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Research Article

EXERGETIC ANALYSIS OF A VAPOUR COMPRESSION REFRIGERATION SYSTEM WITH R134A, RE170, R429A, R435A AND R510A

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A B S T R A C T

This communication deals with the exergetic analysis of a vapour compression refrigeration system with selected refrigerants. The various parameters computed are COP, exergetic efficiency and EDR in the system. Effects of condenser temperature, evaporator temperature and sub-cooling of condenser outlet, super-heating of evaporator out let and effectiveness of vapour liquid heat exchanger are also computed and discussed. In this study, it was found that R429A has the better performance in all respect, whereas R435A refrigerant mixture has lower performance.

INTRODUCTION

For the past half century, chlorofluorocarbons (CFCs) have been used extensively in the field of refrigeration due to their favorable characteristics. In particular, CFC12 has been predominantly used for small refrigeration units including domestic refrigerator/freezers. Since the advent of the Montreal Protocol, as the CFC12 has high ODP and GWP the refrigeration industry has been trying to find out the best substitutes for ozone depleting substances [1]. For a past decade, HFC134a has been used to replace CFC12 used in refrigerators and automobile air conditioners. HFC134a has such favorable characteristics as zero ozone depleting potential (ODP), non-flammability, stability, and similar vapor pressure to that of CFC12. A recent survey, however, showed that the performance of HFC134a in refrigerators with a proper compressor and lubricant is quite comparable to that of CFC12. In 1997 the Kyoto protocol was agreed by many nations calling for the reduction in emissions of greenhouse gases including HFCs.[2] Since the Global warming potential (GWP) of HFC134a is relatively high (GWP1430) and also expensive, the production and use of HFC134a will be terminated in the near future. The research and development in the field of Refrigeration and Air-Conditioning apply to the use of natural refrigerants is not only associated with the need to preserve the environment itself, but also has great importance in the latent need for enhanced efficiency energy equipment. Such a feature is observed in Decision XIX/6 of the Montreal Protocol. Hydrocarbons, such as liquefied petroleum gas (LPG) and Di methyl ether are environmentally friendly and its products are available in abundance in nature. In this sense, the use of these substances as refrigerants in domestic refrigerators is very attractive. Little information is available in the scientific literature on the use of di methyl ether in domestic refrigerators.

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B.O.Bolagi, M.A.Akintunde, and T.O.Falade investigated experimentally the performance of three zero ODP HFC refrigerants (R32, R134a and R152a) in a vapour compression refrigerator and compared the results obtained. The results show that the COP of R152a was 2.5% higher than that of R134a and 14.7% higher than that of R32 [3].

Sekhar *et al*. (2004) investigated the mixture of HFC134a/hydrocarbons in two systems of low temperature (household refrigerator and freezer) and two medium-temperature systems (vending machine and bottle cooler). The authors concluded that a mixture containing 9% of hydrocarbon mixtures (mass) has the best performance, resulting in 10-30 % and 5-15% reduction in energy consumption in systems of medium and low temperature, respectively. [4]

Fatouh and El Kafafy (2006) evaluated theoretically a mixture of hydrocarbons composed of 60% and 40% R290/R600 as a better drop-in replacement for domestic refrigerators based on HFC -134a under abnormal weather conditions, subtropical and tropical regions. [5]

Mohanraj *et al*. (2007) presented experimental results of the energy efficient hydrocarbons mixture consisting of 45% HC290 (propane) and 55% HC600a (isobutane) as drop-in replacement for the HFC134a under various loads (40g, 50g, 70g, 90g) in a household refrigerator of 165 liters (class tropical) using synthetic oil as a lubricant and R134a (100g). Tests were performed at room temperature of 30°C, without thermal load and the refrigerator door closed as ISO 8187. The results showed that the load of 70 g of the hydrocarbon mixture has a better COP, lower power consumption, lower pull down and low temperature discharge in relation to the R134a and the equipment need not change [6].

Dimethyl ether (RE170, DME) makes a better refrigerant than R290 / R600a blends as it has no temperature glide and doesn't separate during leakage. It has been extensively adopted by the aerosol industry as the most cost effective replacement for R134a in propellant applications [7].

valentinapostol_etl 2009 conducted a comparative thermodynamic study considering a single-stage vapor-compression refrigeration system (VCRS) using as working fluids DME,R717, R12, R134A, R22 (pure substances) and R404A , R407C (zeotrope mixtures), respectively. The result of this study is that DME could be used as a refrigerant and, more, that DME could be a good substitution alternative for R12 and R134a. [8]

The Dimethyl ether (DME, C2H6O) possesses a range of desirable properties as a replacement for R-134a. These include better heat transfer characteristics than R-134a, a pressure/temperature relationship very close to R-134a, compatibility with mineral oils, low cost and ready availability. It is also highly environmentally friendly. (ODP =0; GWP =1; atmospheric lifetime = 6 days) DME is compatible with most materials commonly found in refrigeration systems. [9]

Ki-Jung Park, Dong Gyu Kang and Dongsoo Jung C, S investigated both numerically and experimentally in an effort to replace HFC134a used in the refrigeration system of domestic water purifiers. Test results show that the energy consumption and the compressor discharge temperature of R429A is 28.9% and 13.4^0 C lower than that of HFC134a with 50% of the refrigerant charge , Overall, R429A is a new long term environmentally safe refrigerant, is a good alternative for HFC134a requiring little change in the refrigeration system of the domestic water purifiers. [10]

Choedaeseong, Dangsoo Jung (2010) presented an experimental study on the application of R435A (mixture of DME and R152a) to replace HFC134a in domestic water purifiers. Test results show that the energy consumption and discharge temperature was 12.7% and 3.7°C lower than that of HFC 134a [11].

Ki-Jung Park/Yohan Lee/Dongsoo Jung investigated both numerically and experimentally in an effort to replace HFC134a used in the refrigeration system of domestic water purifiers. Test results show that the energy consumption and the compressor discharge temperature of R510A is 22.3% and 3.7^0 C lower than that of HFC134a with 50% of the refrigerant charge, Overall, R510A is a new long term environmentally safe refrigerant, is a good alternative for HFC134a requiring little change in the refrigeration system of the domestic water purifiers. [12]

Baskaran *et al*. [18-25] analyzed the performance of a vapor compression refrigeration system with low GWP refrigerants and its blends. The results were compared with R134a as a possible alternative refrigerant.

An exergy analysis is usually aimed to determine the maximum performance of the system and identify the sites of exergy destruction. Exergy analysis of a complex system can be performed by analyzing the components of the system separately. Identifying the main sites of exergy destruction shows the direction for potential improvements [13]. Therefore, exergy analysis identifies the margin available to design more efficient energy systems by reducing inefficiencies. Exergy analysis permits many of the shortcomings of energy analysis to be overcome. Exergy analysis is useful in identifying the causes, locations and magnitudes of process inefficiencies. There has been little analysis about exergy for vapour compression refrigeration using pure hydrocarbons, Dimethyl ether and its blends whereas in many investigations, these natural refrigerants were found as acceptable refrigerant as an alternative to replace R134a.Bolaji.B.O. (2010) Conducted an experimental study on the exergetic performance of a domestic Refrigerator using two environment friendly Refrigerants R134a and R152a as alternative to R12. The results obtained showed that the average COP of R152a was very close to that of R12 with only 1.4% reduction, while 18.2% reduction was obtained for R134a in comparison with that of R12[14].J.U. Ahamed *et al* (2010) conducted a comparative study on thermodynamic performance of R600 and R600a as refrigerant. This study shows that the exergy efficiency is higher for butane compared to that of isobutene and R134a as refrigerant [15].

Limited researches have been performed on exergy analysis of the vapour compression refrigeration system using dimethyl ether refrigerant and its mixtures. It is found that these refrigerants have greater advantage on the basis of energy and other environmental impacts.Now it has become necessary to know the exergy performance as well as energy performance of these refrigerants compared to existing refrigerant R134a.

The literature survey is based on the study of R134a replacement and exergetic analysis. Most of the performance analysis of refrigeration system is investigated using an energy approach based on the first law of thermodynamics (i.e. by means of coefficient of performance). The energy analysis deals with only quantity of energy and it does not give the information that how, where and how much the performance of the system degrade. Thus, modern approach to process analysis required to use the exergy analysis which provides the more realistic view of the process.

Thermodynamic Cycle Analysis

The physical, safety and environmental data of the selected fluids in this study are reported in Table1.[16]. The model used here is CYCLE_D developed by NIST [17]. The system simulated by CYCLE_D consists of a compressor, discharge line, condenser, expansion device, evaporator, compressor suction line, and an optional suction line heat exchanger (SLHX). Thermodynamic properties are regenerated through the Carnahan- Starling-DeSantis (CSD) equations of state. The simulated cycle is out lined by 11 states corresponding to key locations in a real system as shown in Fig. 1. These states are the following: (1) Inlet to the shell of the hermetic compressor; (2) Cylinder inlet before the compression process; (3) Cylinder outlet after the compression process; (4) Condenser inlet; (5) Saturated vapor in the condenser; (6) Saturated liquid in the Condenser; (7) Condenser outlet; (8) inlet to the adiabatic expansion device; (9) Expansion device outlet or evaporator inlet; (10) Saturated vapor in the evaporator and (11) Evaporator outlet. The rating conditions are an evaporating temperature of -10°Cand a condensing temperature which is varying between 30 °Cand of 55°C. For mixtures, CYCLE_D computes the condensing temperature as the mean of bubble and dew point temperatures. Similarly, the evaporating temperature is the mean of evaporator inlet temperature and the dew point temperature. In this study, the condenser sub cooling is adjusted to 5 °C. The superheat is fixed to 10°C. The pressure drops across the suction line and the discharge line have been neglected. The suction and discharge lines are assumed as adiabatic. The calculated compressor isentropic efficiency of 0.75 was kept fixed for all the refrigerants studied. The volumetric compressor efficiency of 0.75 and electric motor efficiency of 0.75 were also kept fixed. These values are useful to incorporate the efficiency parameters in the comparative analysis. The liquid line heat exchanger effectiveness is taken as 0.8. The Cooling capacity of the system = 1kW. Surrounding temperature (T_0) = 30°C. The parasitic powers like indoor fan power, outdoor fan power and power for controls are kept fixed for all the conditions.

In this paper CYCLE_D model has been used to calculate the coefficient of performance, exergetic efficiency and exergy destruction ratio for selected refrigerants based on energy and exergy concept. It is also studies the effects of evaporating and condensing temperatures, degree of sub cooling, degree of super heating and effectiveness of liquid vapour heat exchanger on coefficient of performance (COP), exergetic efficiency and exergy destruction ratio.

The energy analysis based on first law of thermodynamic, the performance of vapour compression refrigeration system can be predicted in terms of coefficient of performance (COP), which is defined as the ratio of net refrigerating effect produced by the refrigerator to the work done by the compressor. It is expressed as

$$COP = \frac{Q_e}{W}$$

$$COP = \frac{h_1 - h_9}{h_3 - h_2}$$

The modern approach based on second law of thermodynamic i.e. exergy analysis can be used to measures the performance of the vapour compression refrigeration system. This analysis derives the concept of exergy, which is always decreasing due to thermodynamic irreversibilities. Exergy is the maximum useful work that could be obtained from the system at a given state in a specified environment. Exergy balance for a control volume undergoing steady state process is expressed as

$$Edi{=}\Sigma(me_x\ )_{in}{-}\Sigma(me_x\ )_{out}\ +[\Sigma(Q(1{-}T_0T\ )_{in}{-}\Sigma(Q(1{-}T_0T\ )_{out}]{\pm}\Sigma W$$

Exergy Destruction (ED) in the system components

Exergy destruction in each component of the cycle is calculated as

A. Exergy destruction in Evaporator

$$E_{de}{=}E_{X9}{+}Q_e\ (1{-}\frac{T_0}{T_r}){-}E_{X11}$$

$$={m_r}\ (h_9{-}T_oS_9\ ){+}Q(1{-}\frac{T_0}{T_r}){-}m_r\ (h_{11}{-}T_oS_{11})$$

B. Exergy destruction in Compressor

$$E_{dcomp}{=}E_{X2}{+}W\ {-}E_{X3}$$

$$={m_r}\ (h_2{-}T_oS_2)\ {+}\mathrm{CP}{-}(h_3{-}T_oS_3)$$

C. Exergy destruction in Condenser

$$E_{dc}{=}E_{X4}{-}E_{X7}$$

$$={m_r}\ (h_4{-}T_oS_4)\ {-}m_r\ (h_7{-}T_oS_7)$$

D. Exergy destruction in Expansion device

$$Ed_{\mathrm{ex}}{=}E_{X8}{-}E_{X9}$$

$$={m_r}\ (h_8{-}T_oS_8)\ {-}m_r\ (h_9{-}T_oS_9)$$

E. Exergy destruction in liquid vapour heat exchanger

$$E_{dlvhe}{=}E_{X7}{-}E_{X8}{+}E_{X11}{-}E_{X1}$$

$$=(h_7{-}h_8{+}h_{11}{-}h_1){-}\ T_0(S_7{-}S_8{+}S_{11}{-}S_1)$$

Total Exergy destruction

Total exergy destruction in the system is the sum of the exergy destruction in different components of the system and is given by

$$\Sigma E_{di}{=}E_{de}\ {+}E_{dcomp}\ {+}E_{dc}{+}E_{d\mathrm{ex}}{+}E_{dlvhe}$$

Thermal Exergy Loss

Thermal exergy loss rate in a component is given by

$$E_{Li}{=}(1{-}\frac{T_0}{T_i})$$

The term thermal exergy loss rate is related to external irreversibility which takes place because of temperature difference between the control volume and the immediate surroundings. It depends upon how the boundary of the system is selected. If the system includes the immediate surroundings then the boundary of the system is at the same temperature as the temperature of the immediate surroundings, hence the value of the thermal exergy loss become zero. If the system boundary does not include the immediate surroundings, the temperature difference between the system boundary and immediate surroundings exits. In vapour compression refrigeration system condenser is the component where heat is rejected. Then the equation (9) becomes:

$$E_{L\mathrm{c}}{=}Q_{\mathrm{c}}\,(1{-}\frac{T_0}{T_c})$$

When consider the thermal exergy loss total exergy destruction in the system is given as:

$$\Sigma E_{di}{+}\Sigma E_{Li}{=}E_{de}\ {+}E_{dcomp}\ {+}E_{dc}{+}E_dt{+}E_{dlvhe}{-}E_{Lc}$$

Now, total exergy supplied is given by:

$$EF\ {=}EP{+}\Sigma E_{di}{+}\Sigma E_{Li}$$

For refrigeration system, product is the exergy of the heat abstracted into the evaporator from the space to be cooled at temperature T_r.

$EP = Q_e\,(1 - \frac{T_0}{T_r})$

Exergetic Efficiency (η_{ex})

$$\eta_{ex} = 1 - \frac{\text{Total Exergy Destruction}}{\text{Total Exergy Supplied}}$$

$$\eta_{ex} = 1 - \frac{\Sigma Edi + \Sigma ELi}{EF}$$

Exergy Destruction Ratio (EDR)

Exergy destruction ratio is the ratio of the total exergy destruction in the system to the exergy in the product and it is given by

$$EDR = \frac{EDtotal}{EP}$$

Also, in terms of second law efficiency

$$EDR = \frac{1}{\eta ex} - 1$$

RESULT AND DISCUSSIONS

Fig.2 shows the effects of evaporator temperatures on coefficient of performance. The pressure ratio across the compressor decreases, with increase in evaporator temperature causing work required by the compressor decrease and cooling capacity increases due to increase in refrigerating effect. Hence, the combined effects of these two factors increase the coefficient of performance (COP). At lower evaporating temperature, the Refrigerants RE170, R429A, R435A and R510A are having higher COP value than R134a.At higher evaporating temperature, all selected refrigerants are having higher COP. In general, R429A and R510A are having more COP value than R134a over the range of evaporating temperatures. The COP of R429A is 2.2-1.5% higher than R134a.

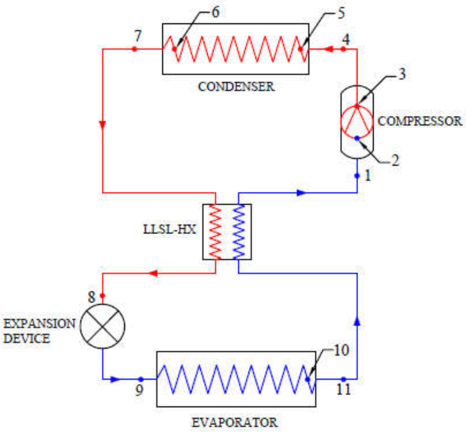

Fig 1 Thermodynamicsimulation model CYCLE_D

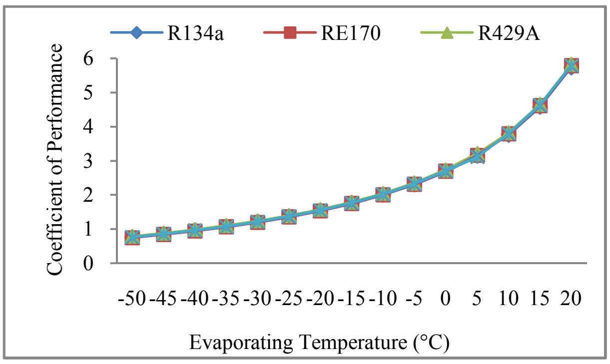

Fig 2 Effect of evaporating temperatures on coefficient of performance

Fig 3-4 shows the effect of evaporator temperatures on exergetic efficiency (ηex) and exergy destruction ratio (EDR). With increase in evaporator temperatures exergetic efficiency increases till the optimum evaporator temperature and beyond the optimum temperature it decrease. The optimum evaporator is the temperature at which maximum exergetic efficiency is achieved. The curves trend for EDR almost reverses to curves of exergetic efficiency. The increasing and decreasing of exergetic efficiency depends upon the two factors, first factor is the exergy Second factor is compressor work required by compressor W which decreases with increase in evaporator temperature. The term Qe and W have positive effect on increase of exergetic efficiency while the term $(1 - T_0/\,Tr)$ have negative effect on increase of exergetic efficiency. The combined effect of these two factors, increases exergetic efficiency increases till the optimum evaporator temperature and beyond the optimum temperature decrease.

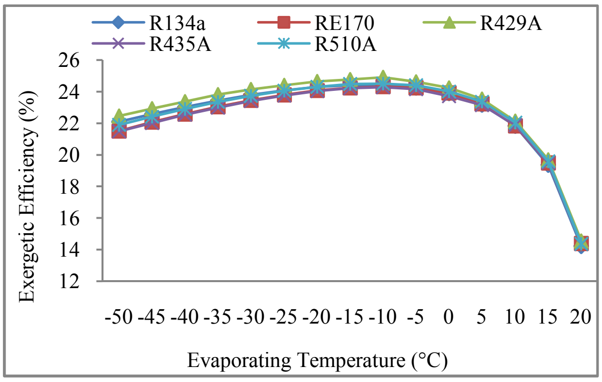

Fig 3 Effect of evaporating temperatures on exergetic efficiency

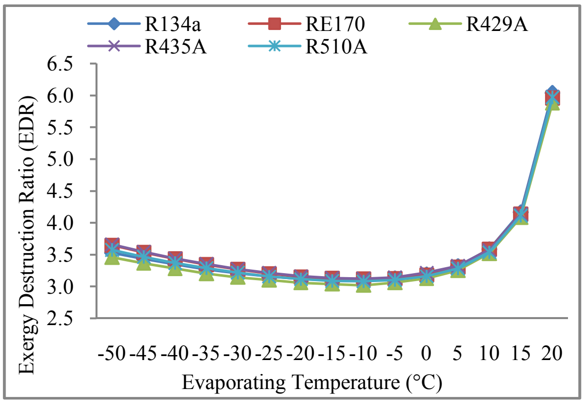

Fig 4 Effect of evaporating temperatures on exergy destruction ratio (EDR)

The curves trend for EDR almost reverses to curves of exergetic efficiency because of exergetic efficiency is inversely proportional to exergy destruction ratio (EDR). The EDR decreases with increases in evaporator temperatures till the optimum evaporator temperature and beyond the optimum temperature it increase. The optimum evaporator is the temperature at which minimum EDR is achieved. At lower evaporating temperature, the Refrigerant R429A is having higher exergetic efficiency than R134a.At higher evaporating temperature, all selected refrigerants are having higher exergetic efficiency. In general, R429A is having more exergetic efficiency value than R134a over the range of evaporating temperatures. The exergetic efficiency of R429A is 1.6-2.3% higher than R134a.

Fig.5 shows the effects of condensation temperatures on coefficient of performance. The pressure ratio across the compressor increases, with increase in condenser temperature causing work required by the compressor increase and cooling capacity decreases due to decrease in refrigerating effect. Hence, the combined effects of these two factors decrease the coefficient of performance (COP). At lower condensation temperature, the Refrigerant R429A, is having higher COP value than R134a. At higher condensing temperature, all selected refrigerants are having higher COP. In general, R429A and R510A are having more COP value than R134a over the range of condensing temperatures. The COP of R429A is 0.864-2.7% higher than R134a.

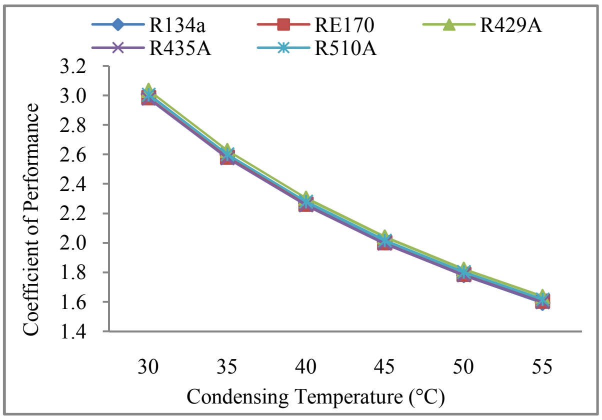

Fig 5 Effect of condensing temperatures on coefficient of performance

Fig.6-7 shows the effect of condensation temperatures on exergetic efficiency (ηex) and exergy destruction ratio (EDR). With increase in condenser temperatures exergetic efficiency decreases. The curves trend for EDR almost reverses to curves of exergetic efficiency because of exergetic efficiency is inversely proportional to exergy destruction ratio (EDR).

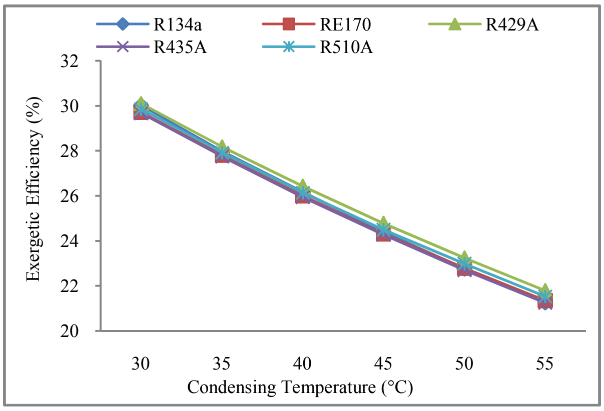

Fig 6 Effect of condensing temperature on exergetic efficiency

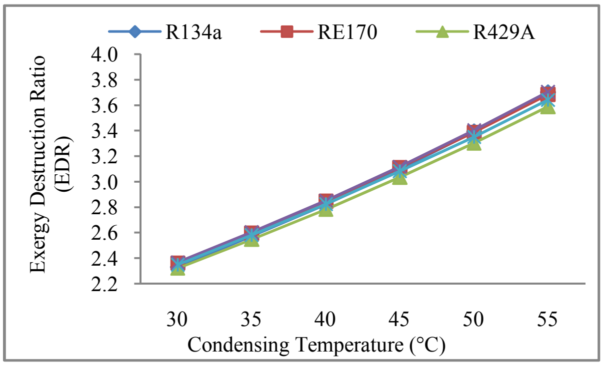

Fig 7 Effect of condensing temperature on exergy destruction ratio (EDR)

The EDR increases with increases in condenser temperatures. At lower condensation temperature, the Refrigerant R429A, is having higher exergetic efficiency than R134a. At higher evaporating temperature, all selected refrigerants are having higher exergetic efficiency. In general, R429A and R510A are having more exergetic efficiency than R134a over the range of condensing temperatures. The exergetic efficiency of R429A is 0.30-2.49% higher than R134a.

Fig.8-10 presents the effect of degree of sub cooling on coefficient of performance (COP), exergetic efficiency and exergy destruction ratio (EDR). With increase in degree of sub cooling cooling capacity increase because of increase in refrigerating effect and there is no change in compressor work, hence COP increases. From the study of equations it is evident that increase in COP increases the exergetic efficiency and decreases exergy destruction ratio (EDR). The rate of increase in COP is approximately 0.78%/℃ of sub cooling in case of R134a. The rate increase in COP is approximately 0.65%/°Cof sub cooling in case of R429A. The total increase in exergetic efficiency for 100C sub-cooling is 7.43% and 6.1% for R134a and R429A respectively.

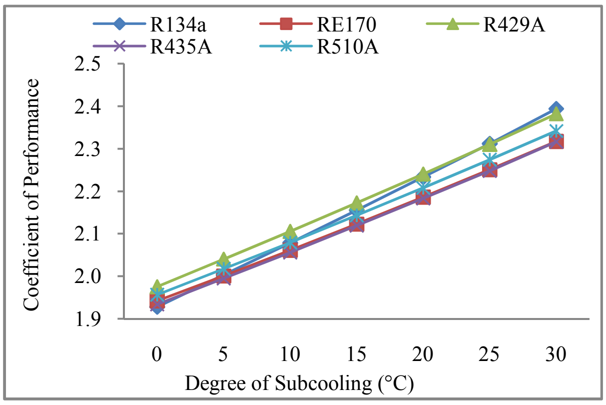

Fig 8 Effect of degree of subcooling on coefficient of performance

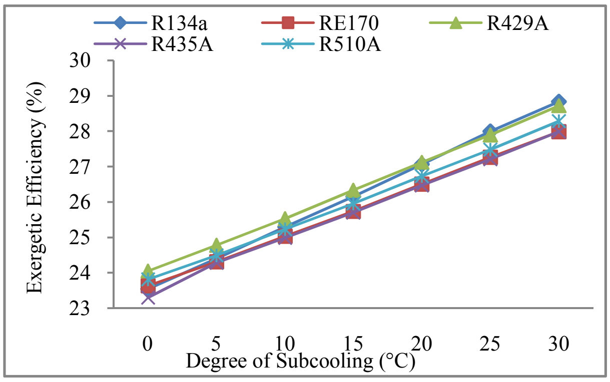

Fig 9 Effect of degree of subcooling on exergetic efficiency

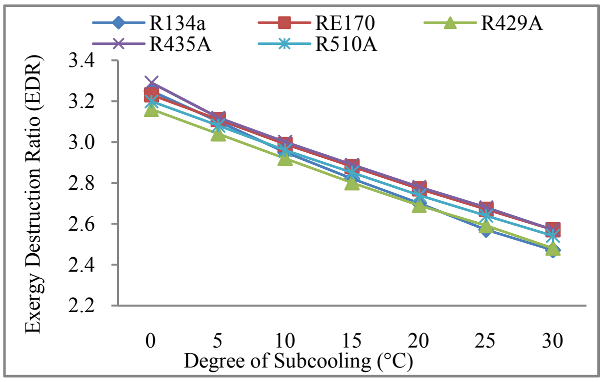

Fig 10 Effect of degree of subcooling on exergy destruction ratio (EDR)

Fig.11-13 presents the effect of degree of superheating on coefficient of performance (COP), exergetic efficiency and exergy destruction ratio (EDR). With increase in degree of superheating the COP value slightly increases for all refrigerants and there is no appreciable change in exergetic efficiency and EDR.

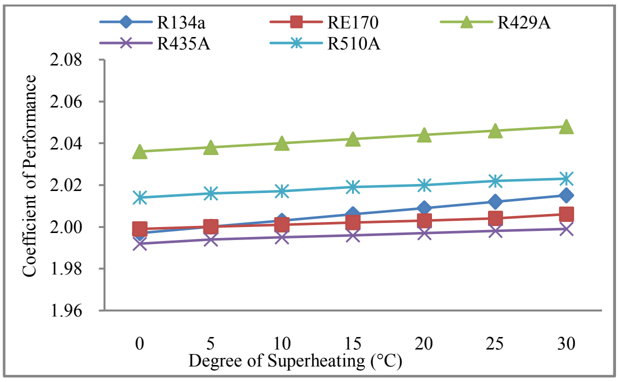

Fig. 11 Effect of degree of superheating on coefficient of performance

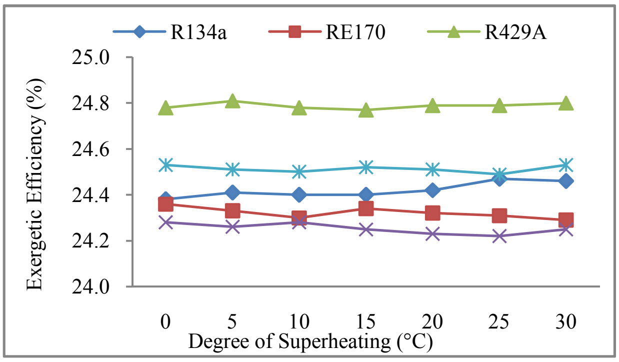

Fig 12 Effect of degree of superheatingon exergetic efficiency

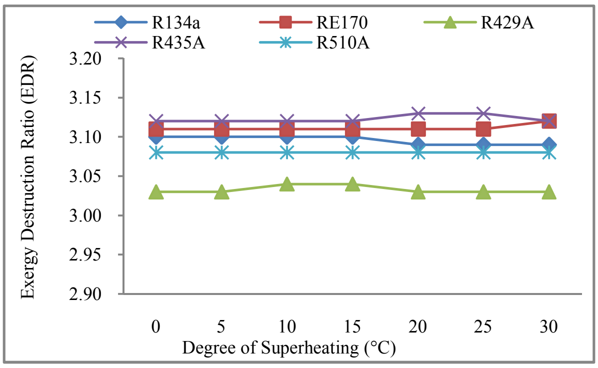

Fig. 13 Effect of degree of superheating on exergy destruction ratio (EDR)

Fig. 14-16 shows the effect of effectiveness of liquid-vapour heat exchanger on coefficient of performance (COP), exergetic efficiency and exergy destruction ratio (EDR). With increase in effectiveness of liquid-vapour heat exchanger COP increases for all selected refrigerants and exergetic efficiency increases while EDR decreases for the refrigerants R134a and R429A. The COP of the refrigerants R429A and R510A are higher than R134a when the effectiveness range from 0.1 to 1.0.The COP of the refrigerants R435A and RE170 are higher than R134a when the effectiveness range is up to 0.6 and 0.7 respectively. The exergetic efficiency of the refrigerant R429A is higher than R134a when the effectiveness range from 0.1 to 1.0. The exergetic efficiency of the refrigerants R435A, RE170, and R510A are higher than R134a when the effectiveness range is up to 0.5, 0.6 and 0.9 respectively.

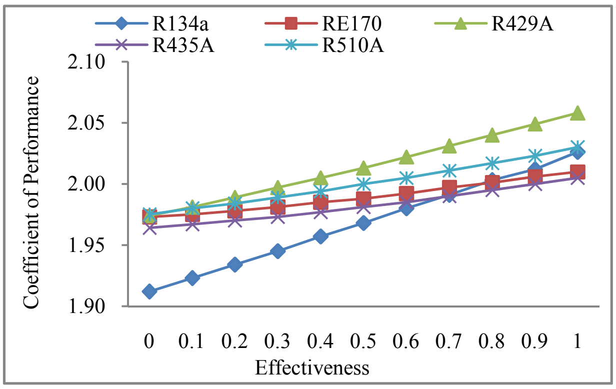

Fig. 14 Effect of effectiveness of liquid-vapour heat exchanger on coefficient of performance

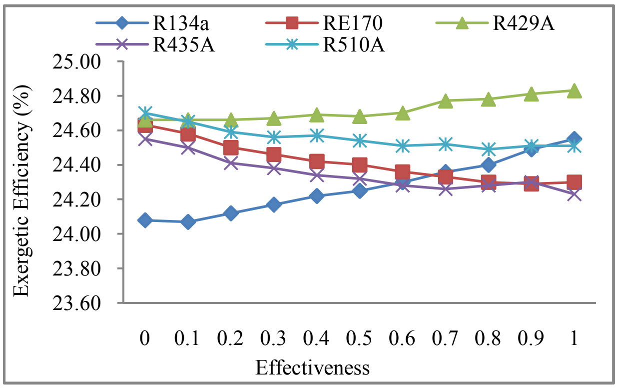

Fig. 15 Effect of effectiveness of liquid-vapour heat exchanger on exergetic efficiency

Table 1 Physical, Safety and Environmental data of Refrigerants

Refrigerant	Number	R134a	RE170	R429A	R435A	R510A
	Chemical Formula, Blend composition, Common name	CH2FCF3	CH3OCH3	RE170/R152a/R600a (60/10/30)	RE170/R152a (80/20)	RE170/R600a (88/12)
Physical Data	Molecular mass	102.3	46.07	50.76	49.04	47.24
	NBP (°C)	-26.1	-24.8	-25.5	-26.1	-25.2
	Tcr (°C)	101.1	127.2	123.5	125.2	127.9
	Pcr (Mpa)	4.06	5.34	4.86	5.39	5.33
Safety Data	OFL PPMv	1000	1000	1000	1000	1000
	LFL (%)	None	3.4	2.9	3.5	3
	HOC (MJ/Kg)	4.2	31.8	-	28.9	33.9
	ASHRAE Safety Group	A1	A3	A3	A3	A3
Environmental Data	Atm life (yr)	14	0.015	3.749	0.292	1.4532
	ODP	0	0	0	0	0
	GWP	1430	0	20	27	3

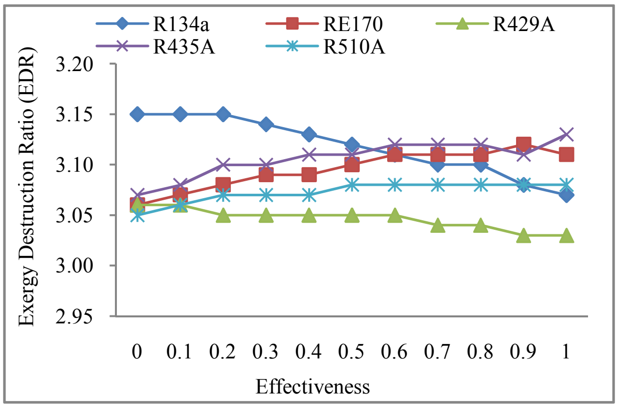

Fig.16 Effect of effectiveness of liquid-vapour heat exchanger on exergy destruction ratio (EDR)

CONCLUSIONS

A computational model based on energy and exergy analysis is presented for the investigation of the effects of evaporating temperatures, condensing temperatures, degree of sub cooling degree of superheating and effectiveness of the liquid vapour heat exchanger on the COP, exergetic efficiency and EDR of the vapour compression refrigeration cycle for the refrigerants R134a, RE170, R429A, R435A and R510A

The conclusions present in this analysis are given as follows

1. The COP and exergetic efficiency of R429A is better than that of R134a. The EDR of R429A is lower than that of R134a. The COP of R429A is 2.2-1.5% higher than R134a. The exergetic efficiency of R429A is 1.6-2.3% higher than R134a.This analysis performed at condenser temperature 45°C and evaporator temperature ranging from-50°C to 20°C.
2. The refrigerants R429A and R510A are having more COP and exergetic efficiency than R134a over the range of condensing temperatures from 30^0C to 55^oC at -10^0C evaporation temperature. The COP of R429A is 0.864-2.7% higher than R134a.The exergetic efficiency of R429A is 0.30-2.49% higher than R134a.
3. When the sub cooling increases, the COP increases for all refrigerants. The increase in COP increases the exergetic efficiency and decreases exergy destruction ratio (EDR). The rate of increase in COP per degree sub cooling is approximately 0.78% and 0.65% for R134a and R429A respectively. The total increase in exergetic efficiency for 10°C sub cooling is 7.43% and 6.1% for R134a and R429A respectively.
4. When the superheating increases, the COP value slightly increases for all refrigerants and there is no appreciable change in exergetic efficiency and EDR.
5. With increase in effectiveness of liquid-vapour heat exchanger COP increases for all selected refrigerants and exergetic efficiency increases while EDR decreases for the refrigerants R134a, R429A. The COP of the refrigerants R429A and R510A are higher than R134a when the effectiveness range from 0.1 to 1.0.For the effectiveness value 0.8,the COP of the refrigerant R429A is 1.85%higher than that of R134a.The exergetic efficiency of R429A is 1.56%higher than that of R134a.The EDR decreases by 1.94% for R429A

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