Energetic and Exergetic Based Comparison Multiple Evaporators with Compound Compression and Flash Intercooler with Individual or Multiple Throttle Valves

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Abstract

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. Due to effect of global warming and ozone depletion the comparison and impact of environmental friendly refrigerants (R507a, R410a, R290, R600, R600a, R1234yf, R404a, R125, R717, R152a and R407C) on multiple evaporators at different temperature with compound compression and flash intercooler with individual and multiple throttle valves is important for calculating first law and second law performance on the basis of energetic and exergetic approach. Comparison was done for multiple evaporators with compound compression and flash intercooler with individual throttle valves (system-1) and multiple evaporators with compound compression and flash intercooler with multiple throttle valves (system-2) in terms of coefficient of performance, rational efficiency and total system defect. It was observed that for all considered refrigerants second law & first law efficiency of system-1 is lower than sytem-2 conversely system defect of system-1 is higher than system-2.In terms of energetic efficiency, rational efficiency and system defect for both systemsR407C shows minimum performance and performances of R600, R152a and R717 better with comparison of other selected refrigerants for system-1 and system-2. But R600 is highly inflammable and R717 is toxic in nature and restricted to limited applications, so R152a is suggested for both systems.

Nomenclature

COP coefficient of performance (non-dimensional)
ODP ozone depletion potential
GWP global warming potential
P power (kJ/s)
f flash intercooler
Q rate of heat transfer (kW)
W work rate (kW)
T temperature (K)
ΔT_{sc} degree of subcooling
sc subcooler
TV throttle valve
x dryness fraction(non-dimensional)
EP evaporator
Φ specific enthalpy (kJ/kg)
Ψ irreversibility rate(kW)
c compressor
X exergy rate of fluid (kW)
$\dot{m}$ mass flow rate (kg/s)
s specific entropy (kJ/kgK)
$\dot{EP}$ exergy rate of product (kW)

Subscript

e evaporator
c compressor
o dead state
f flash intercooler

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r refrigerant, space to be cooled
tv throttle valve
sc subcooler
k kth component
gen generation
cond condenser

1. Introduction

Nowadays most of the energy utilize in cooling and air conditioning in industrial as well as for domestic applications. In addition with energy consumption, using of refrigerants in cooling and air conditioning having high GWP and ODP are responsible for global warming and ozone depletion. The primary requirements of ideal refrigerants is having good physical and chemical properties, due to good physical and chemical properties such as non-corrosiveness, non-toxicity, non- flammability, low boiling point, Chlorofluorocarbons (CFCs) have been used over the last many decades. But hydrochloro fluorocarbons (HCFCs) and Chlorofluorocarbons (CFCs) having large amount of chlorine content as well as high GWP and ODP, so after 90s refrigerants under these categories are almost prohibited [1].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 determined [2], so exergetic or second law analysis is the advanced approach for thermodynamic analysis which gives a additional practical view of the processes [3-5]. In addition to this second law analysis also provides new thought for development in the existing system [6].In this paper great emphasis put on saving of energy and using of eco friendly refrigerants due to increase of energy crises, global warming and depletion of ozone layer. In this investigation the work input required running the vapour compression refrigeration system reduced by using compound compression and work input further decrease by flash inter-cooling between two compressors using of eco-friendly refrigerants. The methods for finding the first law and second law efficiency of vapour compression and vapour absorption refrigeration systems are well defined in literature.COP of system can be enhanced either by decreasing the work of compressor by introduction of multi stages compressors or increasing the refrigeration effect. It is also possible to reduce the compressor work to considerable extent by compressing the refrigerant very close to the saturation line this can be achieved by compressing the refrigerants in more stages with intermediate intercooler. The refrigeration effect can be increase by maintaining the condition of refrigerants in more liquid stage at the entrance of evaporator which can be achieved by expanding the refrigerant very close to the liquid line. The expansion can be brought close to the liquid line by sub-cooling the refrigerant and removing the flashed vapours by incorporating the flash chamber in the working cycle. The evaporator size can be reduced because unwanted vapours formed are removed before the liquid refrigerant enters in the evaporator.

Xuan and Chen presented in this manuscript about the replacement of R502 by mixture of HFC-161.Through experimental study it was found that mixture of HFC-161 gives same and higher performance than R404A at lower and higher evaporative temperature respectively on the vapour compression refrigeration system designed for R404A.

Cabello et al. effect of condensing pressure, evaporating pressure and degree of superheating was experimentally investigated on single stage vapour compression refrigeration system using R22, R134a and R407C.It was observed that mass flow rate is greatly affected by change in suction conditions of compressor in results on refrigeration capacity because refrigeration capacity depended on mass flow rate through evaporator. It was also found that for higher compression ratio R22 gives lower COP than R407C.

Spatz and Motta, focused on replacement of R12 with R410a through experimental investigation of medium temperature vapour compression refrigeration cycles. In terms of thermodynamic analysis, comparison of heat transfer and pressure drop characteristics, R410a gives best performance among R12, R404a and R290a.

Han et al. under different working conditions experimental results revealed that there could be replacement of R407C in vapour compression refrigeration system having rotor compressor with mixture of R32/R125/R161 showing higher COP, less pressure ratio and slightly high discharge compressor temperature without any modification in the same system.

Most of the researchers did not gone through second law analysis in terms of system defect defined as irreversibility calculations in various components of multiple evaporators with compound compression and flash intercooler with individual and multiple throttle valves. Therefore objective of the present investigations to find out irreversibility occurred in the components of vapour compression refrigeration systems because second law analysis is very useful for finding the irreversibility in components as well as in whole system it is a powerful tool for designing and analyzing of air conditioning and refrigeration systems.

2. Multiple evaporators at different temperatures with compound compression, flash intercooler and individual throttle valves (system-1)

Multiple evaporators at different temperatures with compound compression, flash intercooler and individual throttle valves (system-1) consists of compressors (C1, C2, C3) throttle valves (TV1, TV2, TV3), condenser and evaporators(EP1, EP2, EP3) as shown in Fig.1.

Exergy at any state is given as

$$X = (\Phi - \Phi_0) - T_0(s - s_0) \quad (1)$$

2.1 Energetic analysis

2.1.1 Mass flow analysis

$$\dot{m}_{c1} = \dot{m}_{e1} = \frac{\dot{Q}_{e1}}{(\Phi_1 - \Phi_{10})} \quad (2)$$

$$\dot{m}_{e2} = \frac{\dot{Q}_{e2}}{(\Phi_3 - \Phi_9)} \quad (3)$$

$$\dot{m}_{f1} = \frac{\dot{m}_{c1}(\Phi_2 - \Phi_3)}{(\Phi_3 - \Phi_9)} \quad (4)$$

$$\dot{m}_{c2} = \dot{m}_{c1} + \dot{m}_{e2} + \dot{m}_{f1} \quad (5)$$

$$\dot{m}_{e3} = \frac{\dot{Q}_{e3}}{(\Phi_5 - \Phi_8)} \quad (6)$$

$$\dot{m}_{f2} = \frac{\dot{m}_{c2}(\Phi_4 - \Phi_5)}{(\Phi_5 - \Phi_8)} \quad (7)$$

$$\dot{m}_{c3} = \dot{m}_{c2} + \dot{m}_{e3} + \dot{m}_{f2} \quad (8)$$

2.1.2 Power required running the compressors

$$P_{c1} = \frac{\dot{m}_{c1}(\Phi_2 - \Phi_1)}{60} \quad (9)$$

$$P_{c2} = \frac{\dot{m}_{c2}(\Phi_4 - \Phi_3)}{60} \quad (10)$$

$$P_{c3} = \frac{\dot{m}_{c3}(\Phi_6 - \Phi_5)}{60} \quad (11)$$

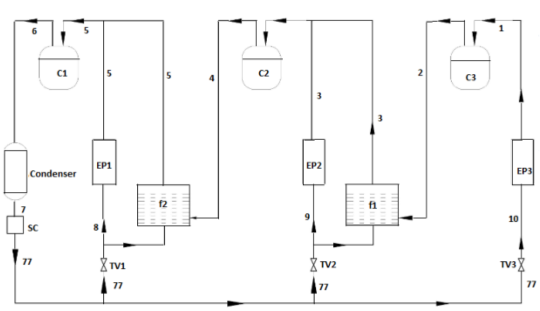

Fig: 1. Multiple evaporators with compound compression and flash intercooler with individual throttle valves

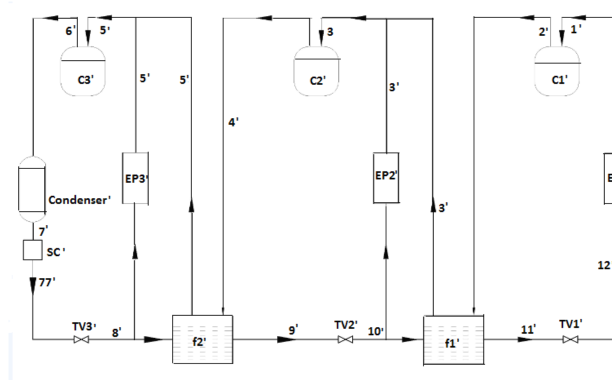

Fig: 2. Multiple evaporators with compound compression and flash intercooler with multiple throttle valves

2.1.3 Energetic performance

Energetic performance

$$= \frac{\dot{Q}_e}{P_c * 60} \quad (12)$$

2.2 Rate of exergy loss due to irreversibilties $(T_o\dot{S}_{gen})$ in various components of system-1

Compressors

$$(T_o\dot{S}_{gen})_{c1} = \dot{W}_{c1} + \dot{m}_{c1}(X_2 - X_1) \quad (13)$$

$$(T_o\dot{S}_{gen})_{c2} = \dot{W}_{c2} + \dot{m}_{c2}(X_4 - X_3) \quad (14)$$

$$(T_o\dot{S}_{gen})_{c3} = \dot{W}_{c3} + \dot{m}_{c3}(X_6 - X_5) \quad (15)$$

Total irreversibility due to compressors

$$\dot{\Psi}_c = (T_o\dot{S}_{gen})_{c1} + (T_o\dot{S}_{gen})_{c2} + (T_o\dot{S}_{gen})_{c3} \quad (16)$$

Evaporators

$$(T_o\dot{S}_{gen})_{e1} = \dot{m}_{e1}(X_1 - X_{10}) - \dot{Q}_{e1}\left(1 - \frac{T_0}{T_{r1}}\right) \quad (17)$$

$$(T_o\dot{S}_{gen})_{e2} = \dot{m}_{e2}(X_3 - X_9) - \dot{Q}_{e2}\left(1 - \frac{T_0}{T_{r2}}\right) \quad (18)$$

$$(T_o\dot{S}_{gen})_{e3} = \dot{m}_{e3}(X_5 - X_8) - \dot{Q}_{e3}\left(1 - \frac{T_0}{T_{r3}}\right) \quad (19)$$

Total irreversibility due to evaporators

$$\dot{\Psi}_e = (T_o\dot{S}_{gen})_{e1} + (T_o\dot{S}_{gen})_{e2} + (T_o\dot{S}_{gen})_{e3} \quad (20)$$

Condenser

$$\dot{\Psi}_{cond} = (T_o\dot{S}_{gen})_{cond} = \dot{m}_{c3}(X_6 - X_7) - \dot{Q}_e\left(1 - \frac{T_0}{T_r}\right) \quad (21)$$

Throttle Valves

$$(T_o\dot{S}_{gen})_{tv1} = \dot{m}_{e1}(X_{77} - X_{10}) \quad (22)$$

$$(T_o\dot{S}_{gen})_{tv2} = (\dot{m}_{e2} + \dot{m}_{f1})(X_{77} - X_9) \quad (23)$$

$$(T_o\dot{S}_{gen})_{tv3} = (\dot{m}_{e3} + \dot{m}_{f2})(X_{77} - X_8) \quad (24)$$

Total irreversibility due to throttle valves

$$\dot{\Psi}_{tv} = (T_o\dot{S}_{gen})_{tv1} + (T_o\dot{S}_{gen})_{tv2}(T_o\dot{S}_{gen})_{tv3} \quad (25)$$

Subcooler

$$\dot{\Psi}_{sc} = (T_o\dot{S}_{gen})_{sc} = \dot{m}_{c3}(X_7 - X_{77}) \quad (26)$$

Flash intercoolers

$$(T_o\dot{S}_{gen})_{f1} = \dot{m}_{f1}(X_9 - X_3) + \dot{m}_{c1}(X_2 - X_3) \quad (27)$$

$$(T_o\dot{S}_{gen})_{f2} = \dot{m}_{f2}(X_8 - X_5) + \dot{m}_{c1}(X_4 - X_5) \quad (28)$$

Total irreversibility due to flash intercoolers

$$\dot{\Psi}_f = (T_o\dot{S}_{gen})_{f1} + (T_o\dot{S}_{gen})_{f2} \quad (29)$$

Total irreversibility destruction in system-1

$$\sum \dot{\Psi}_k = \dot{\Psi}_e + \dot{\Psi}_c + \dot{\Psi}_{cond} + \dot{\Psi}_{tv} + \dot{\Psi}_{sc} + \dot{\Psi}_f \quad (30)$$

3. Multiple evaporators at different temperatures with compound compression, flash intercooler and multiple throttle valves (system-2)

The main components of Multiple evaporators at different temperatures with compound compression, flash intercooler and multiple throttle valves (system-2) are compressors (C1′, C2′, C3′) throttle valves (TV1′, TV2′, TV3′), condenser (cond′) and evaporators (EP1′, EP2′, EP3′) as shown in Fig. 2.

3.1 Energetic analysis

3.1.1 Mass flow analysis

$$\dot{m}_{c1'} = \dot{m}_{e1'} = \frac{\dot{Q}_{e1'}}{(\Phi_{1'} - \Phi_{12'})} \quad 2A$$

$$\dot{m}_{e2'} = \frac{\dot{Q}_{e2'}}{(\Phi_{3'} - \Phi_{10'})} + \dot{m}_{c1'}\left(\frac{x_{10'}}{1 - x_{10'}}\right) \quad 3A$$

$$\dot{m}_{f1'} = \frac{\dot{m}_{c1'}(\Phi_{2'} - \Phi_{3'})}{(\Phi_{3'} - \Phi_{10'})} \quad 4A$$

$$\dot{m}_{c2'} = \dot{m}_{c1'} + \dot{m}_{e2'} + \dot{m}_{f1'} \quad 5A$$

$$\dot{m}_{e3'} = \frac{\dot{Q}_{e3'}}{(\Phi_{5'} - \Phi_{8'})} + \dot{m}_{c2'}\left(\frac{x_{8'}}{1 - x_{8'}}\right) \quad 6A$$

$$\dot{m}_{f2'} = \frac{\dot{m}_{c2'}(\Phi_{4'} - \Phi_{5'})}{(\Phi_{5'} - \Phi_{8'})} \quad 7A$$

3.1.2 Power required for running the compressors

$$P_{c1'} = \frac{\dot{m}_{c1'}(\Phi_{2'} - \Phi_{1'})}{60} \quad 8A$$

$$P_{c2'} = \frac{\dot{m}_{c2'}(\Phi_{4'} - \Phi_{3'})}{60} \quad 9A$$

$$P_{c3'} = \frac{\dot{m}_{c3'}(\Phi_{6'} - \Phi_{5'})}{60} \quad 10A$$

3.1.3 Energetic performance

$$\text{Energetic performance} = \frac{\dot{Q}_{e'}}{P_{c'} * 60} \quad 11A$$

3.2 Rate of exergy loss due to irreversibilties ($T_o\dot{S}_{gen}$) in various components of system-2

Compressors

$$(T_o\dot{S}_{gen})_{c1'} = \dot{W}_{c1'} + \dot{m}_{c1'}(X_{2'} - X_{1'}) \quad 12A$$

$$(T_o\dot{S}_{gen})_{c2'} = \dot{W}_{c2'} + \dot{m}_{c2'}(X_{4'} - X_{3'}) \quad 13A$$

$$(T_o\dot{S}_{gen})_{c3'} = \dot{W}_{c3'} + \dot{m}_{c3'}(X_{6'} - X_{5'}) \quad 14A$$

Total irreversibility due to compressors

$$\dot{\Psi}_{c'} = (T_o\dot{S}_{gen})_{c1'} + (T_o\dot{S}_{gen})_{c2'} + (T_o\dot{S}_{gen})_{c3'} \quad 15A$$

Evaporators

$$(T_o\dot{S}_{gen})_{e1'} = \dot{m}_{e1'}(X_{1'} - X_{12'}) - \dot{Q}_{e1'}\left(1 - \frac{T_0}{T_{r1'}}\right) \quad 16A$$

$$(T_o\dot{S}_{gen})_{e2'} = \dot{m}_{e2'}(X_{3'} - X_{10'}) - \dot{Q}_{e2'}\left(1 - \frac{T_0}{T_{r2'}}\right) \quad 17A$$

$$(T_o\dot{S}_{gen})_{e3'} = \dot{m}_{e3'}(X_{5'} - X_{8'}) - \dot{Q}_{e3'}\left(1 - \frac{T_0}{T_{r3'}}\right) \quad 18A$$

Total irreversibility due to evaporators

$$\dot{\Psi}_{c'} = (T_o\dot{S}_{gen})_{c1'} + (T_o\dot{S}_{gen})_{c2'} + (T_o\dot{S}_{gen})_{c3'} \quad 19A$$

Condenser

$$\dot{\Psi}_{cond'} = (T_o\dot{S}_{gen})_{cond'} = \dot{m}_{c3'}(X_{6'} - X_{7'}) - \dot{Q}_{e'}\left(1 - \frac{T_0}{T_{r'}}\right) \quad 20A$$

Throttle Valves

$$(T_o\dot{S}_{gen})_{tv1'} = \dot{m}_{e1'}(X_{11'} - X_{12'}) \quad (21A)$$

$$(T_o\dot{S}_{gen})_{tv2'} = \dot{m}_{c2'}(X_{9'} - X_{10'}) \quad (22A)$$

$$(T_o\dot{S}_{gen})_{tv3'} = \dot{m}_{c3'}(X_{77'} - X_{8'}) \quad (23A)$$

Total irreversibility due to throttle valves

$$\dot{\Psi}_{tv'} = (T_o\dot{S}_{gen})_{tv1'} + (T_o\dot{S}_{gen})_{tv2'} + (T_o\dot{S}_{gen})_{tv3'} \quad (24A)$$

Subcooler

$$\dot{\Psi}_{sc'} = (T_o\dot{S}_{gen})_{sc'} = \dot{m}_{c3'}(X_{7'} - X_{77'}) \quad (25A)$$

Flash intercoolers

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$$(T_o\dot{S}_{gen})_{f1'} = \dot{m}_{f1'}(X_{10'} - X_{3'}) + \dot{m}_{c1'}(X_{2'} - X_{3'}) \quad (26A)$$

$$(T_o\dot{S}_{gen})_{f2'} = \dot{m}_{f2'}(X_{8'} - X_{5'}) + \dot{m}_{c2'}(X_{4'} - X_{5'}) \quad (27A)$$

Total irreversibility due to flash intercoolers

$$\dot{\Psi}_{f'} = (T_o\dot{S}_{gen})_{f1'} + (T_o\dot{S}_{gen})_{f2'} \quad (28A)$$

Total irreversibility destruction in system-1

$$\sum \dot{\Psi}_{k'} = \dot{\Psi}_{e'} + \dot{\Psi}_{c'} + \dot{\Psi}_{cond'} + \dot{\Psi}_{tv'} + \dot{\Psi}_{sc'} + \dot{\Psi}_{f'} \quad (29A)$$

4. Rational efficiency or exergetic efficiency

Rational efficiency

$$= \frac{\text{Exergy of cooling load of evaporators}}{\text{Compressors work}} = \frac{\dot{EP}}{\dot{W}} \quad (31)$$

For System-1

Rational efficiency

$$= \frac{(\dot{Q}_{e1} + \dot{Q}_{e2} + \dot{Q}_{e3}) - T_o\left(\frac{\dot{Q}_{e1}}{T_{r1}} + \frac{\dot{Q}_{e2}}{T_{r2}} + \frac{\dot{Q}_{e3}}{T_{r3}}\right)}{P_c * 60} \quad (32)$$

For System-2

Rational efficiency

$$= \frac{(\dot{Q}_{e1'} + \dot{Q}_{e2'} + \dot{Q}_{e3'}) - T_o\left(\frac{\dot{Q}_{e1}}{T_{r1'}} + \frac{\dot{Q}_{e2}}{T_{r2'}} + \frac{\dot{Q}_{e3}}{T_{r3'}}\right)}{P_{c'} * 60} \quad (33)$$

5. Results and discussion

For carrying out the energetic and exergetic analysis a numerical model has been developed. Comparison of multiple evaporators at different temperatures with compound compression and flash intercooler with individual and multiple throttle valves and impact of chosen refrigerants on theses systems was made using Engineering Equation Solver software[7].In this investigation following assumptions were made:

1. Loads ($\dot{Q}_{e1}$, $\dot{Q}_{e2}$ and $\dot{Q}_{e3}$) on the evaporators EP1, EP2 and EP3 are 35KW, 70KW and 105KW respectively.
2. Dead state temperature (T_0): 298K
3. Difference between evaporator and space temperature (T_r-T_e):5K.
4. Adiabatic efficiency of compressor (η_c):76%.
5. Dead state enthalpy (Φ_0) and entropy (s_0) of the refrigerants have been calculated corresponding to the dead state temperature (T_0) of 298K.
6. Temperature of evaporators EP_1, EP2 and EP3 are 263K, 273K and 283K respectively.
7. Condenser temperature (T_c): 313K.
8. Degree of sub cooling (ΔT_{sc}): 10K.

Fig.3-5 presents the variation of EP1, EP2 and EP3 temperature of system-1 with coefficient of performance of multiple evaporators and compressors with individual expansion valves (System-1) respectively on the other hand Fig.6-8 shows the variation of EP1, EP2 and EP3 temperature of system-2 verses coefficient of performance of multiple evaporators and compressors with multiple expansion valves (System-2) respectively for selected refrigerants. Both systems (system-1& system-2) were analytically analyzed and observed that COP of system-2 is better than system-1for different refrigerants.

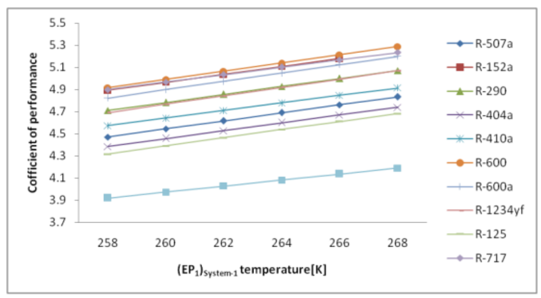

Fig.3: Evaporator-1 temperature of system-1 versus coefficient of performance

The maximum and minimum percentage difference of COP between system-2 and system-1 is 10.65% for R404a at 268K EP3 temperature and 1.70% for R717 at 268K EP1 temperature respectively.

The energetic efficiency of both system-1 and system-2 increase with increase in evaporator temperature for chosen refrigerants. It was also observed that R600, R717 and R152a show better energetic performance (COP) than other refrigerants for both systems and R407c shows lowest COP.

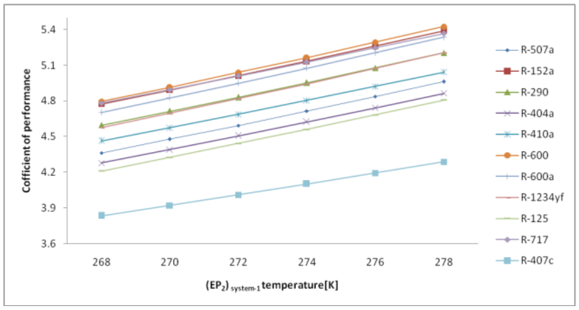

Fig: 4. Evaporator-2 temperature of system-1 versus coefficient of performance

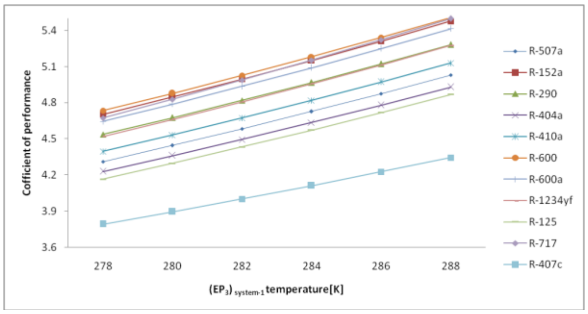

Fig: 5. Evaporator-3 temperature of system-1 versus coefficient of performance

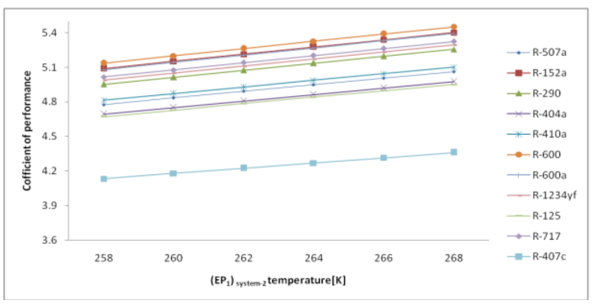

Fig: 6. Evaporator-1 temperature of system-2 versus coefficient of performance

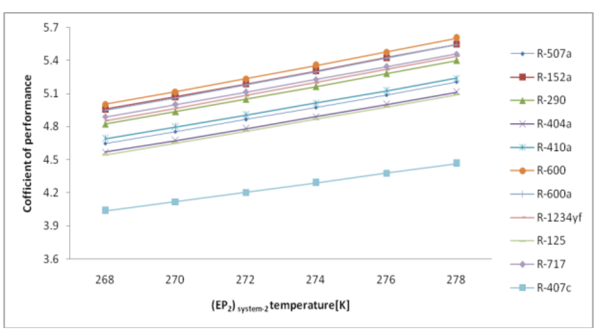

Fig: 7. Evaporator-2 temperature of system-2 versus coefficient of performance

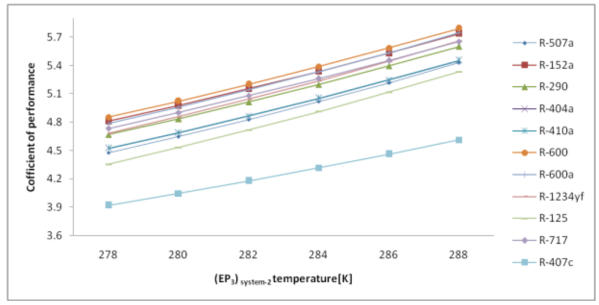

Fig: 8. Evaporator-3 temperature of system-2 versus coefficient of performance

Fig.9-11and Fig.11-14 presents impact of rational efficiency with change in temperature of EP1, EP2 and EP3 of system-1 and system-2 respectively and observed that that rational efficiency decrease with increase in evaporator temperature. As with Similar case of energetic performance R600 shows maximum and both R717 and R152a show second highest energetic performance than chosen refrigerants.

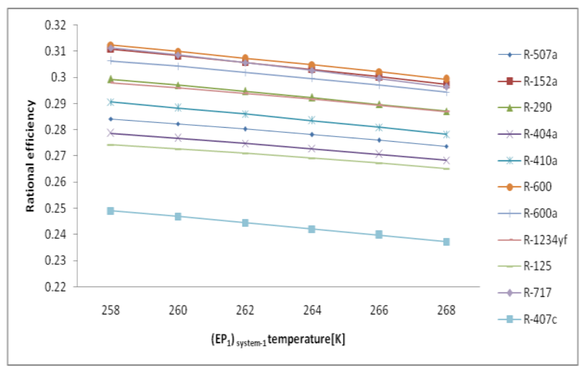

Fig: 9. Evaporator-1 temperature of system-1 versus rational efficiency

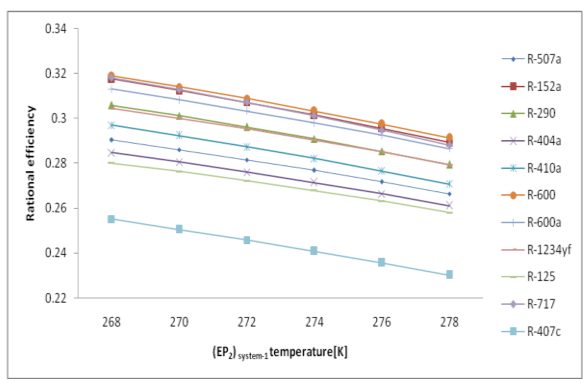

Fig: 10. Evaporator-2 temperature of system-1 versus rational efficiency

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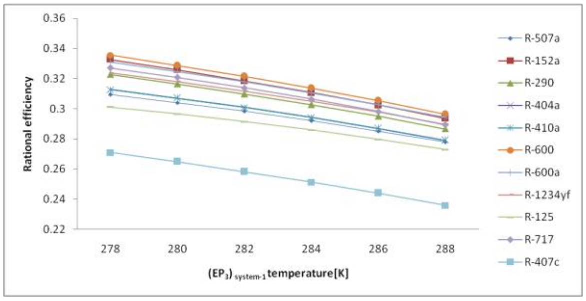

Fig: 11. Evaporator-3 temperature of system-1 versus rational efficiency

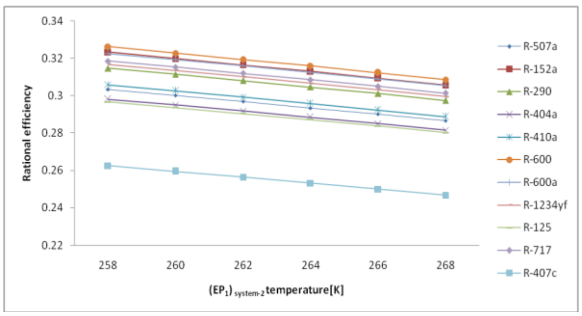

Fig: 12. Evaporator-1 temperature of system-2 versus rational efficiency

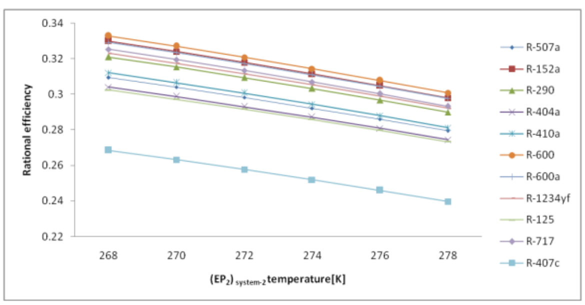

Fig: 13. Evaporator-2 temperature of system-2 versus rational efficiency

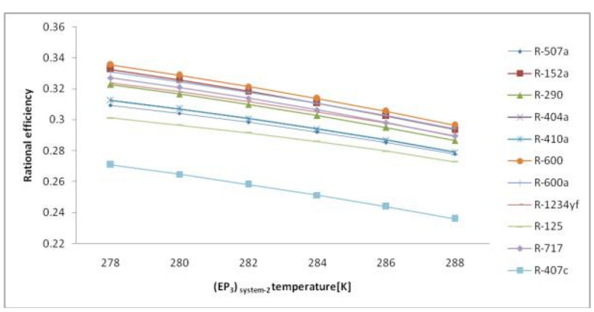

Fig: 14. Evaporator-3 temperature of system-2 versus rational efficiency

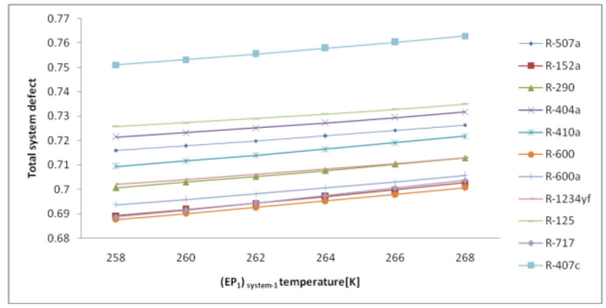

Fig: 15. Evaporator-1 temperature of system-1 versus total system defect

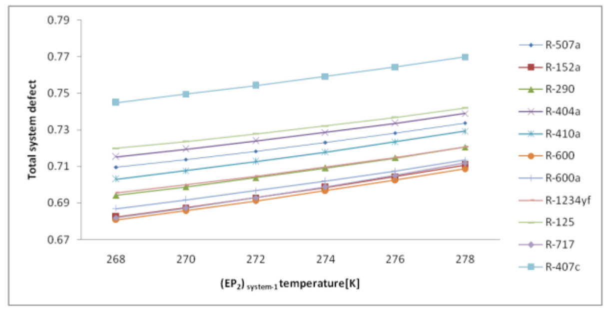

Fig: 16. Evaporator-2 temperature of system-1 versus total system defect

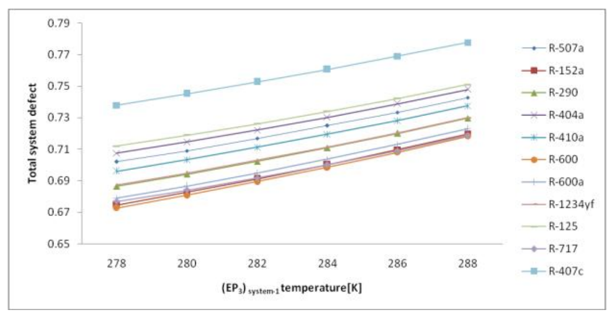

Fig: 17. Evaporator-3 temperature of system-1 versus total system defect

The irreversibility analysis of system-1 and system-2 is shown by Figs.15-17 and Figs.18-20 respectively. It was experienced that system defect of both system-1 and system-2 increase with increase in temperature of any evaporator.R407C shows maximum system defect but R600, R717 and R152a show minimum system defect compare with another selected refrigerants.

The impact of change in condenser temperature from 298K to 318K on energetic efficiency, exergetic efficiency and total system defect shown in Figs.21-26 for sytem-1 and system-2 using eco-friendly refrigerants. This analysis reveals that first law and second law efficiency decreases with increase in condenser temperature on the other hand exergy destruction increase with increase in condenser temperature for system-1 & sytem-2

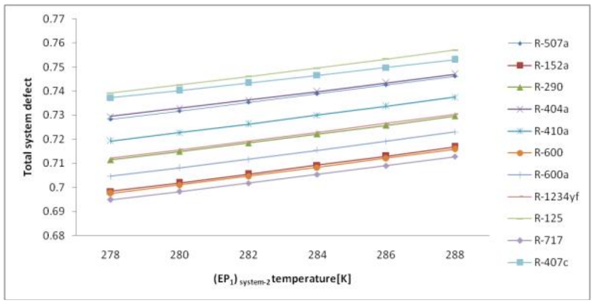

Fig: 18. Evaporator-1 temperature of system-2 versus total system defect

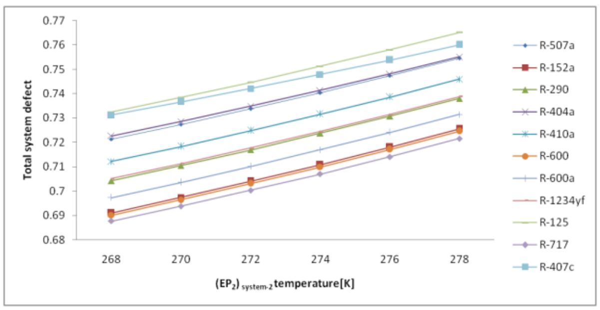

Fig: 19. Evaporator-2 temperature of system-2 versus total system defect

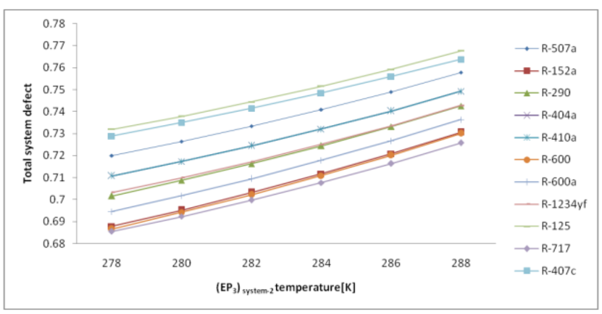

Fig: 20. Evaporator-3 temperature of system-2 versus total system defect

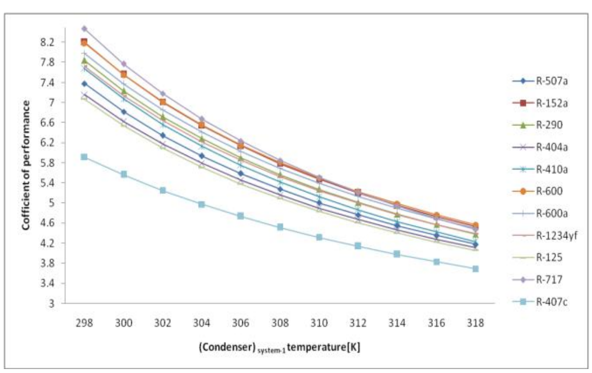

Fig: 21. Condenser temperature of system-1 versus coefficient of performance

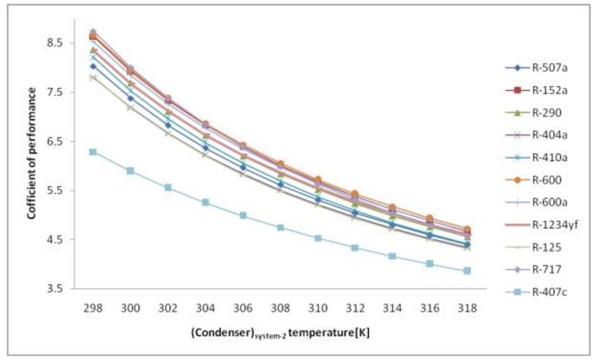

Fig: 22. Condenser temperature of system-2 versus coefficient of performance

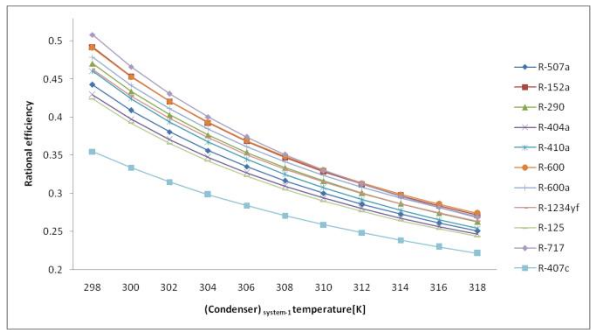

Fig: 23. Condenser temperature of system-1 versus rational efficiency

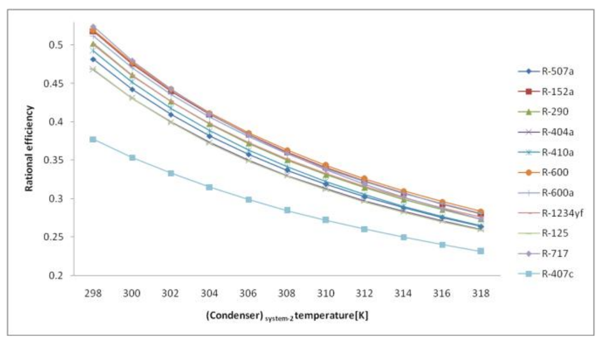

Fig: 24. Condenser temperature of system-2 versus rational efficiency

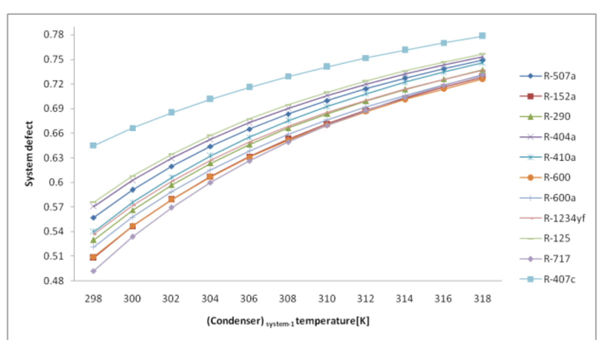

Fig: 25. Condenser temperature of system-1 versus system defect

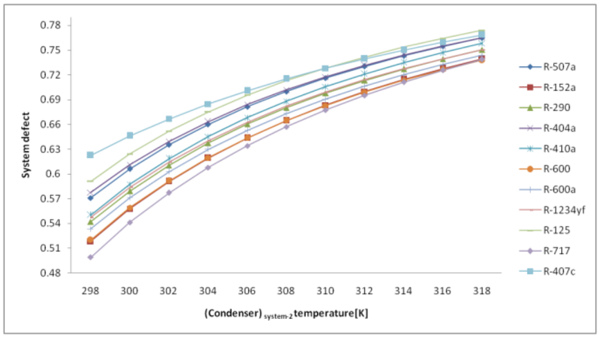

Fig: 26. Condenser temperature of system21 versus system defect

6. Conclusions

Analysis multiple evaporators at different temperature with compound compression and flash intercooler with individual throttle valves and multiple evaporators at different temperature with compound compression and flash intercooler with multiple throttle valves have been made in terms of energetic efficiency, exergetic efficiency and irreversibility destruction and from the current study following conclusions were made:

1. Energetic and exergetic performance of system-2 is higher than system-1 for selected temperature range of condenser and evaporators for chosen ecofriendly refrigerants.
2. System defect in sytem-2 is less as compare with system-1, so system-2 is better system than system-1 for selected refrigerants.
3. R407C shows minimum performance in terms of first law efficiency, second law efficiency and system defect for both systems
4. Performances of R600, R152a and R717 better with comparison of other selected refrigerants for system-1 and system-2. But R600 is highly inflammable and R717 is toxic and limited to industrial application, so R152a is recommended for both systems.

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