorption refrigeration system is decreasing as generator temperature is increasing. solar collector area is also increasing as generator temperature is increasing Similarly exergy destruction ratio based on exergy of product is also increasing as condenser temperature is increased

Fig-5(a) shows the effect of various ecofriendly refrigerants of Combined Half effect Li/BrVapour absorption refrigeration system cascaded with Vapour compression refrigeration system and it was observed that as the first law efficiency (COP_Cascade) and second law efficiency (exergetic efficiency) of half effect vapour absorption-compression refrigeration system using R141b is higher and lower first and second law efficiencies when R125 is used. . Similarly exergy destruction ratio based on exergy of product is also increased using R125.

Table 5(a): Effect of Thermodynamic Performances (First Law Performance (COP_VCRS), Second Law Performance (Exergetic Efficiency) and System Exergy Destruction Ratio with Generator Temperature of Vapour Compression Refrigeration System Coupled with Half Effectvapour Absorption Refrigeration Li/BrSystem Using Following Ecofriendly Refrigerants

Performance Parameters	COP_cascade	EDR_cascade	Exergetic Efficiency _Cascade
R134a	0.6155	2.581	0.2793
R1234yf	0.6079	2.762	0.2658
R152a	0.6216	2.445	0.2902
R 245fa	0.6196	2.490	0.2866
R236fa	0.6084	2.749	0.2668
R 227ea	0.5956	3.076	0.2453
R290	0.6151	2.59	0.2786
R600a	0.6144	2.606	0.2773
R600	0.6203	2.474	0.2878
R141b	0.6296	2.277	0.3052
R143a	0.6068	2.789	0.2639
R32	0.6138	2.62	0.2763
R507a	0.6042	2.852	0.2596
R125	0.5951	3.091	0.2445
R404a	0.6011	2.931	0.2544
R717	0.6157	2.577	0.2795
R123	0.6238	2.398	0.2943
R410a	0.6142	2.613	0.2768
R407c	0.5956	3.078	0.2452

Fig-5(b) shows the effect of various ecofriendly refrigerants of Combined Half effect Li/BrVapour absorption refrigeration system cascaded with Vapour compression refrigeration system and it was observed that as the first law efficiency (COP_VCRS) and second law efficiency (exergetic efficiency) of half effect vapour absorption refrigeration system using R141b is higher and lower first and second law efficiencies when R125 is used. . Similarly exergy destruction ratio based on exergy of product is also increased using R125.

Table 5(b): Effect of Thermodynamic Performances (First Law Performance (COP_VCRS), Second Law Performance (Exergetic Efficiency) and System Exergy Destruction Ratio with Generator Temperature of Vapour Compression Refrigeration System Coupled with Half Effect Vapour Absorption Refrigeration Li/BrSystem Using Following Ecofriendly Refrigerants

Performance Parameters	COP_VCRS	EDR_VCRS	Exergetic Efficiency _Cascade
R134a	1.92	0.5487	0.6457
R1234yf	1.814	0.5419	0.6102
R152a	2.008	0.4806	0.6757
R245fa	1.976	0.5030	0.6653
R236fa	1.821	0.5419	0.6126
R227ea	1.659	0.7921	0.5580
R290	1.914	0.5534	0.6437
R600a	1.904	0.5615	0.6404
R600	1.989	0.4952	0.6688
R141b	2.132	0.3946	0.7171
R143a	1.80	0.6522	0.6053
R32	1.896	0.5683	0.6376
R507a	1.766	0.6835	0.5940
R125	1.653	0.7991	0.5558
R404a	1.727	0.7217	0.5808
R717	1.922	0.5471	0.6464
R123	2.041	0.4566	0.6865
R410a	1.90	0.5647	0.6391
R407c	1.658	0.793	0.5577

Fig-6(a) shows the variation of Low temperature circuit evaporator Temperature of combined Half effect Li/BrVapour absorption refrigeration system cascaded with Vapour compression refrigeration system using R134a eco-friendly refrigerant and it was observed that as Low temperature circuit evaporator

Temperatureis increasing from (-70oC to -30oC), the first law efficiency(COP_Cascade) of cascaded vapour compression -half effect vapour absorption system is increasing while and second law efficiency (exergetic efficiency) of Cascaded vapour compression half effect vapour absorption refrigeration system is decreasing as generator temperature is increasing. Similarly exergy destruction ratio based on exergy of product is also increasing as Low temperature circuit evaporator Temperature of combined Half effect Li/BrVapour absorption refrigeration system cascaded with Vapour compression refrigeration system using R134a eco-friendly refrigerantis increased.

Table-6(a): Effect of Thermodynamic Performances (First Law Performance (COP_Cascade), Second Law Performance (Exergetic Efficiency) and System Exergy Destruction Ratio with Generator Temperature of Vapour Compression Refrigeration System Coupled with Half Effectvapour Absorption Refrigeration Li/BrSystem using 134a Ecofriendly Refrigerant

Low temperature circuit evaporator Temperature (°C)	COP_Cascade Using R134a	EDR_Cascade	Exergetic Efficiency
-35	0.6662	2.919	0.2552
-40	0.6491	2.765	0.2656
-45	0.6322	2.655	0.2736
-50	0.6155	2.581	0.2793
-55	0.5991	2.534	0.2830
-60	0.5829	2.510	0.2849
-65	0.5669	2.507	0.2852
-70	0.5513	2.521	0.2844

Table-6(b): Effect of Thermodynamic Performances (First Law Performance (COP_Cascade), Second Law Performance (Exergetic Efficiency) and System Exergy Destruction Ratio with Generator Temperature of

Vapour Compression Refrigeration System Coupled with Half Effectvapour Absorption Refrigeration Li/BrSystem Using 1234yf Ecofriendly Refrigerant

Low temperature circuit evaporator Temperature (°C)	COP_Cascade Using R1234yf	EDR_Cascade	Exergetic Efficiency
-30	0.6791	3.249	0.2354
-35	0.6611	3.048	0.2471
-40	0.6432	2.909	0.2558
-45	0.6254	2.817	0.2620
-50	0.6079	2.762	0.2658

Fig-6(b) shows the variation of Low temperature circuit evaporator Temperature of combined Half effect Li/BrVapour absorption refrigeration system cascaded with Vapour compression refrigeration system using R1234yf eco-friendly refrigerant and it was observed that as Low temperature circuit evaporator Temperatureis increasing from (-50oC to -30oC), the first law efficiency(COP_Cascade) of cascaded vapour compression -half effect vapour absorption system is increasing while and second law efficiency (exergetic efficiency) of Cascaded vapour compression half effect vapour absorption refrigeration system is decreasing as generator temperature is increasing. Similarly exergy destruction ratio based on exergy of product is also increasing as Low temperature circuit evaporator Temperature of combined Half effect Li/BrVapour absorption refrigeration system cascaded with Vapour compression refrigeration system using R1234yf eco-friendly refrigerantis increased.

Fig-6(c) shows the variation of Low temperature circuit evaporator Temperature of combined Half effect Li/BrVapour absorption refrigeration system cascaded with Vapour compression refrigeration system using R134a eco-friendly refrigerant and it was observed that as Low temperature circuit evaporator Temperatureis increasing from (-70oC to -30oC), the first law efficiency(COP_VCRS) of cascaded vapour compression system is increasing while and second law efficiency (exergetic efficiency) of Cascaded vapour compression half effect vapour absorption refrigeration system is increasing as Low temperature circuit evaporator Temperature is increasing. Similarly exergy destruction ratio based on exergy of product is also increasing as Low temperature circuit evaporator Temperature of combined Half effect Li/BrVapour absorption refrigeration system cascaded with Vapour compression refrigeration system using R134a eco-friendly refrigerantis decreased.

Table-6(c): Effect of Thermodynamic Performances (First Law Performance (COP_VCRS), Second Law Performance (Exergetic Efficiency) and System Exergy Destruction Ratio with Generator Temperature of Vapour Compression Refrigeration System Coupled with Half Effect Vapour Absorption Refrigeration Li/BrSystem Using R134a Ecofriendly Refrigerant

Low temperature circuit evaporator Temperature (°C)	COP_VCRS Using R134a	EDR_VCRS	Exergetic Efficiency
-35	2.836	0.3985	0.7151
-40	2.476	0.4476	0.6908
-45	2.175	0.4975	0.6678
-50	1.92	0.5487	0.6457
-55	1.701	0.6018	0.6243
-60	1.517	0.6572	0.6034
-65	1.347	0.7154	0.5830
-70	1.203	0.7769	0.5628

Table-6(d): Effect of Thermodynamic Performances (First Law Performance (COP_VCRS), Second Law Performance (Exergetic Efficiency) and System Exergy Destruction Ratio with Generator Temperature of Vapour Compression Refrigeration System Coupled with Half Effect Vapour Absorption Refrigeration Li/BrSystem Using 1234yf Ecofriendly Refrigerant

Low temperature circuit evaporator Temperatur	COP_VCRS using R1234yf	EDR_VCRS	Exergetic Efficiency

e (°C)			
-30	3.157	0.3995	0.7145
-35	2.722	0.4573	0.6862
-40	2.365	0.5158	0.6597
-45	2.067	0.5761	0.6345
-50	1.814	0.6388	0.6102

Fig-6(d) shows the variation of Low temperature circuit evaporator Temperature of combined Half effect Li/Br Vapour absorption refrigeration system cascaded with Vapour compression refrigeration system using R1234yf eco-friendly refrigerant and it was observed that as Low temperature circuit evaporator Temperature is increasing from (-70oC to -30oC), the first law efficiency (COP_VCRS) of vapour compression system is increasing while and second law efficiency (exergetic efficiency) of Cascaded vapour compression half effect vapour absorption refrigeration system is increasing as Low temperature circuit evaporator Temperature is increasing. Similarly exergy destruction ratio based on exergy of product is also increasing as Low temperature circuit evaporator Temperature of combined Half effect Li/Br Vapour absorption refrigeration system cascaded with Vapour compression refrigeration system using R134a eco-friendly refrigerant is decreased.

Table-7(a) shows the comparison between HFC-134a ecofriendly refrigerant with HFO-1234yf in terms of Thermodynamic performances (First law Performance (COP_Cascade), Second law performance (Exergetic efficiency) and system exergy destruction Ratio of Vapour compression Refrigeration System coupled with half Effect vapourAbsorption Refrigeration LiBrSystem using HFC-134a and HFO-1234yf ecofriendly refrigerants and it is found that the first and second law performances of Cascaded vapour compression -vapour half effect absorption system is higher by using HFC-134a and slightly lower by using HFO-1234yf.

Table-7(a): Comparison between HFC-134a Ecofriendly Refrigerant with HFO-1234yf in Terms of Thermodynamic Performances (First Law Performance (COP_Cascade), Second Law Performance (Exergetic Efficiency) and System Exergy Destruction Ratio of Vapour Compression Refrigeration System Coupled with Half Effect Vapour Absorption Refrigeration LiBrSystem Using HFC-134a and HFO-1234yf Ecofriendly Refrigerants

Low temperature circuit evaporator Temperature (°C)	First Law Efficiency of cascaded vapour compression Absorption system using R134a) (COP_Cascade	First Law Efficiency of cascaded vapour compression Absorption system using R1234yf COP_Cascade	Exergetic Efficiency of cascaded vapour compression Absorption system using R134a	Exergetic Efficiency of cascaded vapour compression Absorption system using R1234yf
-35	0.6662	0.6611	0.2552	0.2471
-40	0.6491	0.6432	0.2656	0.2558
-45	0.6322	0.6254	0.2736	0.2620
-50	0.6155	0.6079	0.2793	0.2658

Table-7(b) shows the omparison between HFC-134a ecofriendly refrigerant with HFO-1234yf in terms of Thermodynamic performances (First law Performance (COP_VCRS), Second law performance (Exergetic efficiency) and system exergy destruction Ratio of Vapour compression Refrigeration System coupled with half Effect vapourAbsorption Refrigeration LiBrSystem using HFC-134a and HFO-1234yf ecofriendly refrigerants and it is found that the first and second law performances of Cascaded vapour compression -vapour half effect absorption system is higher by using HFC-134a and slightly lower by using HFO-1234yf

Table-7(b): Comparison between HFC-134a Ecofriendly Refrigerant with HFO-1234yf in Terms of Thermodynamic Performances (First Law Performance (COPVCRS), Second Law Performance (Exergetic Efficiency) and System Exergy Destruction Ratio of Vapour Compression Refrigeration System Coupled with Half Effect Vapour Absorption Refrigeration LiBrSystem Using HFC-134a and HFO-1234yf Ecofriendly Refrigerants

Low temperature circuit evaporator Temperature (0C)	First Law Efficiency of cascaded vapour compression Absorption system using R134a) (COP_VCRS	First Law Efficiency of cascaded vapour compression Absorption system using R1234yf COP_VCRS	Exergetic Efficiency of cascaded vapour compression Absorption system using R134a	Exergetic Efficiency of cascaded vapour compression Absorption system using R1234yf
-35	2.836	2.722	0.7151	0.6862
-40	2.476	2.365	0.6908	0.6597
-45	2.175	2.067	0.6678	0.6345
-50	1.92	1.814	0.6457	0.6102

3.0 Conclusions

The following conclusions were drawn from present investigations.

i. Thermodynamic performance in terms of first law efficiency (COP_Cascade_System) of combined cascaded vapour compression -half effect vapour absorption refrigeration system using HFC-134a is higher than the combined cascaded vapour compression -half effect vapour absorption refrigeration system using HFC-1234yf
ii. Thermodynamic performance in terms of second law efficiency(Exergetic Efficiency _Cascade_System) of combined cascaded vapour compression -half effect vapour absorption refrigeration system using HFC-134a is higher than the combined cascaded vapour compression -half effect vapour absorption refrigeration system using HFC-1234yf
iii. As Low temperature circuit evaporator Temperature is decreasing , the first law performances ((COP_Cascade_System) and second law efficiency (Exergetic efficiency) of cascaded vapour compression -half effect vapour absorption refrigeration system is decreasing and exergy destruction ratio of combined vapour compression-half effect vapour absorption system is increasing.
iv. The best thermodynamic performances in terms of first and second law efficiencies have been found by using R141b.
v. Use of hydrocarbon is also feasible by considering safety measures because hydrocarbons are flammable .
vi. Thermodynamic performances in terms of first and second law efficiencies also affected by variation of generator temperature and also decreasing as generator temperature is increasing.
vii. Thermodynamic performances in terms of first and second law efficiencies also affected by variation of absorber temperature and also decreasing as absorber temperature is increasing.
viii. Thermodynamic performances in terms of first and second law efficiencies also affected by variation of condenser temperature and also decreasing as condenser temperature is increasing.
ix. Thermodynamic performances in terms of first and second law efficiencies also affected by variation of approach (temperature over lapping) and also decreasing as temperature over lapping is increasing.
x. By increasing generator temperature , the solar collector area is increasing
xi. By increasing condenser temperature , the solar collector area is increasing
xii. By increasing absorber temperature , the solar collector area is increasing

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