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RESEARCH PAPER

Thermodynamic Performances of Vapour Compression Refrigeration System using Liquid Vapour Heat Exchanger New Ecofriendly HFO Refrigerants

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ABSTRACT

Global warming potential and ozone layer depletion are one of the important issues in front of the researcher. As R22 and R12 is the most widely used as refrigerants in industrial and household applications. Lately it was found that these have high value of ozone depletion potential. Most of researches are going on searching better refrigerant and replacement of old refrigerants have high global warming potential and ozone depletion potential with modern one have low both GWP and ODP values .HFC-134a has GWP of 1430 has zero ozone pepletion potential (ODP). However HFC-245fa has zero Ozone Depletion Potential (ODP) but has global warming potentials (GWP) of 858. Some low GWP working fluids are required to replace HFC-134a and R404a and R410a in various applications, HCFO-1233zd-E is a hydro-chloro-fluoro-olefin (HCFO) with a GWP of 1. Despite the presence of chlorine in its molecule, HCFO-1233zd (E) was found to have a low ODP (of 0.00034) due to its very short atmospheric lifetime. HFO-1336mzz (Z) (commercially also referred to as DR-2) is a hydro-fluoroolefin (HFO) with a GWP of 2 and zero ODP. HFO-1234ze (Z) is an HFO with a GWP of 1 and zero ODP. HCFO-1233zd-E and HFO-1336mzz-Z as alternatives to HFC-245fa. In the present work, a thermodynamic performance evaluation of the low GWP fluids HCFO-1233zd-E, HFO-1336mzz-Z and HFO-1234ze-Z as alternatives to HFC-134 is investigated.

Key words: *HFO refrigerants, Thermodynamic Performance, Energy-Exergy Analysis, Modified VCRS*

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INTRODUCTION

Hydro-fluoroolefins (HFOs) HFOs are some of the most viable emerging alternative refrigerants. Refrigerant manufacturers have developed numerous HFO blends tailored to specific applications. HFO-1234yf and HFO1234ze are furthest along in development. HFO-1234yf and HFO-1234ze are both classified as A2L and have GWP values less than10. The performance of HFO-1234yf closely matches that of HFC-134a. HFO-1234yf has been widely adopted outside the U.S. for future HVAC systems, and one U.S. automobile manufacturer committed to using HFO-1234yf beginning in 2013. HFO-1234yf also shows promise in chillers and commercial refrigeration applications that currently use HFC-134a. HFO-1234ze has a lower volumetric capacity than HFO-1234yf. It could potentially be used for centrifugal compressors. HFO-1234ze is easier to manufacture than HFO-1234yf, and less costly, so it could be particularly attractive for large chillers, which require high quantities ofrefrigerant. HFO-1234ze has been approved for use with centrifugal, reciprocating, and screw chillers. It is also marketed for blowing agent and propellant applications. HFO-1233zd, which is an A1 refrigerant with a GWP value of less than 7, as a replacement for HCFC-123 using a centrifugal chiller in Europe in the vapour compression refrigeration systems. This paper highlights the utility of ecofriendly ten low GWP HFO refrigerants to replace HFC- refrigerantsMishra, 2019.

ENERGY-EXERGY OF VAPOUR COMPRESSION REFRIGERATION SYSTEM

First law analysis (energy analysis) is restricted to calculate only coefficient of performance of system but exergy analysis is the one of the most useful analyses to evaluate the plant losses, the actual amount of energy flow through process exergetic efficiency and exergetic destruction ratio. Mishra, *et. al.* 2015. A computational model based on the exergy analysis is presented by yumrutas, et.al, 2002 for the investigation of the effects of the evaporating and condensing temperatures on the pressure losses, exergy losses, second law of efficiency, and the COP of a vapour compression cycle Padila, *et. al.* , 2010 computed the exergy performance of a domestic vapor compression refrigeration system (VCRS) by using zeotropic mixture (R413A) for direct replacement of R12 and found that the overall energy and exergy performances of this system working with R413A is far better than R12. Mishra, 2015 (a&c) carried out the exergy analysis on multi-evaporators vapor compression refrigeration system emphasized on replacement of R134a with R1234ze and R1234yf, because R134a having high global warming potential (GWP=1430), while R1234ze has zero ODP & 6 GWP) and R1234yf (GWP= 4 and zero ODP) respectively. Comparative analysis of modified vapour compression systems working in multi-evaporators with subcooling and superheating is also carried out by him using ecofriendly HFO and HFC refrigerants (i.e. R134a, R1234yf and R1234ze). Most of the study has been carried out for the performance evaluation of vapour compression refrigeration system using energetic analysis, but with the help of first law analysis irreversibility destruction or losses in components of system unable to determine by Kapil Chopra *et. al.* , 2013(a,b,c), so that second law thermodynamic analysis is the advanced approach for thermodynamic analysis which gives an additional practical view of the processes. The utility of second law analysis on vapour compression refrigeration systems is well defined because it gives the idea for improvements in efficiency due to modifications in existing design in terms of reducing exergy destructions in the components. The second law exergetic analysis also provides new thought for development in the existing systems Kapil Chopra 2014(a&b). Mishra 2019 developed theoretical model of vapour compression refrigeration using eco-friendly refrigerants and observed that the coefficient of performance (COP) of the vapour compression refrigeration system, increases with increasing evaporator in the range of (-20°C to +5°C) temperature for a constant condensing temperature (40°C) and decreases with increasing condenser temperature (30°C to 60°C) for constant evaporator -20°C R.S. Mishra (2015) From the irreversibility or exergy destruction viewpoint, Mishra [3] worst component is compressor followed by evaporator and condenser, throttle valve, and liquid vapour heat exchanger, the most efficient component. Total efficiency defect is more for HFO-1234yf followed by HFO-1234ze and HFC-134a, but the difference is small. Increase in ambient state temperature has an increasing (positive) effect on second law efficiency in terms of exergetic efficiency and exergy destruction ratio which was computed based on exergy of fuel or based on exergy of product (EDR). When exergy destruction ratio (EDR) reduced, then the exergetic efficiency increases. Therefore HFO-1234yf gives lesser values of exergetic efficiency whereas HFO-1234ze gives approximately 4% less values. HFC-134a gives higher COP and exergetic efficiency than HFO-1234yf but lesser value than HFO1234ze, R.S. Mishra, et. al, 2015 (a,c), Based on the literature it was observed that Researchers have gone through detailed first law analysis in terms of coefficient of performance and second law analysis in term of exergetic efficiency of simple vapour compression refrigeration system using HFO-1234yf and R1234ze refrigerants Researchers did not go through the irreversibility analysis or second law analysis of modified vapour compression refrigeration systems using vapour liquid heat exchanger using ten new ecofriendly low GWP refrigerants. In the next section the detailed computational results are presented

RESULTS AND DISCUSSION

Tables-1 show, the thermodynamic (energy-exergy) performances of modified VCRS using following ecofriendly HFO refrigerants using liquid vapour heat exchanger and it was found that the best thermodynamic energy efficiency in terms of coefficient of performance (COP) and second law efficiency by using R-1234ze(z) and worst thermodynamic performances obtained by using R1234yf as shown in Table-1.

Table 1: Variation of thermodynamic performance of modified vapour compression refrigeration system using liquid vapour heat exchanger using new HFO ecofriendly refrigerants for reducing global warming and ozone depletion for following input values: (Condenser temperature = 323"K", Evaporator temperature = 263"K", Compressor Efficiency = 80%, Degree of subcooling = 10°C, Degree of super heating = 10°C, Heat exchanger effectiveness = 80%)

Ecofriendly refrigerants	COP_VCRS	*EDR_System*	*Rational _EDR*	*Second law Efficiency*	*Exergy of Fuel(kW)*	*Exergy of Product(kW)*
HFO-1336mzz(Z)	3.336	1.252	0.5560	0.4440	39.19	17.37
R1243zf	3.141	1.392	0.582	0.4180	45.65	19.8
R1233zd(E)	3.429	1.191	0.5437	0.4563	45.0	20.54
R1234ze(Z)	3.57	1.105	0.5249	0.4751	48.36	22.97
R1234ze(E)	3.210	1.341	0.5728	0.4272	40.08	17.12
R1224yd(Z)	3.381	1.223	0.5501	0.4499	38.34	17.25
R1225ye(z)	3.169	1.371	0.5782	0.4218	34.52	14.56
R1234yf	3.015	1.444	0.5908	0.4092	35.84	14.66
R134a	3.215	1.337	0.5721	0.4249	44.53	19.06
R124	3.282	1.289	0.5560	0.4368	35.0	15.29

Tables-2 show, the percentage of exergy destruction in modified VCRS using following ecofriendly HFO refrigerants using liquid vapour heat exchanger and it was found that the maximum exergy destruction occurred in compressor and then evaporator however exergy destruction in throttle valves is lowest due to only interversibility takes place in the throttle valve.The maximum exergy destruction also occurred by using R1234yf which lowered exergetic efficiency of modified vapour compression refrigeration systems.

Table 2(a): Percentage of exergy destruction in components in the modified vapour compression refrigeration system using liquid vapour heat exchanger using new HFO ecofriendly refrigerants for reducing global warming and ozone depletion for following input values: (Condenser temperature= 323"K", Evaporator temperature= 273"K", Compressor Efficiency= 80%, Degree of subcooling= 10°C, Degree of super heating= 10°C, Heat exchanger effectiveness= 80%)

Percentage exergy destruction (%)	HFO-1336mzz (Z)	R1243zf	R1233zd(E)	R1234yf	R134a
Compressor(%)	53.38	54.13	53.07	54.53	53.88
Evaporator(%)	23.75	23.0	24.05	22.3	22.98
Condenser (%)	7.878	7.561	7.839	7.43	7.785
Throttle valve(%)	2.776	3.477	2.493	4.102	3.361
Total exergy destruction (%)	87.61	88.17	87.45	88.36	88.0
ExergeticEfficiency(%)	12.39	11.83	12.55	11.64	12.0

Table 2(b): Percentage of exergy destruction in components in the modified vapour compression refrigeration system using liquid vapour heat exchanger using new HFO ecofriendly refrigerants for reducing global warming and ozone depletion (for following input values: Condenser temperature= 323"K", Evaporator temperature= 273"K", Compressor Efficiency= 80%, Degree of subcooling= 10^{o}C, Degree of super heating= 10^{o}C, Heat exchanger effectiveness= 80%))

Percentage exergy destruction (%)	R1234ze(Z)	R1234ze(E)	R1224yd(Z)	R1225ye(Z)	R124	R152a
Compressor(%)	52.64	53.89	53.25	54.10	53.62	53.39
Evaporator(%)	24.14	22.97	23.86	22.88	23.32	23.53
Condenser (%)	8.162	7.631	7.765	7.585	7.712	8.143
Throttle valve(%)	2.20	3.459	2.682	3.496	3.134	2.655
Total exergy destruction (%)	87.19	87.95	87.55	88.06	87.57	87.72
ExergeticEfficiency(%)	12.80	12.05	12.45	11.94	12.21	12.28

Table- 3(a) & (b) show, the variation of condenser temperature with thermodynamic first law performance (COP) of modified vapour compression refrigeration system using liquid vapour heat exchanger using new HFO ecofriendly refrigerants for reducing global warming and ozone depletion and it was found that when condenser temperature increasing, the first law efficiency in terms of coefficient of performance is also decreasing for all HFO refrigerants

Table 3(a): Effect of condenser temperature on thermodynamic performance of modified vapour compression refrigeration system usingliquidvapour heat exchanger using new HFO ecofriendly refrigerants for reducing global warming and ozone depletion (for following input values: Condenser temperature= 323"K", Evaporator temperature= 273"K", Compressor Efficiency= 80%, Degree of subcooling= 10^{o}C, Degree of super heating= 10^{o}C, Heat exchanger effectiveness= 80%)

Condenser temperature(K)	**HFO-1336mzz(Z)**	**R1233zd(E)**	**R1234ze(Z)**	**R1234ze(E)**	***R1234yf***	***R152a***	***R134a***
333	2.592	2.70	2.825	2.45	2.269	2.63	2.47
328	2.933	3.033	3.165	2.799	2.626	2.96	2.812
323	3.336	3.429	3.570	3.210	3.043	3.352	3.215
318	3.825	3.904	4.061	3.705	3.541	3.825	3.70
313	4.427	4.502	4.671	4.314	4.153	4.411	4.297
308	5.195	5.261	5.451	5.089	4.927	5.158	5.057
303	6.212	6.267	6.487	6.111	5.946	6.149	6.06

Table 3(b): Effect of condenser temperature on thermodynamic exergy destruction ratio (EDR) of modified vapour compression refrigeration system usingliquidvapour heat exchanger using new HFO ecofriendly refrigerants for reducing global warming and ozone depletion (for following input values: Condenser temperature= 323"K", Evaporator temperature= 273"K", Compressor Efficiency= 80%, Degree of subcooling= 10^{o}C, Degree of super heating= 10^{o}C, Heat exchanger effectiveness= 80%)

Condenser temperature (K)	**R1224yd(Z)**	**R1225ye(Z)**	***R124***	***R1243zf***	***R152a***	***R134a***
333	2.64	2.408	2.532	2.409	2.63	2.47
328	2.979	2.754	2.876	2.746	2.96	2.812
323	3.381	3.169	3.282	3.141	3.352	3.215
318	3.866	3.662	3.772	3.615	3.825	3.70
313	4.466	4.269	4.376	4.199	4.411	4.297
308	5.23	5.662	5.146	4.94	5.158	5.057
303	6.242	6.052	6.162	5.917	6.149	6.06

Table 4(a)&(b) show, the variation of condenser temperature with thermodynamic second law performance (COP) of modified vapour compression refrigeration system using liquid vapour heat exchanger using new HFO ecofriendly refrigerants for reducing global warming and ozone depletion and it was found that when condenser temperature increasing, the second law efficiency is also decreasing for all HFO refrigerants

Table 4(a): Effect of condenser temperature on thermodynamic first law performance (COP) of modified vapour compression refrigeration system using liquid vapour heat exchanger using new HFO ecofriendly refrigerants for reducing global warming and ozone depletion (for following input values: Condenser temperature= 323"K", Evaporator temperature= 273"K", Compressor Efficiency= 80%, Degree of subcooling= 10°C, Degree of super heating= 10°C, Heat exchanger effectiveness= 80%)

Condenser temperature (K)	HFO-1336mzz(Z)	R1233zd(E)	R1234ze(Z)	R1234ze(E)	*R1234yf*	*R152a*	*R134a*
333	0.3450	0.3593	0.3760	0.3280	0.3020	0.350	0.3287
328	0.3903	0.4037	0.4212	0.4930	0.3438	0.3940	0.3743
323	0.4440	0.4563	0.4751	0.4272	0.4049	0.4460	0.4279
318	0.5089	0.5201	0.5404	0.4930	0.4713	0.5090	0.4924
313	0.5891	0.5992	0.6216	0.5742	0.5527	0.5870	0.5719
308	0.6914	0.7002	0.7254	0.6772	0.6557	0.6865	0.6729
303	0.8267	0.8340	0.8633	0.8132	0.7913	0.8183	0.8064

Table 4(b): Effect of condenser temperature on thermodynamic performance of modified vapour compression refrigeration system using liquid vapour heat exchanger using new HFO ecofriendly refrigerants for reducing global warming and ozone depletion (for following input values: Condenser temperature= 323"K", Evaporator temperature= 273"K", Compressor Efficiency= 80%, Degree of subcooling= 10°C, Degree of super heating= 10°C, Heat exchanger effectiveness= 80%)

Condenser temperature (K)	R1224yd(Z)	R1225ye(Z)	R124	R1243zf	R152a	R134a
333	0.3513	0.3255	0.3370	0.3206	0.350	0.3287
328	0.3965	0.3671	0.3828	0.3654	0.3940	0.3743
323	0.4499	0.4218	0.4368	0.4180	0.4460	0.4279
318	0.5144	0.4874	0.5020	0.4811	0.5090	0.4924
313	0.5943	0.5681	0.5814	0.5588	0.5870	0.5719
308	0.6960	0.6705	0.6848	0.6575	0.6865	0.6729
303	0.8307	0.8054	0.8201	0.7875	0.8183	0.8064

Table 5(a): Effect of condenser temperature on thermodynamic exergy destruction ratio ($EDR_{\_System}$) of modified vapour compression refrigeration system usingliquidvapour heat exchanger using new HFO ecofriendly refrigerants for reducing global warming and ozone depletion (for following input values: Condenser temperature= 323"K", Evaporator temperature= 273"K", Compressor Efficiency= 80%, Degree of subcooling= 10°C, Degree of super heating= 10°C, Heat exchanger effectiveness= 80%)

Condenser temperature (K)	HFO-1336mzz(Z)	R1233zd(E)	R1234ze(Z)	R1234ze(E)	*R1234yf*	*R152a*	*R134a*
333	1.899	1.783	1.660	2.068	2.311	1.857	2.042
328	1.562	1.471	1.374	1.685	1.872	1.538	1.672
323	1.252	1.191	1.105	1.341	1.470	1.242	1.337
318	0.9651	0.9226	0.8505	1.028	1.122	0.9646	1.031
313	0.6874	0.6689	0.6088	0.7417	0.8094	0.7036	0.7486
308	0.4463	0.4282	0.3785	0.4766	0.5251	0.4567	0.486
303	0.2097	0.1990	0.1584	0.2297	0.2638	0.2220	0.240

Table 5(b): Effect of condenser temperature on thermodynamic exergy destruction ratio ($EDR_{\_System}$) of modified vapour compression refrigeration system usingliquidvapour heat exchanger using new HFO ecofriendly refrigerants for reducing global warming and ozone depletion (for following input values: Condenser temperature= 323"K", Evaporator temperature= 273"K", Compressor Efficiency= 80%, Degree of subcooling= 10°C, Degree of super heating= 10°C, Heat exchanger effectiveness= 80%)

Condenser temperature (K)	R1224yd(Z)	R1225ye(Z)	*R124*	*R1243zf*	*R152a*	*R134a*
333	1.846	2.120	1.968	2.119	1.857	2.042
328	1.522	1.724	1.613	1.737	1.538	1.672
323	1.223	1.371	1.289	1.392	1.242	1.337
318	0.9438	1.052	0.9924	1.078	0.9646	1.031
313	0.6827	0.7603	0.7170	0.7894	0.7036	0.7486
308	0.4367	0.4915	0.4613	0.5210	0.4567	0.486
303	0.2039	0.2416	0.2194	0.2698	0.2220	0.240

Table 5(a&b) show, the variation of condenser temperature with thermodynamic exergy destruction ratio ($EDR_{\_System}$) of modified vapour compression refrigeration system using liquid vapour heat exchanger using new HFO ecofriendly refrigerants for reducing global warming and ozone depletion and it was found that when condenser temperature increasing, the first law efficiency in terms of coefficient of performance is also increasing for all HFO refrigerants

Table 6(a): Effect of evaporator temperature on thermodynamic first law performance of modified vapour compression refrigeration system usingliquidvapour heat exchanger using new HFO ecofriendly refrigerants for reducing global warming and ozone depletion (for following input values: Condenser temperature= 323"K", Evaporator temperature= 273"K", Compressor Efficiency= 80%, Degree of subcooling= 10°C, Degree of super heating= 10°C, Heat exchanger effectiveness= 80%)

Evaporator Temperature (K)	HFO-1336mzz(Z)	R1233zd(E)	R1234ze(Z)	R1234ze(E)	*R1243zf*	*R1234yf*	*R134a*
253	2.527	2.623	2.767	2.428	2.381	2.284	2.449
258	2.894	2.988	3.131	2.783	2.725	2.628	2.796
263	3.336	3.429	3.570	3.210	3.141	3.043	3.215
268	3.880	3.970	4.108	3.736	3.652	3.553	3.730
273	4.564	4.648	4.782	4.395	4.295	4195	4.376
278	5.446	5.523	5.652	5.246	5.124	5.024	5.210
283	6.626	6.692	6.815	6.384	6.234	6.133	6.325

Table 6(b): Effect of evaporator temperature on thermodynamic first law performance (COP) of modified vapour compression refrigeration system usingliquidvapour heat exchanger using new HFO ecofriendly refrigerants for reducing global warming and ozone depletion (for following input values: Condenser temperature= 323"K", Evaporator temperature= 273"K", Compressor Efficiency= 80%, Degree of subcooling= 10°C, Degree of super heating= 10°C, Heat exchanger effectiveness= 80%)

Evaporator Temperature (K)	R1224yd(Z)	R1225ye(Z)	*R124*	*R1243zf*	*R152a*	*R134a*
253	2.578	2.399	2.495	2.381	2.577	2.449
258	2.942	2.748	2.852	2.725	2.929	2.796
263	3.381	3.169	3.282	3.141	3.352	3.215
268	3.920	3.688	3.811	3.657	3.871	3.730
273	4.596	4.339	4.475	4.295	4.522	4.376
278	5.469	5.18	5.332	5.124	5.362	5.210
283	6.637	6.307	6.478	6.234	6.484	6.325

Table 6(a&b) show, the variation of evaporator temperature with thermodynamic first law performance (COP) of modified vapour compression refrigeration system using liquid vapour heat exchanger using new HFO ecofriendly refrigerants for reducing global warming and ozone depletion and it was found that when evaporator temperature increasing, the first law efficiency in terms of coefficient of performance is also increasing for all HFO refrigerants.

Table 7(a): Effect of evaporator temperature on thermodynamic second law performance of modified vapour compression refrigeration system usingliquidvapour heat exchanger using new HFO ecofriendly refrigerants for reducing global warming and ozone depletion (for following input values: Condenser temperature= 323"K", Evaporator temperature= 273"K", Compressor Efficiency= 80%, Degree of subcooling= 10°C, Degree of super heating= 10°C, Heat exchanger effectiveness= 80%)

Evaporator Temperature (K)	HFO-1336mzz(Z)	R1233zd(E)	R1234ze(Z)	R1234ze(E)	*R1243zf*	*R1234yf*	*R134a*
253	0.4495	0.4665	0.4922	0.4319	0.4235	0.4063	0.4366
258	0.4179	0.4633	0.4855	0.4314	0.4225	0.4074	0.4335
263	0.4440	0.4563	0.4751	0.4272	0.4180	0.4049	0.4279
268	0.4344	0.444	0.4598	0.4182	0.4088	0.3977	0.4175
273	0.4179	0.4257	0.4379	0.4025	0.3933	0.3841	0.4007
278	0.3918	0.3973	0.4066	0.3774	0.3687	0.3641	0.3748
283	0.3512	0.3547	0.3612	0.3384	0.3304	0.3251	0.3352

Table 7(b): Effect of evaporator temperature on thermodynamic second law performance of modified vapour compression refrigeration system usingliquidvapour heat exchanger using new HFO ecofriendly refrigerants for reducing global warming and ozone depletion (for following input values: Condenser temperature= 323"K", Evaporator temperature= 273"K", Compressor Efficiency= 80%, Degree of subcooling= 10°C, Degree of super heating= 10°C, Heat exchanger effectiveness= 80%)

Evaporator Temperature (K)	R1224yd(Z)	R1225ye(Z)	*R124*	*R1243zf*	*R152a*	*R134a*
253	0.4586	0.4267	0.4438	0.4235	0.4584	0.4366
258	0.4561	0.4260	0.4421	0.4225	0.4540	0.4335
263	0.4499	0.4218	0.4368	0.4180	0.4460	0.4279
268	0.4388	0.4128	0.4266	0.4088	0.4333	0.4175
273	0.4209	0.3973	0.4098	0.3933	0.4141	0.4007
278	0.3936	0.3727	0.3836	0.3687	0.3857	0.3748
283	0.3518	0.3343	0.3434	0.3304	0.3437	0.3352

Table 8(a): Effect of evaporator temperature on thermodynamic exergy destruction ratio ($EDR_{\_System}$) of modified vapour compression refrigeration system usingliquidvapour heat exchanger using new HFO ecofriendly refrigerants for reducing global warming and ozone depletion (for following input values: Condenser temperature= 323"K", Evaporator temperature= 273"K", Compressor Efficiency= 80%, Degree of subcooling= 10°C, Degree of super heating= 10°C, Heat exchanger effectiveness= 80%)

Evaporator Temperature (K)	HFO-1336mzz(Z)	R1233zd(E)	R1234ze(Z)	R1234ze(E)	*R1243zf*	*R1234yf*	*R134a*
253	1.225	1.144	1.032	1.315	1.361	1.461	1.296
258	1.229	1.158	1.06	1.318	1.422	1.455	1.307
263	1.252	1.191	1.105	1.341	1.392	1.470	1.337
268	1.302	1.25	1.175	1.391	1.446	1.514	1.395
273	1.393	1.349	1.283	1.485	1.543	1.603	1.495
278	1.552	1.517	1.459	1.650	1.713	1.767	1.668
283	1.847	1.819	1.768	1.955	2.026	2.076	1.983

Table 8(b): Effect of evaporator temperature on thermodynamic exergy destruction ratio ($EDR_{\_System}$) performance of modified vapour compression refrigeration system using liquid vapour heat exchanger using new HFO ecofriendly refrigerants for reducing global warming and ozone depletion (for following input values: Condenser temperature= 323"K", Evaporator temperature= 273"K", Compressor Efficiency= 80%, Degree of subcooling= 10^{o}C, Degree of super heating= 10^{o}C, Heat exchanger effectiveness= 80%)

Evaporator Temperature (K)	R1224yd(Z)	R1225ye(Z)	*R124*	*R1243zf*	*R152a*	*R134a*
253	1.180	1.343	1.253	1.361	1.181	1.296
258	1.192	1.347	1.262	1.422	1.202	1.307
263	1.223	1.371	1.289	1.392	1.242	1.337
268	1.279	1.423	1.344	1.446	1.308	1.395
273	1.376	1.517	1.44	1.543	1.415	1.495
278	1.542	1.683	1.607	1.713	1.592	1.668
283	1.843	0.1992	1.912	2.026	1.910	1.983

Table 7(a&b) show, the variation of evaporator temperature with thermodynamic second law performance (COP) of modified vapour compression refrigeration system using liquid vapour heat exchanger using new HFO ecofriendly refrigerants for reducing global warming and ozone depletion and it was found that when evaporator temperature increasing, the second law efficiency is also decreasing for all HFO refrigerants.

Table 8(a&b) show, the variation of condenser temperature with thermodynamic exergy destruction ratio ($EDR_{\_System}$) of modified vapour compression refrigeration system using liquid vapour heat exchanger using new HFO ecofriendly refrigerants for reducing global warming and ozone depletion and it was found that when condenser temperature increasing, the first law efficiency in terms of coefficient of performance is also increasing for all HFO refrigerants.

CONCLUSIONS AND RECOMMENDATION

Following conclusions were drawn from present investigations-

1. Thermodynamic performance using R1234ze(z) gives better first and second law performances than R1234yf , R152a and R134a.
2. The performance of HFO refrigerants is slightly less than HF1234ze(E) however it has similar refrigerating properties and can easily replace HFC-134a in all vapour compression refrigeration systems.
3. The exergy destruction in compressor is highest for all HFO refrigerants.
4. The exergy destruction in evaporator is second highest the exergy destruction in throttle valve is lowest.
5. Exergy destruction ratio is increasing as evaporator and condenser temperatures are increasing.
6. Coefficient of performance of modified vapour compression system is increasing when evaporator temperature is increasing for all HFO refrigerants while second law efficiency is decreasing for all refrigerants.
7. Coefficient of performance of modified vapour compression system is decreasing when condenser temperature is increasing for all HFO refrigerants while second law efficiency is decreasing for all refrigerants.

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