ENERGY AND EXERGY ANALYSIS OF VAPOUR COMPRESSION REFRIGERATION SYSTEM WITH R-502 AND ITS ALTERNATE REFRIGERANTS

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In

Thermal Engineering

By
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Candidate's Declaration

I hereby declare that the work which being present in the major thesis entitled "**ENERGY AND EXERGY ANALYSIS OF A VAPOUR COMPRESSION REFRIGERATION SYSTEM FOR R-502 AND ITS ALTERNATE REFRIGERANTS**" in the partial fulfillment for the award of degree of **MASTER of ENGINEERING** with specialization in "**THERMAL ENGINEERING"** submitted to **Delhi College of Engineering, University of Delhi,** is an authentic record of my own work carried out under the supervisions of Prof. R. S. Mishra and Prof. A. Arora, Department of Mechanical Engineering Delhi College of Engineering, University of Delhi. I have not submitted the matter in this dissertation for the award of any other Degree or Diploma or any other purpose whatever.

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Certificate

This is to certify that the above statement made by BHANU PRAKASH SHARMA is true to the best of our knowledge and belief.

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Nomenclature

COP	Coefficient of performance
ED	Exergy destruction (W)
EES	Engineering Equation Solver
EF	Exergy of fuel (W)
EDR	Exergy destruction ratio
EP	Exergy of product (W)
Q	Heat flow rate (W)
R	Refrigerant
T	Temperature (°C)
TR	Ton of Refrigeration
W	Work (W)
e_x	Exergy of fluid (W)
h	Enthalpy
m	Mass (Kg.)
s	Entropy
η	Efficiency
δ	Efficiency Defect

Subscript

c.	Compressor
cs	Isentropic compression
cond.	Condenser
e	Evaporator
ex	Exergetic
i	Irreversibility
iss	Isentropic
t	Throttle
r	Room
vg	Specific volume at inlet to compressor
T_c	Condenser temperature

ABSTRACT

The chlorofluorocarbon (CFC) and hydro chlorofluorocarbon (HCFC) refrigerants are being replaced by hydro fluorocarbon (HFC) and HFC mixtures due to environmental concerns about depletion of the ozone layer and global warming. Various researchers have suggested different alternative to R-502 such as R-404A, R-402A, R-402B, R-403B, R-408A, R-407B etc. R-502 has ozone depletion potential 0.230, which have harmful effect on ozone layer; hence R-502 is required to be phased out by year 2030 in developed countries and by year 2040 in developing countries. A refrigeration system with R-502 using alternative refrigerants needs to be modified or alternatively redesigned due to variation in the physical properties of these new refrigerants. R-507A and R-404A being long term ozone friendly refrigerants is the common choice for R-502 as alternate refrigerants.

In the present work energy and exergy analysis of vapour compression refrigeration cycle for R-502 and its alternate refrigerants (R-404A & R507A) has been carried out by varying evaporator temperature between -50°C to 0°C and condenser temperature between 30°C to 60°C, with the help of Engineering Equation Solver (EES).

The parametric investigation such as coefficient of performance, volumetric cooling capacity, pressure ratio, exergy destruction ratio, exergetic efficiency, and efficiency defect in individual components for R-502, R-507A and R-404A have been carried out theoretically and have been compared with the experimental available data.

The results indicate that evaporating and condensing temperatures have pronounced effect on exergy destruction in the components such as compressor, condenser, and throttle valve where as in the evaporator it is negligible. The exergetic efficiency and COP of the cycle change to large extent with the variation in evaporator and condenser temperatures. The computational analysis has allowed the determination of the best energetic and exergetic performances of R-502 and its substitute refrigerant R-507A and R-404A.

CHAPTER 1

INTRODUCTION

INTRODUCTION

The continuous depletion of the ozone layer, which shields the earth's surface from UV radiation, has resulted in a series of international treaties demanding a gradual phase out of halogenated fluids. The chlorofluorocarbons (CFCs) have been banned since 1996, and also the partially halogenated hydro chlorofluorocarbons (HCFCs) are bound to be prohibited in the near future. The HFCs (hydro fluorocarbons) are candidates for the definite substitution of both CFCs and HCFCs, as they do not contain chlorine. A further problem is the greenhouse effect, stemming from the infrared radiation capture by some components of the atmosphere. Human activities have considerably increased the concentration of greenhouse gases (CFC, HCFC, carbon dioxide, methane, nitrous oxide) that determine the earth's surface and atmosphere warming that might adversely affect the natural ecosystem. Over the last hundred years, the mean temperatures have increased by 0.3°C –0.6°C and doubling the amount of carbon dioxide in the atmosphere is likely to yield a further temperature increase from 1.5°C to 4.5°C. In particular, it is well known that the greenhouse effect resulting from an operating plant is not a secondary matter. Recent estimates indicate that the overall contribution, both direct and indirect, to the green house effect of HCFCs and CFCs exceeds 24% **[Houghton (1995), Engler, Mobner, Oellrich (1995)].** So, the choice of the working fluids in the vapour compression plant must depend on both the absence of chlorine atoms in the molecule (ozone depletion potential (ODP) equal to 0) and their low contribution to the greenhouse effect (low global warming potential (GWP) and high energy efficiency). The phase out of fully halogenated CFCs and the partially halogenated HCFCs is an irreversible process in the industrialized world, but the problems of their replacement have been only partially solved.

R-502 is a binary azeotrope mixture of R-22/115 (48.8/51.2 by weight %) and it is used for super market refrigeration. **Bitzer international** in its thirteenth edition of refrigeration report [www.bitzer.de] has various alternate refrigerants for R-502.

Since R-502 contains R-22, a HCFC and R-115, a CFC both of which contain chlorine and hence an ozone depleting substance.

Therefore it is required to be replaced by an alternate refrigerant. There is no unanimous solution for its substitution.

The various alternates reported **(Bitzer)** containing HCFCs or HFCs are R-402A (a zeotropic mixture of R-125/R-290/R-22 in the ratio of 60/2/38 by weight%), R-402B (a zeotropic mixture of R-125/R-290/R-22 in the ratio of 38/2/60 by weight%), R-403B a zeotropic mixture of (R-290/R-22/R-218 in the ratio of 5/36/39 by weight%), R-408A (a zeotropic mixture of R-22/R-143a in the ratio of 45/55 by weight%).

The various substitute of R-502 which don't contain HCFCs are R-507 (R-125/143a 50/50 by weight%), R-404A (R-125/143a/134a 44/52/4 by weight%), R-407A (R-32/125/134a 20/40/40 by weight%), R-407B(R-32/125/134a 10/70/20 by weight%) and quantenary zeotrope (R-32/125/143a/134a 40/25/25/10 by weight%).

Table 1. Comparison of refrigerant properties R-502, R-402A, R402B, R-403B and R-408A

Working substance	R-502	R-402A	R402B	R-403B	R-408A
Blend type	Binary azeotrope	Ternary near-azeotrope	Ternary near-azeotrope	Ternary near-azeotrope	Binary azeotrope
Composition (%)	R-22/115 (48.8/51.2)	R-125/290/22 (62/2/38)	R-125/290/22 (38/2/60)	R-290/22/218 (5/56/39)	R-22/143A (45/55)
MW (g/mol)	111.63	101.55	94.71	102.06	85.10
NBP (°C)	-45.4	-49.2	-47.4	-50.6	-44.8
Critical temp. (°C)	82.2	75.5	82.61	90	83
Critical pressure(kPa)	4075	4135	4450	5091	4300
ODP	0.23	0.021	0.033	0.03	0.02
GWP	3.74	0.63	0.52	4.08	0.82
Flammability	NF	NF	NF	NF	NF
Toxicity (ppm)	1000	1000	1000	1000	> 400

Table 2. Comparison of refrigerant properties R-502, R-507, R-404A, R-407A and R-404B

Working substance	R-502	R-507	R-404A	R-407A	R-407B
Blend type	Binary azeotrope	Binary azeotrope	Ternary near-azeotrope	Ternary azeotrope	Ternary azeotrope
Composition (%)	R-22/115 (48.8/51.2)	R-125/143a (44/52/4)	R-125/143a/134a22 (44/52/4)	R-32/125/134a (10/70/20)	R-32/125/134a (10/70/20)
MW (g/mol)	111.63	98.9	97.61	90.11	109.6
NBP (°C)	-45.4	-46	-46.7	-45.8	-47.8
Critical temp. (°C)	82.2	70.9	72.7	83	76.5
Critical pressure(kPa)	4075	3794	3735	4541	4156
ODP	0.23	0	0	0	0
GWP	3.74	0.96	0.94	0.8	0.7
Flammability	NF	NF	NF	NF	NF
Toxicity (ppm)	1000	1000	1000	> 400	> 400

R-404A and R-507A are long term alternatives for R-502. These blends are substitutes which are absolutely chlorine free.

However to switch over to alternate refrigerant, the first step is to carry out the performance analysis of alternate refrigerant based on energy and exergy so as to optimise the refrigeration system.

Thermodynamic processes in refrigeration systems release large amounts of heat to the environment. Heat transfer between the system and the surrounding environment takes place at a finite temperature difference, which is a major source of irreversibility for the cycle. Irreversibility causes the system performance to degrade. The losses in the cycle need to be evaluated considering individual thermodynamic processes that make up the cycle. Energy (first

law) analysis is still the most commonly used method in the analysis of thermal systems. The first law is concerned only with the conservation of energy, and it gives no information on how, where, and how much the system performance is degraded. Exergy analysis is a powerful tool in the design, optimization, and performance evaluation of energy systems.

The principles and methodologies of exergy analysis are well established **[Bejan (1982), Moran (1982), Bejan (1988), Wark (1995)]**. An exergy analysis is usually aimed to determine the maximum performance of the system and identify the sites of exergy destruction. Analyzing the components of the system separately can perform exergy analysis of a complex system. Identifying the main sites of exergy destruction shows the direction for potential improvements. An important object of exergy analysis is for systems that consume work such as refrigeration; liquefaction of gases, and distillation of water is finding the minimum work required for a certain desired result

Dincer (2003) has defined exergy as the measure of usefulness, quatility or potential of a stream to cause change and an effective measure of the potential of a substance to impact the environment.

The conventional view expressed by **Strobridge (1974)** that the exergetic efficiency of the actual refrigeration cycles does not depend on the refrigeration temperature was questioned by **Bejan** (1989). He showed that the exergetic efficiencies decrease as the refrigeration temperature decreases.

Said and Ismail (1994) assessed the theoretical performances of HCFC123, HFC134a, CFC11, and CFC12 as coolants. It is established that for a specific amount of desired exergy, more compression work is required for HCFC123 and HFC134a than for CFC11 and CFC12. The differences are not very significant at high evaporation temperatures and hence HCFC123 and HFC134a should not be excluded as alternative coolants. There is an optimum evaporation temperature for each condensation temperature, which yields the highest exergetic efficiency.

Doring et. al. (1997) reported for a blend containing R143a and R125 (50/50% by weight). The thermodynamic data like vapour pressures, liquid densities, as well as the volumetric behaviour of the gaseous phase of this blend, have been experimentally measured and mathematically correlated. This refrigerant blend shows azeotropic behaviour and is known as R507 according to the ASHRAE nomenclature. R507 is a suitable refrigerant for use in refrigeration and air-conditioning units in low and medium temperature applications. Test results based on measurements from a refrigeration installation have shown that similar operating parameters can be achieved in comparison to R502. The compressor discharge temperatures, pressure ratios and coefficients of performance compare well to the traditionally used azeotropic refrigerant R502. Further, the tests have shown that on average the refrigerating capacities of R507 are approximately 5-6% higher than the capacities of R502.

R-507 and R-507A is one and same refrigerant .

Camporese, Bigolaro, and Bobbo (1996) selected several refrigerant mixtures and tested as potential short- and mid-term substitutes for CFC 12 and R-502. HCFC 22 and some hydrocarbons are considered as components of retrofit mixtures. Their influence on the solubility of various lubricant oils was investigated by measuring critical solubility temperatures. The performance of the CFC 12 and R-502 refrigerants and of their proposed alternatives was compared by testing two different refrigerating units.

Aprea and Mastrullo (1996) carried out an experimental study that aimed to evaluate both general characteristics and system performances of the most credited fluids that are likely to substitute for R-502 in a refrigeration plant. They tested R-402A, R-402B, R-403B, R-408A and R-404A and R-407A. These refrigerants performed very close to that of R-502 except R-403B, whose COP has been found to be about 8% lower than that of R-502.

Nikolaidis and Probert (1998) used exergy method to examine the behavior of two-stage compound compression-cycle, with flash inter cooling, using refrigerant R-22. The condenser's saturation-temperature was varied from 298 to 308 K and the evaporator's saturation-

temperature from 238 to 228 K. The effects of temperature changes in the condenser and evaporator on the plant's irreversibility rate were determined. It is established that greater the temperature difference between either (i) the condenser and the environment, or (ii) the evaporator and the cold room, the higher the irreversibility rate. Any reduction in the irreversibility rate of the condenser gives approximately 2.40 times greater reduction in the irreversibility rate for the whole plant, and any reduction in the evaporator's irreversibility rate gives a 2.87 times greater mean reduction in the irreversibility rate of the whole plant. Because the changes in the temperatures in the condenser and the evaporator contribute so significantly to the plant's overall irreversibility. They pointed out that there is considerable scope for optimizing the conditions imposed upon the condenser and evaporator.

Aziz and Alexandria (1998) used the first law and the second law efficiency to evaluate the system behavior for refrigerants R-12, R-22 and R-134a, based on the thermodynamic properties. Test results showed that the system-cooling COP for R-134a is 8% and 22% higher than the COP of R-12 and R-22, respectively. Based on the second law analysis, the irreversibility of the components varies considerably; in such a way that the main source of exergy loss is due to the heat transfer in the evaporator, condenser and suction line for which effective measures should be taken. This analysis indicates that the exergetic efficiency of R-134a is 20% and 8% higher than that of R-12 and R-22, respectively.

Goktun (1998) unfold the various blends as substitute for R-502. He compared thermo physical properties for blends containing HCFCs i.e. R-402A, R-402B, R-403B, R-408A and blends which don't contain HCFCs i.e. R-404A, R-407A, R-407B, and R-507.

Sami and Desjardins (2000) In this paper the test results of a performance evaluation of new alternatives; R-407B, R-507, R-408A and R-404A as substitutes to R-502 were presented. The test results were obtained using an air-source heat pump with enhanced surface tubing . The data demonstrated that, as an interim replacement, R-408A blend has a superior performance among the proposed blends including R-502, in the range investigated. Furthermore, the alternatives to R-502 are characterized by high discharge pressure compared to R-502. In particular, R-407B and R-408A have higher discharge temperatures compared to R-502.

Sami and Desjardins (2000) carried out an experimental study on the behaviour of R-407B, R-507, R-408A and R-404A as the substitutes to R-502 using heated suction accumulator are presented. The experimental set up was composed of a fully instrumented air-source heat pump with a capacity of 12000 BTUH and equipped with a heated suction accumulator. The refrigerant temperatures were varied at the evaporator entrance to simulate various extreme conditions encountered in air-source heat pump applications. The primary parameters observed during the course of this study were mass flux, heat flux, quality evaporator and condenser thermal capacities, power consumed and pressure ratios for the
azeotropic refrigerant mixtures under investigation. The test results showed that a heated suction accumulator enhanced the evaporation of more volatile component of ternary azeotropic refrigerant mixtures. Thus, increasing the mixture thermal capacity as well as the COP. Furthermore, experiments have also shown capacity increases of 27 per cent with a heat accumulator over an unheated accumulator at -15°C outside air temperatures.

Stegou-Sagia (2003) carried the studied to describe irreversibility's in one stage refrigerating process for vapour compression cycle with refrigerant mixtures R-404A, R-410A, R-410B and R-507 as working fluids. They are calculated as exergy losses by an algorithm developed on the basis of thermodynamics. The proposed relationships have been derived from exergy balances on the system components. Emphasis was placed on parameters influencing the losses and the related results were presented through Grassmann diagrams (diagrams of exergy fluxes).

Yongmei and Chen (2004) have reported a ternary near-azeotropic mixture of R-161/R-125/R161A (10/45/45 by weight%). It has an ODP of zero and a GWP smaller than those of R502, R404A and R507. The experimental results show higher COP and slightly higher discharge temperature as compared to R404A. This new refrigerant can achieve a high level of COP and can be considered as a promising retrofit refrigerant to R502.

Stegou et. al. (2005) In their article, the mixtures considered were R-401B, R-401C, R-402A, R-404A, R-406A, R-408A, R-409A, R-410A, R-410B and R-507. Some of them do not have

zero ODP, but they are in use due to their low ODP. The performance comparisons of these working fluids in vapor compression refrigerating cycles was on the basis of exergy aspects.

Arcaklioglu and Ali (2005) In this study, they formed an algorithm to find refrigerant mixtures of equal volumetric cooling capacity (VCC) when compared to CFC based refrigerants in vapour compression refrigeration systems. According to their results, for R-12, R-290/R-600a (56%/44% by weight) mixture, for R-22, R-32/R-125/R-134a (32.5%/5%/62.5% by weight) mixture and for R-502, R-32/R-125/R-134a (43%/5%/52%) mixture are appropriate and can be used as replacements.

From the literature review it is clear that HCFC based alternatives to R-502 are R-402 A, R-402B, R-403B, R-408A, R-507, R-404A, R-407A, R-407B and quantenary zeotrope are alternatives to R-502 which do not contain HCFCs. Due to Montreal Protocol and provision of 1990 Clean Air Act alternate which contain HCFC are not considered and quaternary mixture is also not considered due to its complexity. R-404A and R-507A are long term alternatives for R-502. These blends are substitutes which are absolutely chlorine free.

Further literature shows that exergy analysis of these two refrigerants has not been done in detail and irreversibilities at the local component level have also not been found out for these refrigerants.

Thus the work carried out in this thesis consists of energy and exergy analysis of R-502 and for its alternate refrigerants R-404A and R-507A. The exergy analysis shall include calculations of irreversibility or exergy destruction at the component level over a wide range of condenser and evaporator temperatures.

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CHAPTER 2

ENERGY AND EXERGY ANALYSIS

ENERGY AND EXERGY ANALYSIS

Vapour compression refrigeration cycle composed of a condenser, an evaporator, a compressor, and a capillary tube as shown in figure 1.

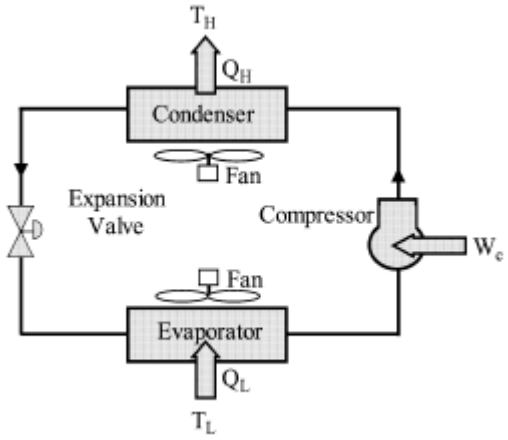

Figure 1. Simple vapour compression refrigeration cycle

1. ASSUMPTIONS

An analysis is based on following relevant assumptions.

- Pressure losses due to friction and pipelines are considered to be negligible.
- Heat losses to the surroundings through the system components are negligible.
- Refrigerant leaving the condenser is assumed to be saturated at its respective saturation temperature.
- Refrigerant vapour leaving the evaporator is assumed to be saturated.

2. ENERGY ANALYSIS

Energy changes in each component of vapour compression refrigeration system are as follows:

Evaporator: Evaporator abstracts the heat (Qe) from the cold room, which is given by

$$Qe = m_R (h_1 - h_4) \quad (1)$$

Compressor: The isentropic work input to compressor (Wcs) is expressed as

$$Wcs = m_R (h_{2s} - h_1) \quad (2)$$

and actual compressor work (Wc) is specified as

$$Wc = \frac{W_{cs}}{\eta_{is}}$$

or

$$Wc = m_R (h_2 - h_1) \quad (3)$$

Condenser: The heat rejected by the condenser (Qcond.) to the atmosphere is given as

$$Qcond. = m_R (h_2 - h_3) \quad (4)$$

Throttle valve: In throttle valve the enthalpy remains constant.

From the first law point of view, the measure of performance of the refrigeration cycle is the coefficient of performance (COP) and is defined as the net refrigeration effect produced per unit of work required. It is expressed as

$$COP = \frac{Q_e}{W_c} \quad (5)$$

Volumetric Cooling Capacity

The volumetric cooling capacity is the cooling capacity per unit volume flow rate at the inlet to the compressor.

Volumetric cooling capacity $= \frac{Q_e}{(m_R x v_s)}$ kJ/m^3 (6)

Where:
m_R = mass flow rate of refrigerant
v_s = specific volume at inlet to the compressor

Pressure Ratio

Compressor pressure ratio (Pr.) is given as:

$$Pr. = P_c/P_e \quad (7)$$

where P_c = Condenser pressure at state 2
and P_e = Evaporator pressure at state 1

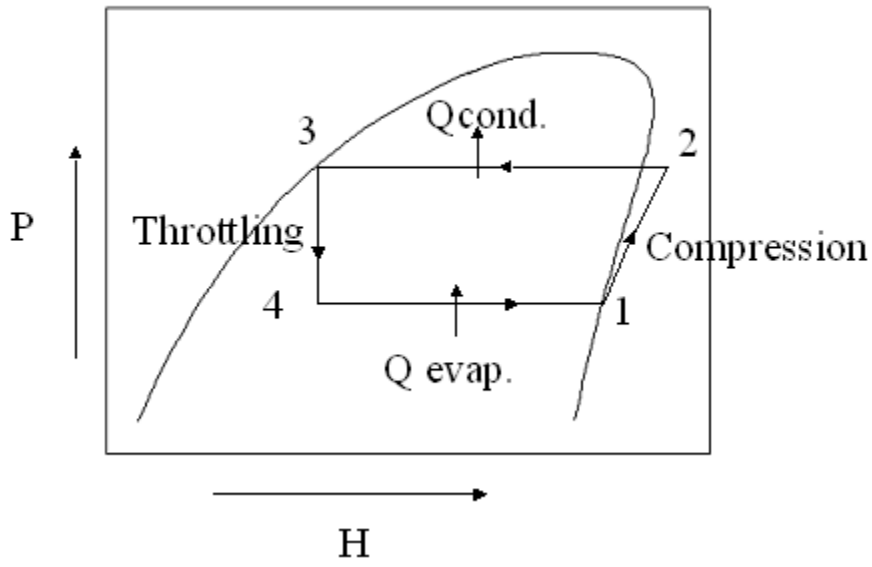

Figure 2. Simple vapour compression refrigeration cycle P-h diagram

3. EXERGY ANALYSIS

A reversible thermodynamic process can be reversed without leaving any trace on the surroundings. That is, the system and the surroundings are returned to their initial states at the end of the reverse process. This is possible only if the net heat and network exchange between the system and the surrounding is zero. All real processes are irreversible. Some factors causing irreversibility in a refrigeration cycle include friction and heat transfer across a finite temperature difference in the evaporator, compressor, condenser, and refrigerant lines, subcooling to ensure pure liquid at throttling valve inlet, superheating to ensure pure vapor at compressor inlet, pressure drops, and heat gains in refrigerant lines. The vapor-compression refrigeration cycle investigated is presented in Fig. 2 (p-h) diagram. The exergy destruction in system components is calculated as:

Evaporator

Exergy entering in the evaporator = $m_R\left(h_4\text{-}T_0 s_4\right)+Q_e\left(1\text{-}\frac{T_0}{T_r}\right)$

Exergy leaving the evaporator = $m_R\left(h_1\text{-}T_0 s_1\right)$

Exergy destruction (EDe) in evaporator is given as:

$$ED_e = m_R\left(h_4\text{-}T_0 s_4\right)+Q_L\left(1\text{-}\frac{T_0}{T_r}\right)\text{-}m_R\left(h_1\text{-}T_0 s_1\right) \quad (8)$$

where

m_R = mass flow of refrigerant (kg./sec)
Q_e = Refrigerating effect (kW)
h = enthalpy kJ/kg.
T = Temperature
s = entropy
0= reference state

Compressor

Exergy entering the compressor = $m_R(h_1-T_0s_1)+W_c$

Exergy leaving the compressor = $m_R(h_2-T_0s_2)$

Exergy destruction in compressor (Ed_c)

$$ED_c = m_R(h_1-T_0s_1)+W_c-m_R(h_2-T_0s_2) \quad (9)$$

where

Wc =Compressor work

Condenser

Exergy entering the condenser = $m_R(h_2-T_0s_2)$

Exergy leaving the condenser = $m_R(h_3-T_0s_3)$

Exergy destruction in condenser ($ED_{cond.}$)

$$ED_{cond} = m_R(h_2-T_0s_2)-m_R(h_3-T_0s_3) \quad (10)$$

Throttle valve

As enthalpy across the throttle valve remains constant. Hence exergy destruction across the throttle valve (ED_t) is given as:

$$ED_t = m_R(s_4-s_3) \quad (11)$$

Total exergy destruction

The total exergy destruction in the system is the sum of exergy destruction in the various components of the system and is given as follows

$$ED\ Total = EDe + EDc + EDcond + EDt \quad (12)$$

Exergetic efficiency

The exergetic efficiency **(Bejan, 1996)** is defined the as :

$$\eta_{ex} = \frac{\text{Exergy equivalent of refrigerating effect}}{\text{Exergy of compressor work}} = \frac{EQ_e}{Ew_c}$$

$$\eta_{ex} = \frac{\left| Q_e \left(1 - \frac{T_0}{T_r} \right) \right|}{W_c} \quad (13)$$

Exergy destruction ratio (EDR)

Exergy destruction ratio **(Said and Ismail, 1994)** is defined as the ratio of total exergy destruction in system to exergy in the product and can be stated as follows

$$EDR = \frac{ED_{TOTAL}}{EP} \quad (14)$$

Efficiency defect

The efficiency defect **(Kotas 1985)** is the ratio between the exergy flow destroyed in each component and the exergy flow required to sustain the process, i.e. the electrical power supplied to the compressor:

$$\delta_i = \frac{ED_i}{w_c} \quad (15)$$

where i stands for particular component.

The efficiency defects of the components are linked to the exergetic efficiency of the whole plant by means of the following relation:

$$\eta_{ex} = (1 - \sum_i \delta_i) \quad (16)$$

Annexure 1 shows the computer programme in ENGINEERING EQUATION SOLVER (S. A. Klein 2006, academic version V7.714) for energetic and exergetic performance of R-502 and its alternate refrigerants R-404A and R-507. The evaporator temperature varied between -50°C and 0°C in a step of 1°C. The condenser temperature is varied between 30°C and 60°C in a step of 6°C.

The parameters used in this work are as follows

- Isentropic efficiency of compressor is 75%
- Room temperature is 5°C higher than evaporator temperature.
- The reference enthalpy (ho) and entropy (so) of the working fluids have been determined corresponding to an environment temperature (To) 25°C.

CHAPTER 3

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

The comparative performance analysis of various parameters are given below:

3.1 Pressure Ratio

The figure 3, 4 and 5 shows the variation of pressure ratio with varying evaporator or/and condenser temperature for R-502, R-404A and R-507A respectively**.** The figures show that pressure ratio decreases with increase in evaporator temperature at particular condenser temperature, but pressure ratio increases with the increase in condenser temperature at particular evaporator temperature. The trends are similar for R-502 and its candidature substitutes. These results of varying pressure ratio are also presented in table 2, 3and 4 for R-502, R-404A and R-507A respectively**.**

Fig. 6, 7, 8, 9, 10 and 11 represents the comparison of pressure ratio for R-502 and its substitutes with varying evaporator temperature and condenser temperature at 30°C,

36°C, 42°C, 48°C, 54°C and 60°C.

Results show that at condenser temperature 54°C and evaporator temperature –50°C pressure ratio required for R-404A and R-507A are 9.31% and 4.51% higher than R-502.

At 0°C evaporator temperature and condenser temperature 54°C pressure ratio required for R-404A and R-507A are 4.8% and 2.9% higher than R-502 which means heavy compressor and higher compressor work is required while using R-404A and R-507A. The trends are similar for condenser temperature 30°C, 36 °C, 42°C, 48°C, 54°C and 60°C.

3.2 Volumetric Cooling Capacity

The figure 12, 13 and 14 shows the variation of volumetric cooling capacity with varying evaporator or/and condenser temperature for R-502, R-404A and R-507A respectively**.** The figures show that the volumetric cooling capacity increases with increase in evaporator temperature at particular condenser temperature and decrease with increase in condenser

temperature at particular evaporator temperature. The trends are similar for R-502 and its substitute R-404A and R-507A. These results of varying volumetric cooling capacity are also presented in table 12, 13 and 14 for R-502, R-404A and R-507A respectively**.**

Fig.15, 16, 17, 18, 19 and 20 represents the comparison of volumetric cooling capacity for R-502 and its substitutes with varying evaporator temperature and condenser temperature at 30°C, 36 °C, 42°C, 48°C, 54°C and 60°C.

Results show that at condenser temperature 54°C and evaporator temperature –50°C volumetric cooling capacity for R-404A and R-507A are 18.25% and 13.78% lower in comparison to R-502. At 0°C evaporator temperature and condenser temperature 54°C volumetric cooling capacity for R-404A and R-507A are 5.05% and 2.12% lower in comparison to R-502, which means that size of compressor for R-502, is smaller than R-404A and R-507A. The trends are similar for condenser temperature 30°C, 36 °C, 42°C, 48°C, 54°C and 60°C.

3.3 Coefficient of performance (COP)

Fig.21, 22 and 23 shows the variation of COP with varying evaporator or/and condenser temperature for R-502, R-404A and R-507A respectively. The figures shows that the COP increases with increase in evaporator temperature at particular condenser temperature and decrease with increase in condenser temperature at particular evaporator temperature. The trends are similar for R-502 and its substitute R-404A and R-507A. These results of varying coefficient of performance are also presented in table 21, 22 and 23 for R-502, R-404A and R-507A respectively**.**

Fig. 24, 25, 26, 27, 28 and 29 shows the comparison of COP for R-502 and its substitute refrigerants with varying evaporator temperature and condenser temperature at 30°C, 36 °C, 42°C, 48°C, 54°C and 60°C.

Results show that at condenser temperature 54°C and evaporator temperature 0°C, coefficient of performance for R-404A and R-507A are 10.36% and 10.23% lower in comparison to R-502. The difference decreases with decrease in evaporator temperature, which means that for per kg. of refrigerant flow in the system at any given evaporating temperature, R502 yields a greater refrigerating power at the expenses of a lower mechanical power at the compressor. Conversely, a plant working with R-507A requires higher electric power consumption in order to provide the

same refrigerating load. Apart from direct costs, this is disadvantageous in terms of overall environmental pollution, since more fuel must be burned and higher amounts of carbon dioxide are discharged in the atmosphere. Furthermore, R-404A and R-507A are greenhouse gases in its own right related on the fraction of refrigerant charge released in the atmosphere (leakages etc.). Therefore, in terms of greenhouse effect, the use of R-404A and R-507A might result in a higher, overall environmental impact than that of R502, even though the former is totally harmless to the ozone layer. The trends are similar for condenser temperature 30°C, 36 °C, 42°C, 48°C, 54°C and 60°C.

3.4 Exergy Destruction Ratio (EDR)

Variations of exergy destruction ratio with evaporator or/and condenser temperature are shown in fig. 30, 31 and 32 for R-502, R-404A and R-507A respectively. The figures show that EDR increases with increase in evaporator as well as condenser temperature. The increase is more at higher condenser temperature. The trends are similar for R-502 and its substitute R-404A and R-507A. These results of varying EDR are also presented in table 30, 31 and 32 for R-502, R-404A and R-507A respectively**.**

Fig. 33, 34, 35, 36, 37 and 38 represents the comparison of exergy destruction ratio for R-502 and its substitutes with varying evaporator temperature and condenser temperature at 30°C, 36°C, 42°C, 48°C, 54°C and 60°C.

Results shows that at condenser temperature 54°C and evaporator temperature 0°C exergy destruction ratio in comparison to R-502 are 14.028% and 13.83% higher for R-404A and R-507A respectively.

3.5 Exergetic Efficiency

Variations of exergetic efficiency with evaporator or/and condenser temperature are shown in fig. 39, 40 and 41 for R-502, R-404A and R-507A respectively. Exergetic efficiency decreases

with increase in evaporator temperature and decrease in condenser temperature. The trends are similar for R-502 and its substitute R-404A and R-507A. These results of varying exergetic efficiency are also presented in table 39, 40 and 41 for R-502, R-404A and R-507A respectively**.**
Fig. 42, 43, 44, 45, 46 and 47 represents the comparison of exergy destruction ratio for R-502 and its candidatures substitutes with varying evaporator temperature and condenser temperature at 30°C, 36°C, 42°C, 48°C, 54°C and 60°C.

Results show that at condenser temperature 54°C and evaporator temperature 0°C, exergetic efficiency for R-404A and R-507A are 18.73% and 18.54% lower in comparison to R-502.

The trends are similar at condenser temperature 30°C, 36°C, 42°C, 48°C, 54°C and 60°C.

3.6 Efficiency Defect (Compressor)

The effect of variation of evaporator or/and condenser temperature on efficiency defect in compressor is shown in fig. 48, 49 and 50 for R-502, R-404A and R-507A respectively. The figures show that efficiency defect in compressor increases with increase in evaporator temperature and decrease in condenser temperature. The trends are similar for R-502 and its substitute R-404A and R-507A. These results of varying efficiency defect in compressor are also presented in table 48, 49 and 50 for R-502, R-404A and R-507A respectively**.**
Fig. 51, 52, 53, 54, 55 and 56 represents the comparison of efficiency defect in compressor for R-502 and its substitutes with varying evaporator temperature and condenser temperature at 30°C, 36°C, 42°C, 48°C, 54°C and 60°C.

Results show that at condenser temperature 54°C and evaporator temperature 0°C efficiency defect in compressor is 0.40% and 0.954% higher for R-404A and R-507A respectively in comparison to R-502

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3.7 Efficiency Defect (Condenser)

The effect of variation of evaporator or/and condenser temperature on efficiency defect in condenser is shown in fig. 57, 58 and 59 for R-502, R-404A and R-507A respectively. The figures show that efficiency defect in condenser increases with increase in evaporator as well as condenser temperature. The trends are similar for R-502 and its substitutes R-404A and R-507A.

These results of varying efficiency defect in condenser are also presented in table 57, 58 and 59 for R-502, R-404A and R-507A respectively**.**

Fig.60, 61, 62, 63, 64 and 65 represents the comparison of efficiency defect in condenser for R-502 and its substitutes with varying evaporator temperature and condenser temperature at 30°C, 36°C, 42°C, 48°C, 54°C and 60°C.

Results show that at condenser temperature 54°C and evaporator temperature -50°C efficiency defect in condenser is 9.53% and 11.17% lower for R-404A and R-507A respectively in comparison to R-502.

At condenser temperature 54°C and evaporator temperature 0°C efficiency defect in condenser is 7.24% and 8.005% lower for R-404A and R-507A respectively in comparison to R-502. The trends are similar for condenser temperature 30°C, 36 °C, 42°C, 48°C, 54°C and 60°C.

The reason behind it is the temperature glide in zeotropic mixtures during condensation.

Transferring the heat at lower temperature difference can reduce efficiency defect in condenser.

3.8 Efficiency Defect (Throttle Valve)

The effects of variation of evaporator or/and condenser temperature on efficiency defect in throttle valve are shown in fig. 66, 67 and 68 for R-502, R-404A and R-507A respectively.

Efficiency defect in throttle valve decreases with increase in evaporator temperature and decrease in condenser temperature. The trends are similar for R-502 and its substitutes R-404A and R-507A. These results of varying efficiency defect in throttle valve are also presented in table 66, 67 and 68 for R-502, R-404A and R-507A respectively**.**

Fig. 69, 70, 71, 72, 73 and 74 represents the comparison of efficiency defect in condenser for R-502 and its substitutes with varying evaporator temperature and condenser temperature at 30°C, 36°C, 42°C, 48°C, 54°C and 60°C.

Results also show that at condenser temperature 54°C and evaporator temperature -50°C efficiency defect in throttle valve is 14.8% and 14.88% lower for R-404A and R-507A respectively in comparison to R-502 and at evaporator temperature 0°C efficiency defect in

throttle valve is 19.08% and 18.92% lower for R-404A and R-507A respectively in comparison to R-502. Subcooling the liquid refrigerant can reduce efficiency defect in throttle valve.

3.9 Efficiency Defect (Evaporator)

The effect of variation of evaporator or/and condenser temperature on efficiency defect in evaporator are shown in shown in fig.75, 76 and 77 for R-502, R-404A and R-507A respectively. Figures show that efficiency defect in evaporator increases with the increase in evaporator temperature and decrease in condenser temperature. These results of varying efficiency defect in evaporator are also presented in table 75, 76 and 77 for R-502, R-404A and R-507A respectively**.** Fig. 78, 79, 80, 81, 82 and 83 represents the comparison of efficiency defect in condenser for R-502 and its substitutes with varying evaporator temperature and condenser temperature at 30°C, 36°C, 42°C, 48°C, 54°C and 60°C.

Results show that at condenser temperature 54°C and evaporator temperature -50°C efficiency defect in evaporator is 22.02% and 18.54% lower for R-404A and R-507A respectively in comparison to R-502 while at condenser temperature 54°C and evaporator temperature 0°C efficiency defect in evaporator is 12.99% and 10.25% lower for R-404A and R-507A respectively in comparison to R-502.

Efficiency defect in evaporator is marginal in comparison to the overall efficiency defect of the system. Transferring the heat at lower temperature difference can further reduce the efficiency defect in evaporator.

For acceptance of this work results obtained from theoretical analysis is compared with the published data obtained from the work done by **Doring et. al. [***International journal of refrigeration,* vol. 20, No. 2, pp.78-84, 1997] at Evaporation temperature -40°C, Degree of superheat 10°C, Temperature of condensation 35°C, Refrigerant liquid subcooling 5°C and Isentropic compressor efficiency 80%.

Coefficient of performance (COP) Figure 84 shows the comparison of experimental results with present work for COP. Results shows that for R-507 there is almost no difference (0.3%) in COP and for R-502 the deviation in COP is 1.59%.

CHAPTER 4

CONCLUSIONS AND FUTURE SCOPE

CONCLUSIONS

In present work the comparative performance analysis of R-502 and its substitutes R-404A and R-507A have been discussed. The results obtained permit the following remarks:

1. The COP of R-507A and R-404A is lower than R-502.
2. R-502 has higher Volumetric Cooling Capacity than R-404A and R-507A respectively. R-404A and R-507A requires higher compression ratio for same rise of condenser temperature as raised by R-502.
3. The overall exergetic performance of the cycle working with R-502 is consistently better than that of its candidate substitute.
4. R-502 have lower exergy destruction ratio than R-404A and R-507A respectively.
5. Efficiency defect in compressor is higher for R-404A and R-507A respectively in comparison to R-502.
6. Efficiency defect in condenser is lower for R-404A and R-507A respectively in comparison to R-502.
7. Efficiency defect in throttle valve is lower for R-404A and R-507A respectively in comparison to R-502.
8. Efficiency defect in evaporator is lower for R-404A and R-507A respectively in comparison to R-502.

In conclusion, there is no unanimous substitution for R-502. The results indicate that R-404A and R-507A as the alternate refrigerants, when used as drop in replacement will not provide same performance as obtained in case of R-502.With regards to COP and exergy destruction ratio R-502 is superior refrigerant. Even exergetic efficiency of R-502 is better than its substitutes. As the ODP for R-502 is high therefore it is necessary to switch over to an alternate refrigerant i.e. R-507A. This has comparable COP, exergy destruction ratio and exergetic efficiency. Further improvement in the design of individual components may enhance the performance parameter for R-507A and R404A.

FUTURE WORK

- Zeotropic mixture R-422A can also be compared with R-502 to find out its suitability as alternate refrigerant.

Exergoeconomic analysis of these refrigerants is the next step in this direction.

FIGURES

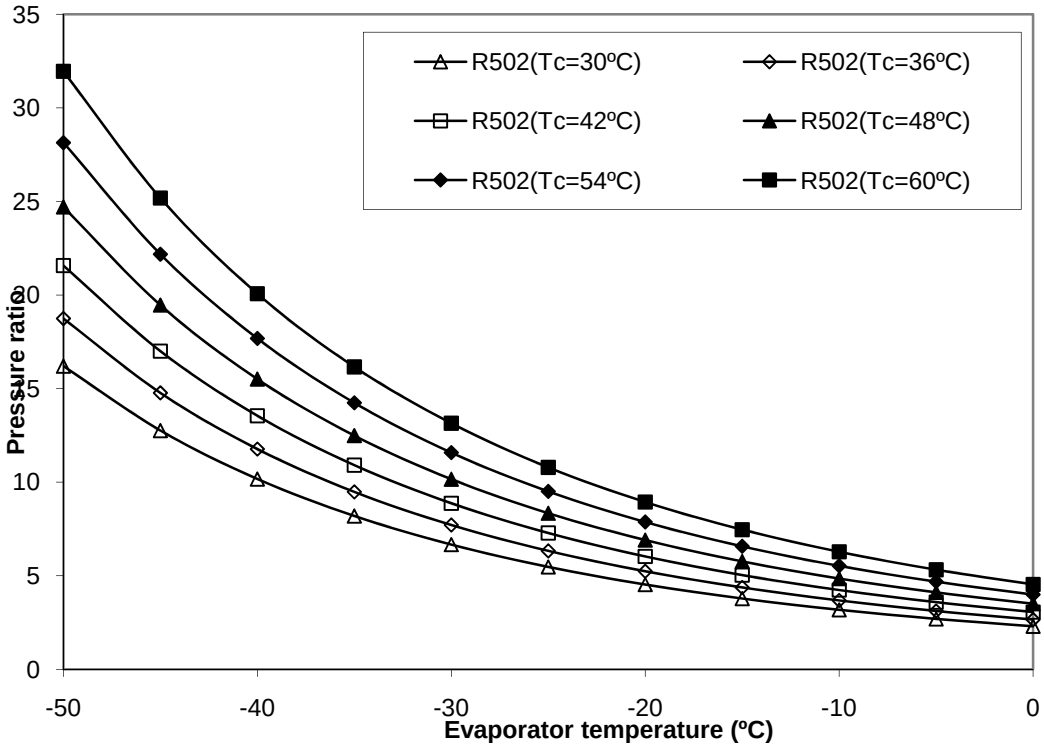

Figure 3. Variation of pressure ratio with varying evaporator temperature (R-502)

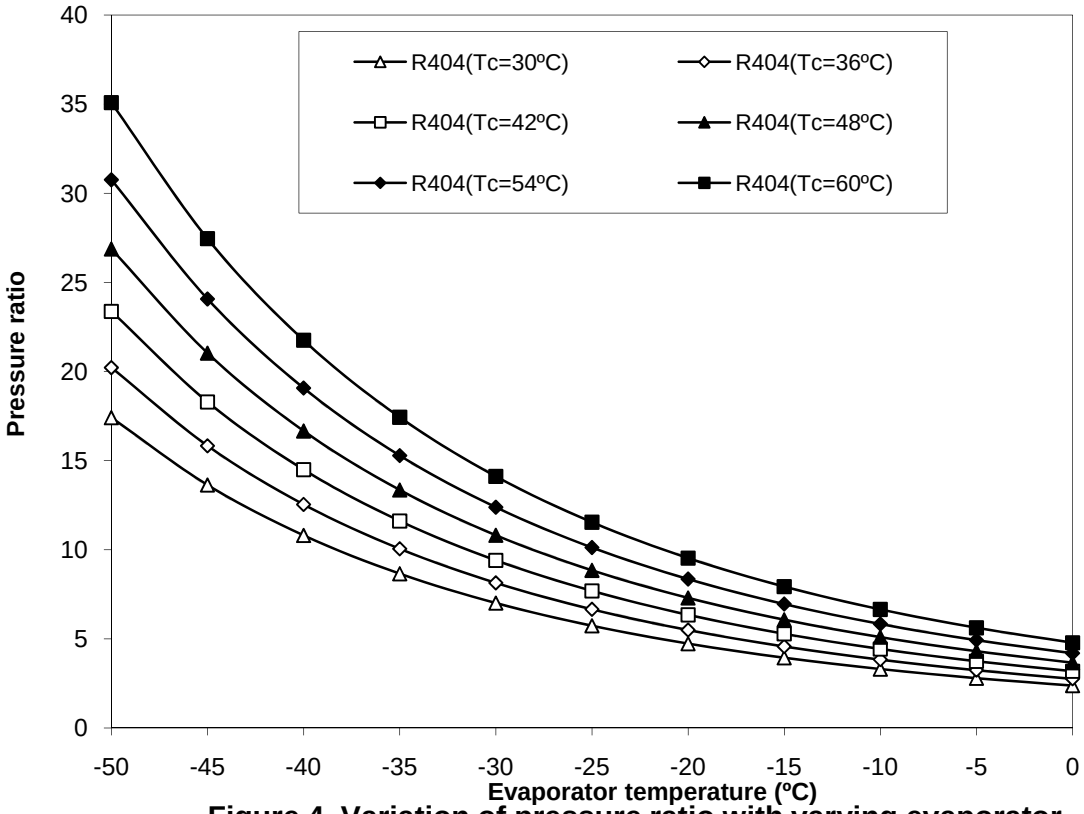

Figure 4. Variation of pressure ratio with varying evaporator temperature (R-404A)

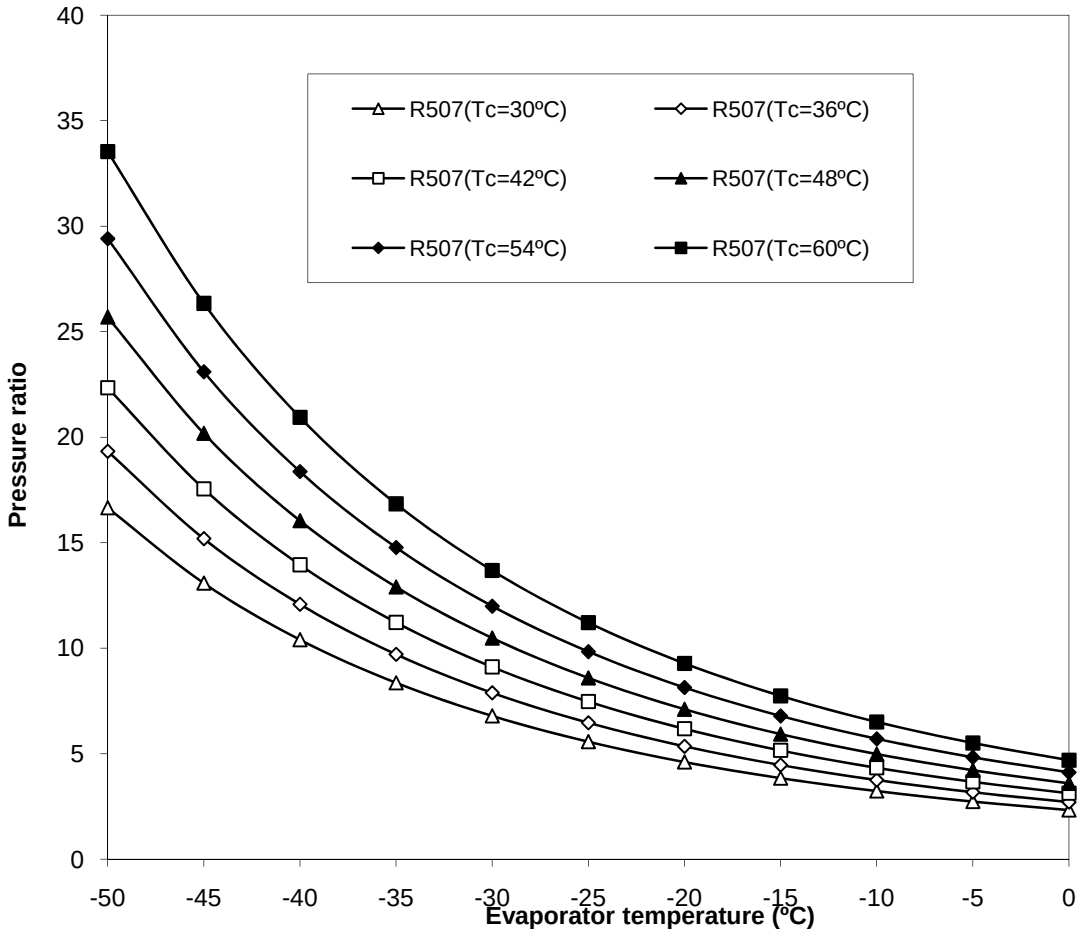

Figure 5. Variation of pressure ratio with varying evaporator temperature (R-507A)

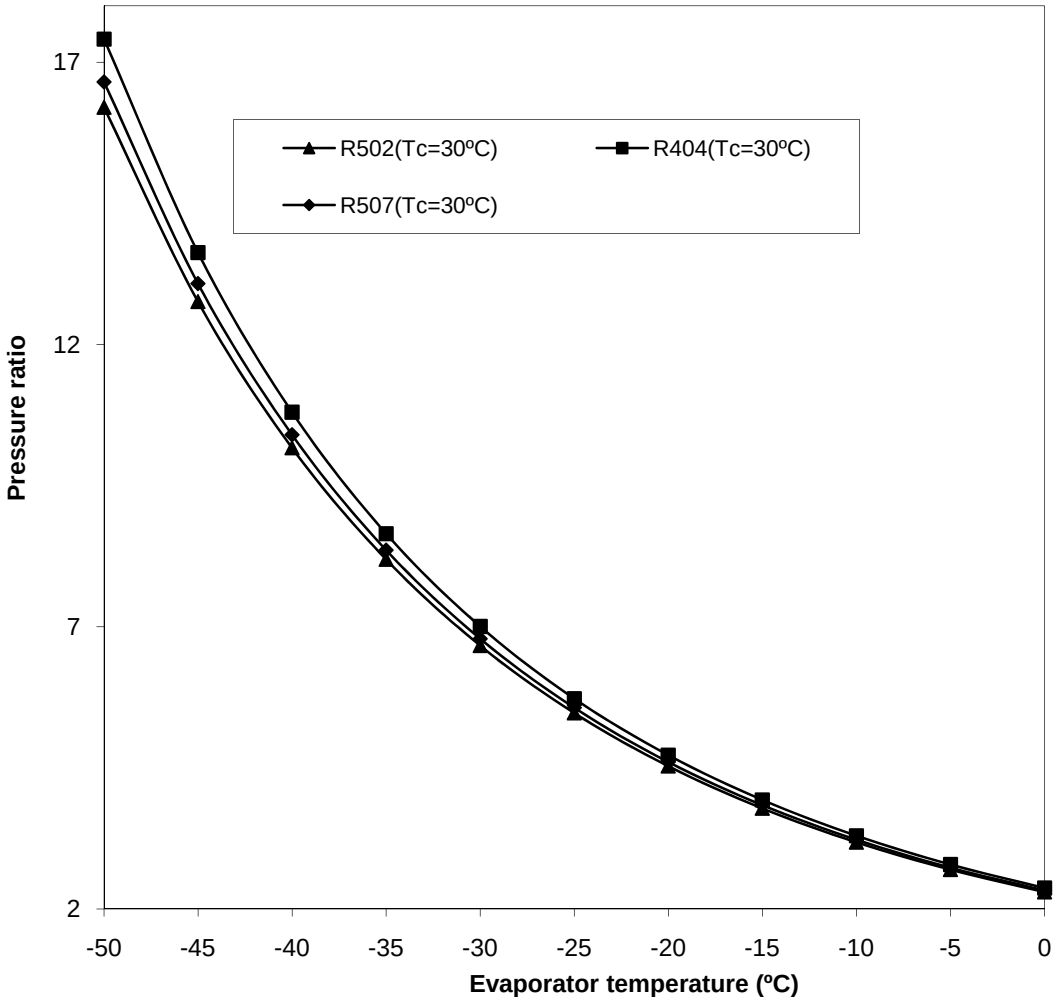

Figure 6.Comparison of pressure ratio with varying evaporator temperature(Tc= 30ºC)

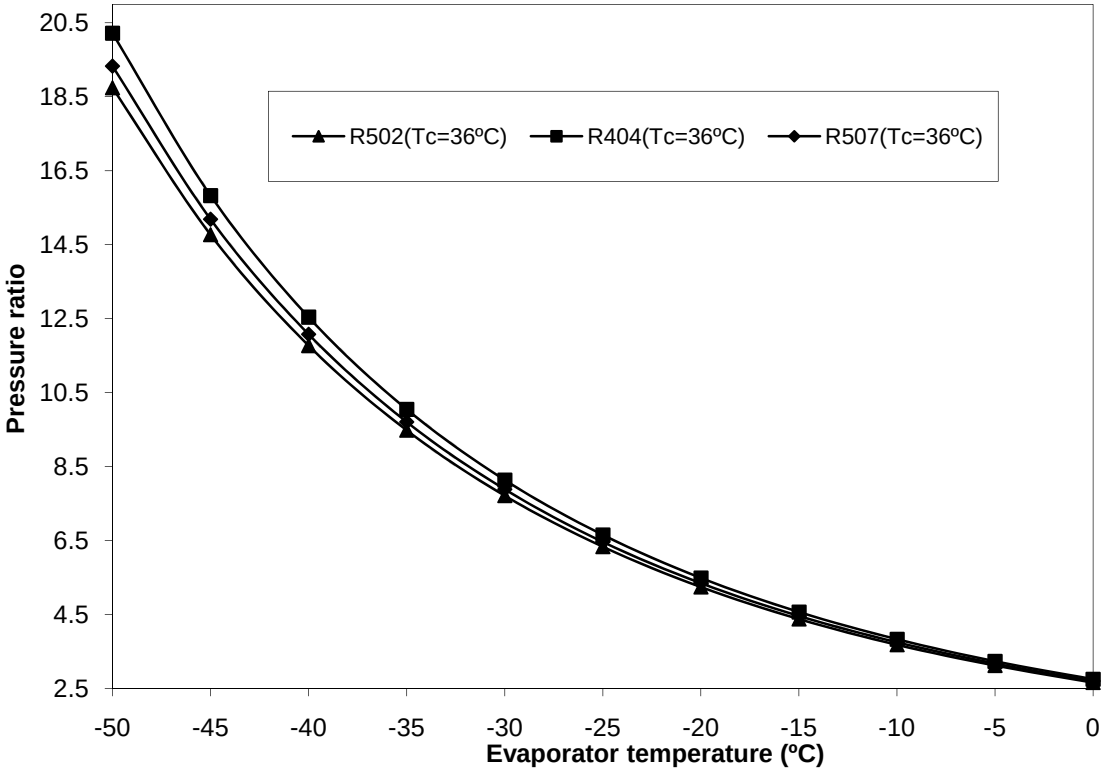

Figure 7.Comparison of pressure ratio with varying evaporator temperature(Tc= 36ºC)

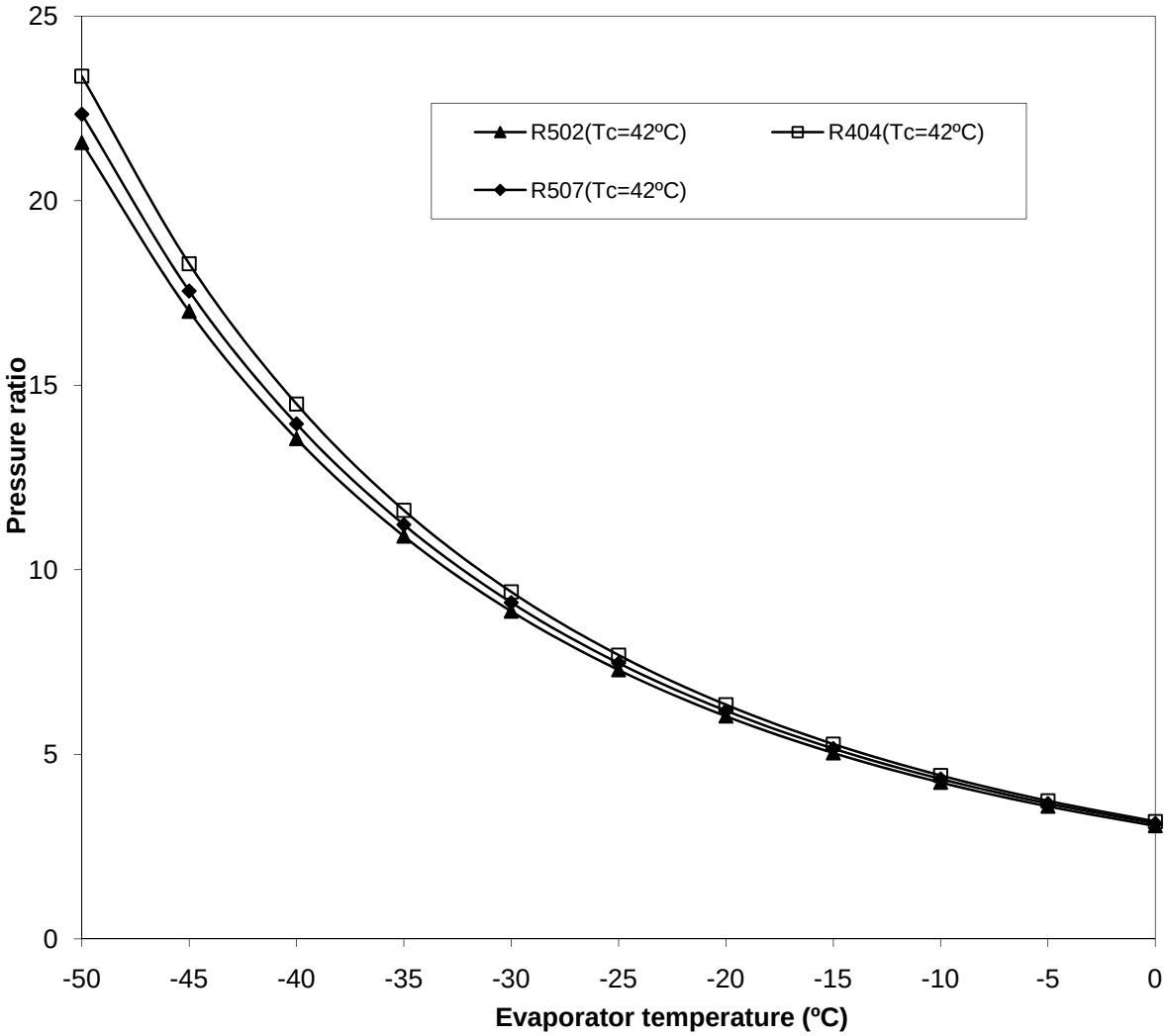

Figure 8.Comparison of pressure ratio with varying evaporator temperature(Tc= 42ºC)

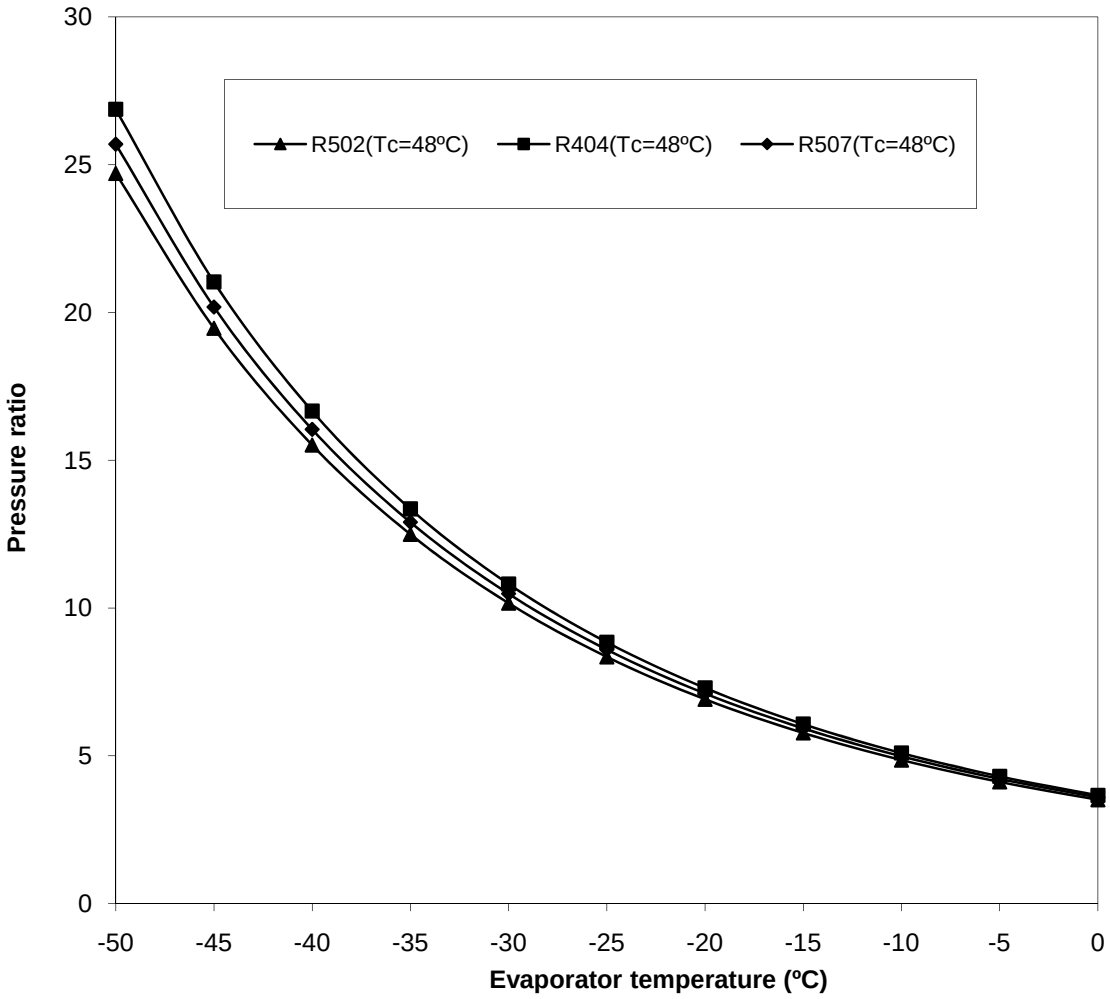

Figure 9.Comparison of pressure ratio with varying evaporator temperature(Tc= 48ºC)

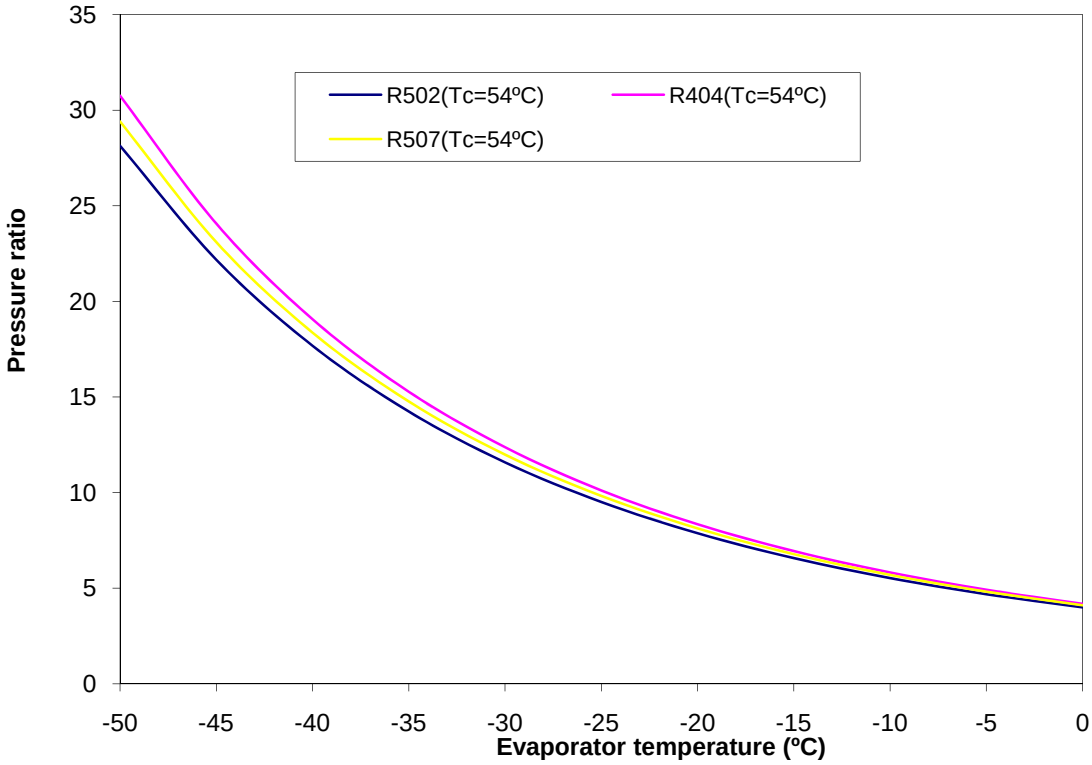

Figure 10.Comparison of pressure ratio with varying evaporator temperature(Tc= 54ºC)

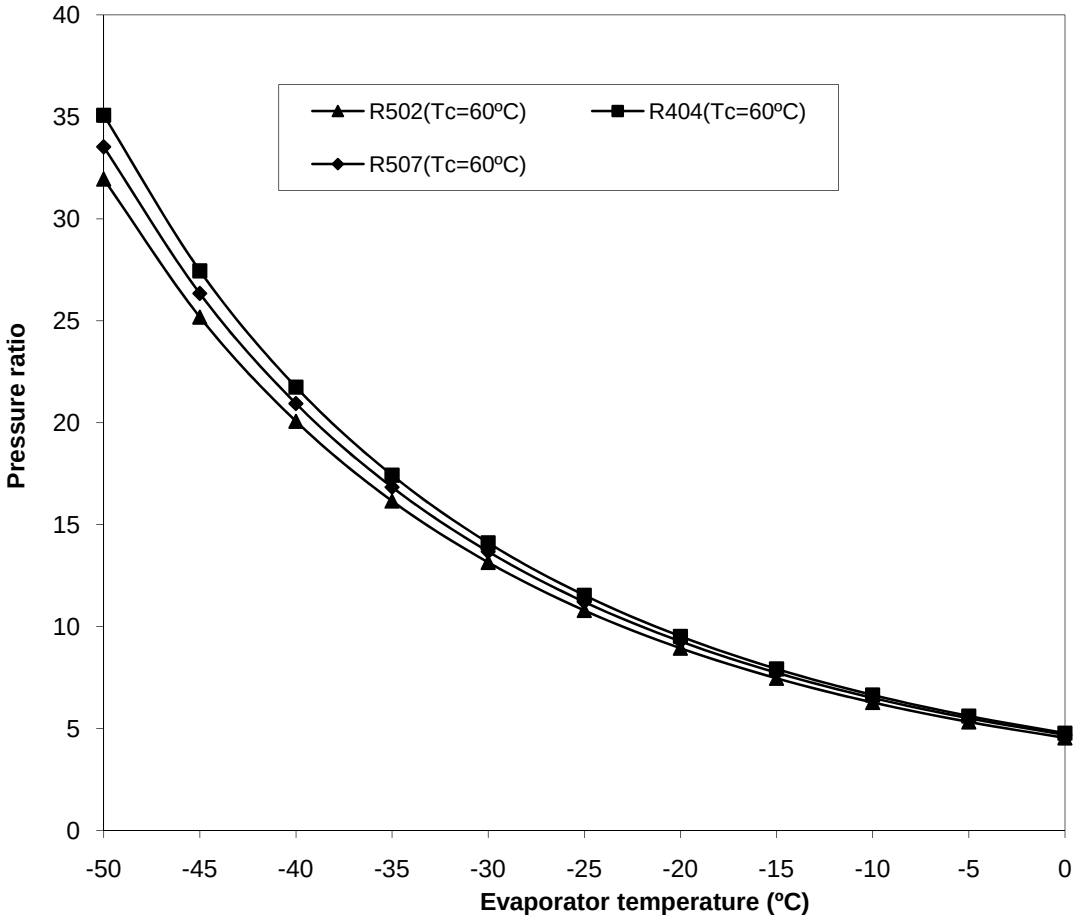

Figure 11.Comparison of pressure ratio with varying evaporator temperature(Tc= 60ºC)

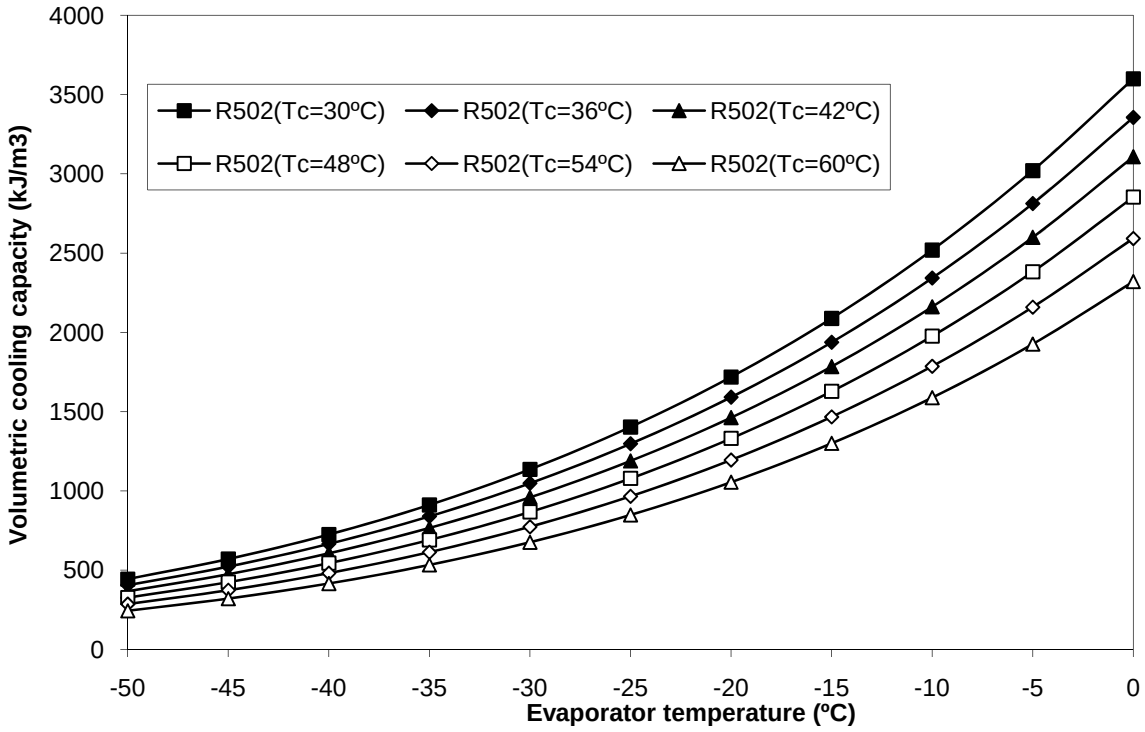

Figure 12. Variation of volumetric cooling capacity with varying evaporator temperature (R-502)

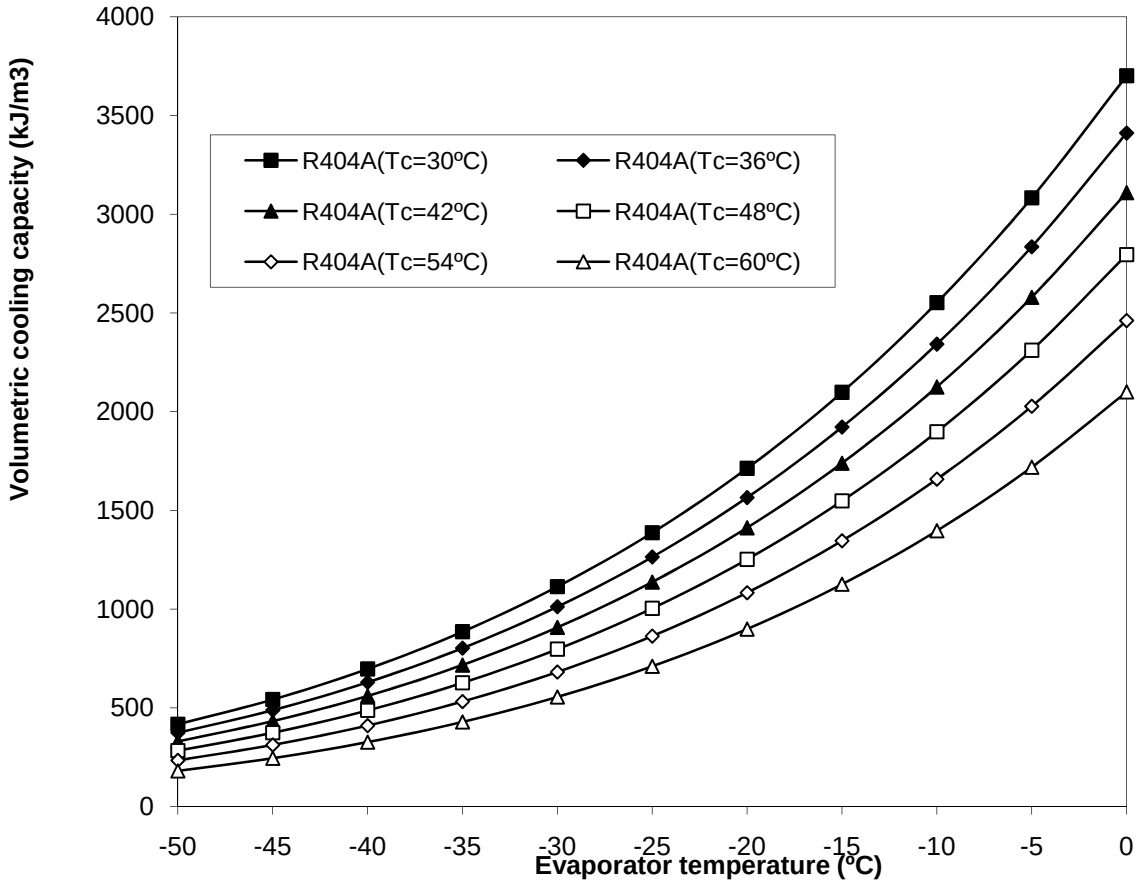

Figure 13. Variation of volumetric cooling capacity with varying evaporator temperature (R-404A)

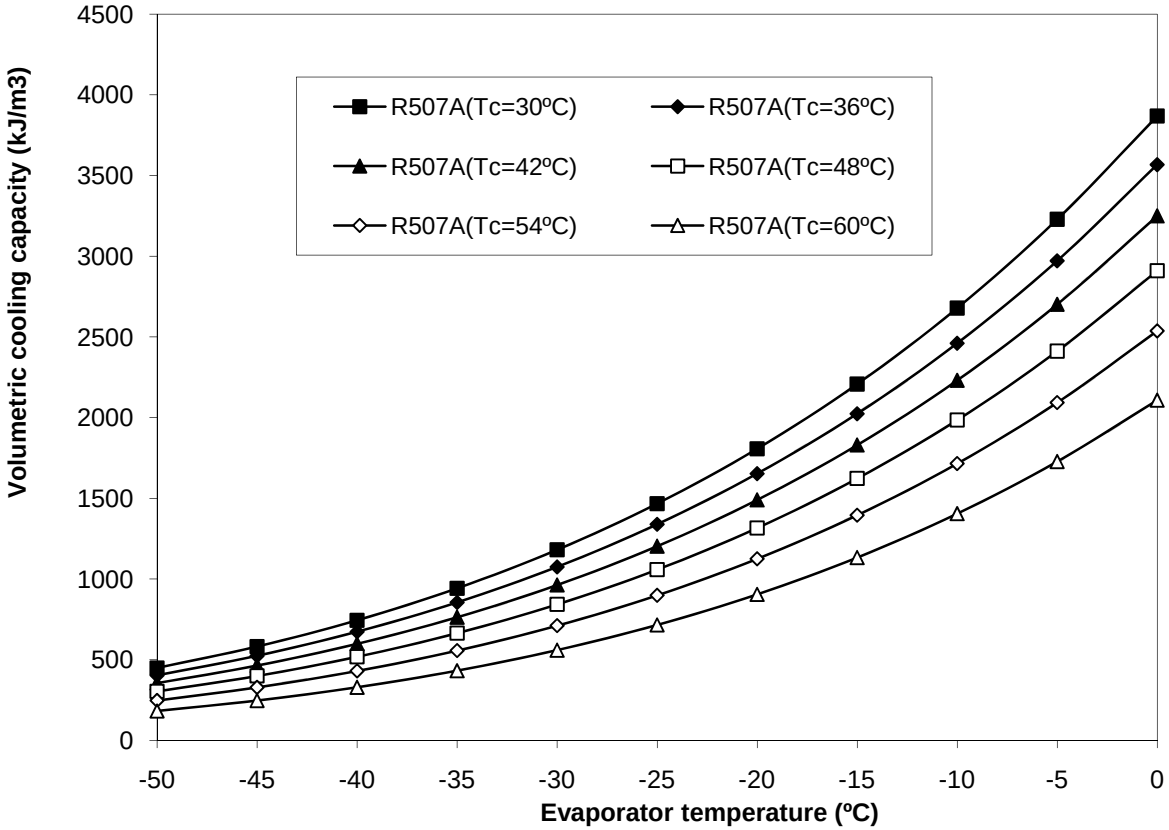

Figure 14. Variation of volumetric cooling capacity with varying evaporator temperature (R-507A)

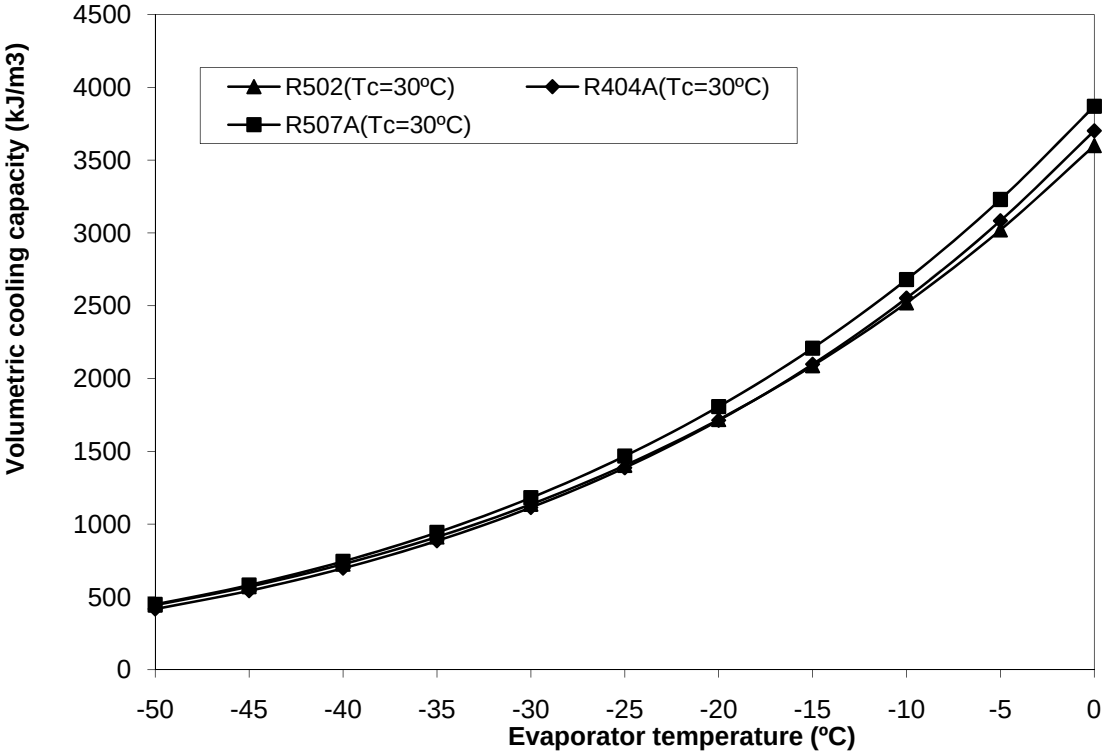

Figure 15.Comparison of volumetric cooling capacity with varying evaporator temperature (Tc= 30ºC)

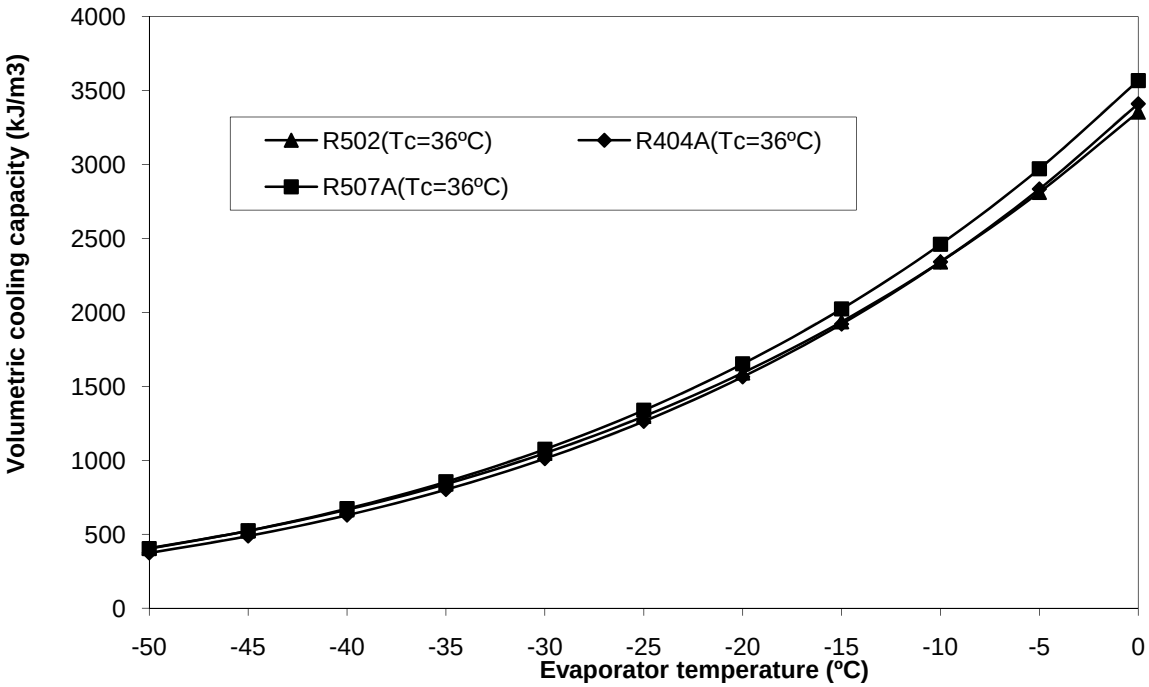

Figure 16.Comparison of volumetric cooling capacity with varying evaporator temperature (Tc= 36ºC)

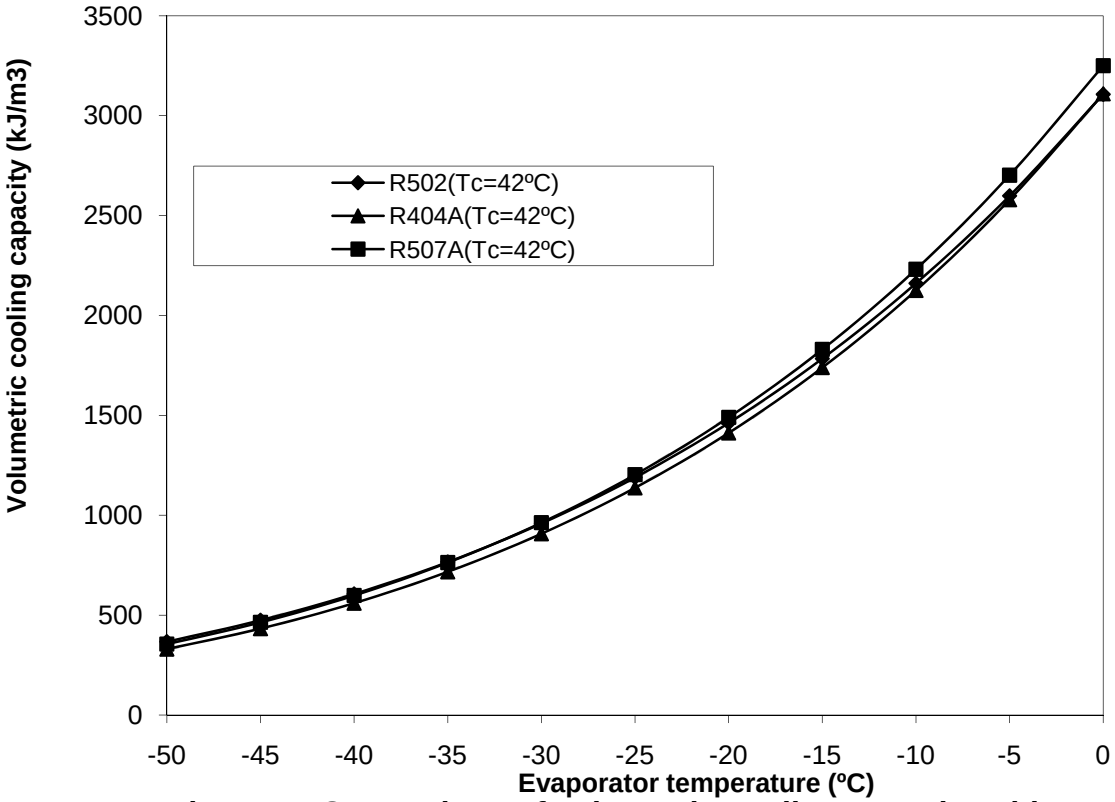

Figure 17.Comparison of volumetric cooling capacity with varying evaporator temperature (Tc= 42ºC)

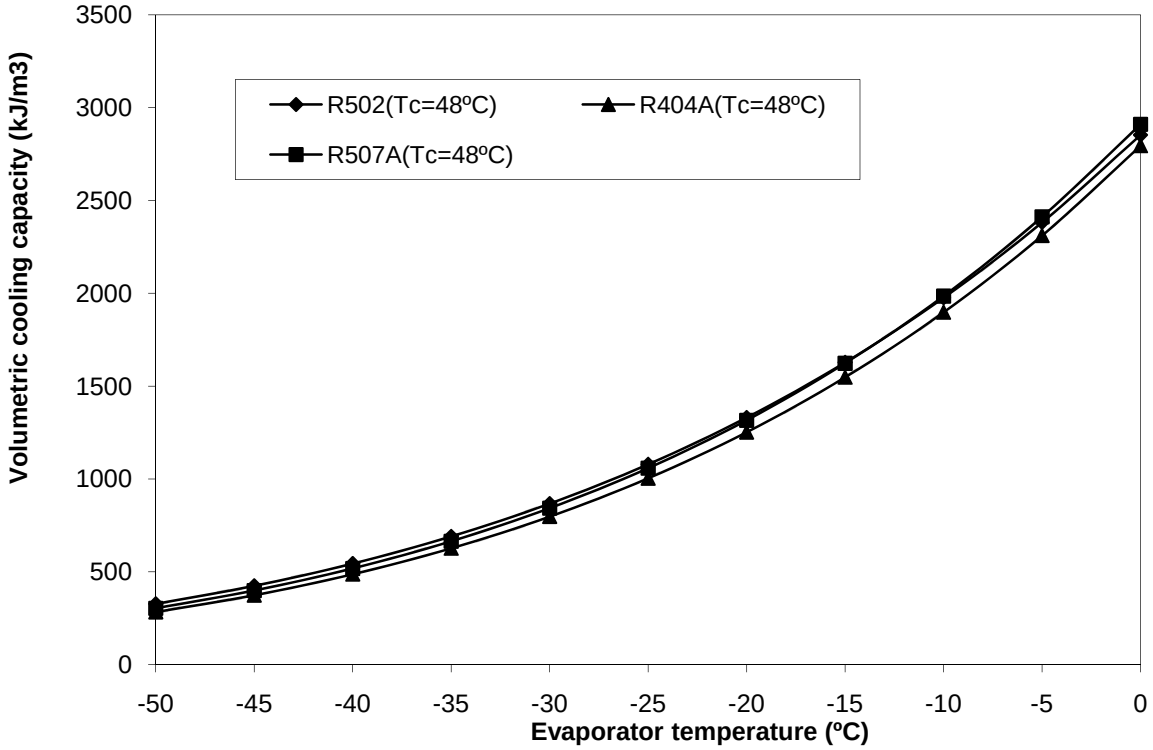

Figure 18.Comparison of volumetric cooling capacity with varying evaporator temperature (Tc= 48ºC)

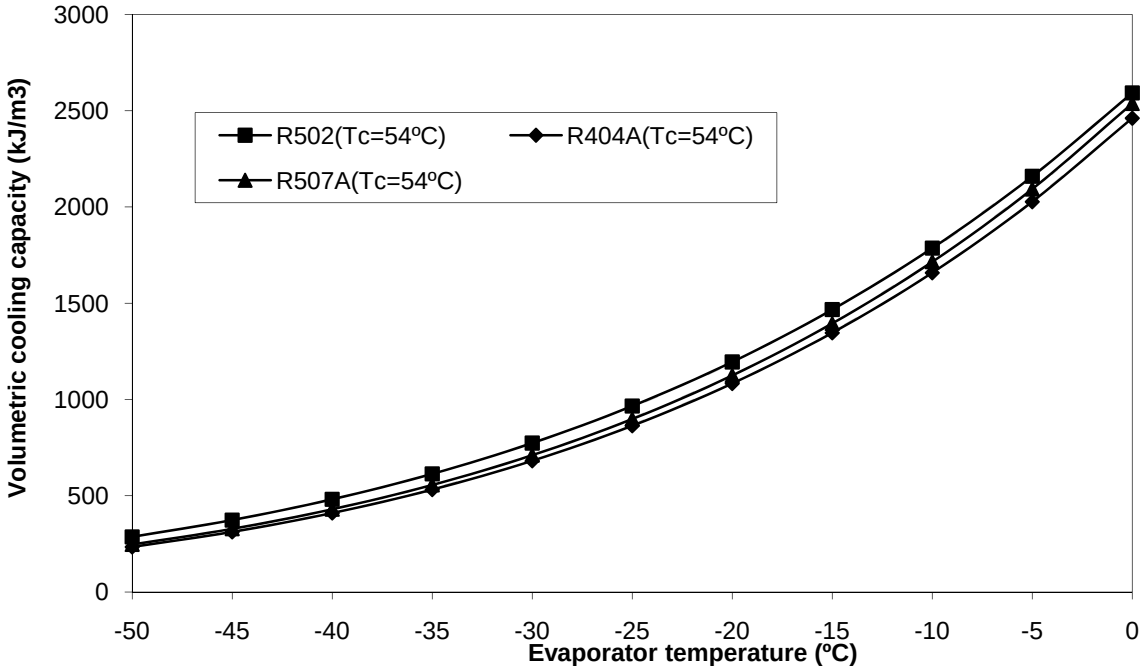

Figure 19.Comparison of volumetric cooling capacity with varying evaporator temperature (Tc= 54ºC)

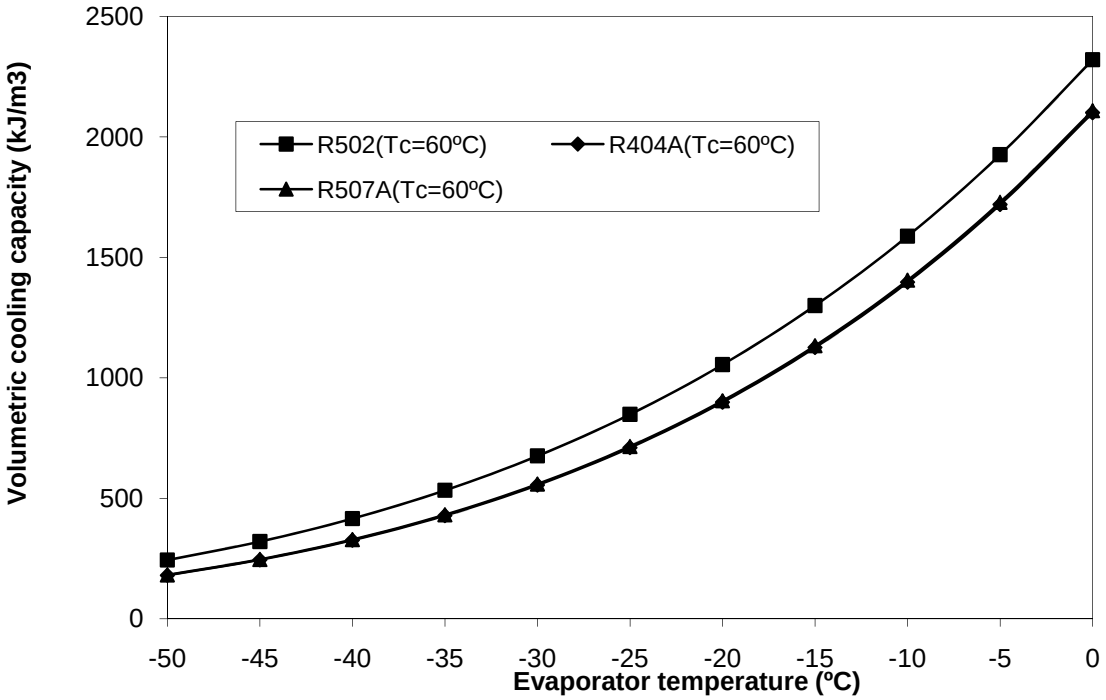

Figure 20.Comparison of volumetric cooling capacity with varying evaporator temperature (Tc= 60ºC)

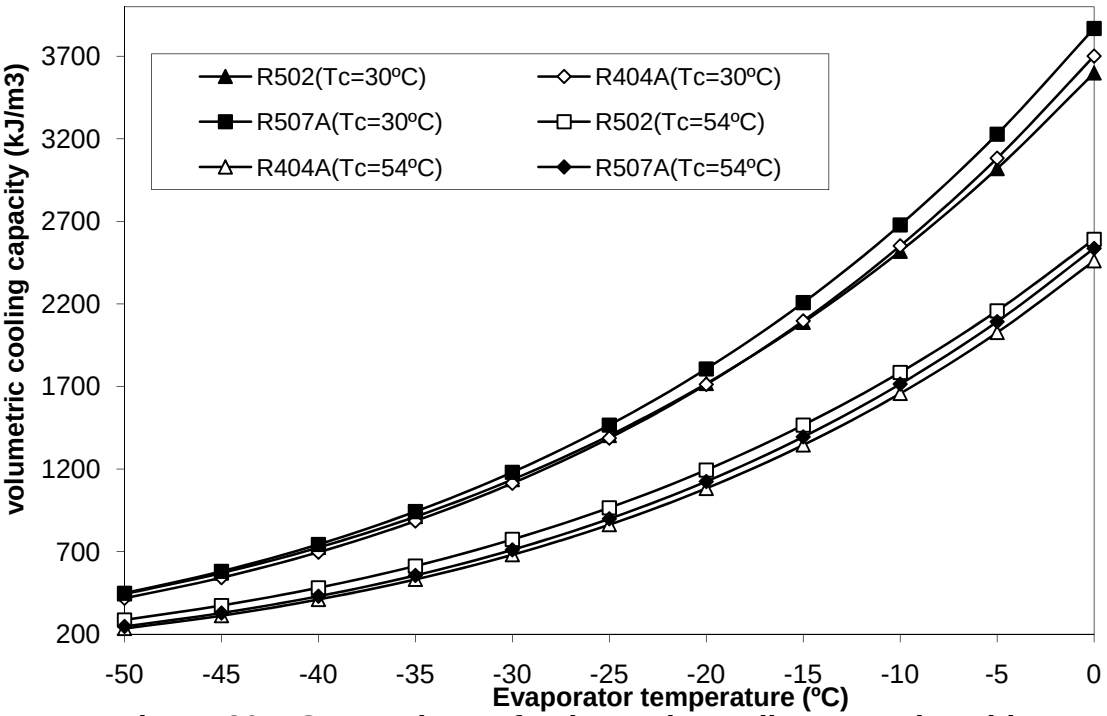

Figure 20a. Comparison of volumetric cooling capacity with varying evaporator temperature and condenser temperature (ºC)

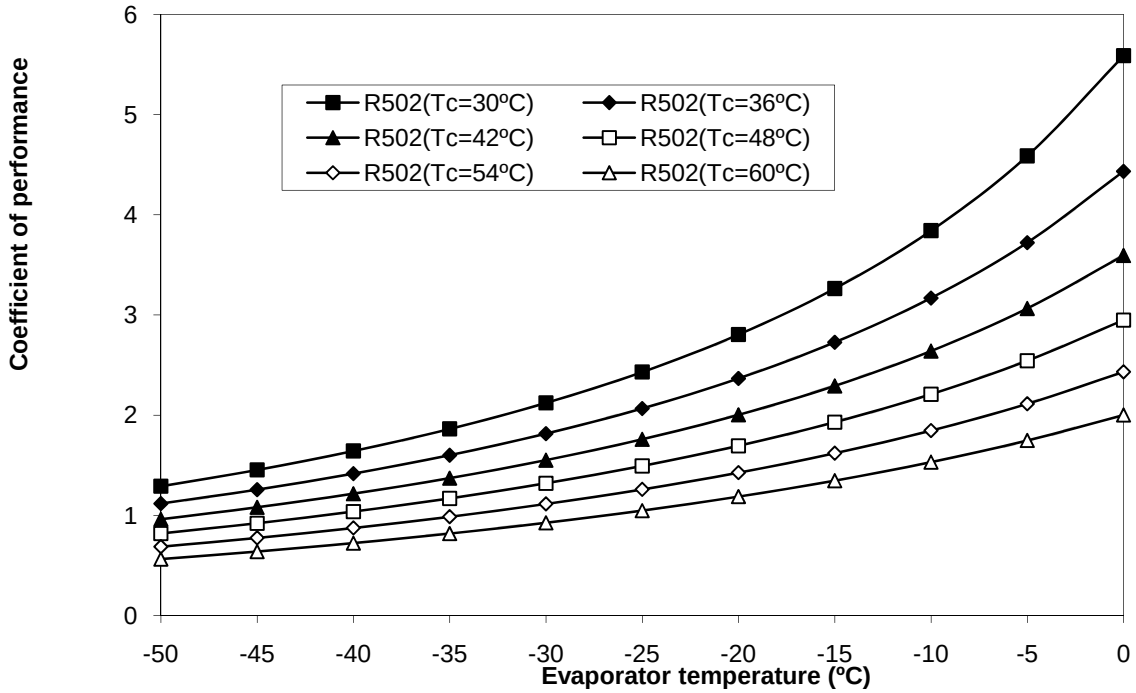

Figure 21. Variation of coefficient of performance with varying evaporator temperature (R-502)

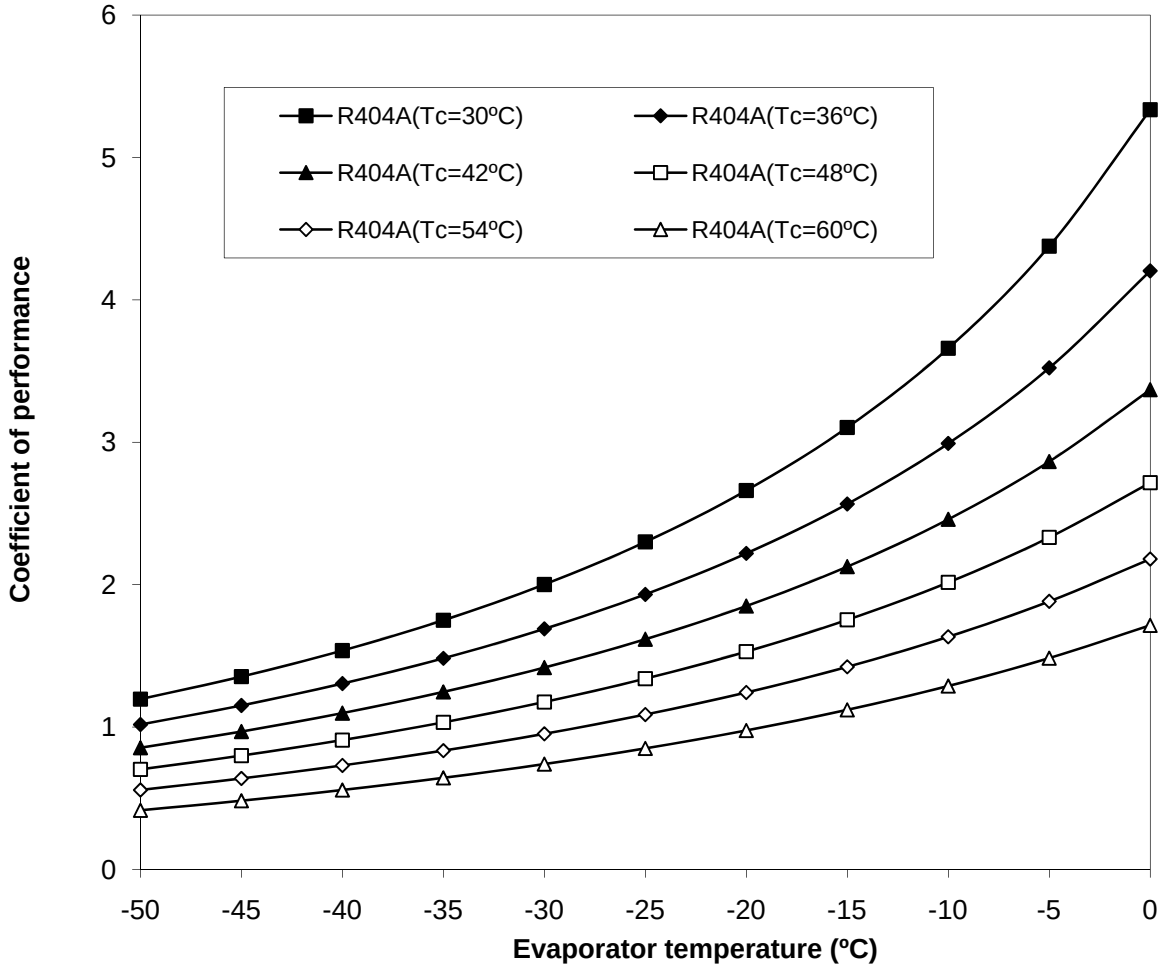

Figure 22. Variation of coefficient of performance with varying evaporator temperature (R-404A)

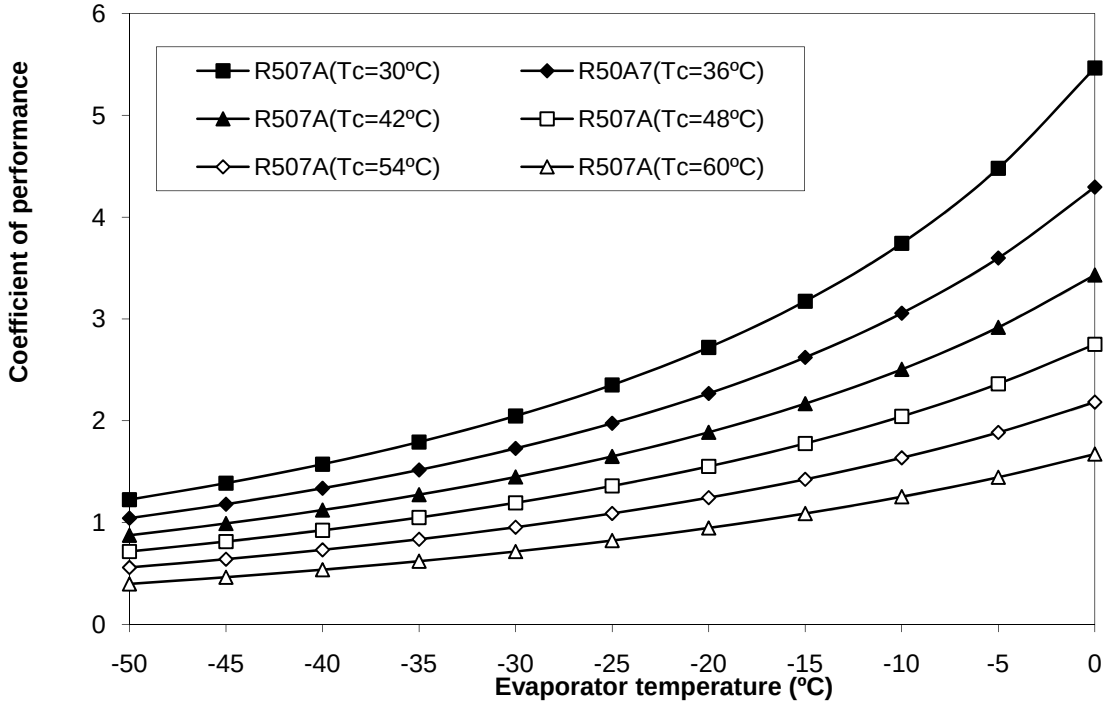

Figure 23. Variation coefficient of performance with varying evaporator temperature (R-507A)

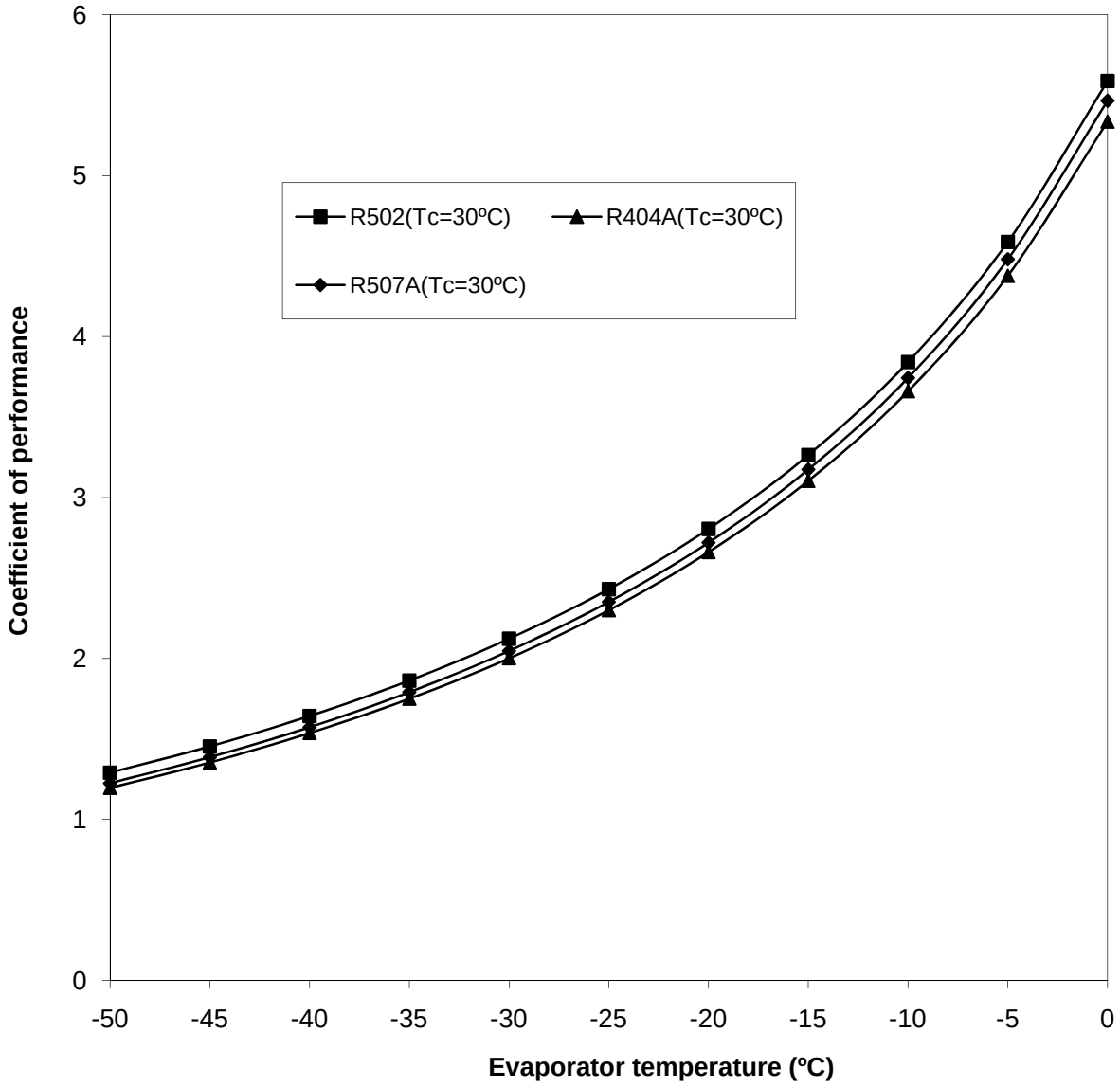

Figure 24.Comparison of coefficient of performance with varying evaporator temperature (Tc= 30ºC)

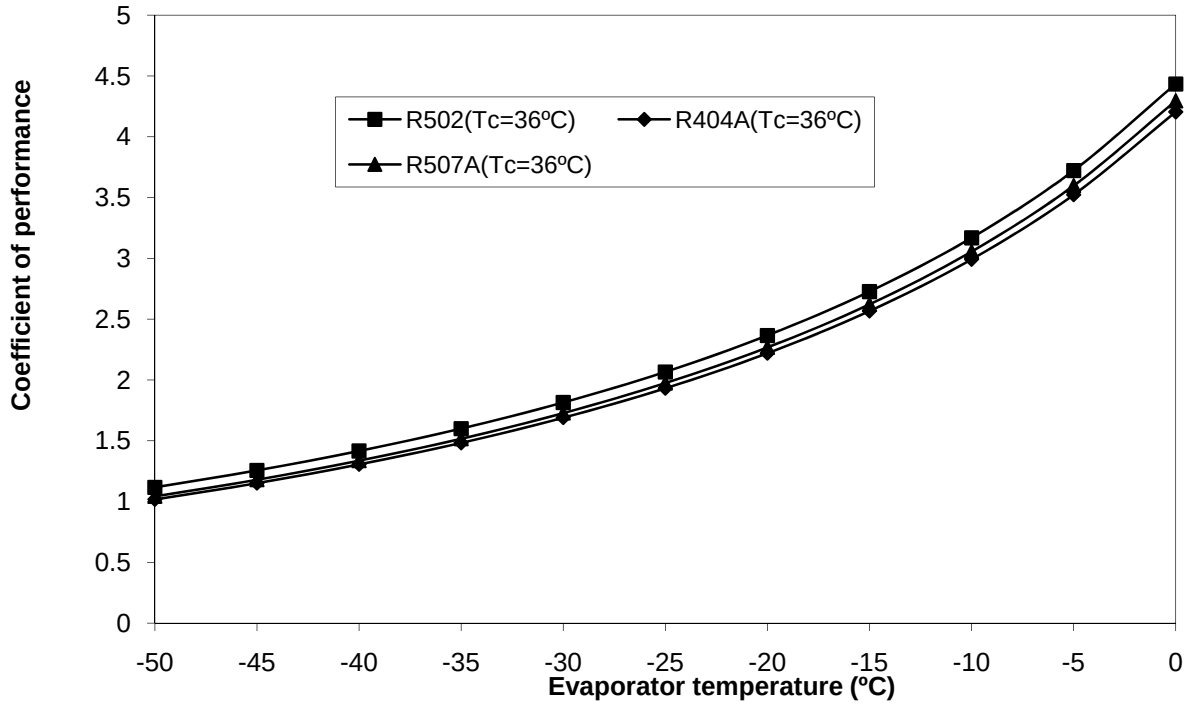

Figure 25.Comparison of coefficient of performance with varying evaporator temperature (Tc= 36ºC)

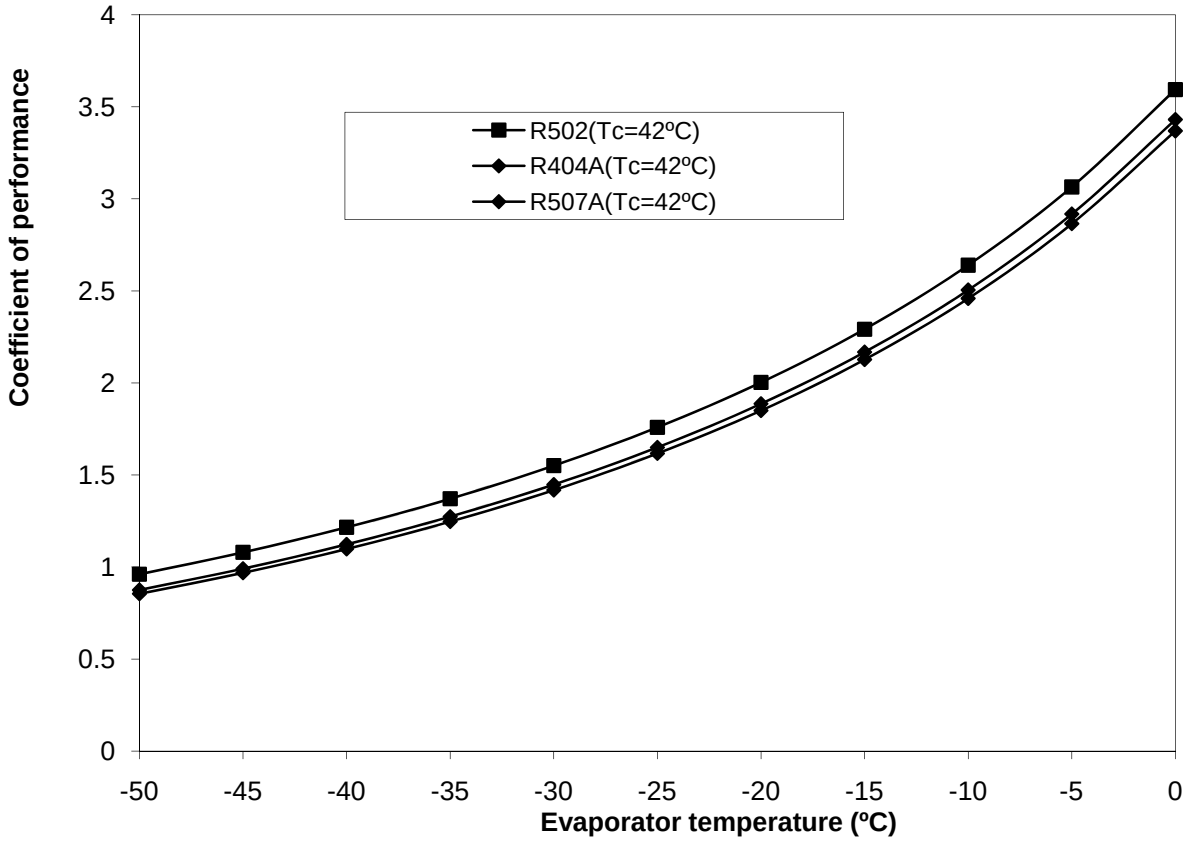

Figure 26.Comparison of coefficient of performance with varying evaporator temperature (Tc= 42ºC)

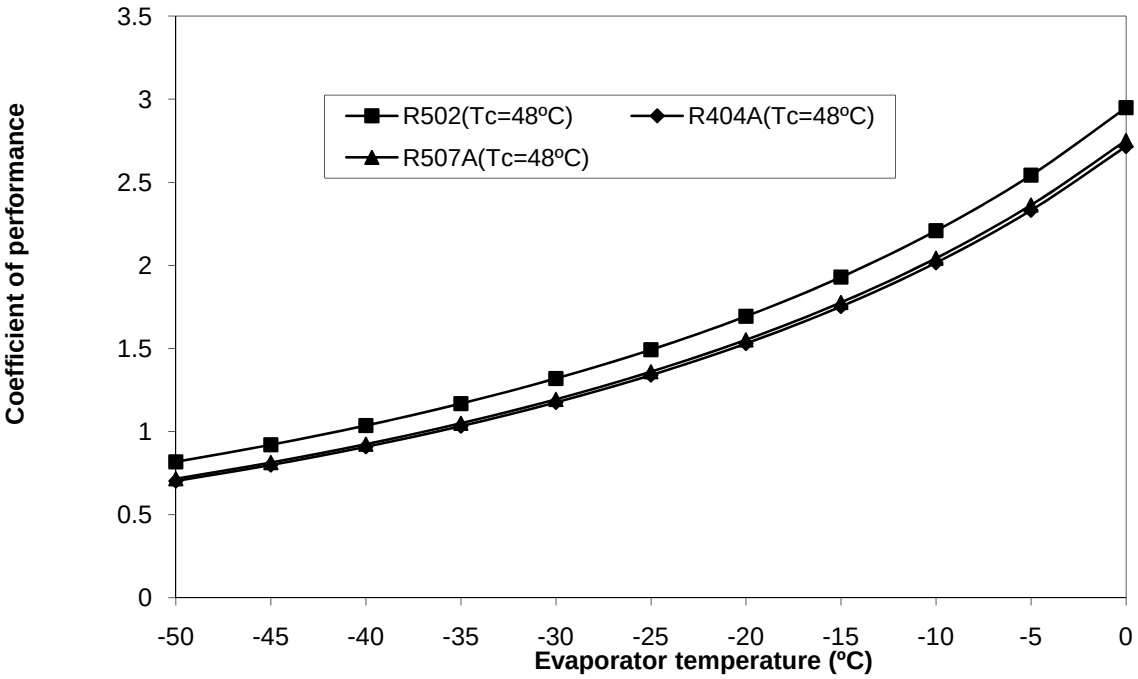

Figure 27.Comparison of coefficient of performance with varying evaporator temperature (Tc= 48ºC)

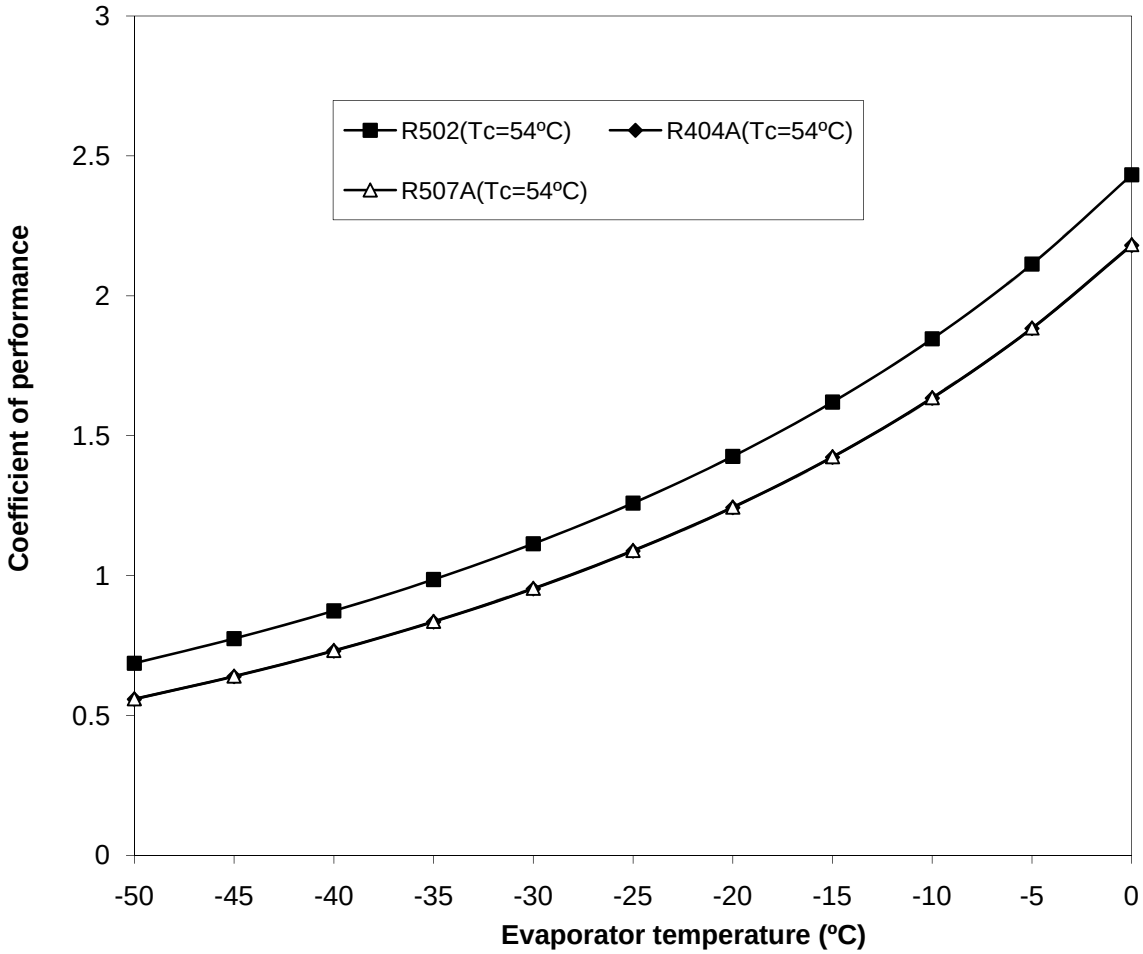

Figure 28.Comparison of coefficient of performance with varying evaporator temperature (Tc= 54ºC)

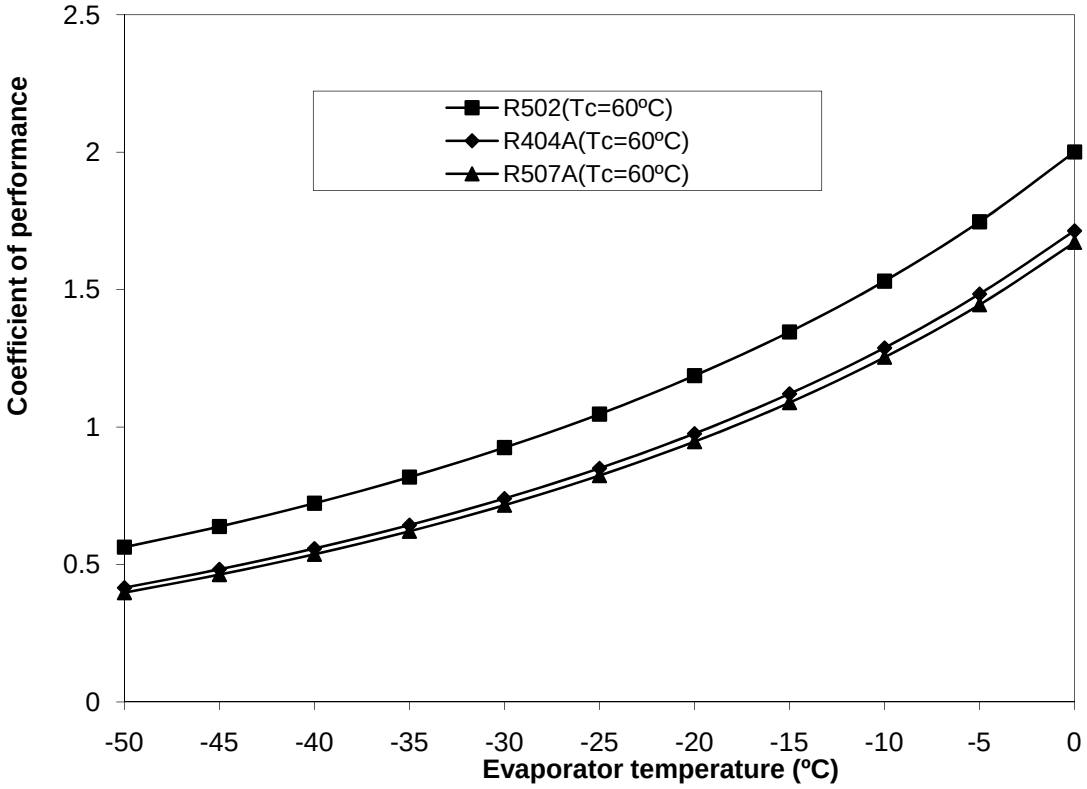

Figure 29.Comparison of coefficient of performance with varying evaporator temperature (Tc= 60ºC)

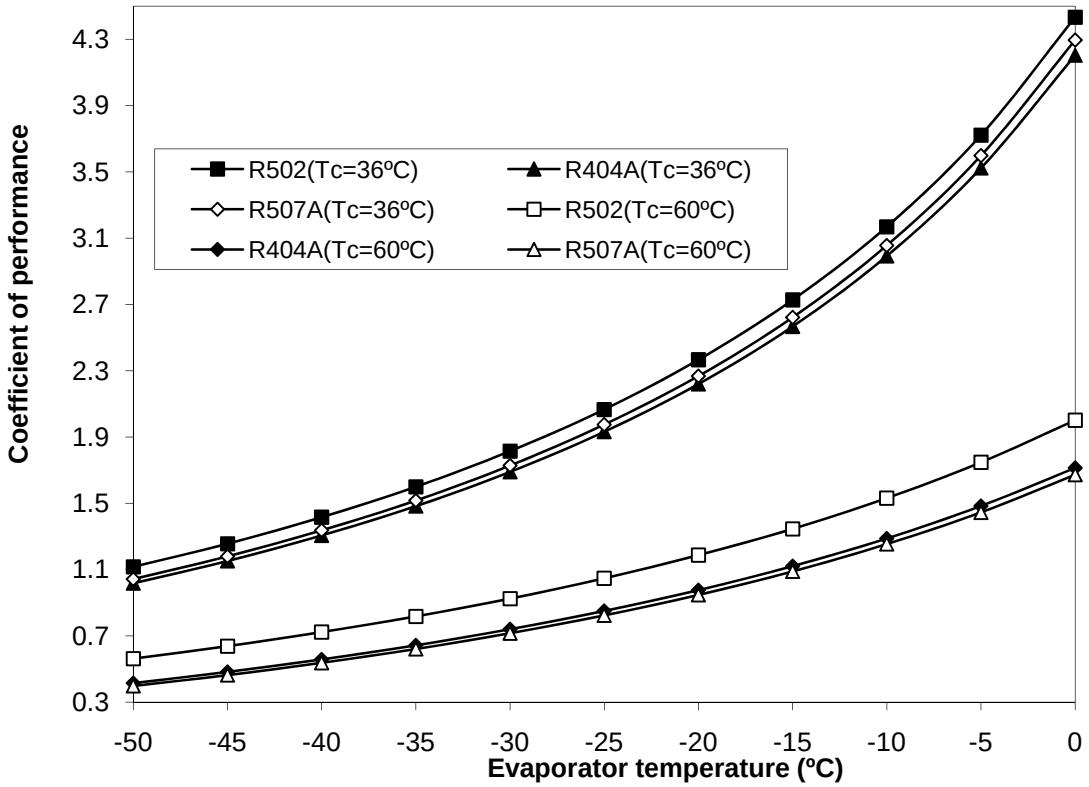

Figure 29A. Comparison of coefficient of performance with varying evaporator and condenser temperature

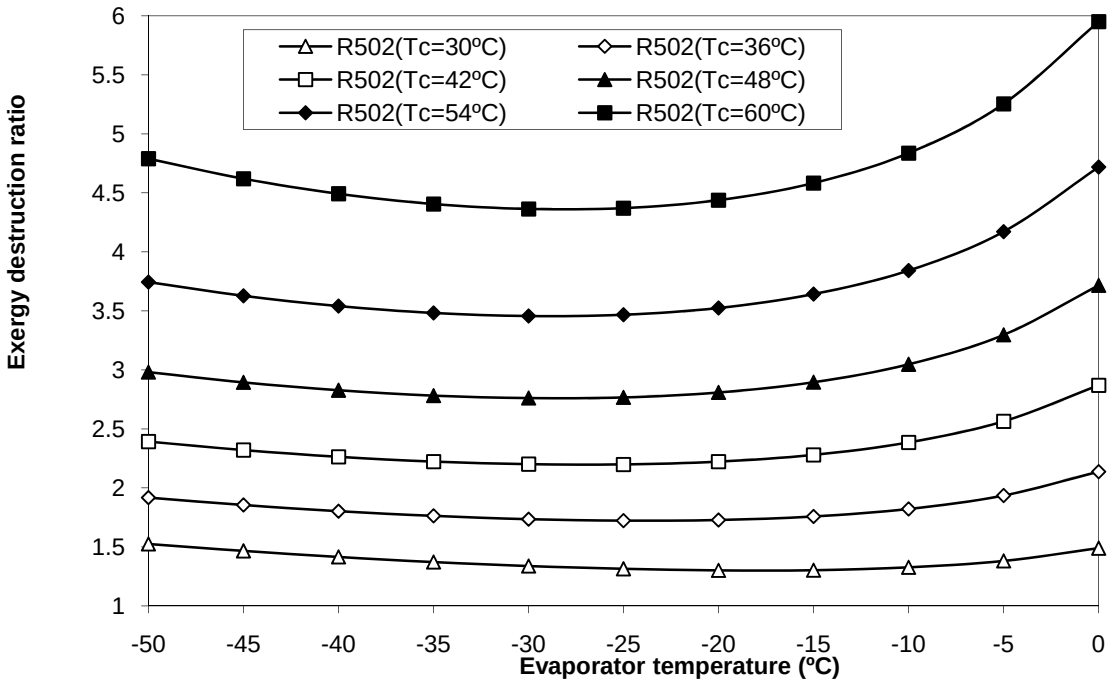

Figure 30. Variation of exergy destruction ratio with varying evaporator temperature (R-502)

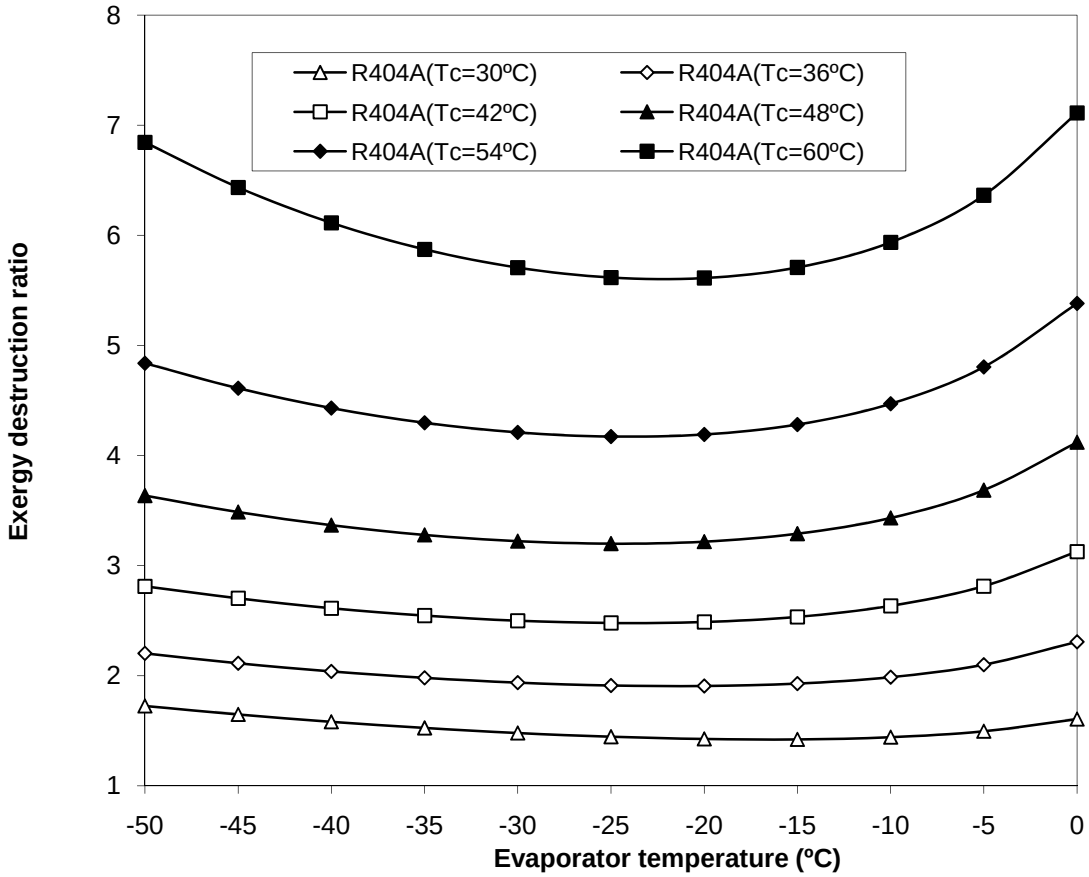

Figure 31. Variation of exergy destruction ratio with varying evaporator temperature (R-404A)

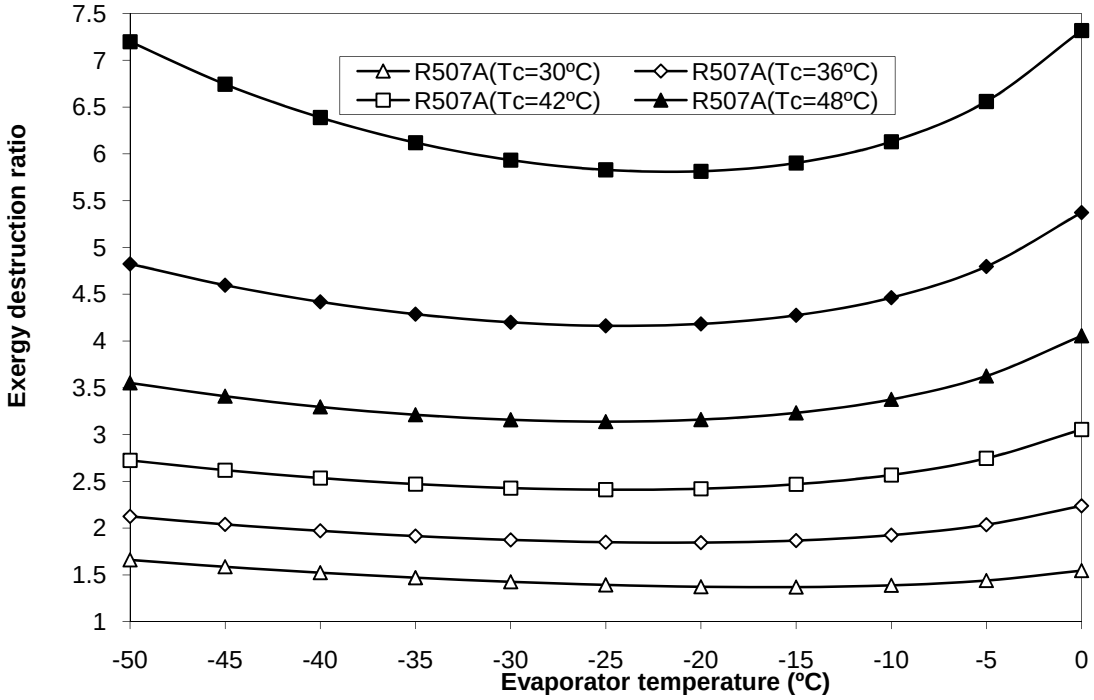

Figure 32. Variation exergy destruction ratio with varying evaporator temperature (R-507A)

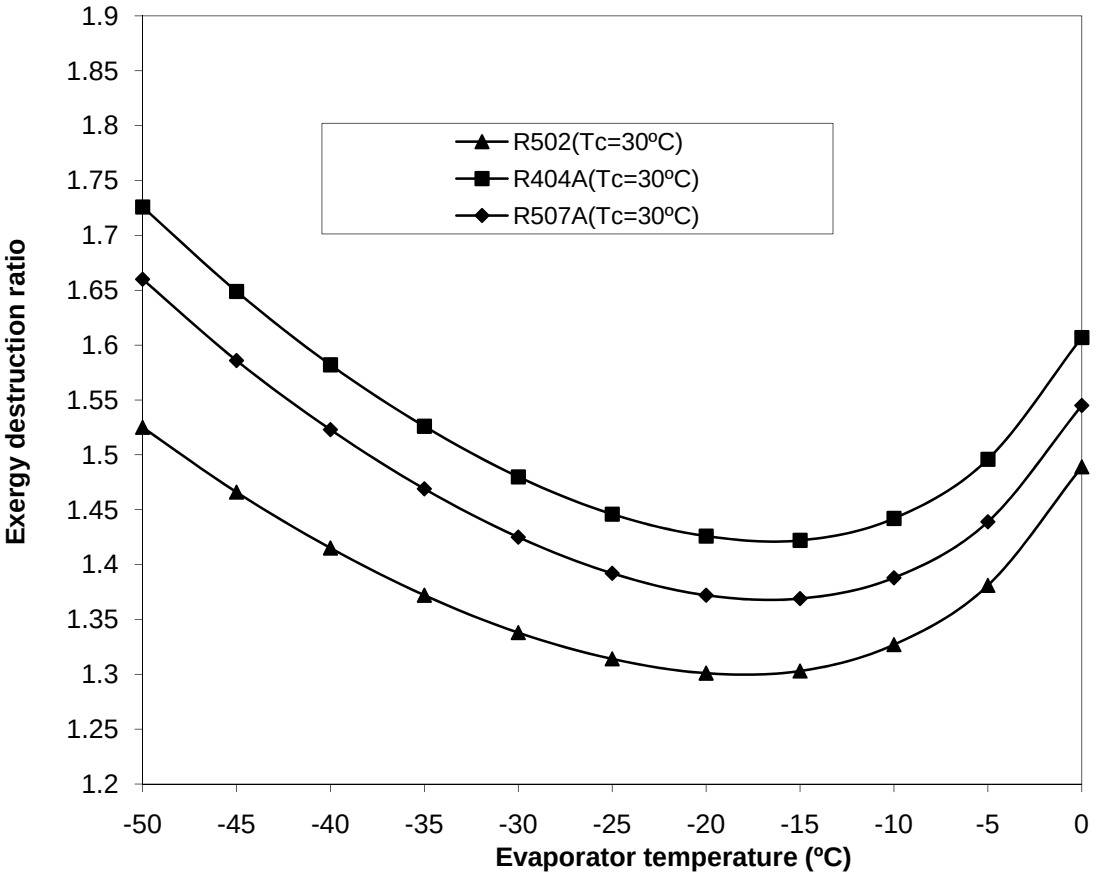

Figure 33.Comparison of exergy destruction ratio with varying evaporator temperature (Tc= 30ºC)

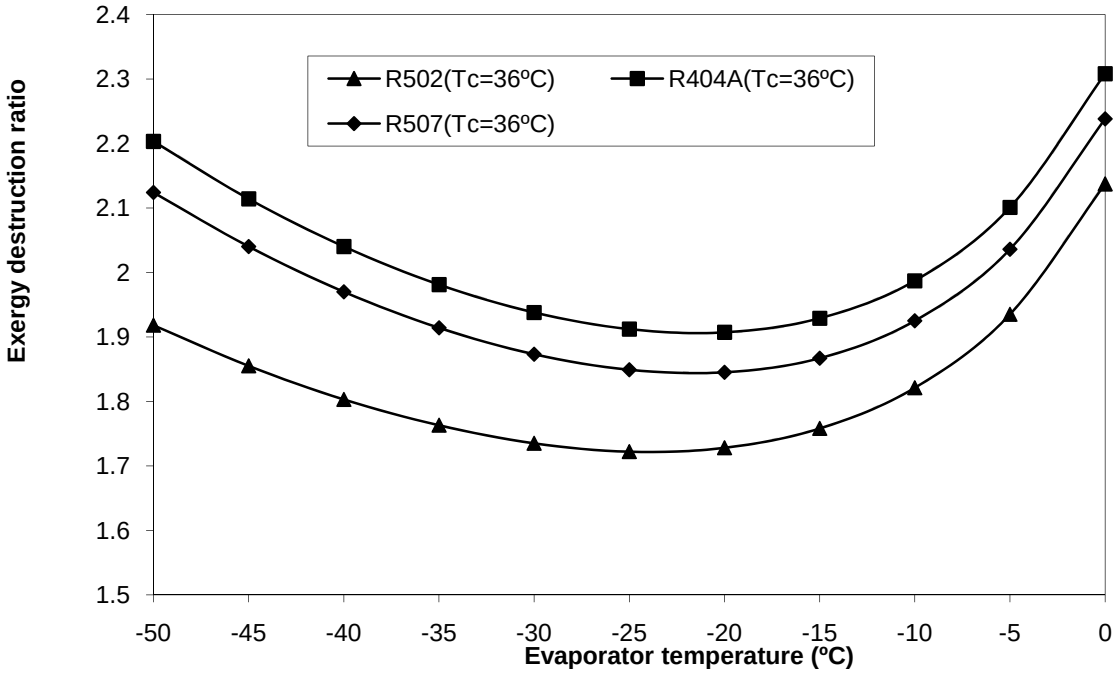

Figure 34.Comparison of exergy destruction ratio with varying evaporator temperature (Tc= 36ºC)

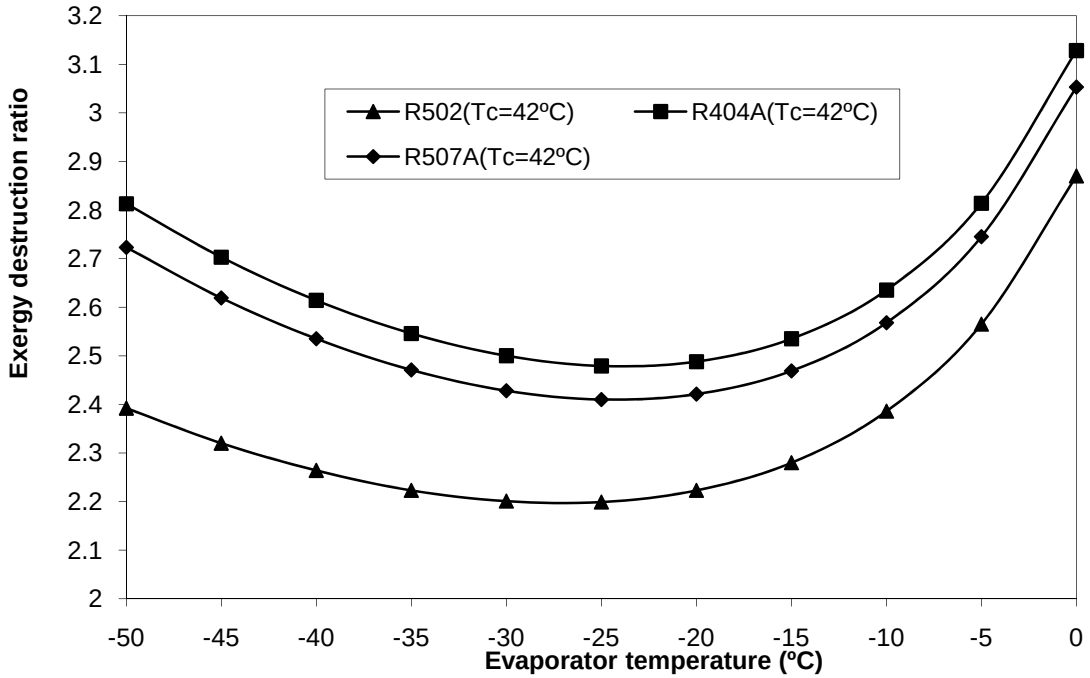

Figure 35.Comparison of exergy destruction ratio with varying evaporator temperature (Tc= 42ºC)

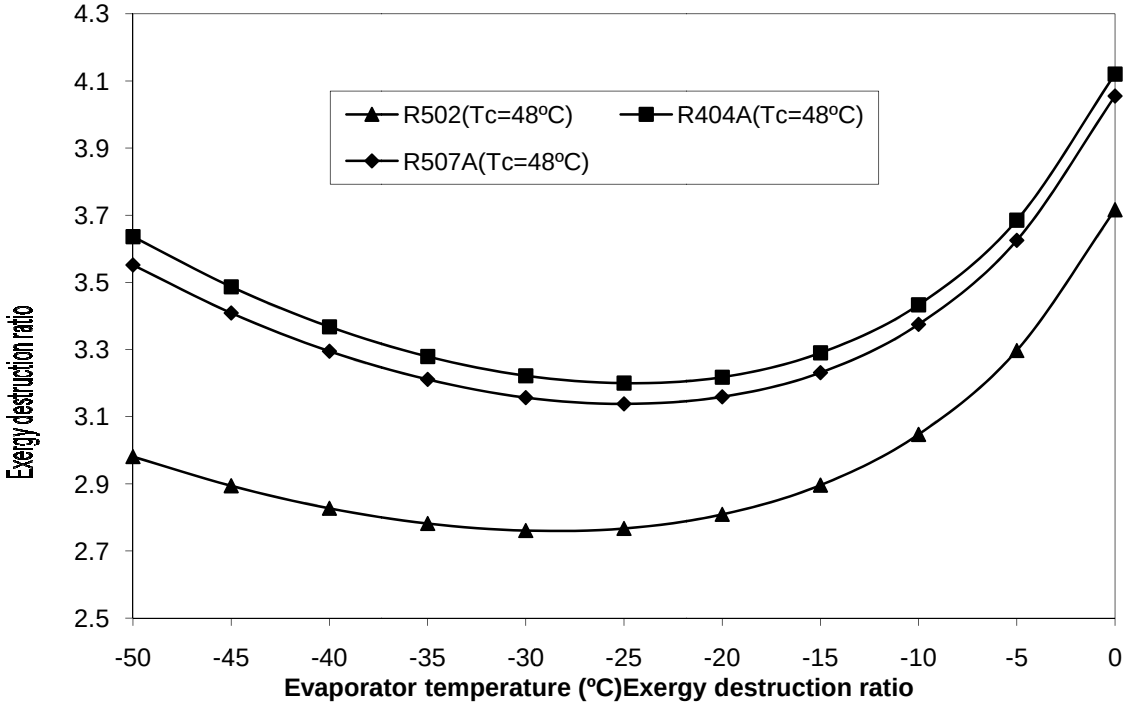

Figure 36.Comparison of exergy destruction ratio with varying evaporator temperature (Tc= 48ºC)

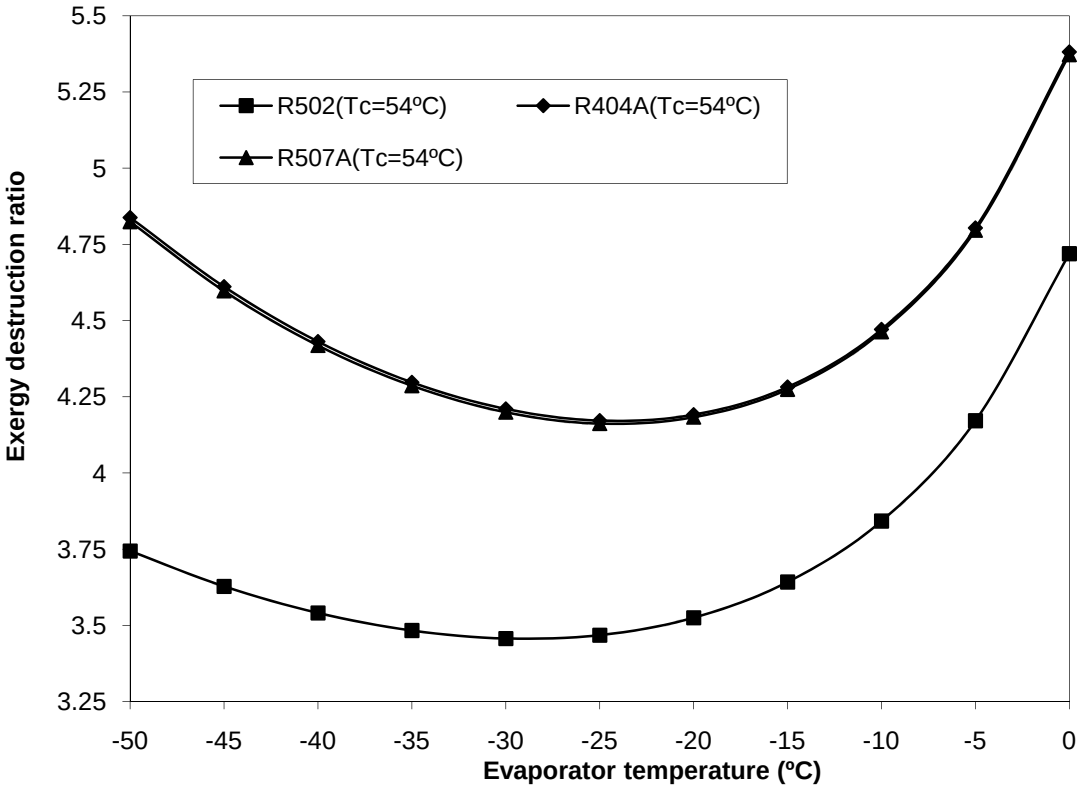

Figure 37.Comparison of exergy destruction ratio with varying evaporator temperature (Tc= 54ºC)

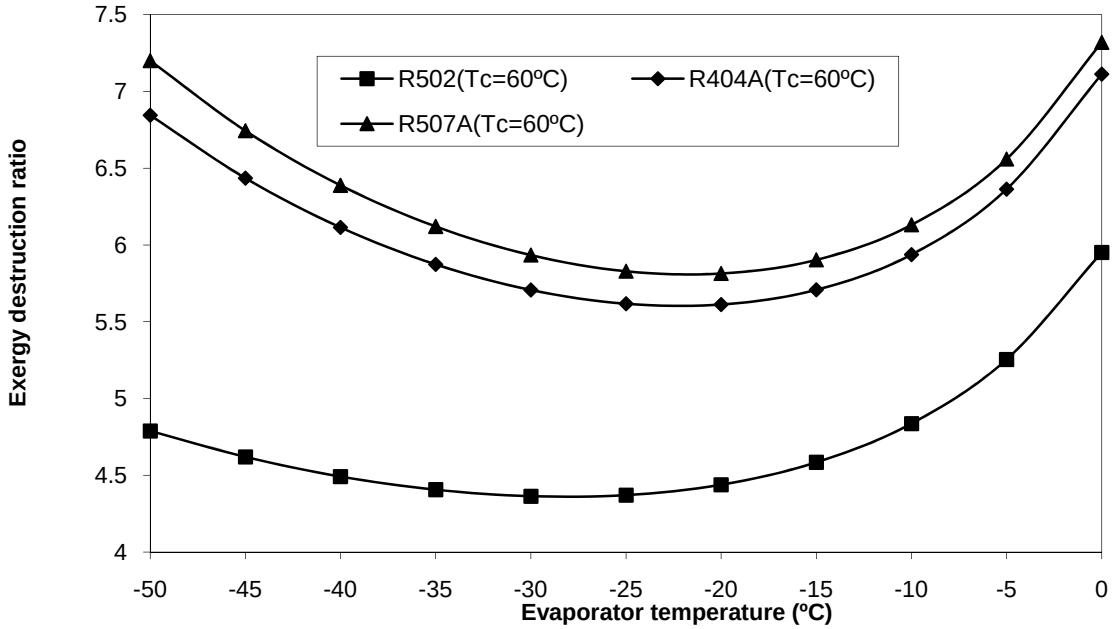

Figure 38.Comparison of exergy destruction ratio with varying evaporator temperature (Tc= 60ºC)

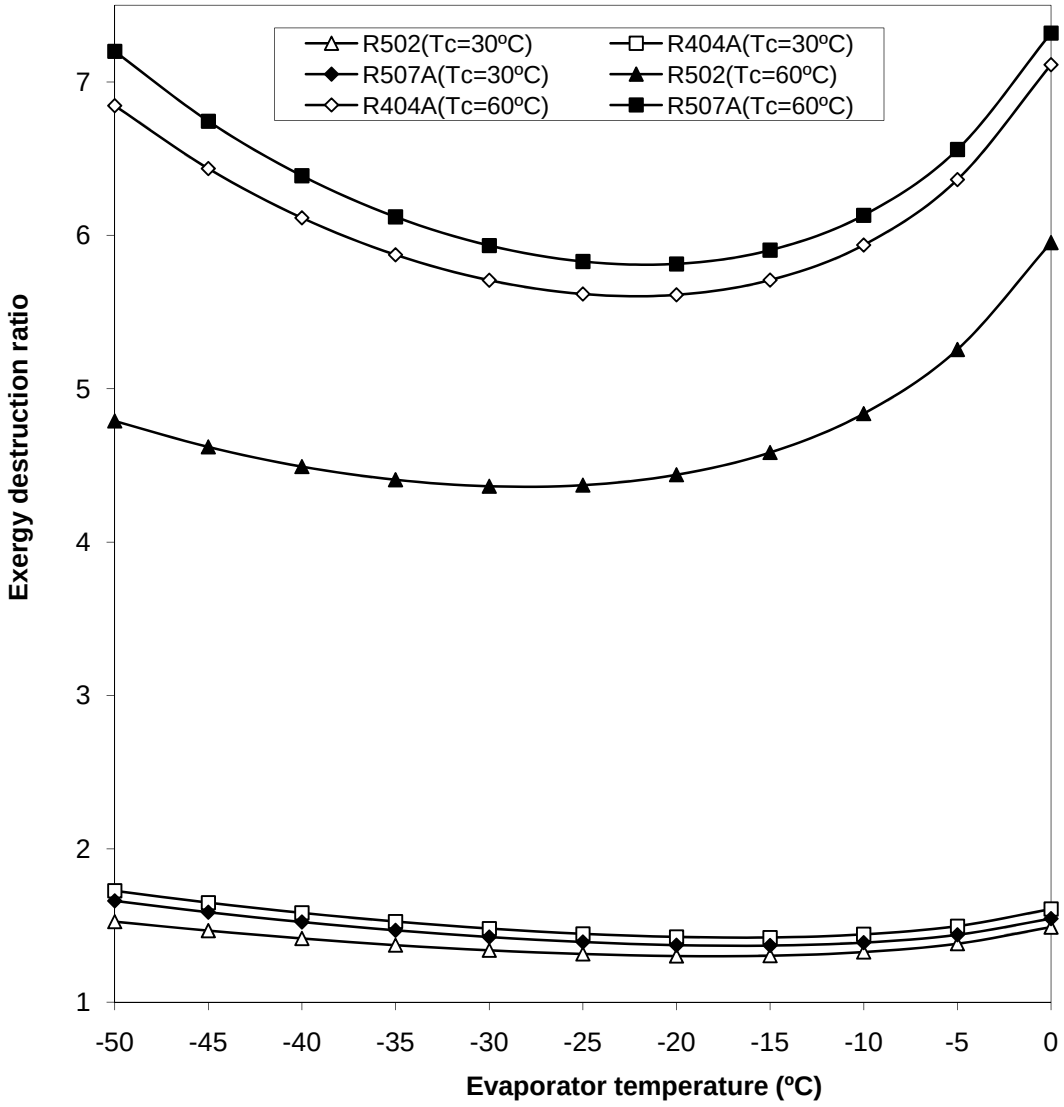

Figure 38a. Comparison of exergy destruction ratio with varying evaporator temperature and condenser temperature (ºC)

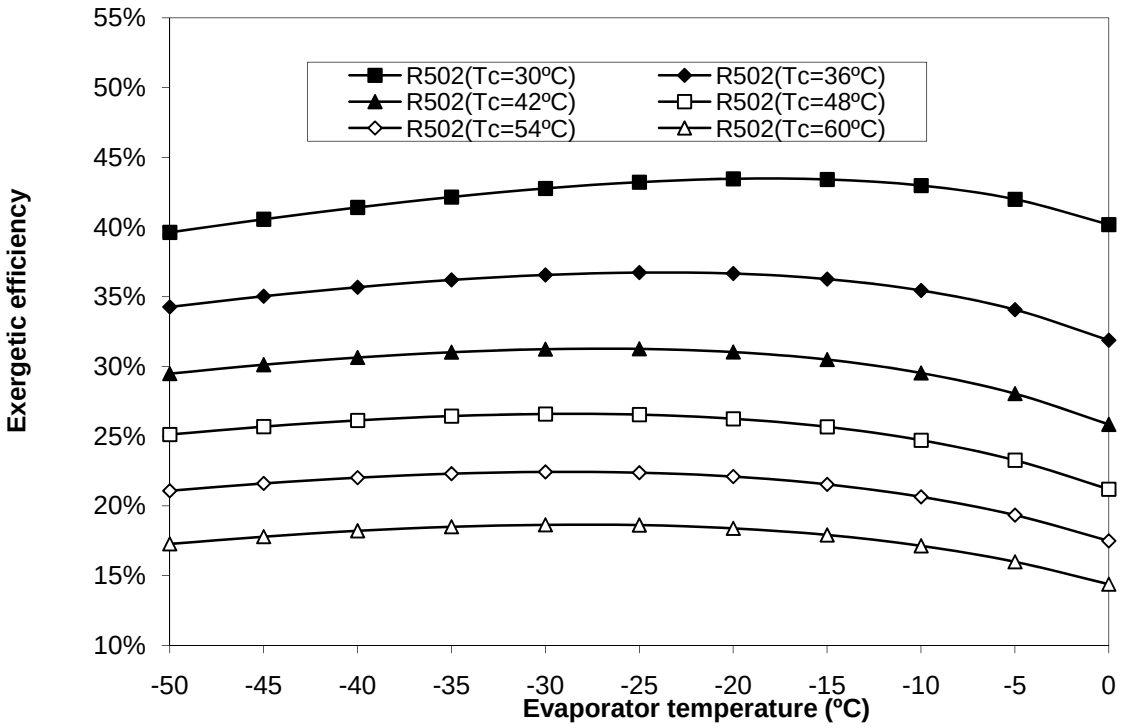

Figure 39. Variation of exergetic efficiency with varying evaporator temperature (R-502)

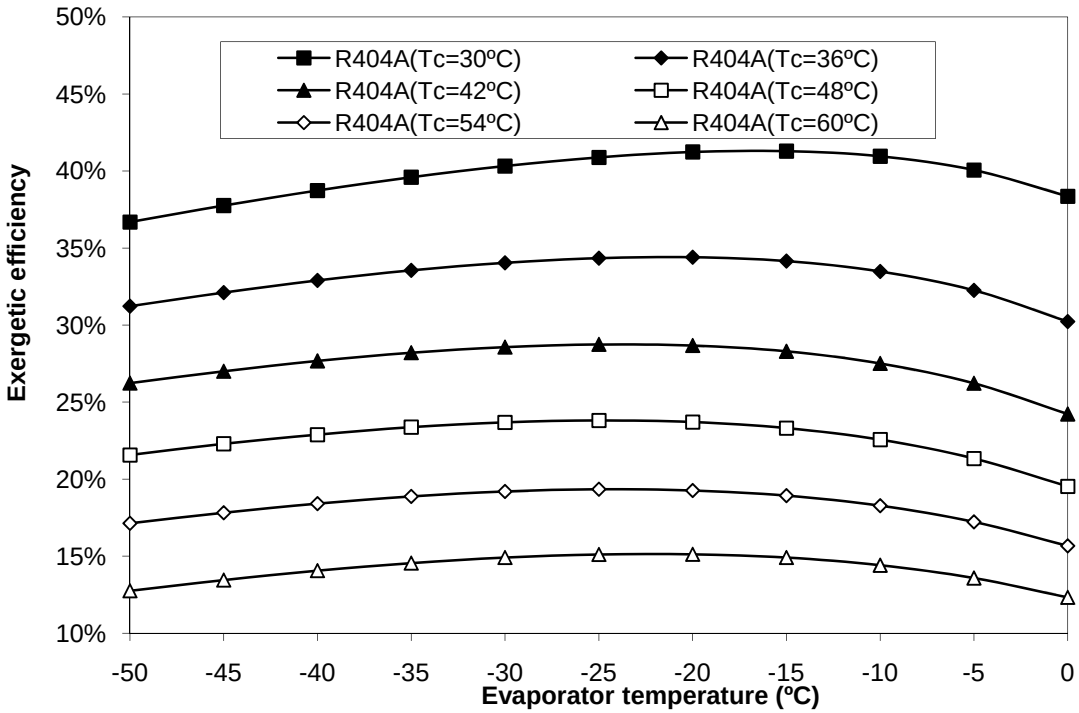

Figure 40. Variation of exergetic efficiency with varying evaporator temperature (R-404A)

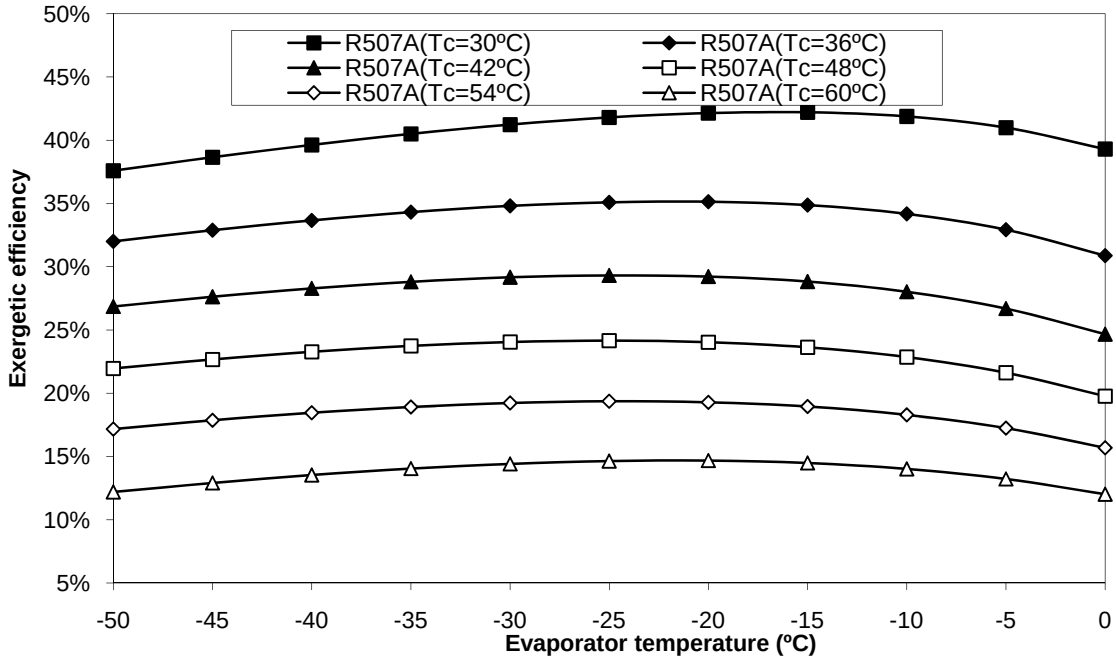

Figure 41. Variation of exergetic efficiency with varying evaporator temperature (R-507A)

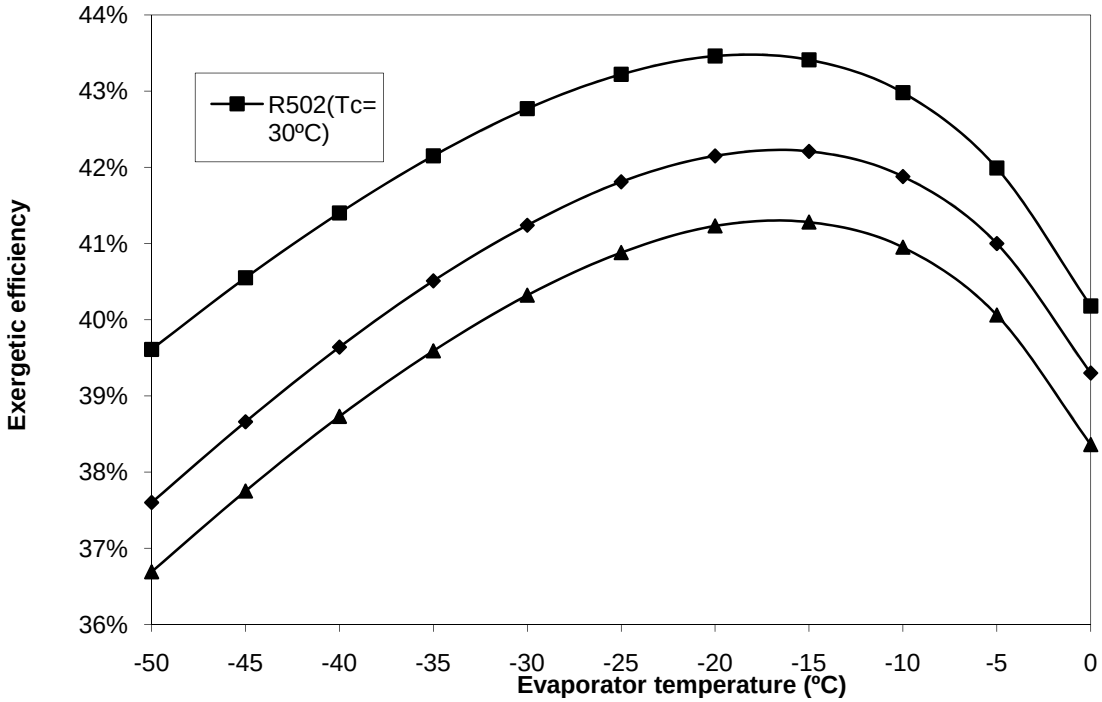

Figure 42.Comparison of exergetic efficiency with varying evaporator temperature (Tc= 30ºC)

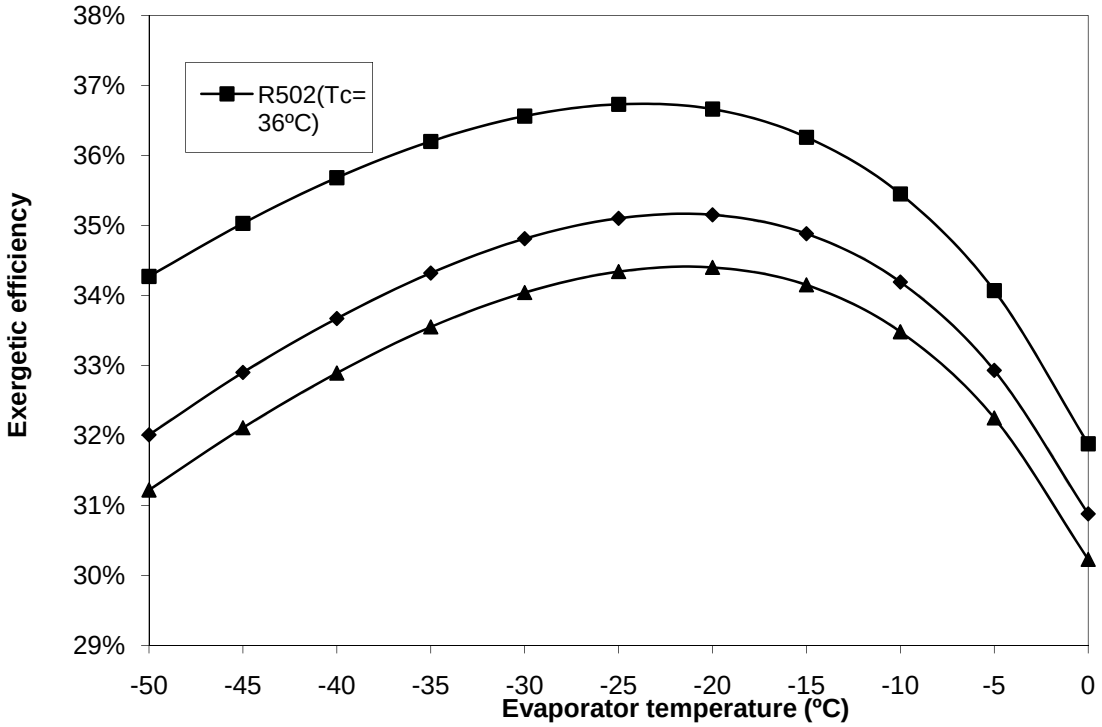

Figure 43.Comparison of exergetic efficiency with varying evaporator temperature (Tc= 36ºC)

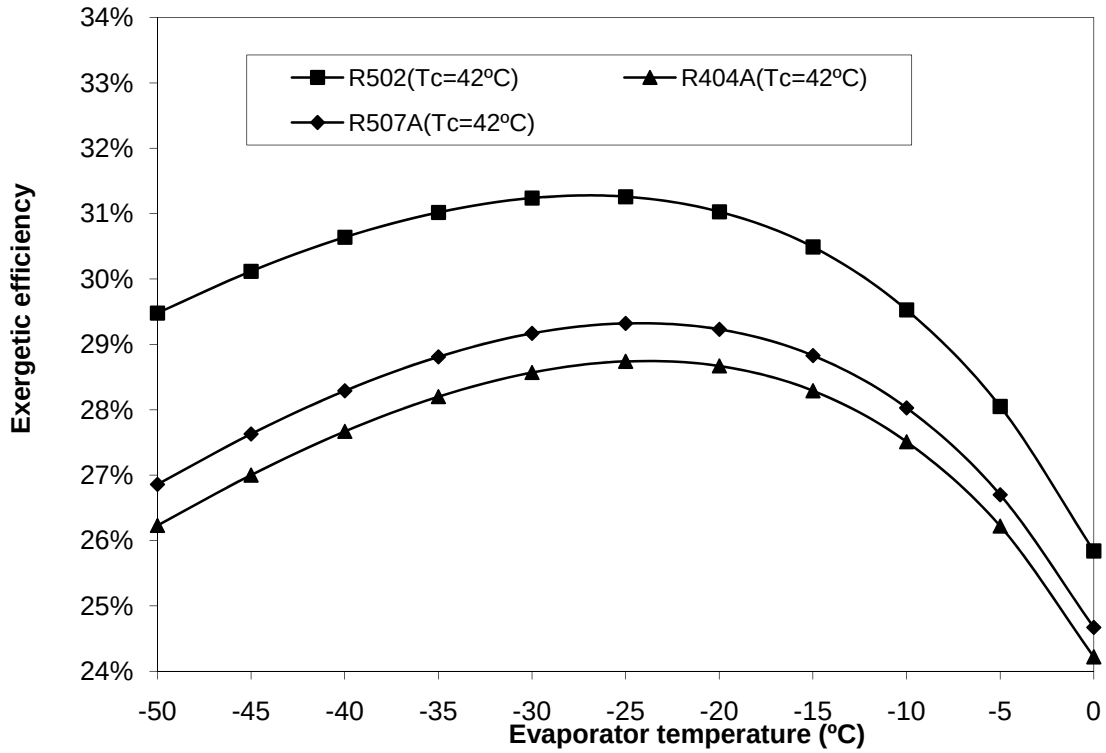

Figure 44.Comparison of exergetic efficiency with varying evaporator temperature (Tc= 42ºC)

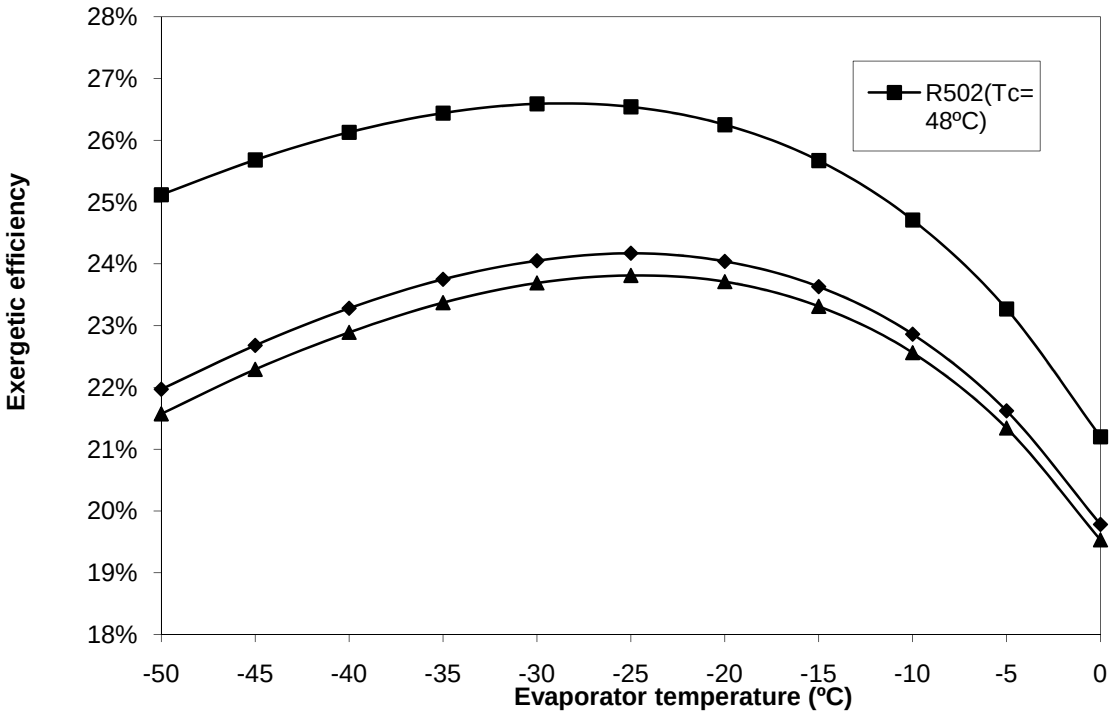

Figure 45.Comparison of exergetic efficiency with varying evaporator temperature (Tc= 48ºC)

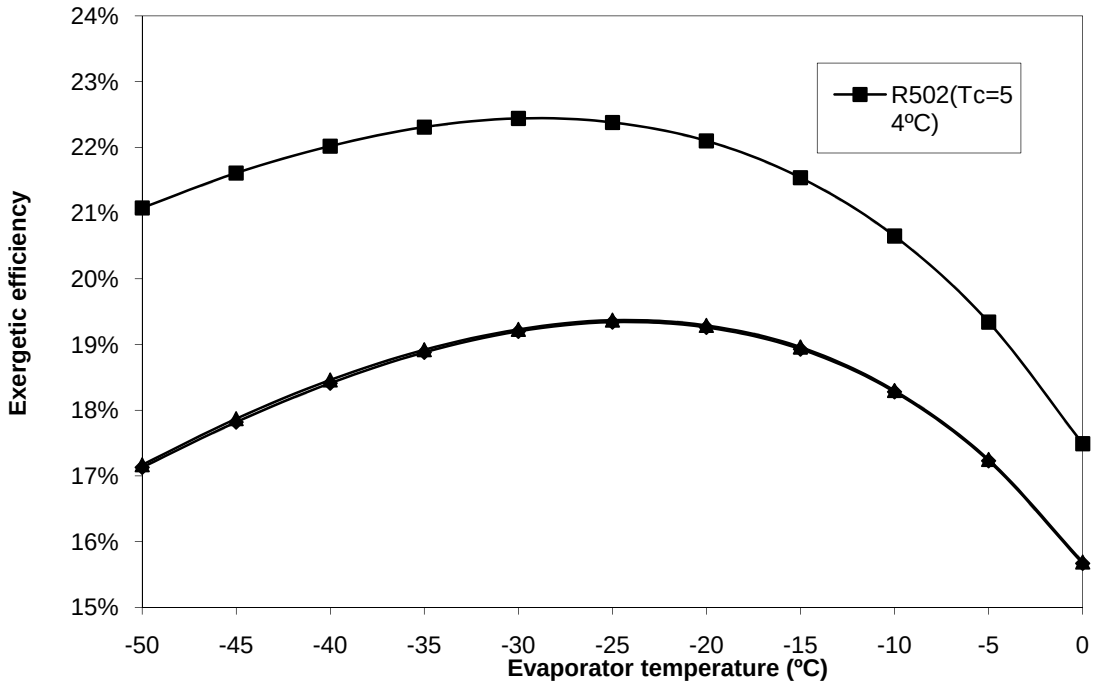

Figure 46.Comparison of exergetic efficiency with varying evaporator temperature (Tc= 54ºC)

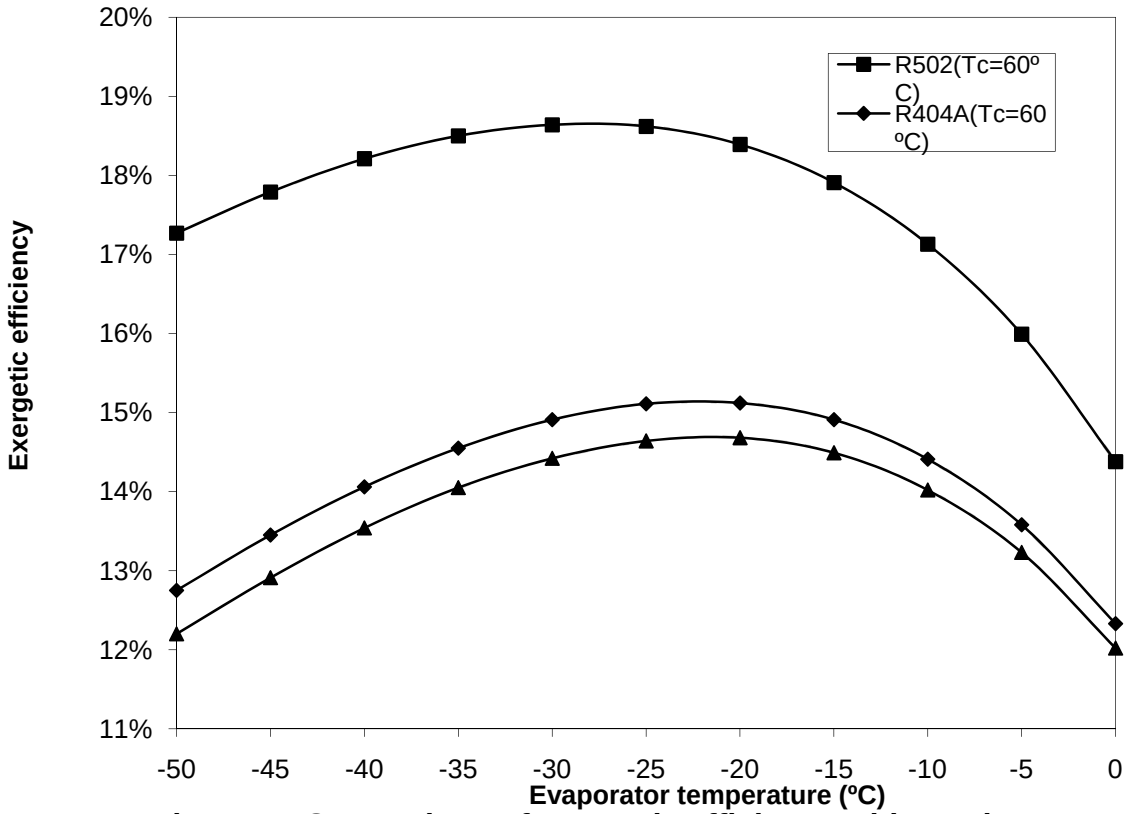

Figure 47.Comparison of exergetic efficiency with varying evaporator temperature (Tc= 60ºC)

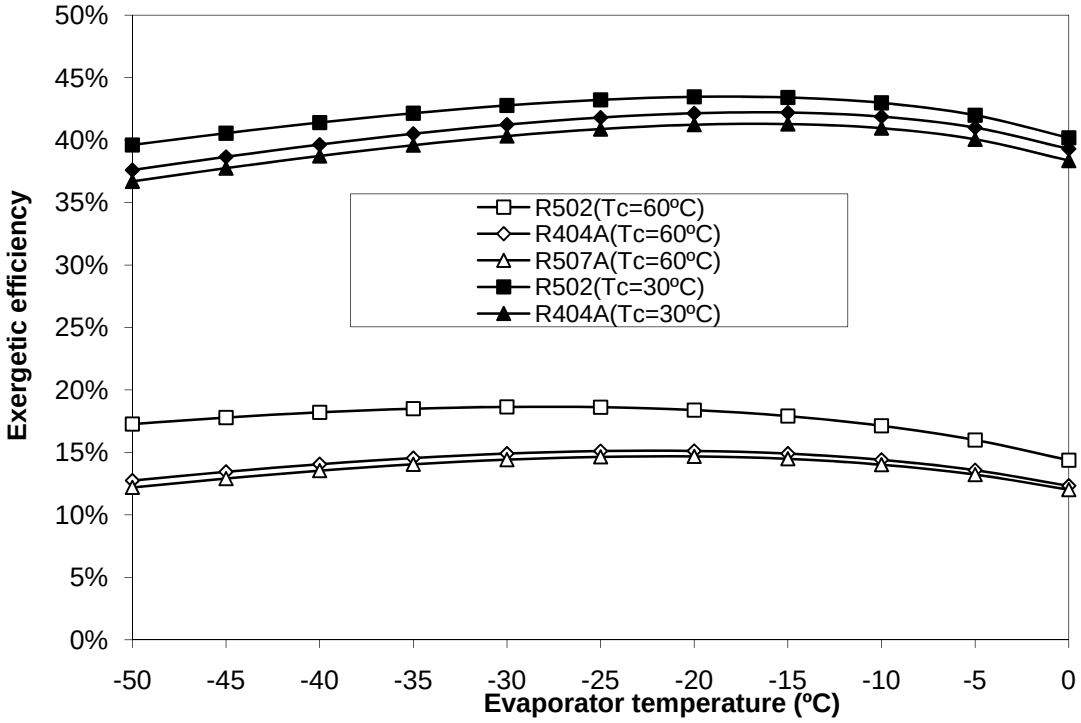

Figure 47a. Comparison of exergetic efficiency with varying evaporator temperature and condenser temperature (ºC)

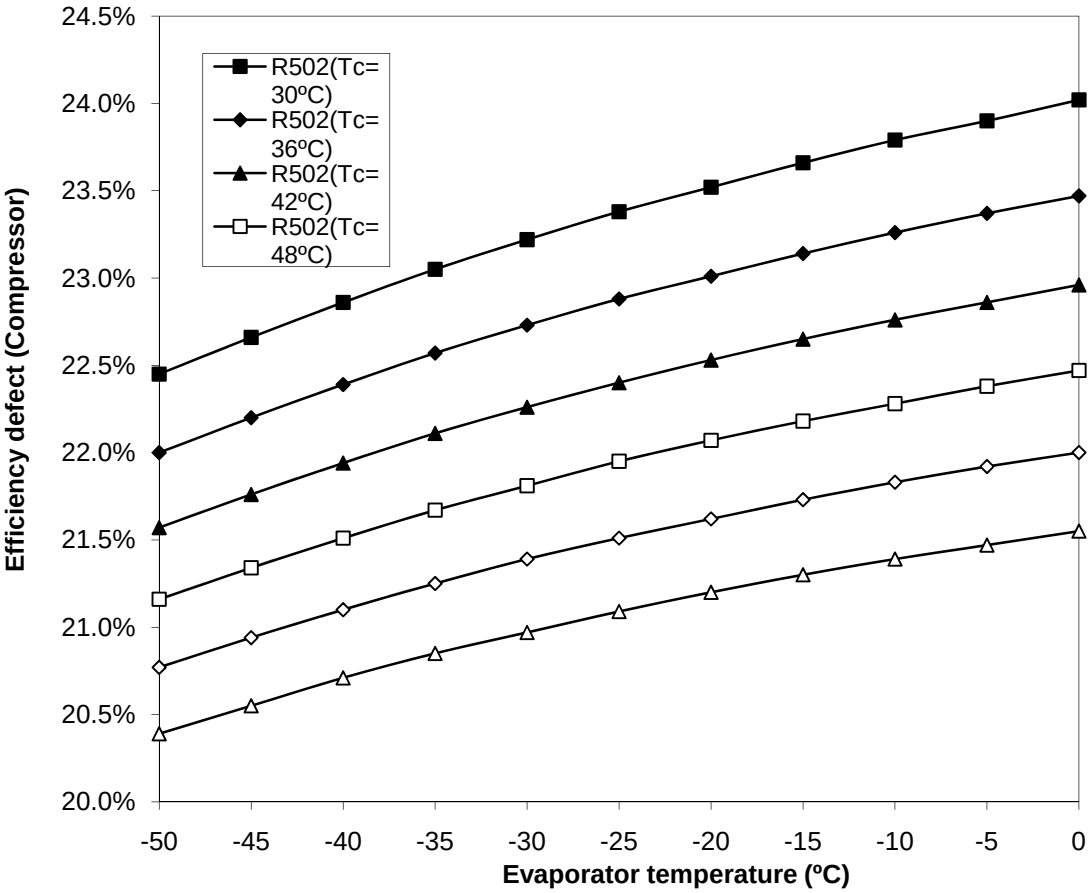

Figure 48. Effect of varying evaporator temperature on efficiency defect in compressor (R-502)

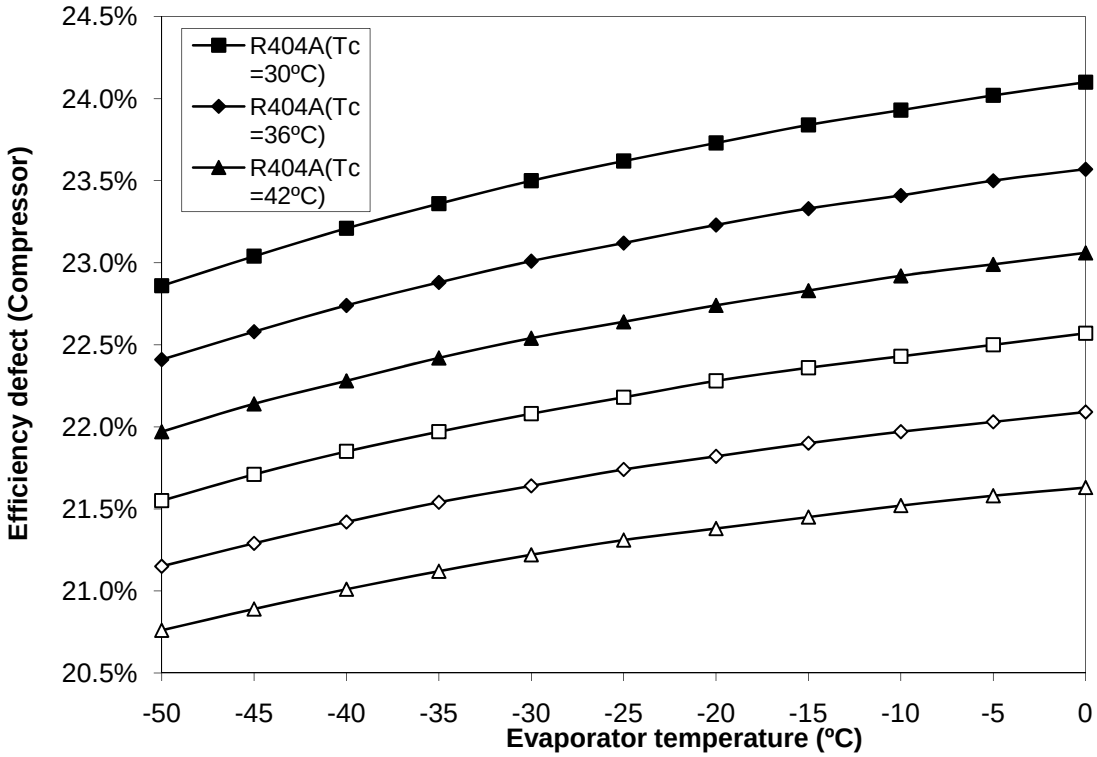

Figure 49. Effect of varying evaporator temperature on efficiency defect in compressor (R-404A)

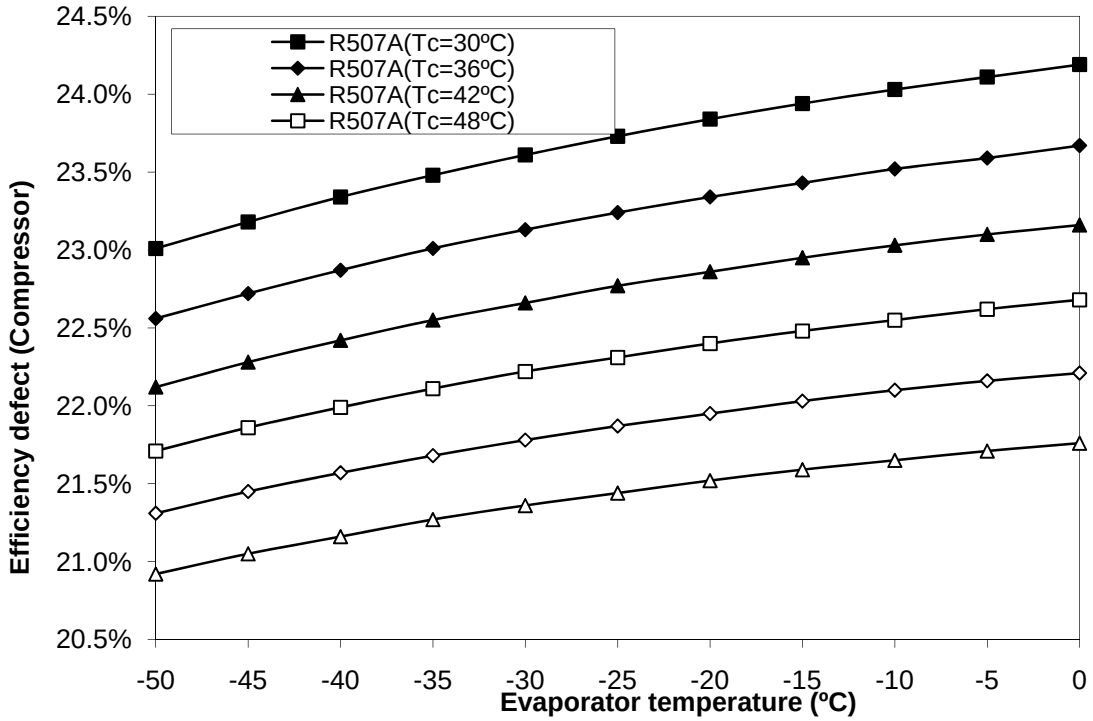

Figure 50. Effect of varying evaporator temperature on efficiency defect in compressor (R-507A)

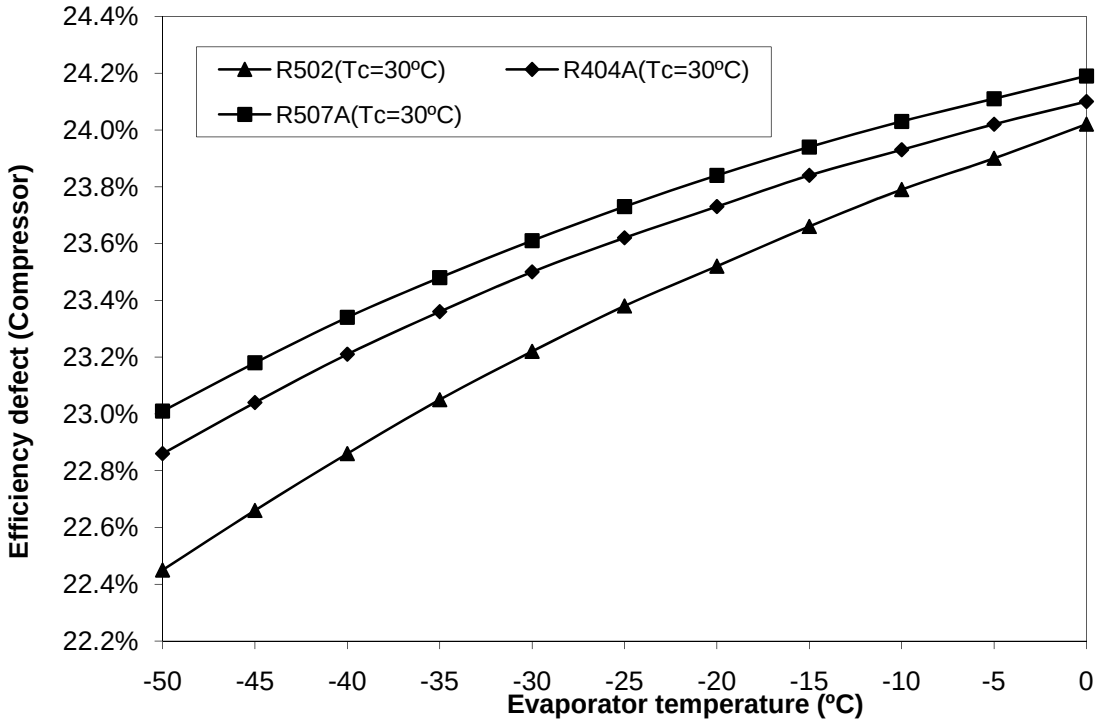

Figure 51.Comparison of efficiency defect in compressor with varying evaporator temperature (Tc= 30ºC)

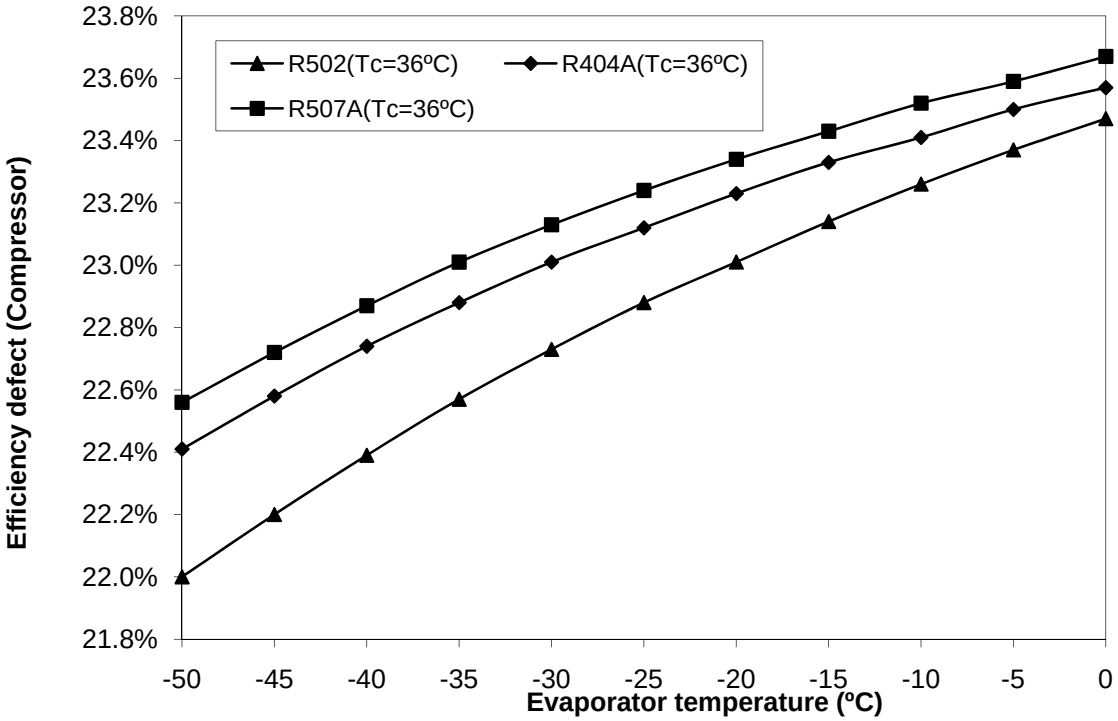

Figure 52.Comparison of efficiency defect in compressor with varying evaporator temperature (Tc= 36ºC)

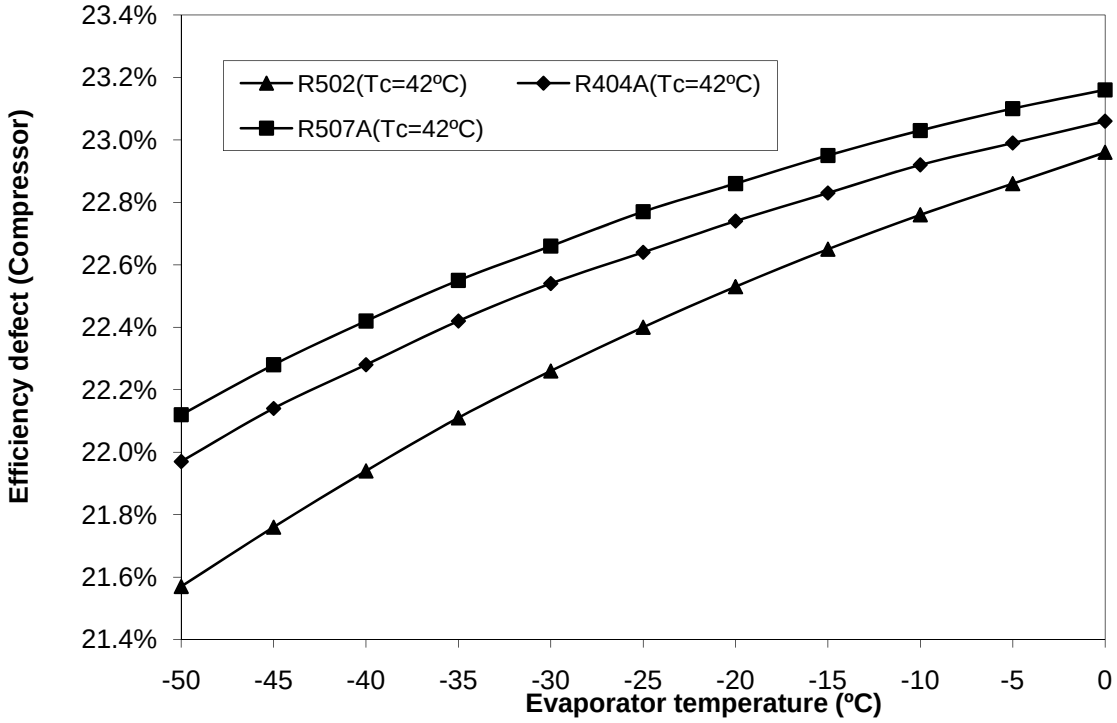

Figure 53.Comparison of efficiency defect in compressor with varying evaporator temperature (Tc= 42ºC)

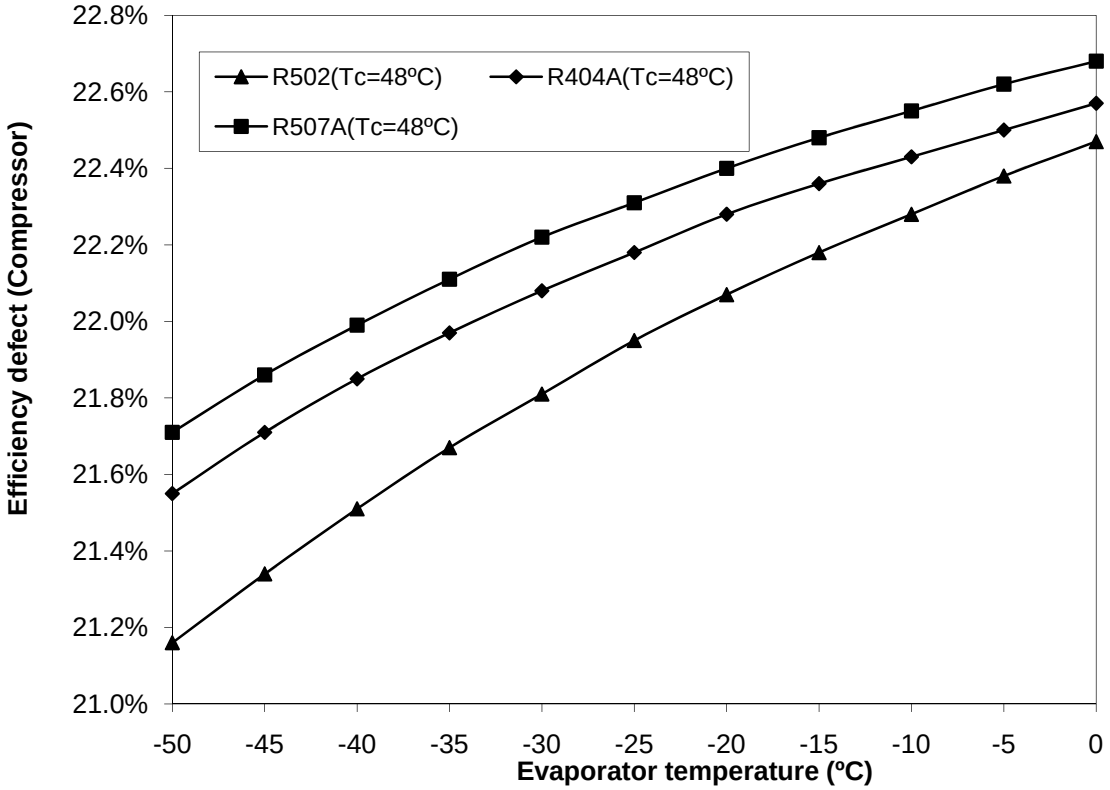

Figure 54.Comparison of efficiency defect in compressor with varying evaporator temperature (Tc= 48ºC)

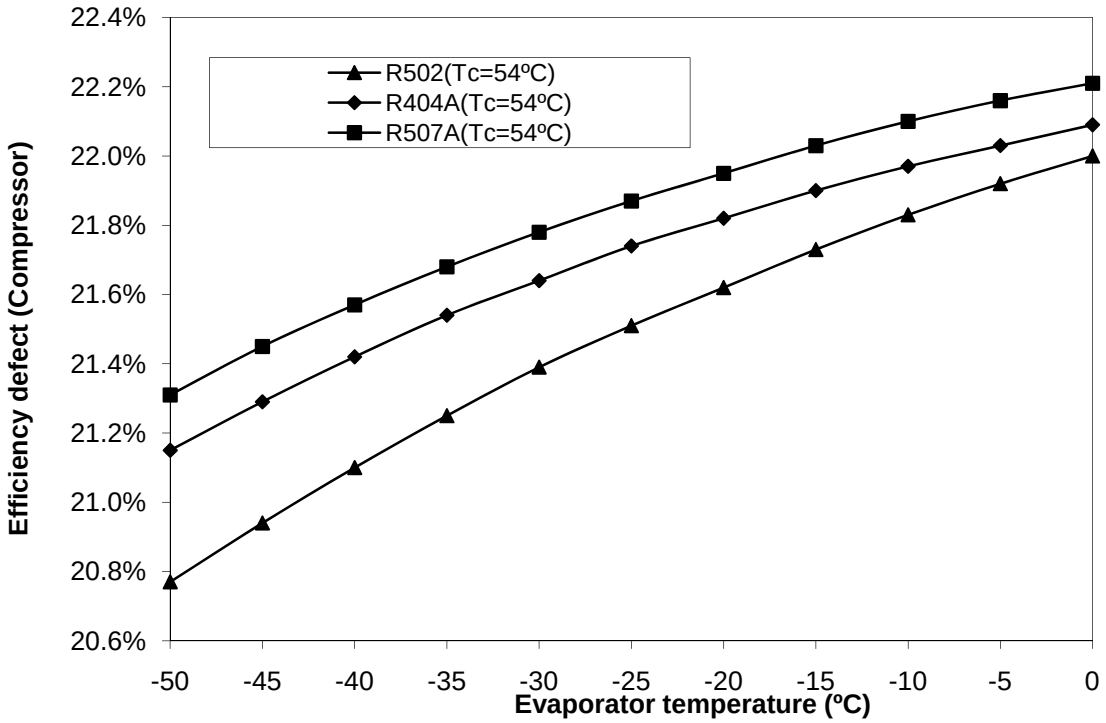

Figure 55.Comparison of efficiency defect in compressor with varying evaporator temperature (Tc= 54ºC)

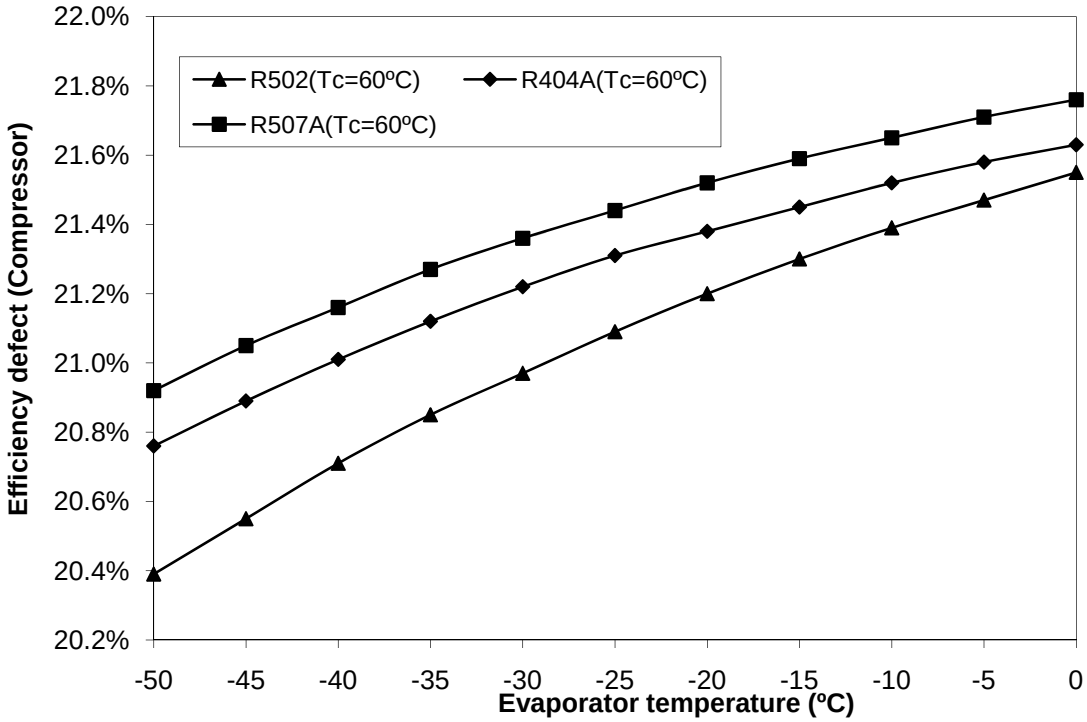

Figure 56.Comparison of efficiency defect in compressor with varying evaporator temperature (Tc= 60ºC)

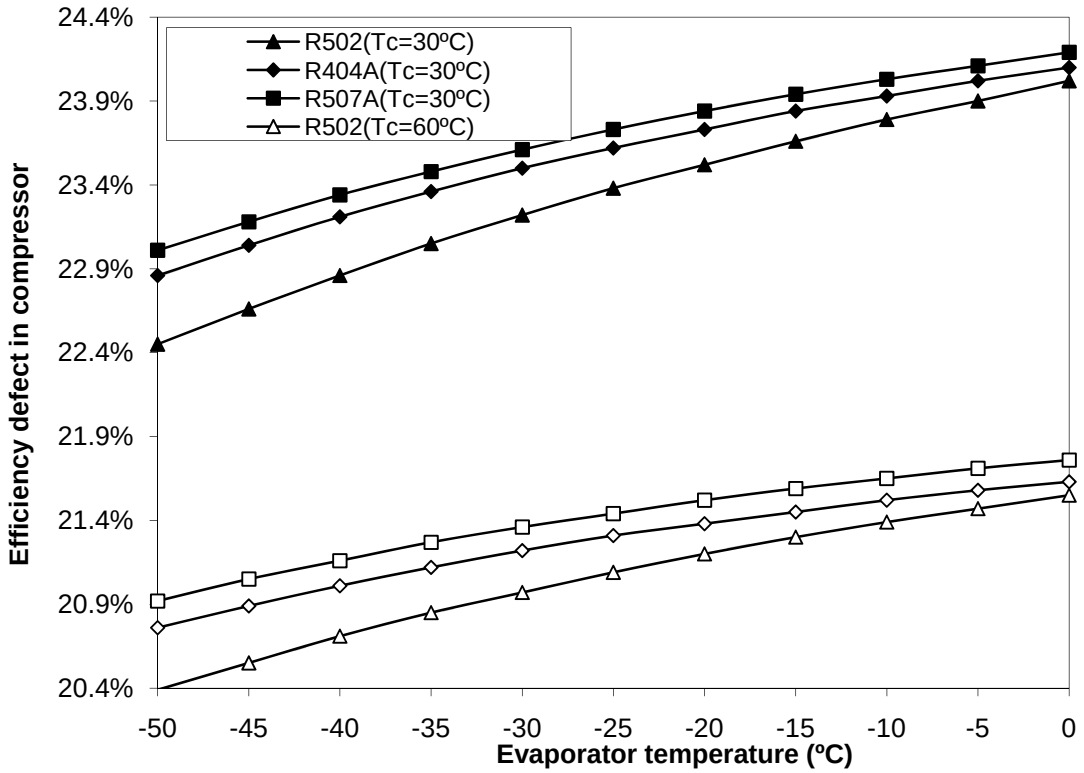

Figure 56a. Comparison of efficiency defect in compressor with varying evaporator temperature and condenser temperature (ºC)

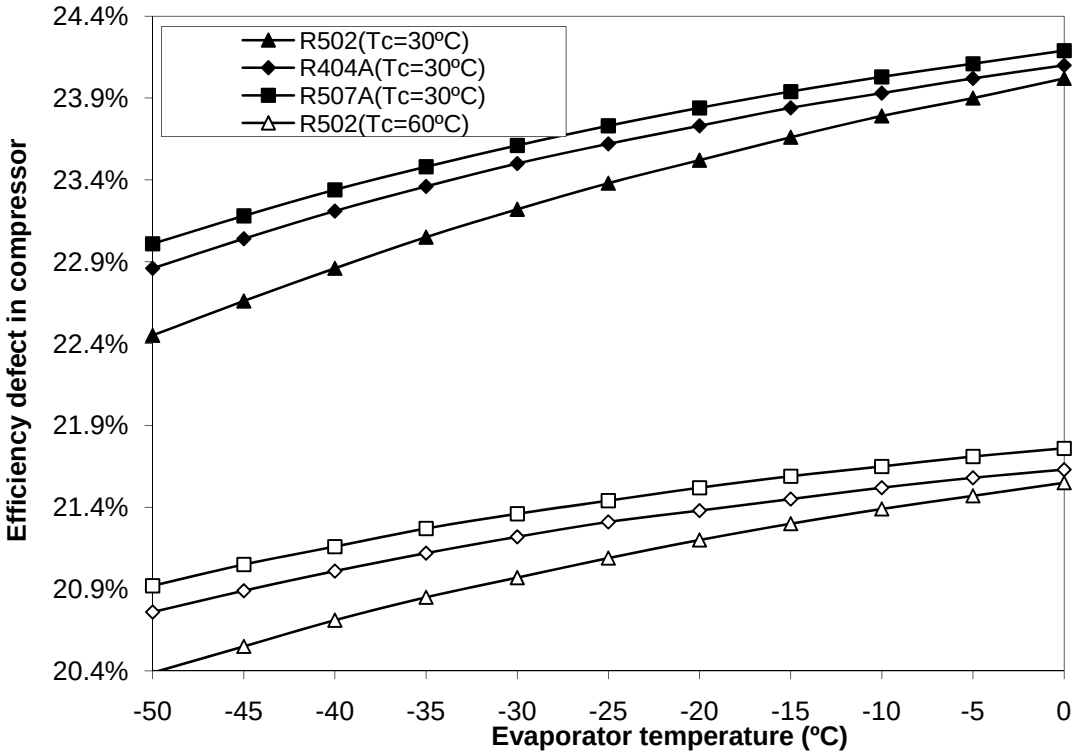

Figure 56a. Comparison of efficiency defect in compressor with varying evaporator temperature and condenser temperature (ºC)

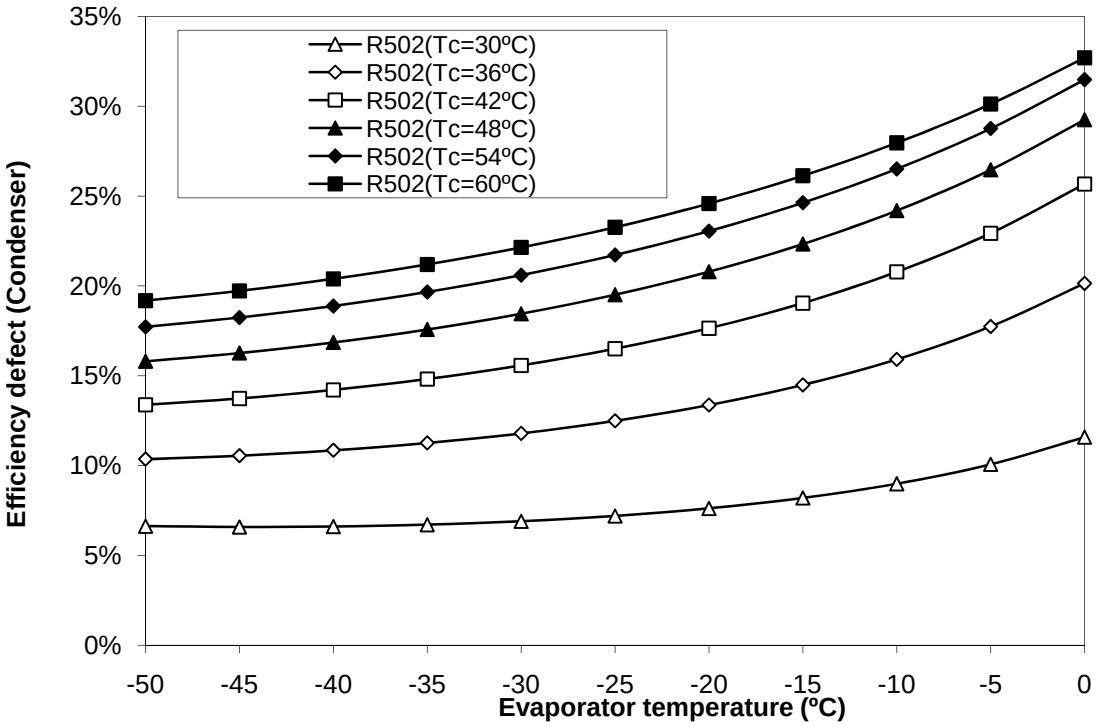

Figure 57. Effect of varying evaporator temperature on efficiency defect in condenser (R-502)

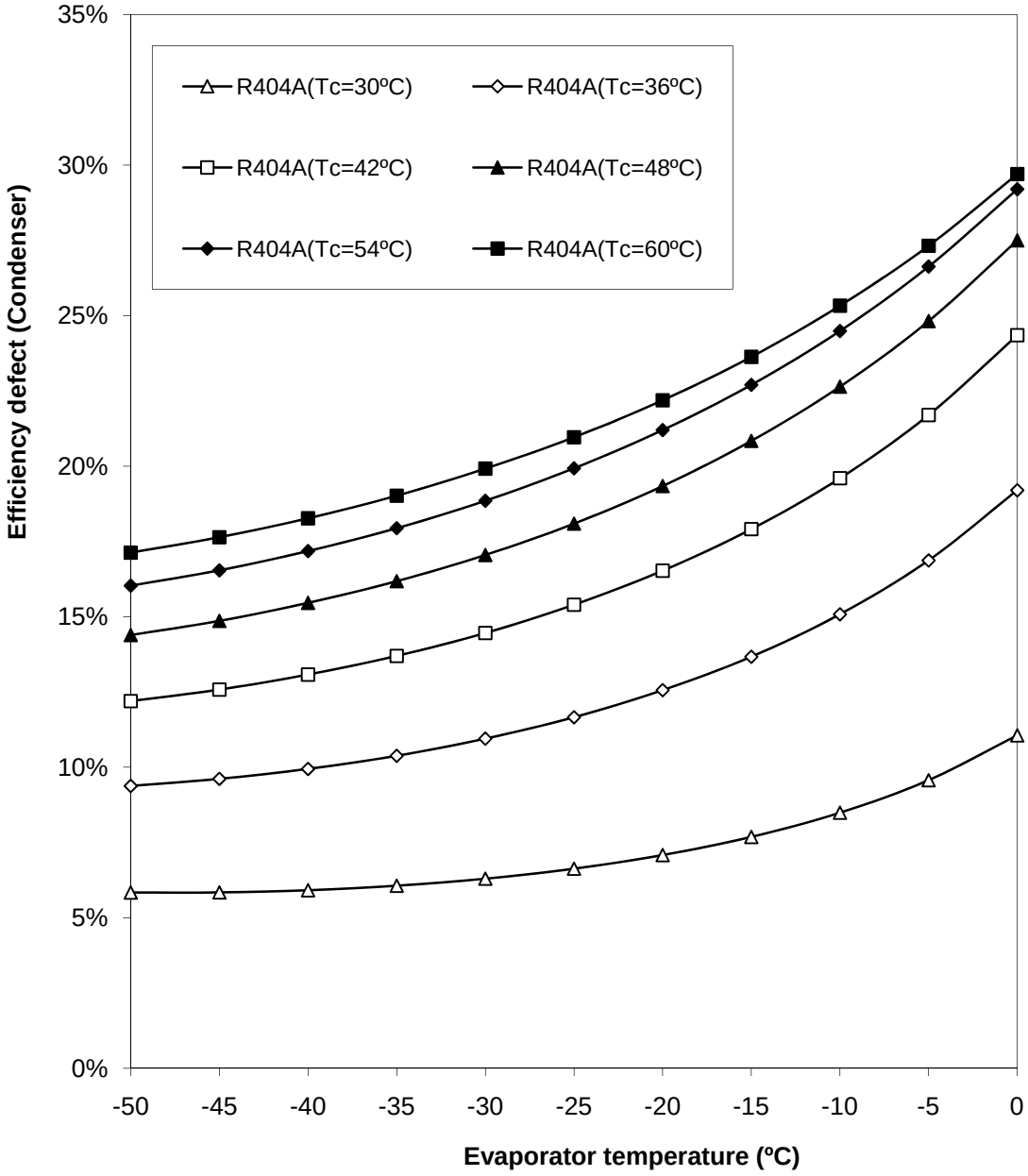

Figure 58. Effect of varying evaporator temperature on efficiency defect in condenser (R-404A)

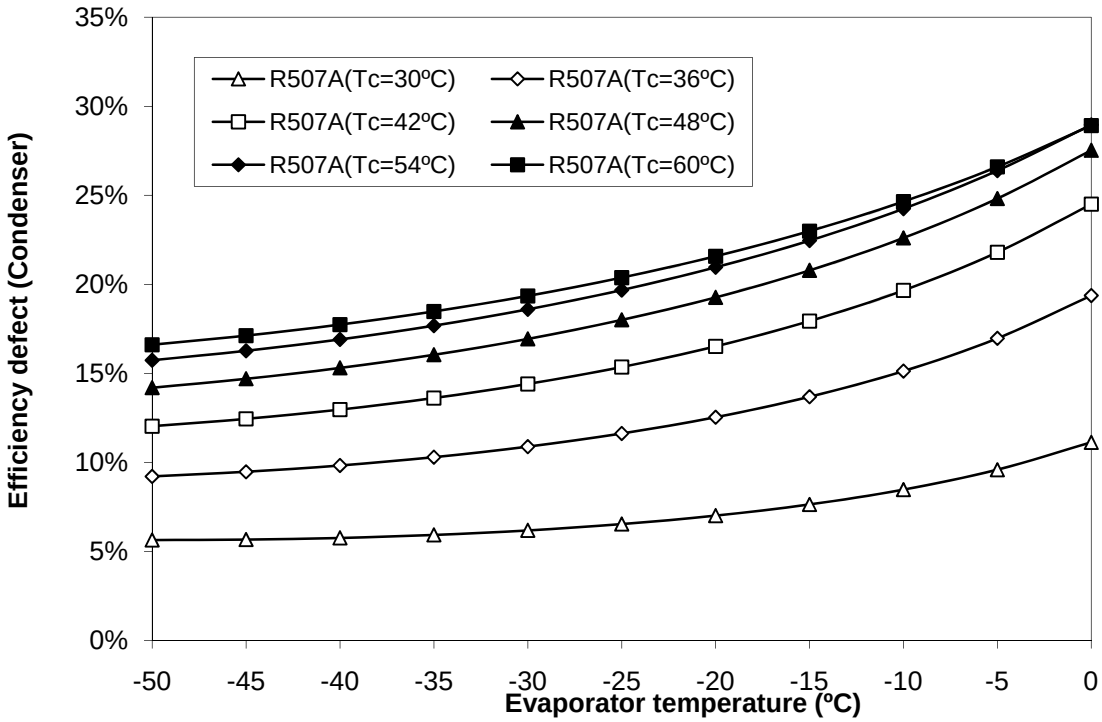

Figure 59. Effect of varying evaporator temperature on efficiency defect in condenser (R-507A)

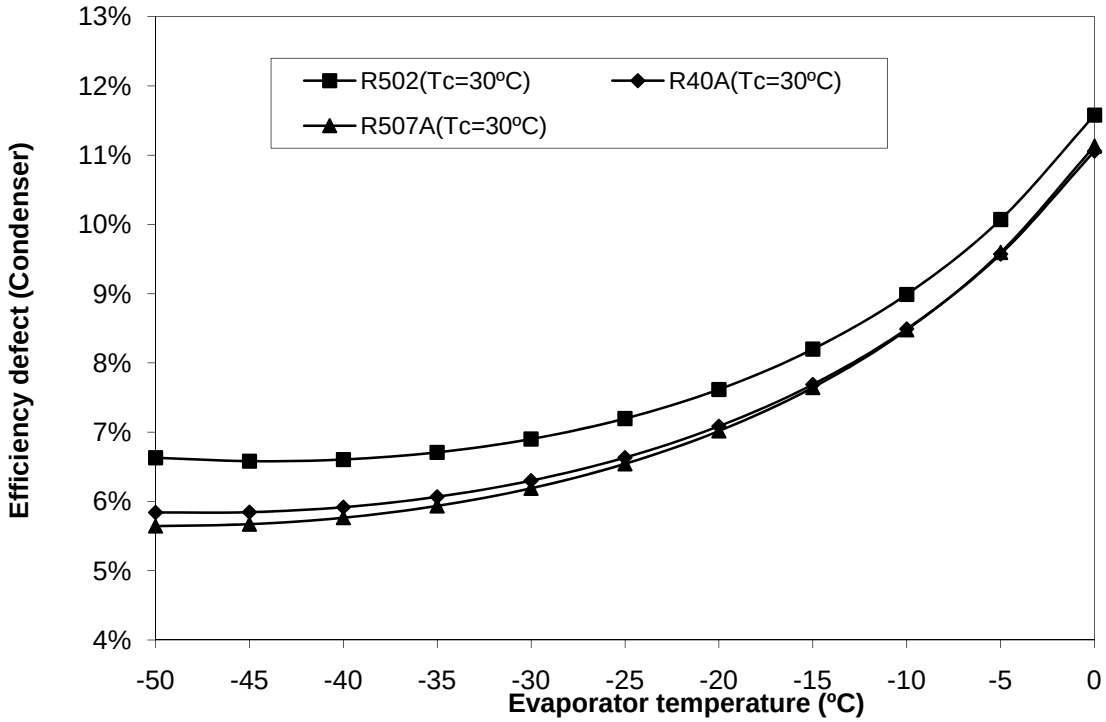

Figure 60.Comparison of efficiency defect in condenser with varying evaporator temperature (Tc= 30ºC)

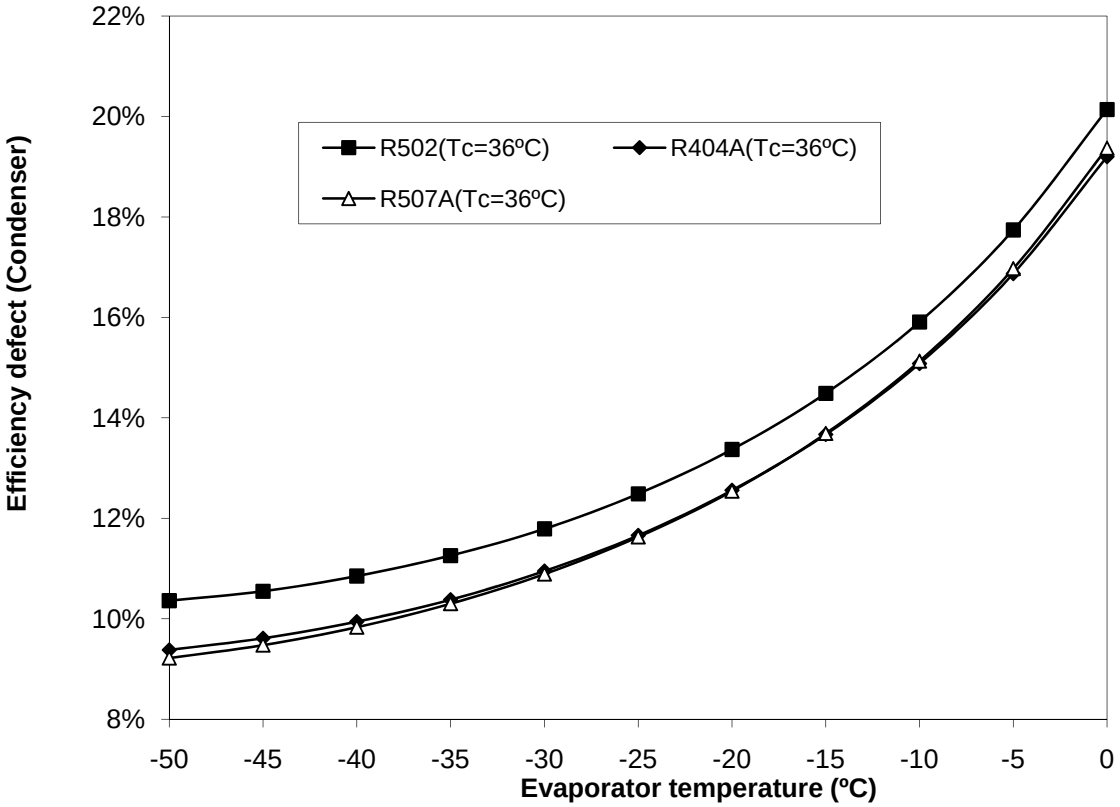

Figure 61.Comparison of efficiency defect in condenser with varying evaporator temperature (Tc= 36ºC)

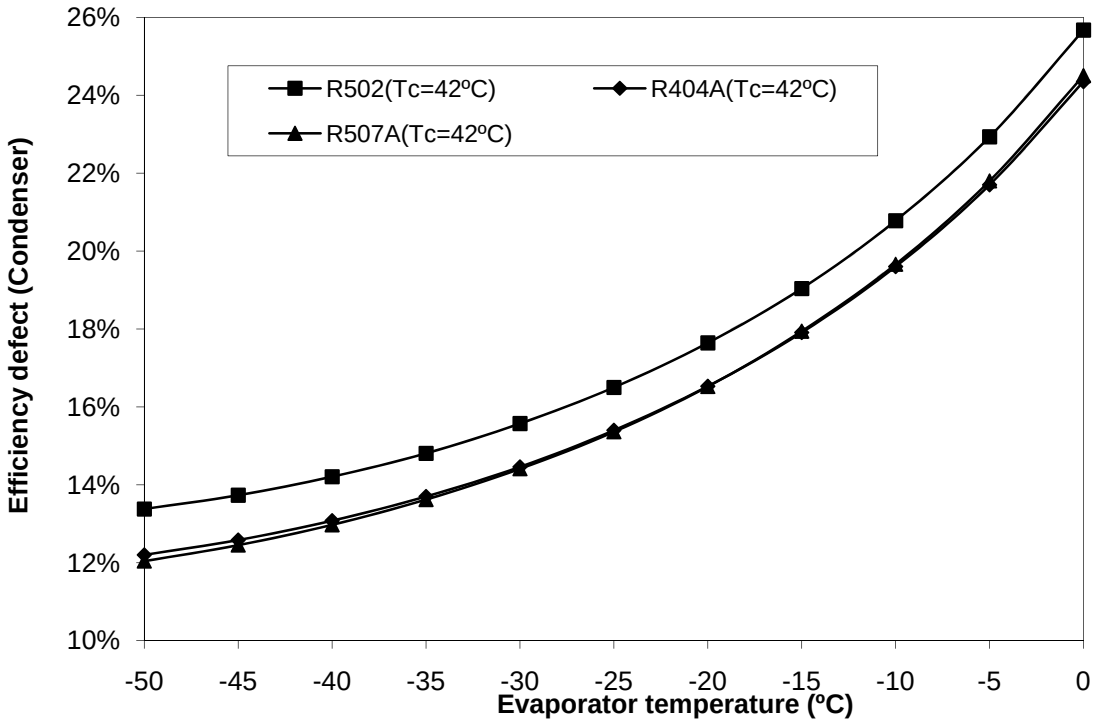

Figure 62.Comparison of efficiency defect in condenser with varying evaporator temperature (Tc= 42ºC)

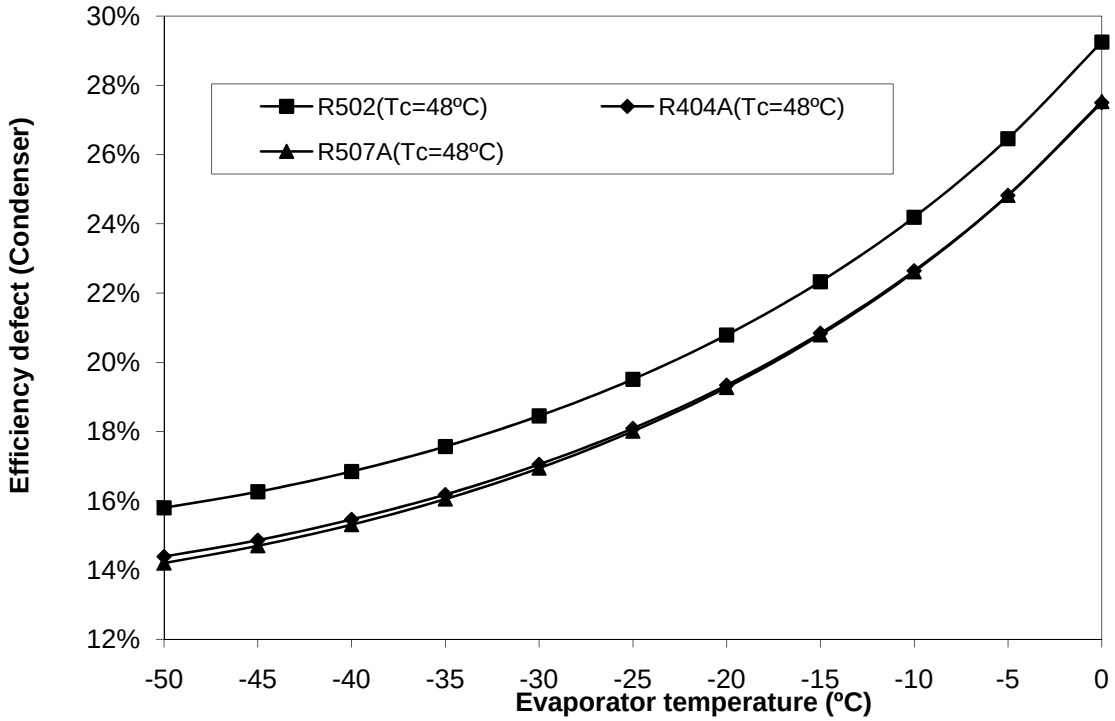

Figure 63.Comparison of efficiency defect in condenser with varying evaporator temperature (Tc= 48ºC)

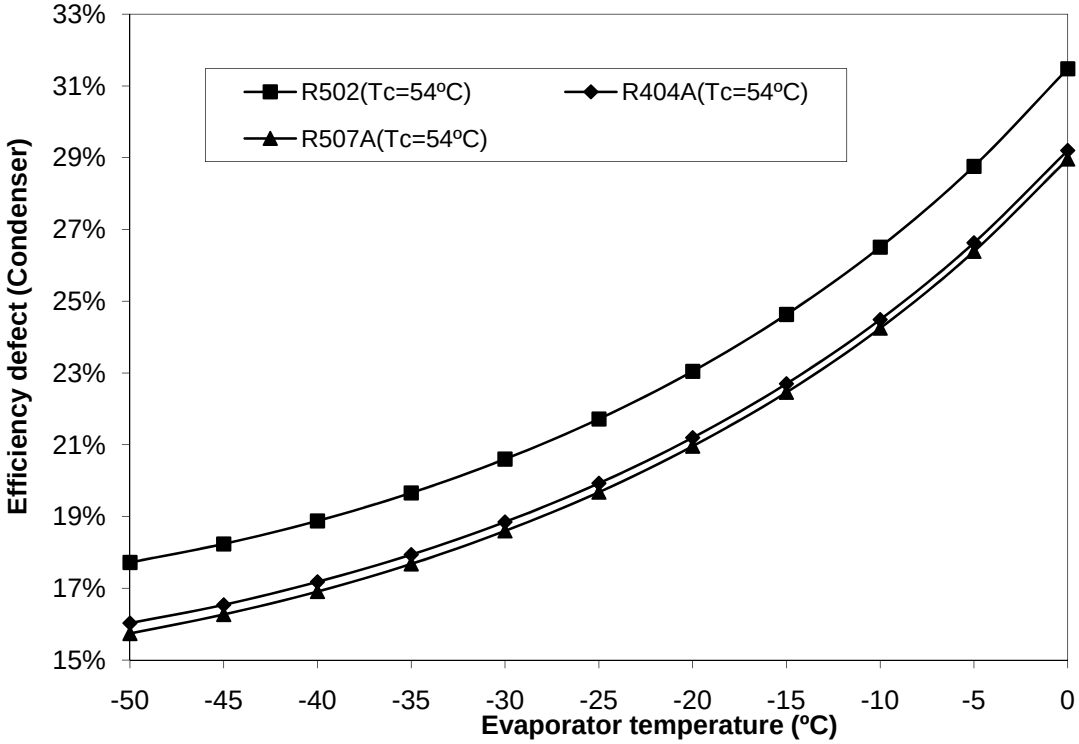

Figure 64.Comparison of efficiency defect in condenser with varying evaporator temperature (Tc= 54ºC)

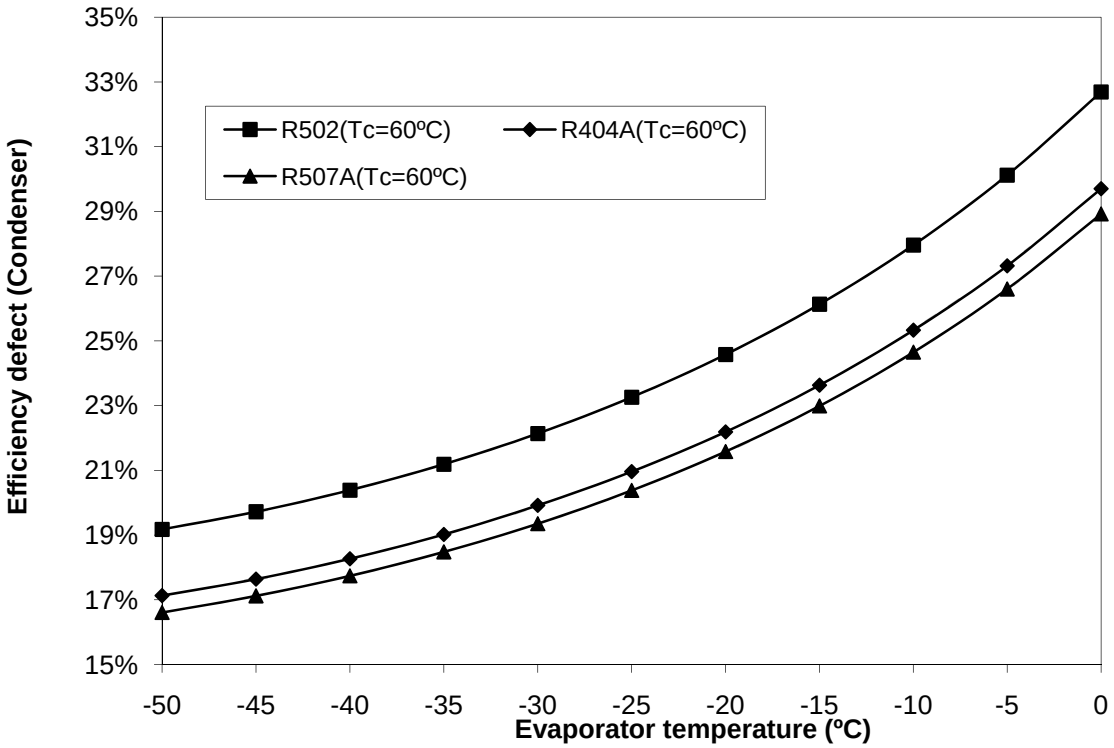

Figure 65.Comparison of efficiency defect in condenser with varying evaporator temperature (Tc= 60ºC)

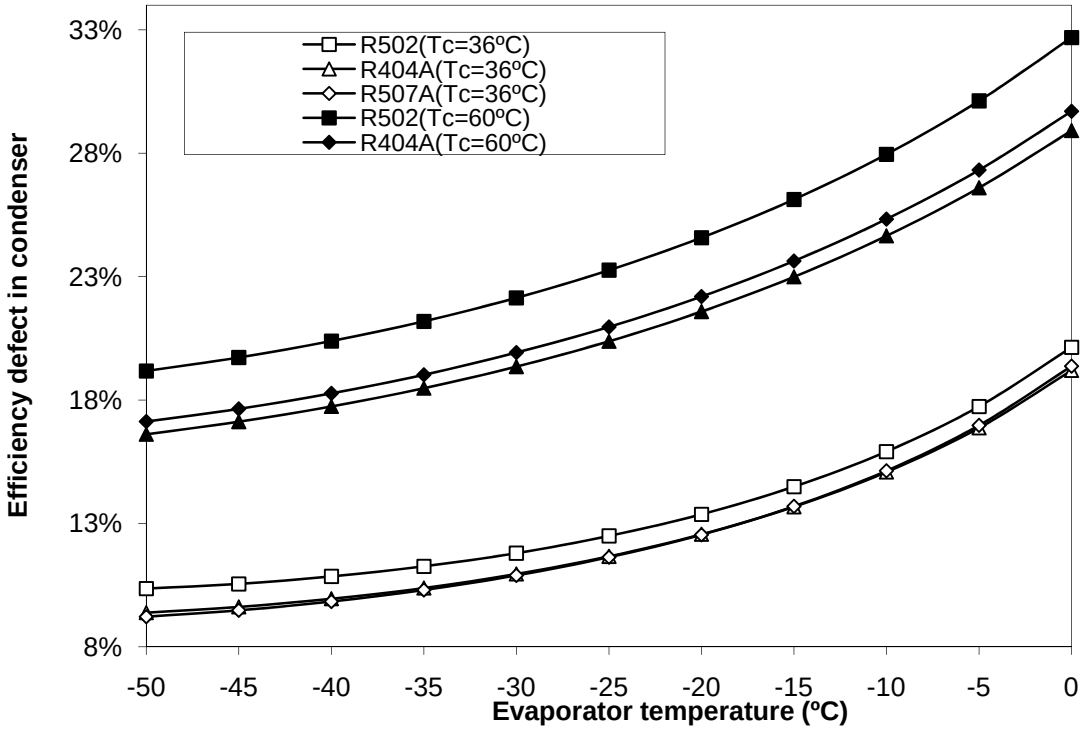

Figure 65a. Comparison of efficiency defect in condenser with varying evaporator temperature and condenser temperature (ºC)

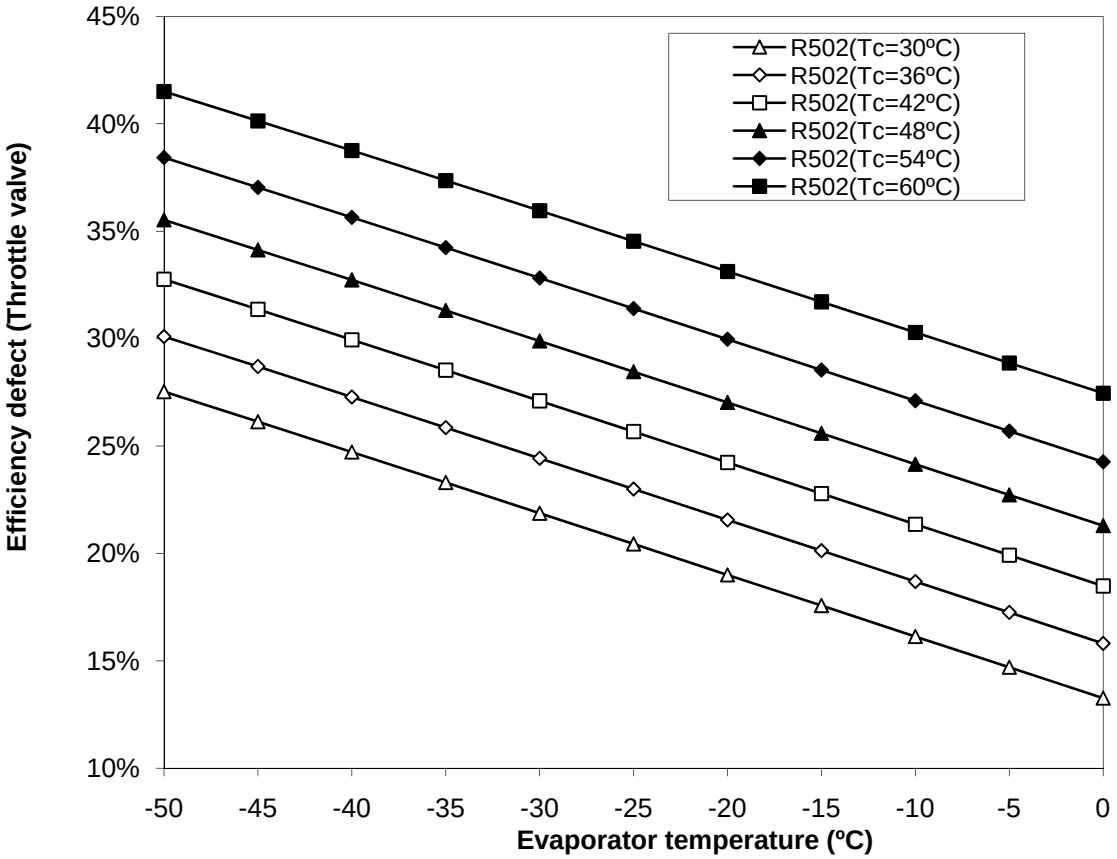

Figure 66. Effect of varying evaporator temperature on efficiency defect in throttle valve (R-502)

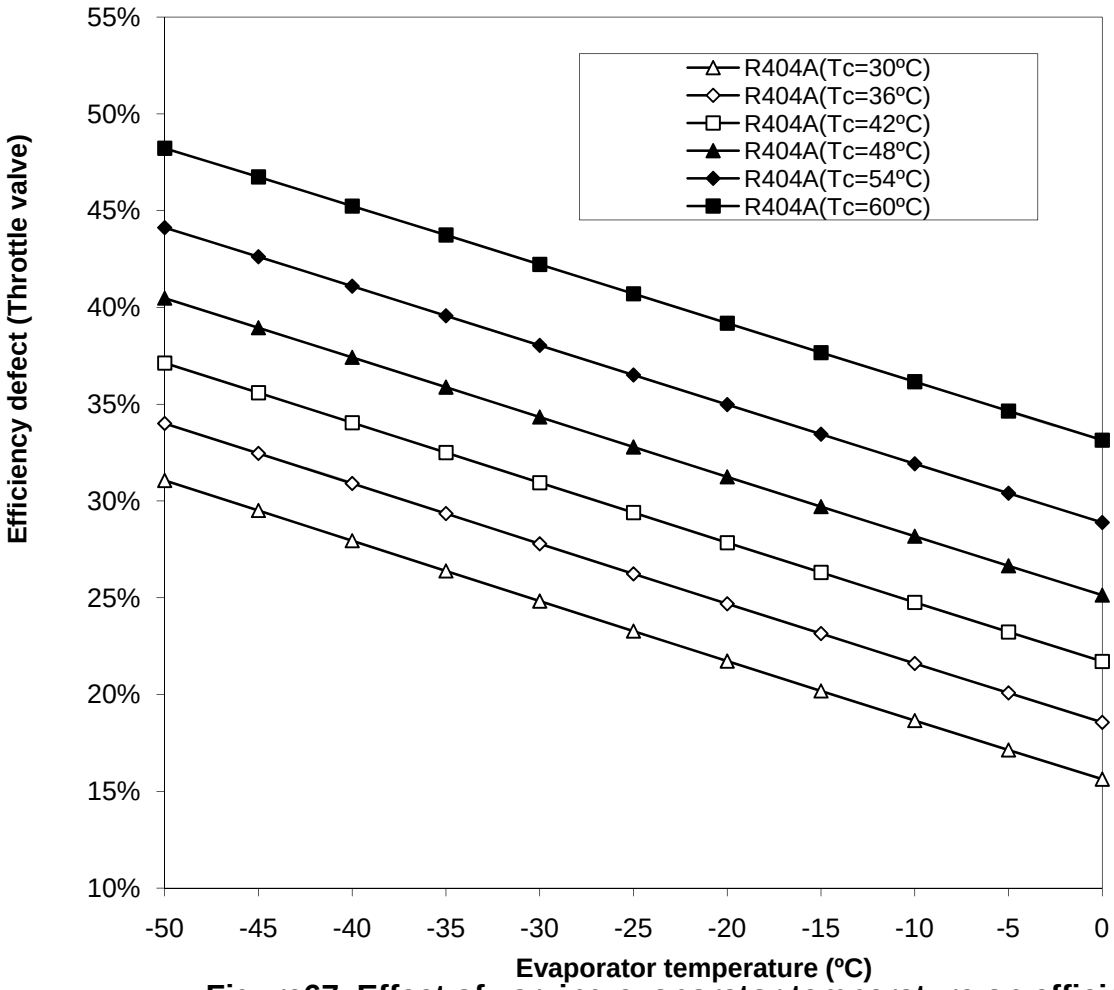

Figure67. Effect of varying evaporator temperature on efficiency defect in throttle valve (R-404A)

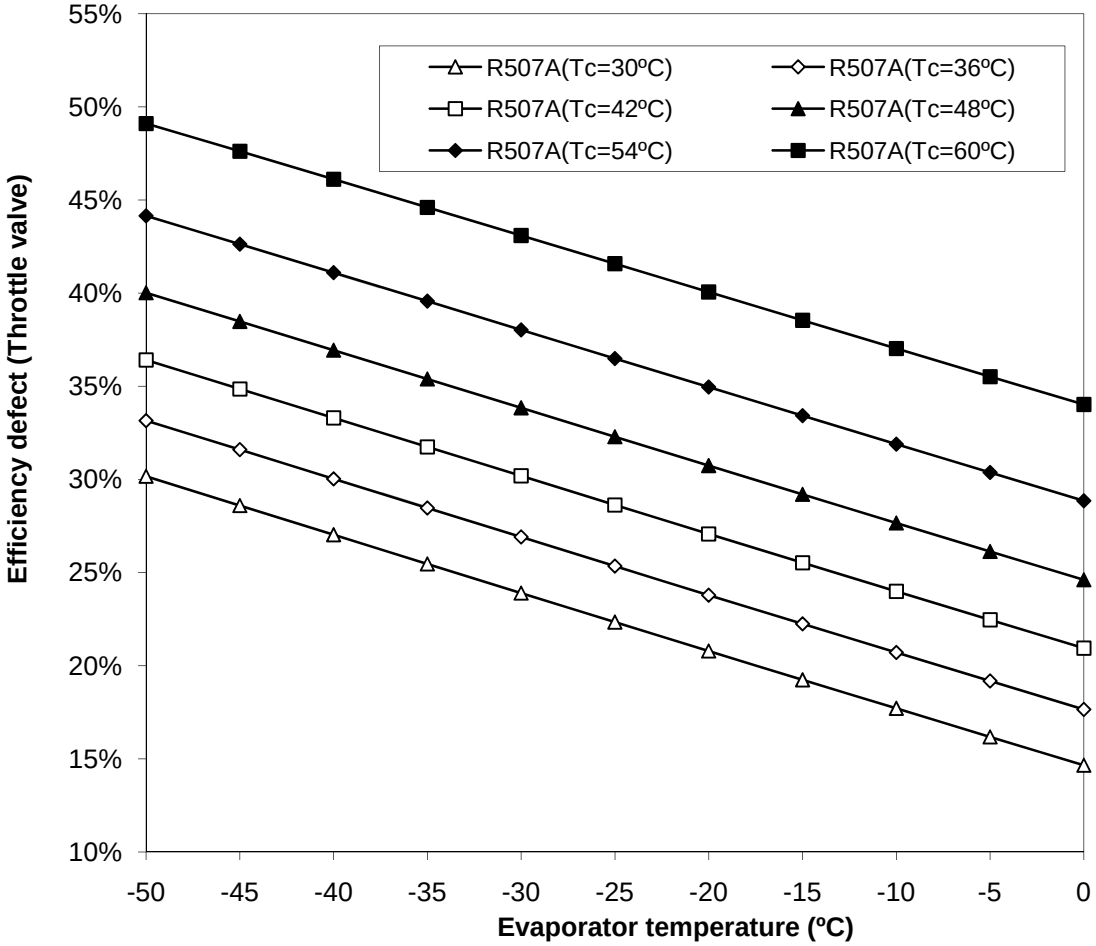

Figure 68. Effect of varying evaporator temperature on efficiency defect in throttle valve (R-507A)

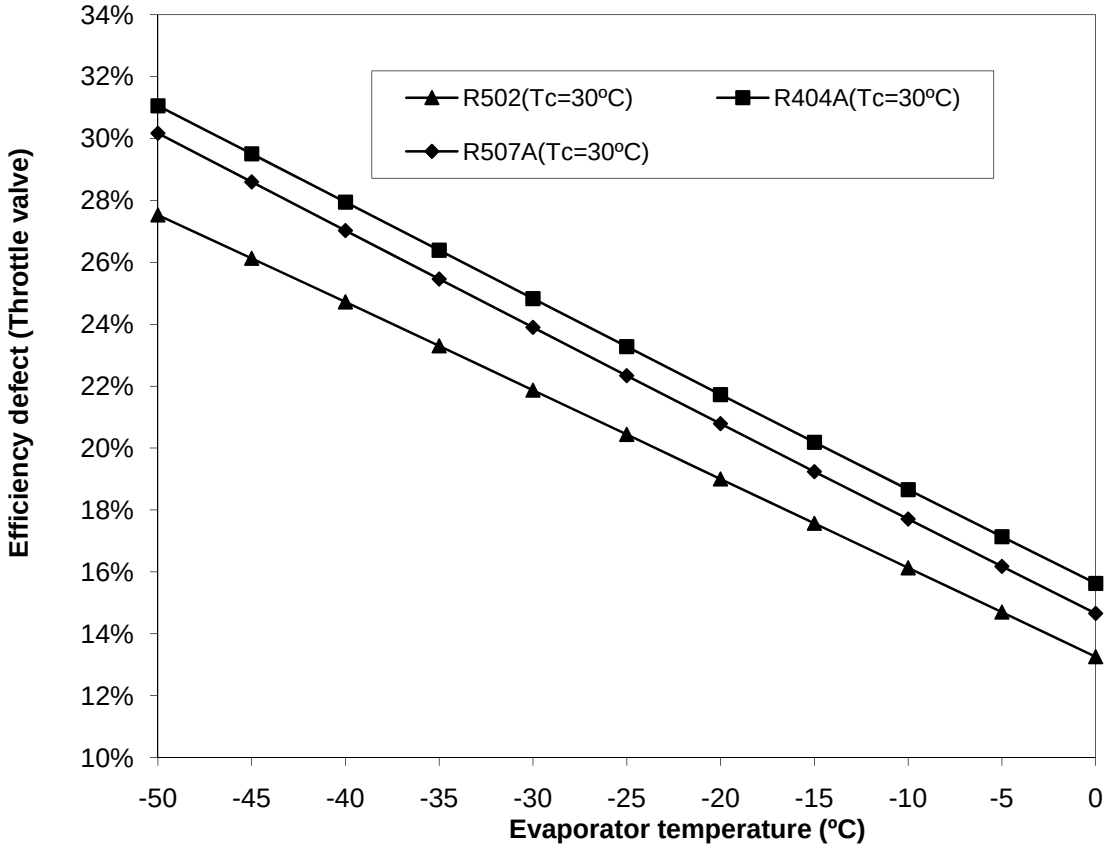

Figure 69.Comparison of efficiency defect in throttle valve with varying evaporator temperature (Tc= 30ºC)

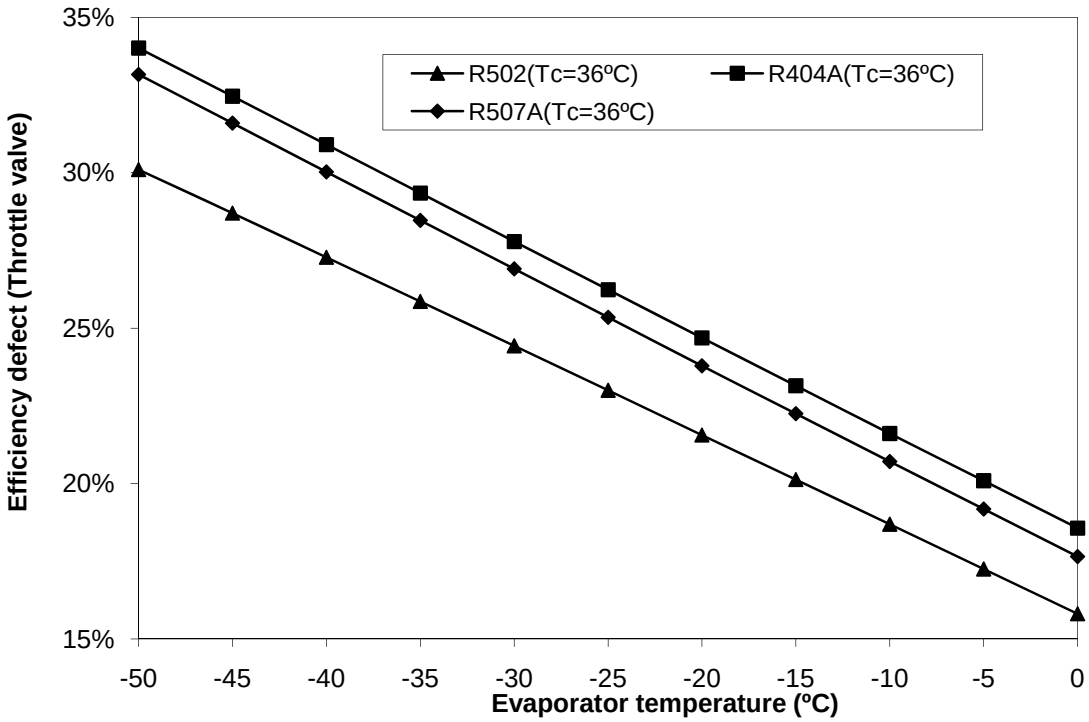

Figure 70.Comparison of efficiency defect in throttle valve with varying evaporator temperature (Tc= 36ºC)

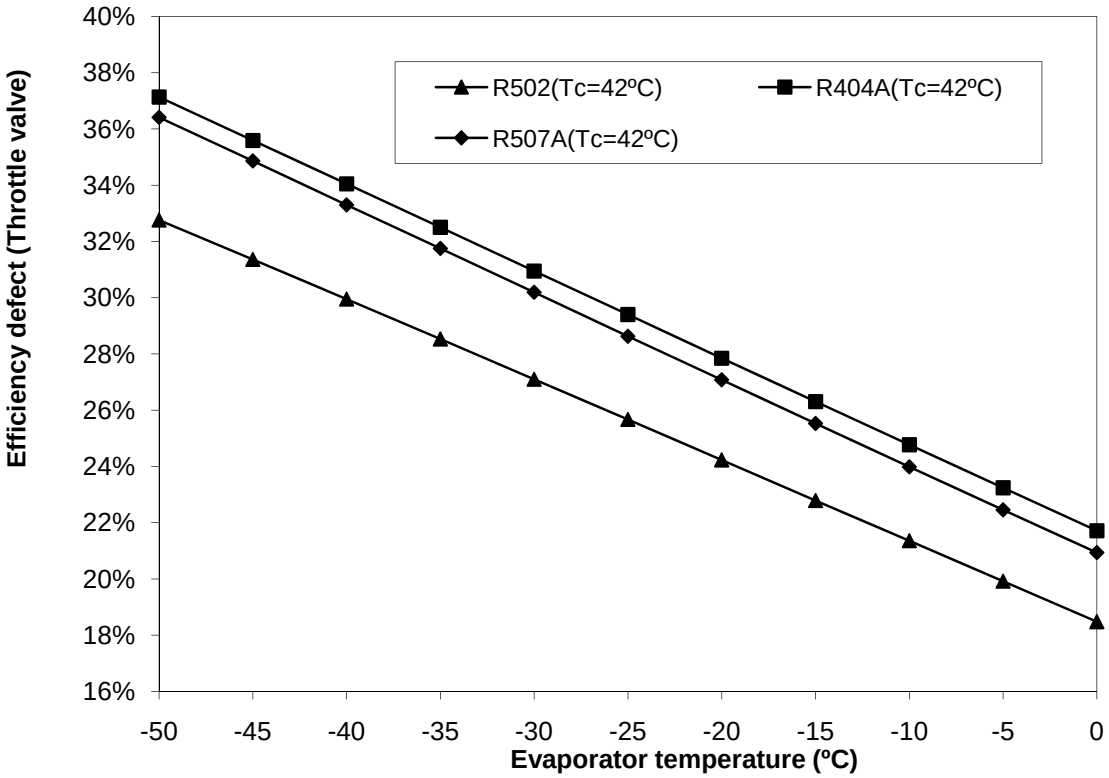

Figure 71.Comparison of efficiency defect in throttle valve with varying evaporator temperature (Tc= 42ºC)

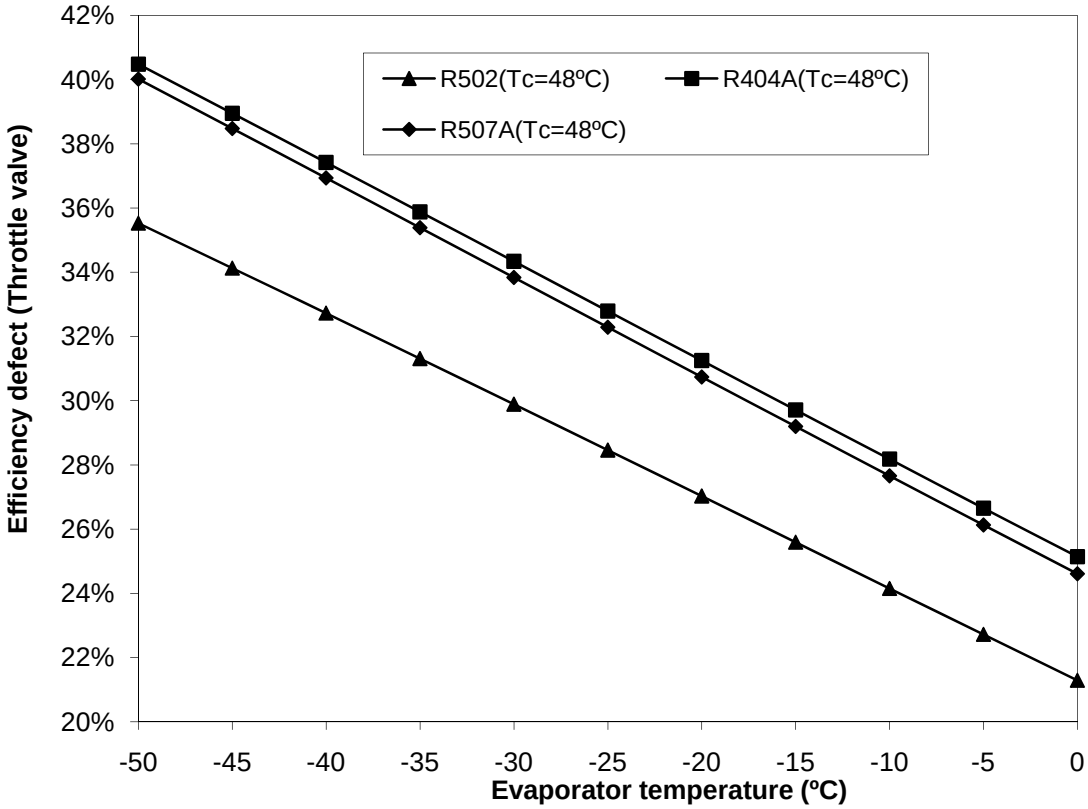

Figure 72.Comparison of efficiency defect in throttle valve with varying evaporator temperature (Tc= 48ºC)

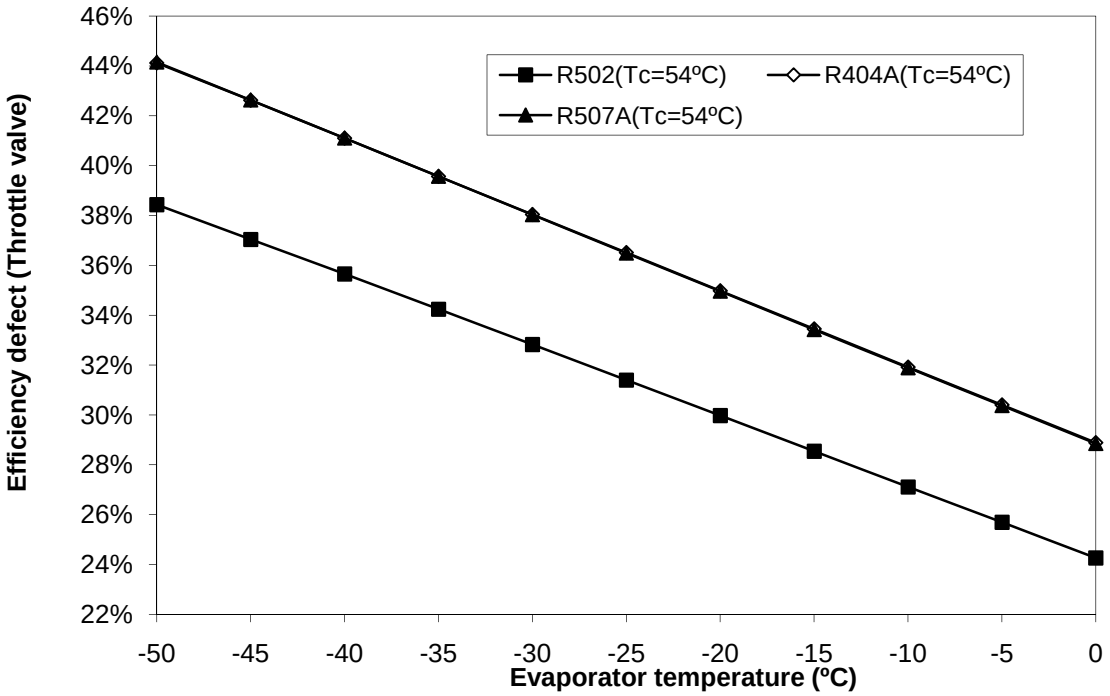

Figure 73.Comparison of efficiency defect in throttle valve with varying evaporator temperature (Tc= 54ºC)

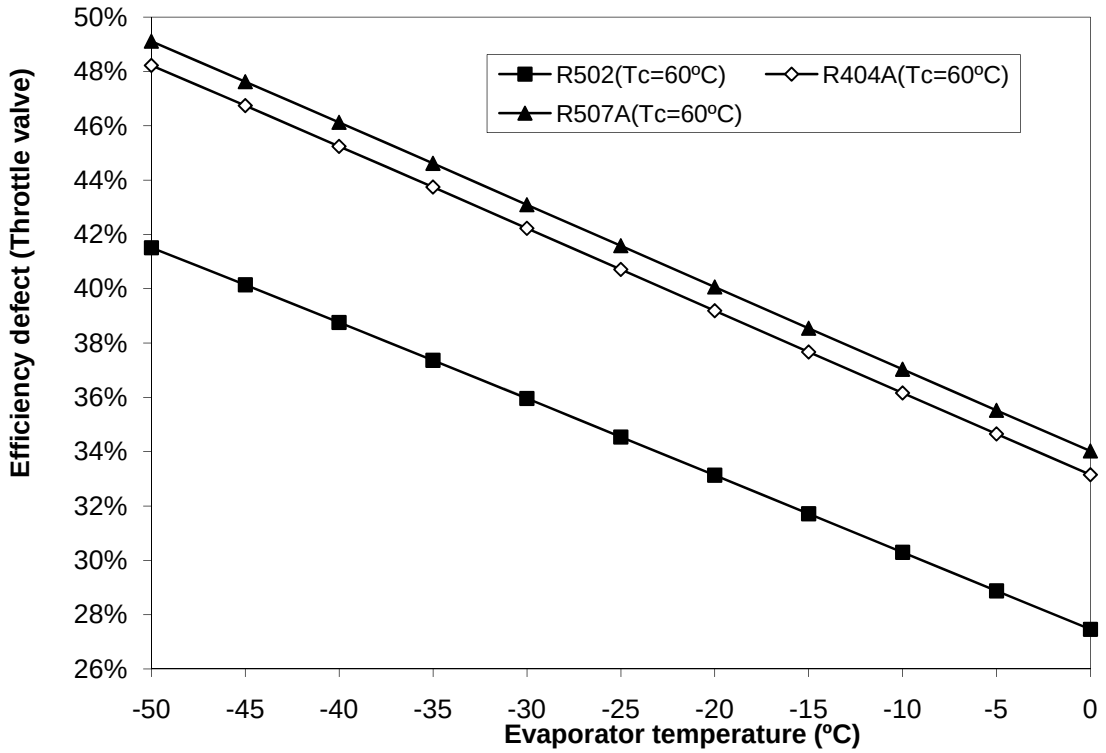

Figure 74.Comparison of efficiency defect in throttle valve with varying evaporator temperature (Tc= 60ºC)

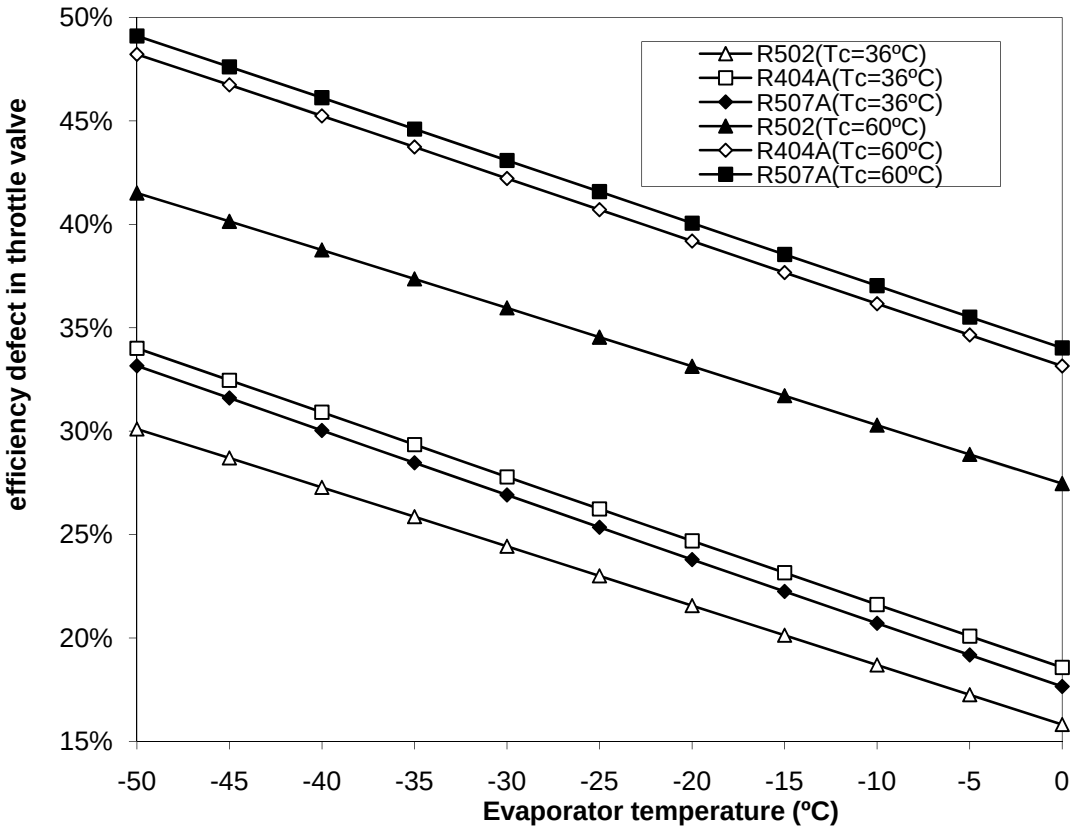

Figure 74a. Comparison of efficiency defect in throttle valve with varying evaporator temperature and condenser temperature (ºC)

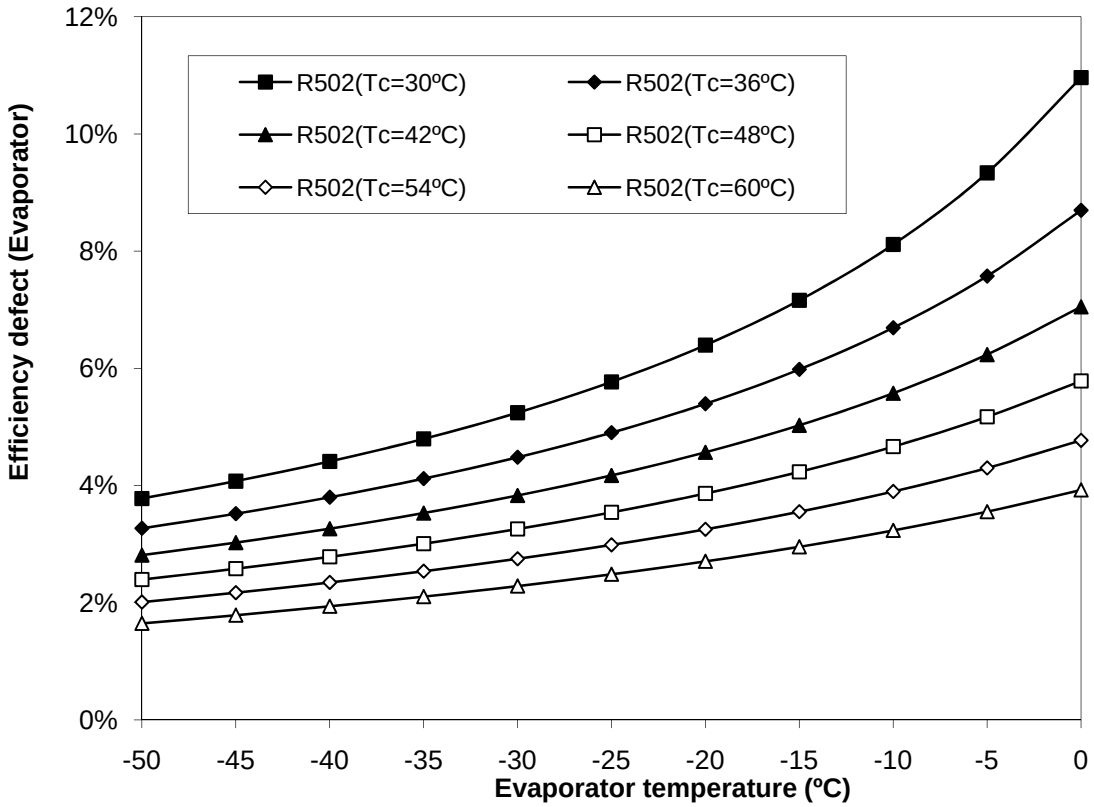

Figure 75. Effect of varying evaporator temperature on efficiency defect in evaporator (R-502)

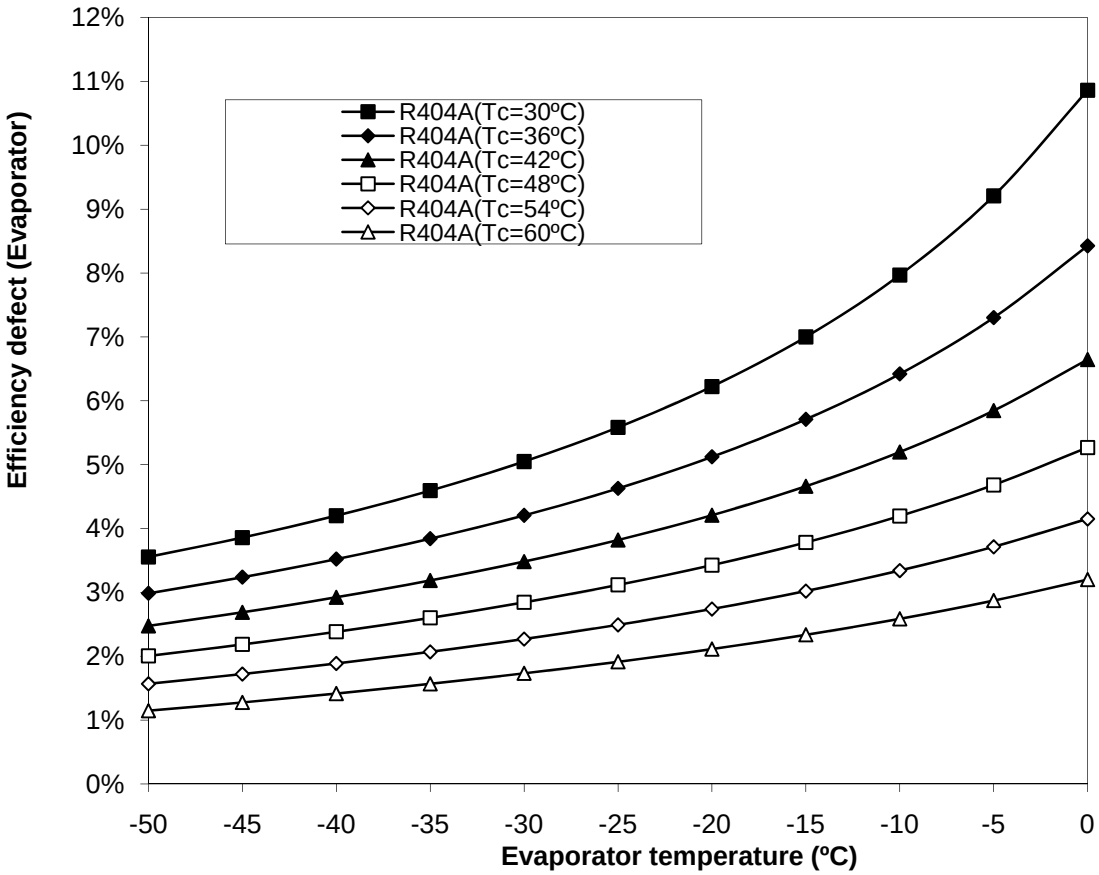

Figure76. Effect of varying evaporator temperature on efficiency defect in evaporator (R-404A)

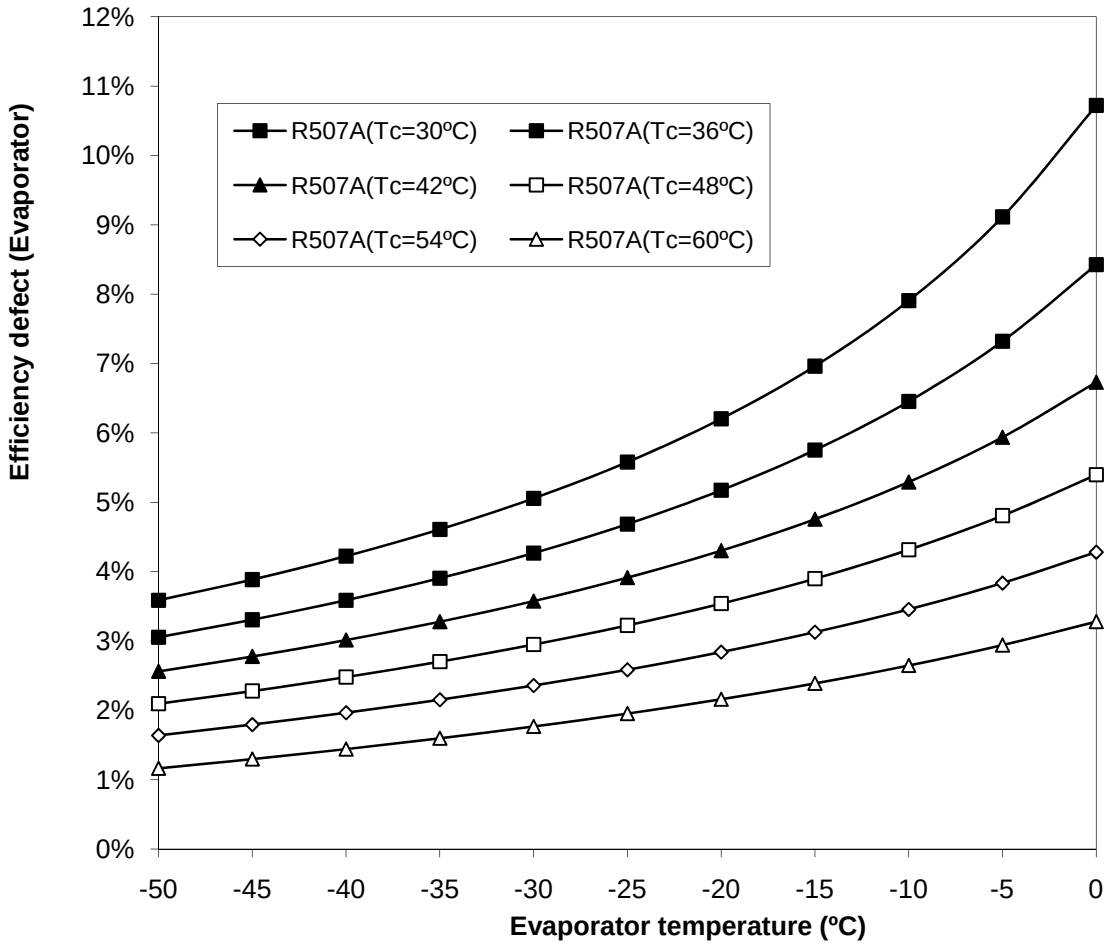

Figure 77. Effect of varying evaporator temperature on efficiency defect in evaporator (R-507A)

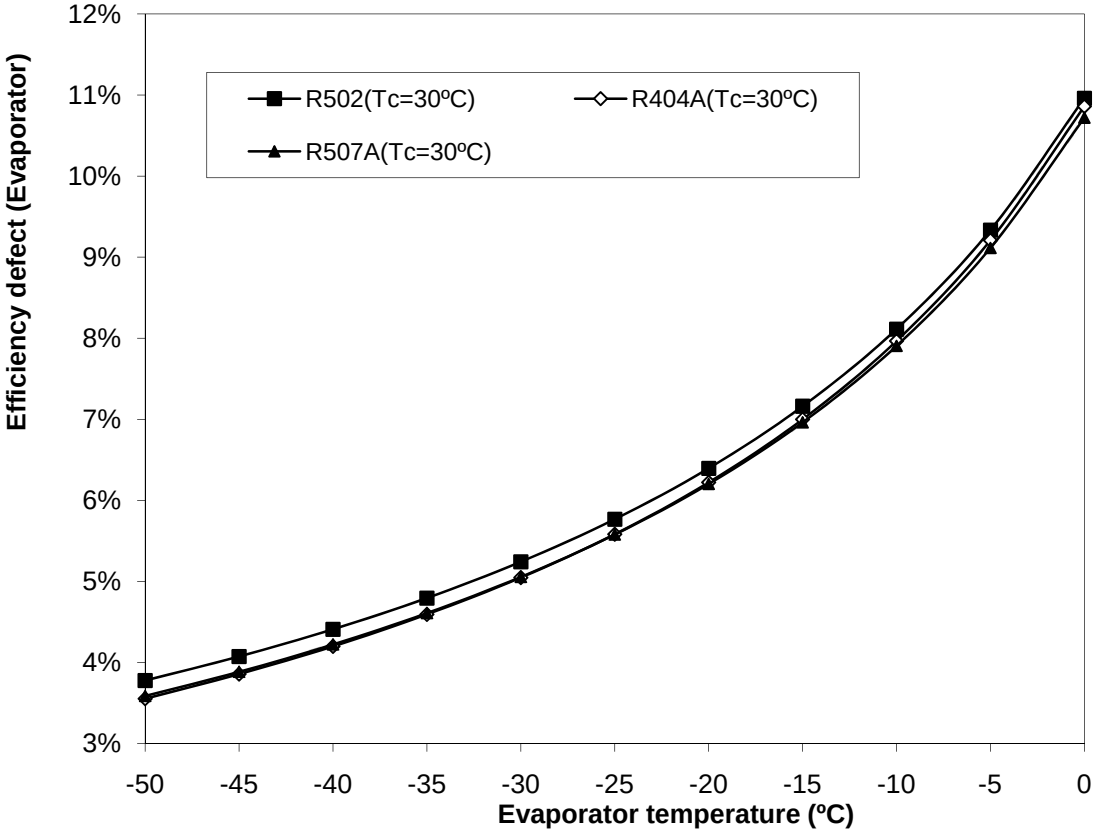

Figure 78.Comparison of efficiency defect in evaporator with varying evaporator temperature (Tc= 30ºC)

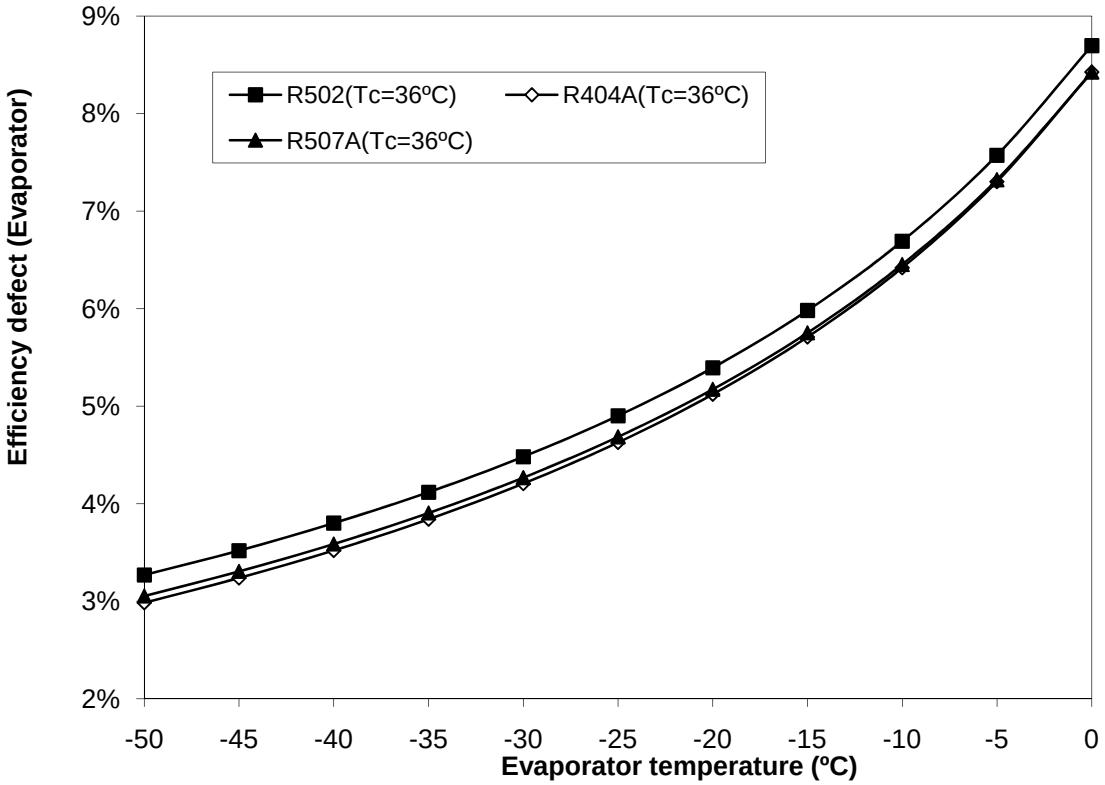

Figure 79.Comparison of efficiency defect in evaporator with varying evaporator temperature (Tc= 36ºC)

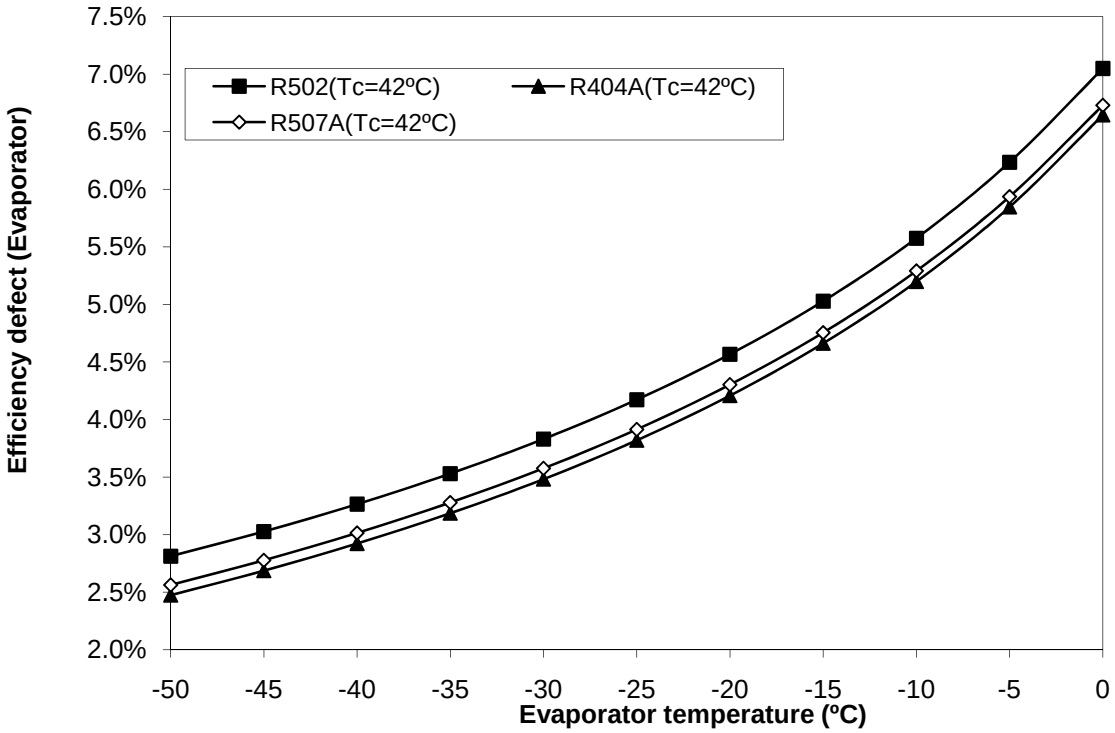

Figure 80.Comparison of efficiency defect in evaporator with varying evaporator temperature (Tc= 42ºC)

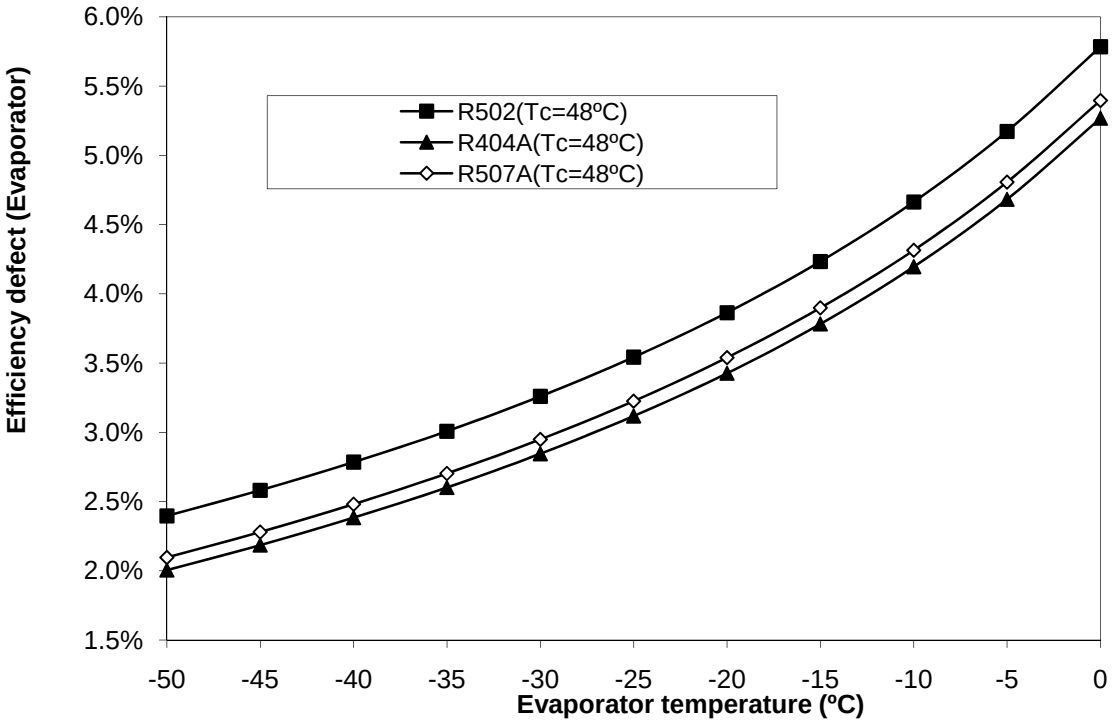

Figure 81.Comparison of efficiency defect in evaporator with varying evaporator temperature (Tc= 48ºC)

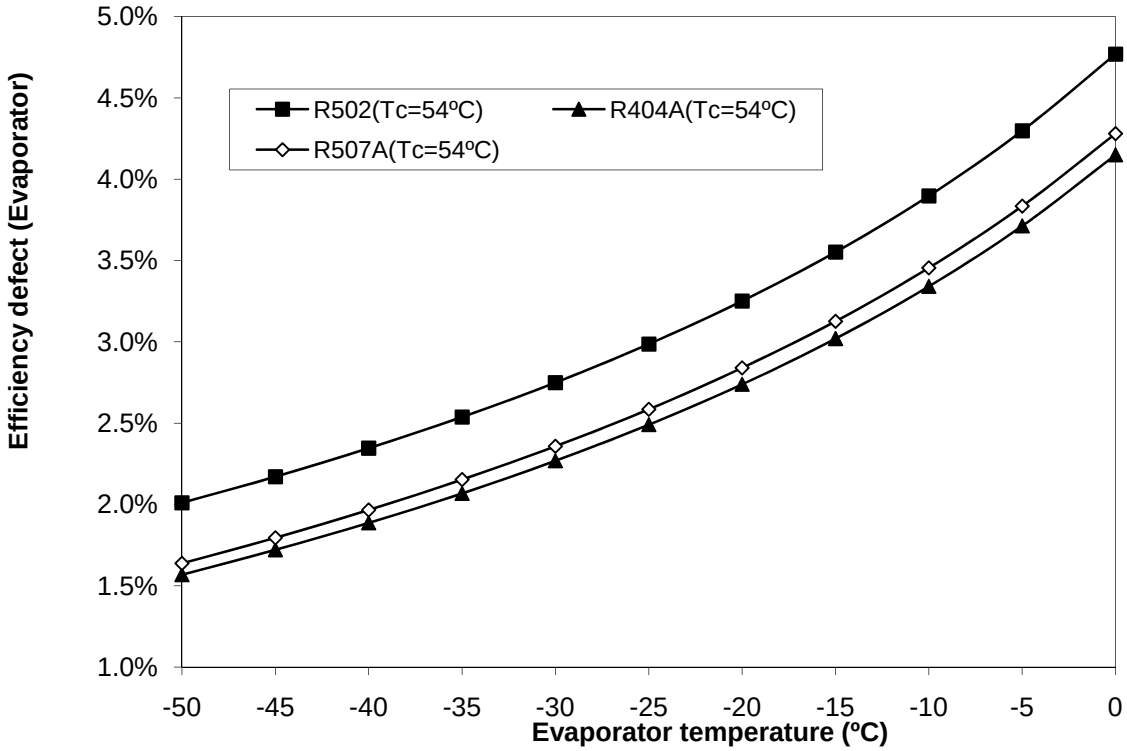

Figure 82.Comparison of efficiency defect in evaporator with varying evaporator temperature (Tc= 54ºC)

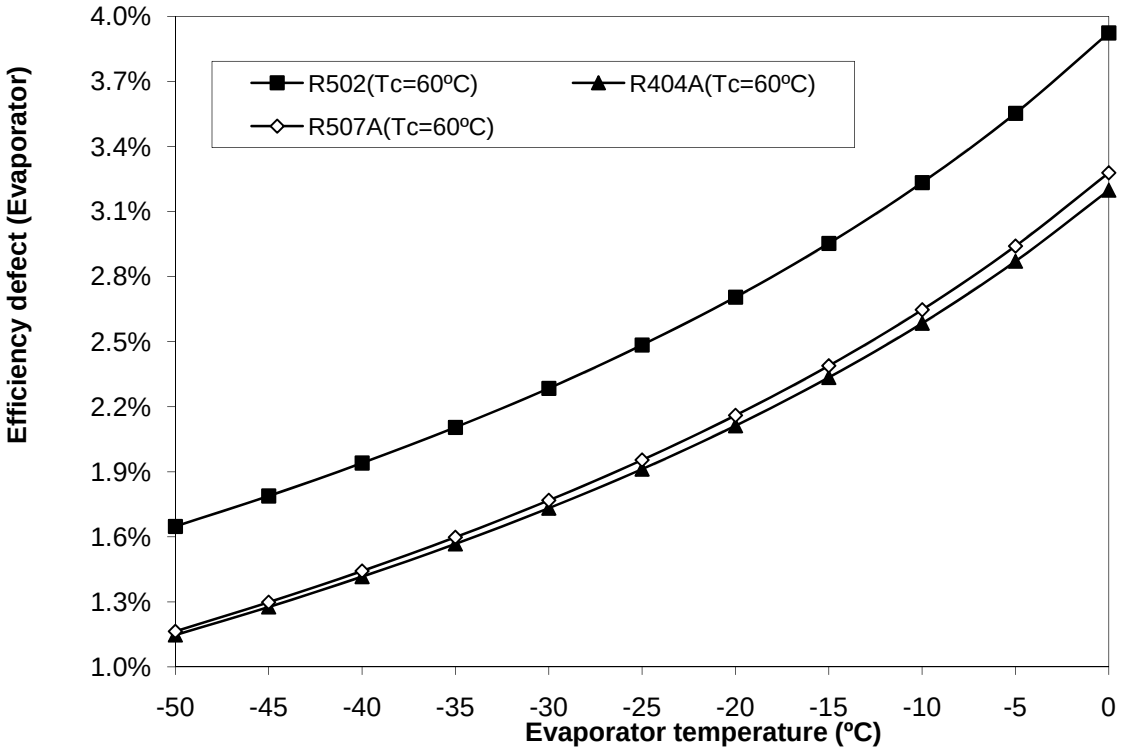

Figure 83.Comparison of efficiency defect in evaporator with varying evaporator temperature (Tc= 60ºC)

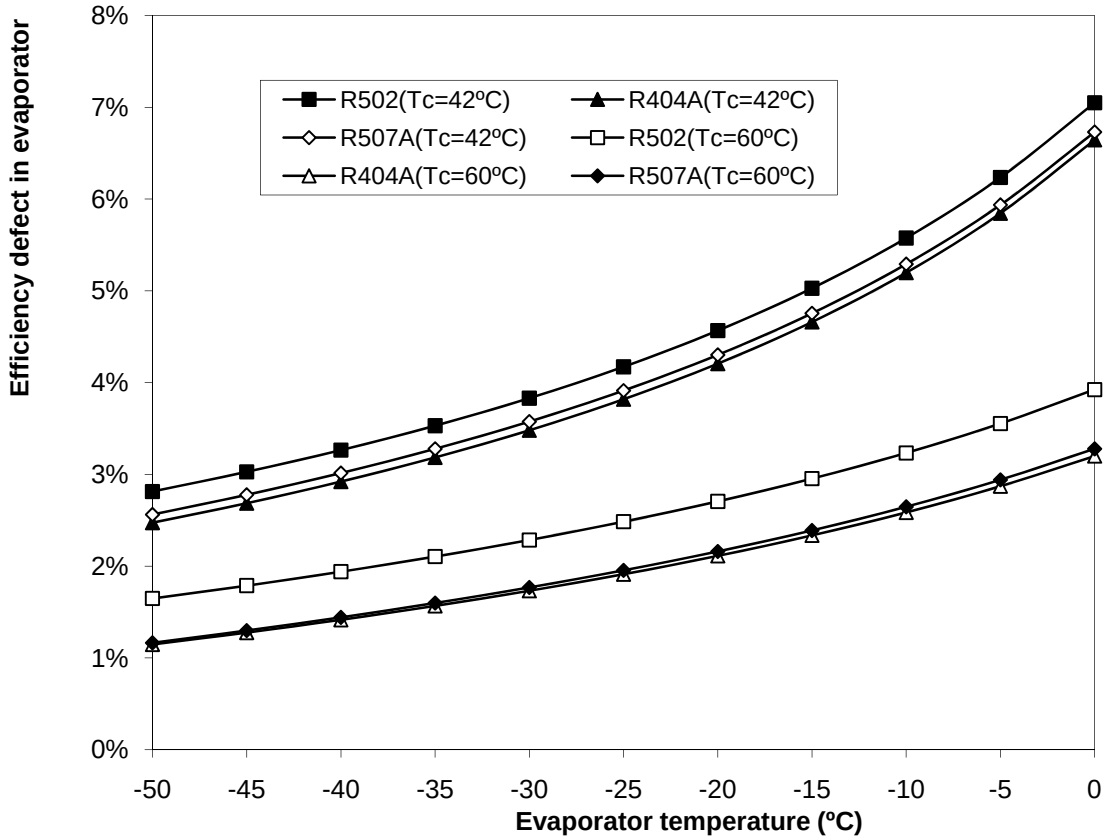

Figure 83a. Comparison of efficiency defect in evaporator with varying evaporator temperature and condenser temperature (ºC)

TABLES

Table 3. Variation of pressure ratio with varying evaporator temperature (R-502)

Te (ºC)	Tc=30ºC	Tc=36ºC	Tc=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	16.2	18.74	21.57	24.7	28.14	31.95
-49	15.43	17.86	20.55	23.52	26.81	30.43
-48	14.71	17.02	19.58	22.42	25.55	29
-47	14.02	16.23	18.67	21.38	24.36	27.66
-46	13.38	15.48	17.81	20.39	23.24	26.38
-45	12.76	14.77	17	19.46	22.18	25.18
-44	12.19	14.1	16.23	18.58	21.18	24.04
-43	11.64	13.47	15.5	17.75	20.23	22.96
-42	11.13	12.87	14.82	16.96	19.33	21.94
-41	10.64	12.31	14.16	16.22	18.48	20.98
-40	10.17	11.77	13.55	15.51	17.68	20.07
-39	9.735	11.27	12.96	14.84	16.91	19.2
-38	9.319	10.78	12.41	14.21	16.19	18.38
-37	8.924	10.33	11.88	13.61	15.51	17.6
-36	8.55	9.894	11.39	13.03	14.86	16.86
-35	8.194	9.483	10.91	12.49	14.24	16.16
-34	7.857	9.092	10.46	11.98	13.65	15.5
-33	7.536	8.721	10.04	11.49	13.09	14.86
-32	7.231	8.368	9.629	11.02	12.56	14.26
-31	6.941	8.033	9.243	10.58	12.06	13.69
-30	6.666	7.714	8.876	10.16	11.58	13.15
-29	6.403	7.41	8.527	9.498	11.05	12.2
-28	6.153	7.121	8.194	9.381	10.69	12.14
-27	5.915	6.845	7.863	9.018	10.28	11.67
-26	5.689	6.583	7.575	8.673	9.884	11.22
-25	5.473	6.333	7.287	8.343	9.509	10.79
-24	5.266	6.04	7.013	8.029	9.15	10.39
-23	5.07	5.867	6.751	7.729	8.809	10
-22	4.882	5.65	6.501	7.443	8.483	9.63
-21	4.703	5.443	6.263	7.17	8.172	9.276
-20	4.532	5.245	6.035	6.909	7.875	8.939
-19	4.216	5.056	5.818	6.66	7.591	8.617
-18	4.213	4.875	5.61	6.422	7.319	8.309
-17	4.063	4.702	5.411	6.195	7.06	8.014
-16	3.921	4.537	5.221	5.977	6.812	7.733
-15	3.784	4.379	5.039	5.769	6.575	7.463
-14	3.653	4.228	4.865	5.57	6.347	7.206
-13	3.528	4.083	4.698	5.379	6.13	6.959
-12	3.408	3.944	4.539	5.196	5.922	6.722
-11	3.293	3.811	4.386	5.021	5.722	6.496
-10	3.183	3.684	4.239	4.853	5.531	6.279
-9	3.078	3.562	4.099	4.693	5.348	6.071
-8	2.977	3.445	3.964	4.538	5.172	5.872
-7	2.88	3.333	3.835	4.391	5.004	5.68
-6	2.787	3.225	3.711	4.249	4.842	5.497
-5	2.698	3.122	3.592	4.112	4.687	5.321

-4	2.612	3.022	3.478	3.982	4.538	5.151
-3	2.529	2.927	3.368	3.856	4.395	4.989
-2	2.45	2.836	3.263	3.736	4.257	4.833
-1	2.374	2.748	3.162	3.62	4.125	4.683
0	2.301	2.663	3.064	3.508	3.998	4.539

Table 4. Variation of pressure ratio with varying evaporator temperature (R-404A)

Te (ºC)	Tc=30ºC	Tc=36ºC	Tc=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	17.41	20.22	23.37	26.87	30.76	35.08
-49	16.56	19.24	22.22	25.56	29.26	33.37
-48	15.76	18.31	21.15	24.32	27.84	31.76
-47	15.01	17.43	20.14	23.16	26.51	30.24
-46	14.3	16.61	19.19	22.06	25.26	28.8
-45	13.63	15.83	18.29	21.03	24.07	27.45
-44	12.99	15.09	17.44	20.05	22.96	26.18
-43	12.4	14.4	16.64	19.13	21.9	24.98
-42	11.83	13.74	15.88	18.26	20.9	23.84
-41	11.3	13.12	15.16	17.44	19.96	22.77
-40	10.8	12.54	14.49	16.66	19.07	21.75
-39	10.32	11.98	13.85	15.92	18.23	20.79
-38	9.867	11.46	13.24	15.23	17.43	19.88
-37	9.44	10.96	12.67	14.57	16.68	19.02
-36	9.035	10.49	12.12	13.94	15.96	18.2
-35	8.651	10.05	11.61	13.35	15.28	17.43
-34	8.286	9.625	11.12	12.79	14.64	16.7
-33	7.941	9.223	10.66	12.25	14.03	16
-32	7.613	8.842	10.22	11.75	13.45	15.34
-31	7.301	8.48	9.798	11.27	12.9	14.71
-30	7.005	8.137	9.401	10.81	12.38	14.11
-29	6.724	7.81	9.023	10.38	11.88	13.55
-28	6.456	7.499	8.664	9.963	11.41	13.01
-27	6.202	7.203	8.322	9.57	10.96	12.5
-26	5.959	6.922	7.997	9.196	10.53	12.01
-25	5.729	6.654	7.688	8.647	10.12	11.54
-24	5.509	6.398	7.3	8.501	9.675	11.1
-23	5.299	6.155	7.112	8.177	9.362	10.68
-22	5.1	5.76	6.843	7.869	9.009	10.24
-21	4.909	5.702	6.588	7.575	8.673	9.891
-20	4.727	5.491	6.344	7.295	8.352	9.525

-19	4.554	5.289	6.111	7.027	8.045	9.175
-18	4.23	5.097	5.889	6.771	7.752	8.841
-17	4.145	4.913	5.676	6.527	7.473	8.522
-16	4.079	4.737	5.473	6.294	7.206	8.218
-15	3.934	4.569	5.279	6.071	6.95	7.926
-14	3.796	4.409	5.094	5.857	6.706	7.648
-13	3.664	4.255	4.916	5.653	6.472	7.381
-12	3.537	4.108	4.747	5.458	6.249	7.126
-11	3.416	3.967	4.584	5.271	6.035	6.882
-10	3.3	3.833	4.428	5.092	5.83	6.648
-9	3.189	3.703	4.279	4.92	5.633	6.424
-8	3.082	3.58	4.136	4.756	5.445	6.21
-7	2.98	3.461	3.999	4.598	5.264	6.004
-6	2.882	3.347	3.867	4.447	5.091	5.806
-5	2.788	3.238	3.741	4.302	4.925	5.617
-4	2.698	3.133	3.62	4.163	4.766	5.435
-3	2.611	3.033	3.504	4.029	4.613	5.261
-2	2.528	2.936	3.393	3.901	4.466	5.093
-1	2.448	2.844	3.285	3.778	4.325	4.933
0	2.371	2.754	3.182	3.659	4.19	4.778

Table 5. Variation of pressure ratio with varying evaporator temperature (R-507A)

Te (ºC)	Tc=30ºC	Tc=36ºC	Tc=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	16.65	19.33	22.34	25.69	29.41	33.53
-49	15.85	18.4	21.26	24.45	27.99	31.92
-48	15.09	17.53	20.25	23.29	26.66	30.4
-47	14.38	16.7	19.3	22.19	25.41	28.97
-46	13.71	15.92	18.4	21.16	24.22	27.62
-45	13.08	15.19	16.3	20.18	23.1	26.34
-44	12.48	14.49	16.75	19.26	22.05	25.14
-43	11.91	13.84	15.99	18.38	21.05	24
-42	11.38	13.22	15.27	17.56	20.1	22.93
-41	10.88	12.63	14.59	16.78	19.21	21.91
-40	10.4	12.08	13.95	16.04	18.37	20.94
-39	9.944	11.55	13.34	15.34	17.57	20.03
-38	9.516	11.05	12.77	14.68	16.81	19.17
-37	9.109	10.58	12.22	14.06	16.09	18.35
-36	8.724	10.13	11.71	13.46	15.41	17.57
-35	8.358	9.708	11.22	12.9	14.77	16.84
-34	8.011	9.305	10.75	12.36	14.15	16.14

-33	7.682	8.922	10.31	11.85	13.57	15.47
-32	7.369	8.559	9.888	11.37	13.02	14.84
-31	7.071	8.213	9.489	10.91	12.49	14.25
-30	6.789	7.885	9.11	10.48	11.99	13.68
-29	6.52	7.572	8.749	10.06	11.52	13.13
-28	6.264	7.275	8.405	9.665	11.07	12.62
-27	6.02	6.992	8.078	9.289	10.63	12.13
-26	5.788	6.722	7.767	8.931	10.22	11.66
-25	5.567	6.465	7.47	8.545	9.492	11.21
-24	5.356	6.22	7.187	8.264	9.461	10.79
-23	5.155	5.987	6.917	7.954	9.106	10.38
-22	4.963	5.671	6.66	7.658	8.767	9.848
-21	4.78	5.552	6.414	7.376	8.444	9.629
-20	4.605	5.349	6.18	7.106	8.135	9.277
-19	4.438	5.155	5.956	6.848	7.84	8.941
-18	4.279	4.969	5.742	6.602	7.559	8.619
-17	4.045	4.792	5.537	6.367	7.289	8.312
-16	3.98	4.623	5.342	6.142	7.032	8.019
-15	3.841	4.461	5.154	5.927	6.786	7.738
-14	3.708	4.306	4.975	5.721	6.55	7.469
-13	3.58	4.158	4.804	5.524	6.324	7.212
-12	3.458	4.016	4.64	5.336	6.109	6.966
-11	3.341	3.88	4.483	5.155	5.902	6.73
-10	3.228	3.75	4.332	4.982	5.703	6.504
-9	3.121	3.625	4.188	4.816	5.513	6.287
-8	3.018	3.505	4.05	4.657	5.331	6.079
-7	2.919	3.39	3.917	4.504	5.156	5.88
-6	2.824	3.28	3.79	4.358	4.989	5.689
-5	2.733	3.174	3.667	4.217	4.828	5.505
-4	2.645	3.073	3.55	4.082	4.673	5.329
-3	2.561	2.975	3.437	3.952	4.525	5.16
-2	2.481	2.881	3.329	3.828	4.383	4.997
-1	2.403	2.791	3.225	3.708	4.246	4.841
0	2.329	2.705	3.125	3.593	4.114	4.691

Table 6.Comparison of pressure ratio with varying evaporator temperature(Tc= 30ºC)

Te (ºC)	R502	R404A	R507A
-50	16.2	17.41	16.65
-49	15.43	16.56	15.85
-48	14.71	15.76	15.09
-47	14.02	15.01	14.38
-46	13.38	14.3	13.71
-45	12.76	13.63	13.08
-44	12.19	12.99	12.48

-43	11.64	12.4	11.91
-42	11.13	11.83	11.38
-41	10.64	11.3	10.88
-40	10.17	10.8	10.4
-39	9.735	10.32	9.944
-38	9.319	9.867	9.516
-37	8.924	9.44	9.109
-36	8.55	9.035	8.724
-35	8.194	8.651	8.358
-34	7.857	8.286	8.011
-33	7.536	7.941	7.682
-32	7.231	7.613	7.369
-31	6.941	7.301	7.071
-30	6.666	7.005	6.789
-29	6.403	6.724	6.52
-28	6.153	6.456	6.264
-27	5.915	6.202	6.02
-26	5.689	5.959	5.788
-25	5.473	5.729	5.567
-24	5.266	5.509	5.356
-23	5.07	5.299	5.155
-22	4.882	5.1	4.963
-21	4.703	4.909	4.78
-20	4.532	4.727	4.605
-19	4.369	4.554	4.438
-18	4.213	4.388	4.279
-17	4.063	4.145	4.045
-16	3.921	4.079	3.98
-15	3.784	3.934	3.841
-14	3.653	3.796	3.708
-13	3.528	3.664	3.58
-12	3.408	3.537	3.458
-11	3.293	3.416	3.341
-10	3.183	3.3	3.228
-9	3.078	3.189	3.121
-8	2.977	3.082	3.018
-7	2.88	2.98	2.919
-6	2.787	2.882	2.824
-5	2.698	2.788	2.733
-4	2.612	2.698	2.645
-3	2.529	2.611	2.561
-2	2.45	2.528	2.481
-1	2.374	2.448	2.403
0	2.301	2.371	2.329

Table 7.Comparison of pressure ratio with varying evaporator temperature(Tc= 36ºC)

Te (ºC)	R502	R404A	R507A
-50	18.74	20.22	19.33
-49	17.86	19.24	18.4
-48	17.02	18.31	17.53
-47	16.23	17.43	16.7
-46	15.48	16.61	15.92
-45	14.77	15.83	15.19
-44	14.1	15.09	14.49
-43	13.47	14.4	13.84
-42	12.87	13.74	13.22
-41	12.31	13.12	12.63
-40	11.77	12.54	12.08
-39	11.27	11.98	11.55
-38	10.78	11.46	11.05
-37	10.33	10.96	10.58
-36	9.894	10.49	10.13
-35	9.483	10.05	9.708
-34	9.092	9.625	9.305
-33	8.721	9.223	8.922
-32	8.368	8.842	8.559
-31	8.033	8.48	8.213
-30	7.714	8.137	7.885
-29	7.41	7.81	7.572
-28	7.121	7.499	7.275
-27	6.845	7.203	6.992
-26	6.583	6.922	6.722
-25	6.333	6.654	6.465
-24	6.04	6.398	6.22
-23	5.867	6.155	5.987
-22	5.65	5.76	5.671
-21	5.443	5.702	5.552
-20	5.245	5.491	5.349
-19	5.056	5.289	5.155
-18	4.875	5.097	4.969
-17	4.702	4.913	4.792
-16	4.537	4.737	4.623
-15	4.379	4.569	4.461
-14	4.228	4.409	4.306
-13	4.083	4.255	4.158
-12	3.944	4.108	4.016
-11	3.811	3.967	3.88
-10	3.684	3.833	3.75
-9	3.562	3.703	3.625
-8	3.445	3.58	3.505
-7	3.333	3.461	3.39
-6	3.225	3.347	3.28

-5	3.122	3.238	3.174
-4	3.022	3.133	3.073
-3	2.927	3.033	2.975
-2	2.836	2.936	2.881
-1	2.748	2.844	2.791
0	2.663	2.754	2.705

Table 8.Comparison of pressure ratio with varying evaporator temperature(Tc= 42ºC)

Te (ºC)	R502	R404A	R507A
-50	21.57	23.37	22.34
-49	20.55	22.22	21.26
-48	19.58	21.15	20.25
-47	18.67	20.14	19.3
-46	17.81	19.19	18.4
-45	17	18.29	16.3
-44	16.23	17.44	16.75
-43	15.5	16.64	15.99
-42	14.82	15.88	15.27
-41	14.16	15.16	14.59
-40	13.55	14.49	13.95
-39	12.96	13.85	13.34
-38	12.41	13.24	12.77
-37	11.88	12.67	12.22
-36	11.39	12.12	11.71
-35	10.91	11.61	11.22
-34	10.46	11.12	10.75
-33	10.04	10.66	10.31
-32	9.629	10.22	9.888
-31	9.243	9.798	9.489
-30	8.876	9.401	9.11
-29	8.527	9.023	8.749
-28	7.877	8.664	8.405
-27	7.863	8.322	8.078
-26	7.575	7.997	7.767
-25	7.287	7.688	7.47
-24	7.013	7.3	7.187
-23	6.751	7.112	6.917
-22	6.501	6.843	6.66
-21	6.263	6.588	6.414
-20	6.035	6.344	6.18
-19	5.818	6.111	5.956
-18	5.61	5.889	5.742

-17	5.411	5.676	5.537
-16	5.221	5.473	5.342
-15	5.039	5.279	5.154
-14	4.865	5.094	4.975
-13	4.698	4.916	4.804
-12	4.539	4.747	4.64
-11	4.386	4.584	4.483
-10	4.239	4.428	4.332
-9	4.099	4.279	4.188
-8	3.964	4.136	4.05
-7	3.835	3.999	3.917
-6	3.711	3.867	3.79
-5	3.592	3.741	3.667
-4	3.478	3.62	3.55
-3	3.368	3.504	3.437
-2	3.263	3.393	3.329
-1	3.162	3.285	3.225
0	3.064	3.182	3.125

Table 9.Comparison of pressure ratio with varying evaporator temperature(Tc= 48ºC)

Te (ºC)	R502	R404A	R507A
-50	24.7	23.37	25.69
-49	23.52	22.22	24.45
-48	22.42	21.15	23.29
-47	21.38	20.14	22.19
-46	20.39	19.19	21.16
-45	19.46	18.29	20.18
-44	18.58	17.44	19.26
-43	17.75	16.64	18.38
-42	16.96	15.88	17.56
-41	16.22	15.16	16.78
-40	15.51	14.49	16.04
-39	14.84	13.85	15.34
-38	14.21	13.24	14.68
-37	13.61	12.67	14.06
-36	13.03	12.12	13.46
-35	12.49	11.61	12.9
-34	11.98	11.12	12.36
-33	11.49	10.66	11.85
-32	11.02	10.22	11.37

-31	10.58	9.798	10.91
-30	10.16	9.401	10.48
-29	9.498	9.023	10.06
-28	9.381	8.664	9.665
-27	9.018	8.322	9.289
-26	8.673	7.997	8.931
-25	8.343	7.688	8.545
-24	8.029	7.3	8.264
-23	7.729	7.112	7.954
-22	7.443	6.843	7.658
-21	7.17	6.588	7.376
-20	6.909	6.344	7.106
-19	6.66	6.111	6.848
-18	6.422	5.889	6.602
-17	6.195	5.676	6.367
-16	5.977	5.473	6.142
-15	5.769	5.279	5.927
-14	5.57	5.094	5.721
-13	5.379	4.916	5.524
-12	5.196	4.747	5.336
-11	5.021	4.584	5.155
-10	4.853	4.428	4.982
-9	4.693	4.279	4.816
-8	4.538	4.136	4.657
-7	4.391	3.999	4.504
-6	4.249	3.867	4.358
-5	4.112	3.741	4.217
-4	3.982	3.62	4.082
-3	3.856	3.504	3.952
-2	3.736	3.393	3.828
-1	3.62	3.285	3.708
0	3.508	3.182	3.593

Table 10.Comparison of pressure ratio with varying evaporator temperature(Tc= 54ºC)

Te (ºC)	R502	R404A	R507A
-50	28.14	30.76	29.41
-49	26.81	29.26	27.99

-48	25.55	27.84	26.66
-47	24.36	26.51	25.41
-46	23.24	25.26	24.22
-45	22.18	24.07	23.1
-44	21.18	22.96	22.05
-43	20.23	21.9	21.05
-42	19.33	20.9	20.1
-41	18.48	19.96	19.21
-40	17.68	19.07	18.37
-39	16.91	18.23	17.57
-38	16.19	17.43	16.81
-37	15.51	16.68	16.09
-36	14.86	15.96	15.41
-35	14.24	15.28	14.77
-34	13.65	14.64	14.15
-33	13.09	14.03	13.57
-32	12.56	13.45	13.02
-31	12.06	12.9	12.49
-30	11.58	12.38	11.99
-29	11.05	11.88	11.52
-28	10.69	11.41	11.07
-27	10.28	10.96	10.63
-26	9.884	10.53	10.22
-25	9.509	10.12	9.492
-24	9.15	9.675	9.461
-23	8.809	9.362	9.106
-22	8.483	9.009	8.767
-21	8.172	8.673	8.444
-20	7.875	8.352	8.135
-19	7.591	8.045	7.84
-18	7.319	7.752	7.559
-17	7.06	7.473	7.289
-16	6.812	7.206	7.032
-15	6.575	6.95	6.786
-14	6.347	6.706	6.55
-13	6.13	6.472	6.324
-12	5.922	6.249	6.109
-11	5.722	6.035	5.902
-10	5.531	5.83	5.703
-9	5.348	5.633	5.513
-8	5.172	5.445	5.331
-7	5.004	5.264	5.156
-6	4.842	5.091	4.989
-5	4.687	4.925	4.828
-4	4.538	4.766	4.673
-3	4.395	4.613	4.525
-2	4.257	4.466	4.383
-1	4.125	4.325	4.246
0	3.998	4.19	4.114

Table 11.Comparison of pressure ratio with varying evaporator temperature(Tc= 60ºC)

Te (ºC)	R502	R404A	R507A
-50	31.95	35.08	33.53
-49	30.43	33.37	31.92
-48	29	31.76	30.4
-47	27.66	30.24	28.97
-46	26.38	28.8	27.62
-45	25.18	27.45	26.34
-44	24.04	26.18	25.14
-43	22.96	24.98	24
-42	21.94	23.84	22.93
-41	20.98	22.77	21.91
-40	20.07	21.75	20.94
-39	19.2	20.79	20.03
-38	18.38	19.88	19.17
-37	17.6	19.02	18.35
-36	16.86	18.2	17.57
-35	16.16	17.43	16.84
-34	15.5	16.7	16.14
-33	14.86	16	15.47
-32	14.26	15.34	14.84
-31	13.69	14.71	14.25
-30	13.15	14.11	13.68
-29	12.2	13.55	13.13
-28	12.14	13.01	12.62
-27	11.67	12.5	12.13
-26	11.22	12.01	11.66
-25	10.79	11.54	11.21
-24	10.39	11.1	10.79
-23	10	10.68	10.38
-22	9.63	10.24	9.848
-21	9.276	9.891	9.629
-20	8.939	9.525	9.277
-19	8.617	9.175	8.941
-18	8.309	8.841	8.619
-17	8.014	8.522	8.312
-16	7.733	8.218	8.019
-15	7.463	7.926	7.738
-14	7.206	7.648	7.469
-13	6.959	7.381	7.212
-12	6.722	7.126	6.966
-11	6.496	6.882	6.73
-10	6.279	6.648	6.504
-9	6.071	6.424	6.287

-8	5.872	6.21	6.079
-7	5.68	6.004	5.88
-6	5.497	5.806	5.689
-5	5.321	5.617	5.505
-4	5.151	5.435	5.329
-3	4.989	5.261	5.16
-2	4.833	5.093	4.997
-1	4.683	4.933	4.841
0	4.539	4.778	4.691

Table 12. Variation of volumetric cooling capacity with varying evaporator temperature (R-502)

Te (ºC)	Tc=30ºC	Tc=36ºC	TC=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	444	405.9	367	327.3	286.5	244.1
-49	467.2	427.4	386.7	345.2	302.5	258.1
-48	491.5	449.8	407.3	363.8	319.1	272.7
-47	516.7	473.1	428.7	383.3	336.6	288
-46	543	497.5	451	403.5	354.7	304
-45	570.4	522.8	474.3	424.7	373.7	320.7
-44	598.9	549.2	498.6	446.8	393.5	338.2
-43	628.6	576.7	523.8	469.8	414.2	356.5
-42	659.5	605.3	550.1	493.7	435.8	375.5
-41	691.5	635	577.5	518.7	458.2	395.4
-40	724.9	666	606	544.6	481.6	416.1
-39	759.5	698.1	635.6	571.6	505.9	437.6
-38	795.4	731.5	666.3	599.7	531.3	460.1
-37	832.8	766.2	698.3	629	557.7	483.6
-36	871.5	802.2	731.5	659.3	585.1	507.9
-35	911.7	839.5	766	690.9	613.6	533.3
-34	953.4	878.3	801.8	723.6	643.2	559.7
-33	996.6	918.5	838.9	757.6	674	587.2
-32	1041	960.2	877.5	792.9	706	615.7
-31	1088	1003	917.4	829.5	739.2	645.3
-30	1136	1048	958.8	867.5	773.7	676.1
-29	1186	1095	1002	906.9	809.4	708.1
-28	1237	1143	1046	947.7	846.5	741.3
-27	1290	1192	1092	990	884.9	775.7
-26	1346	1244	1140	1034	924.8	811.4
-25	1403	1297	1189	1079	966	848.5
-24	1462	1352	1240	1126	1009	886.8
-23	1523	1409	1293	1175	1053	926.6
-22	1585	1468	1348	1225	1099	967.8

-21	1651	1529	1404	1277	1146	1010
-20	1718	1591	1462	1331	1195	1055
-19	1787	1656	1523	1386	1246	1100
-18	1859	1723	1585	1444	1299	1148
-17	1933	1792	1649	1503	1353	1197
-16	2009	1864	1716	1564	1409	1247
-15	2088	1937	1784	1628	1467	1300
-14	2169	2013	1855	1693	1527	1354
-13	2253	2092	1928	1761	1588	1409
-12	2339	2173	2003	1830	1652	1467
-11	2428	2256	2081	1902	1718	1527
-10	2519	2342	2161	1976	1786	1588
-9	2614	2430	2243	2052	1856	1652
-8	2711	2522	2328	2131	1928	1717
-7	2811	2615	2416	2212	2003	1785
-6	2914	2712	2506	2296	2079	1855
-5	3020	2812	2599	2382	2159	1926
-4	3130	2914	2695	2471	2240	2001
-3	3242	3020	2793	2562	2324	2077
-2	3358	3128	2895	2656	2411	2156
-1	3477	3240	2999	2753	2500	2237
0	3599	3355	3107	2853	2592	2320

Table 13. Variation of volumetric cooling capacity with varying evaporator temperature (R-404A)

Te (ºC)	Tc=30ºC	Tc=36ºC	TC=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	414.9	372	327.5	281.1	231.9	178.2
-49	437.7	392.8	346.2	297.5	245.9	189.7
-48	461.6	414.5	365.7	314.7	260.7	201.8
-47	486.5	437.2	386.1	332.7	276.1	214.4
-46	512.5	460.9	407.4	351.5	292.3	227.7
-45	539.7	485.7	429.7	371.2	309.3	241.7
-44	567.9	511.5	453	391.8	327	256.4
-43	597.4	538.4	477.2	413.3	345.6	271.7
-42	628.2	566.5	502.6	435.8	365	287.9
-41	660.2	595.7	529	459.2	385.3	304.7
-40	693.5	626.2	556.5	483.7	406.5	322.4
-39	728.1	657.9	585.2	509.2	428.7	340.9
-38	764.2	691	615.1	535.8	451.8	360.2
-37	801.7	725.3	646.2	563.6	475.9	380.4
-36	840.7	761.1	678.6	592.4	501.1	401.6
-35	881.2	798.3	712.3	622.5	527.4	423.6

-34	923.3	836.9	747.4	653.8	554.7	446.7
-33	967	877	783.8	686.4	583.2	470.7
-32	1012	918.7	821.7	720.3	612.9	495.8
-31	1059	962	861	755.5	643.7	521.9
-30	1108	1007	901.9	792.2	675.9	549.1
-29	1159	1054	944.3	830.2	709.3	577.5
-28	1211	1102	988.4	869.7	744	607
-27	1266	1152	1034	910.8	780.2	637.8
-26	1322	1204	1081	953.4	817.7	669.8
-25	1381	1258	1131	997.6	856.7	703.1
-24	1441	1314	1182	1043	897.1	737.7
-23	1504	1371	1234	1091	939.1	773.6
-22	1569	1431	1289	1140	982.7	811
-21	1636	1493	1346	1191	1028	849.8
-20	1705	1557	1404	1244	1075	890.1
-19	1777	1624	1465	1299	1123	931.9
-18	1851	1692	1528	1356	1174	975.3
-17	1928	1763	1593	1415	1226	1020
-16	2007	1837	1660	1476	1280	1067
-15	2089	1913	1730	1539	1336	1115
-14	2174	1991	1802	1604	1394	1166
-13	2261	2072	1876	1671	1454	1217
-12	2351	2156	1953	1741	1516	1271
-11	2444	2242	2032	1813	1580	1327
-10	2541	2331	2114	1887	1647	1385
-9	2640	2423	2199	1964	1715	1444
-8	2742	2518	2286	2044	1786	1506
-7	2848	2616	2376	2126	1860	1570
-6	2957	2718	2470	2210	1936	1636
-5	3070	2822	2566	2298	2014	1705
-4	3185	2930	2665	2388	2095	1775
-3	3305	3041	2767	2481	2178	1848
-2	3428	3156	2873	2578	2265	1924
-1	3555	3274	2982	2677	2354	2002
0	3686	3395	3094	2779	2446	2082

Table 14. Variation of volumetric cooling capacity with varying evaporator temperature (R-507A)

Te (ºC)	Tc=30ºC	Tc=36ºC	TC=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	448.7	403.1	355	303.5	247	182
-49	473	425.2	374.9	321	261.8	193.7
-48	498.4	448.4	395.7	339.3	277.3	206
-47	524.9	472.5	417.4	358.4	293.5	218.9

-46	552.5	497.7	440.1	378.3	310.5	232.5
-45	581.3	524.1	463.8	399.2	328.3	246.7
-44	611.3	551.5	488.5	421	346.9	261.7
-43	642.5	580.1	514.2	443.8	366.3	277.3
-42	675.1	609.8	541.1	467.5	386.7	293.7
-41	709	640.9	569.1	492.3	407.9	310.9
-40	744.2	673.1	598.3	518.1	430.1	328.9
-39	780.8	706.7	628.7	545.1	453.2	347.7
-38	818.9	741.7	660.3	573.1	477.4	367.4
-37	858.5	778	693.2	602.4	502.6	387.9
-36	899.7	815.8	727.4	632.8	528.9	409.4
-35	942.4	855	763	664.5	556.2	431.8
-34	986.7	895.8	800	697.4	584.7	455.2
-33	1033	938.1	838.4	731.7	614.4	479.6
-32	1081	982.1	878.4	767.3	645.3	505
-31	1130	1028	919.8	804.3	677.4	531.6
-30	1181	1075	962.8	842.7	710.8	559.2
-29	1235	1124	1007	882.7	745.6	588
-28	1290	1175	1054	924.1	781.7	618
-27	1347	1228	1102	967.1	819.2	649.1
-26	1406	1282	1152	1012	858.1	681.6
-25	1467	1339	1203	1058	898.6	715.3
-24	1531	1397	1257	1106	940.5	750.4
-23	1596	1458	1312	1156	984.1	786.8
-22	1664	1521	1369	1207	1029	824.6
-21	1735	1586	1429	1261	1076	863.9
-20	1807	1653	1490	1316	1125	904.7
-19	1882	1722	1554	1373	1175	947
-18	1960	1794	1619	1432	1227	990.9
-17	2040	1868	1687	1494	1281	1036
-16	2123	1945	1758	1557	1337	1084
-15	2208	2024	1830	1623	1395	1133
-14	2296	2106	1905	1691	1455	1183
-13	2388	2191	1983	1761	1517	1236
-12	2482	2278	2063	1833	1581	1290
-11	2579	2368	2146	1908	1647	1346
-10	2679	2461	2231	1985	1715	1405
-9	2782	2557	2320	2065	1786	1465
-8	2889	2656	2411	2148	1859	1527
-7	2999	2758	2505	2233	1935	1592
-6	3112	2863	2602	2321	2013	1659
-5	3229	2972	2702	2412	2093	1728
-4	3349	3084	2805	2505	2177	1799
-3	3473	3200	2911	2602	2263	1872
-2	3601	3319	3021	2702	2351	1949
-1	3733	3441	3134	2804	2443	2027
0	3869	3568	3250	2910	2537	2108

Table 15. Comparison of volumetric cooling capacity with varying evaporator temperature(Tc= 30ºC)

Te (ºC)	R502	R404A	R507A
-50	444	414.9	448.7
-49	467.2	437.7	473
-48	491.5	461.6	498.4
-47	516.7	486.5	524.9
-46	543	512.5	552.5
-45	570.4	539.7	581.3
-44	598.9	567.9	611.3
-43	628.6	597.4	642.5
-42	659.5	628.2	675.1
-41	691.5	660.2	709
-40	724.9	693.5	744.2
-39	759.5	728.1	780.8
-38	795.4	764.2	818.9
-37	832.8	801.7	858.5
-36	871.5	840.7	899.7
-35	911.7	881.2	942.4
-34	953.4	923.3	986.7
-33	996.6	967	1033
-32	1041	1012	1081
-31	1088	1059	1130
-30	1136	1108	1181
-29	1186	1159	1235
-28	1237	1211	1290
-27	1290	1266	1347
-26	1346	1322	1406
-25	1403	1381	1467
-24	1462	1441	1531
-23	1523	1504	1596
-22	1585	1569	1664
-21	1651	1636	1735
-20	1718	1705	1807
-19	1787	1777	1882
-18	1859	1851	1960
-17	1933	1928	2040
-16	2009	2007	2123
-15	2088	2089	2208
-14	2169	2174	2296
-13	2253	2261	2388
-12	2339	2351	2482
-11	2428	2444	2579
-10	2519	2541	2679
-9	2614	2640	2782
-8	2711	2742	2889
-7	2811	2848	2999
-6	2914	2957	3112
-5	3020	3070	3229

-4	3130	3185	3349
-3	3242	3305	3473
-2	3358	3428	3601
-1	3477	3555	3733
0	3599	3686	3869

Table 16. Comparison of volumetric cooling capacity with varying evaporator temperature (Tc= 36ºC)

Te (ºC)	R502	R404A	R507A
-50	405.9	372	403.1
-49	427.4	392.8	425.2
-48	449.8	414.5	448.4
-47	473.1	437.2	472.5
-46	497.5	460.9	497.7
-45	522.8	485.7	524.1
-44	549.2	511.5	551.5
-43	576.7	538.4	580.1
-42	605.3	566.5	609.8
-41	635	595.7	640.9
-40	666	626.2	673.1
-39	698.1	657.9	706.7
-38	731.5	691	741.7
-37	766.2	725.3	778
-36	802.2	761.1	815.8
-35	839.5	798.3	855
-34	878.3	836.9	895.8
-33	918.5	877	938.1
-32	960.2	918.7	982.1
-31	1003	962	1028
-30	1048	1007	1075
-29	1095	1054	1124
-28	1143	1102	1175
-27	1192	1152	1228
-26	1244	1204	1282
-25	1297	1258	1339
-24	1352	1314	1397
-23	1409	1371	1458
-22	1468	1431	1521
-21	1529	1493	1586
-20	1591	1557	1653
-19	1656	1624	1722

-18	1723	1692	1794
-17	1792	1763	1868
-16	1864	1837	1945
-15	1937	1913	2024
-14	2013	1991	2106
-13	2092	2072	2191
-12	2173	2156	2278
-11	2256	2242	2368
-10	2342	2331	2461
-9	2430	2423	2557
-8	2522	2518	2656
-7	2615	2616	2758
-6	2712	2718	2863
-5	2812	2822	2972
-4	2914	2930	3084
-3	3020	3041	3200
-2	3128	3156	3319
-1	3240	3274	3441
0	3355	3395	3568

Table 17. Comparison of volumetric cooling capacity with varying evaporator temperature (Tc= 42ºC)

Te (ºC)	R502	R404A	R507A
-50	367	327.5	355
-49	386.7	346.2	374.9
-48	407.3	365.7	395.7
-47	428.7	386.1	417.4
-46	451	407.4	440.1
-45	474.3	429.7	463.8
-44	498.6	453	488.5
-43	523.8	477.2	514.2
-42	550.1	502.6	541.1
-41	577.5	529	569.1
-40	606	556.5	598.3
-39	635.6	585.2	628.7
-38	666.3	615.1	660.3
-37	698.3	646.2	693.2
-36	731.5	678.6	727.4
-35	766	712.3	763
-34	801.8	747.4	800
-33	838.9	783.8	838.4
-32	877.5	821.7	878.4

-31	917.4	861	919.8
-30	958.8	901.9	962.8
-29	1002	944.3	1007
-28	1046	988.4	1054
-27	1092	1034	1102
-26	1140	1081	1152
-25	1189	1131	1203
-24	1240	1182	1257
-23	1293	1234	1312
-22	1348	1289	1369
-21	1404	1346	1429
-20	1462	1404	1490
-19	1523	1465	1554
-18	1585	1528	1619
-17	1649	1593	1687
-16	1716	1660	1758
-15	1784	1730	1830
-14	1855	1802	1905
-13	1928	1876	1983
-12	2003	1953	2063
-11	2081	2032	2146
-10	2161	2114	2231
-9	2243	2199	2320
-8	2328	2286	2411
-7	2416	2376	2505
-6	2506	2470	2602
-5	2599	2566	2702
-4	2695	2665	2805
-3	2793	2767	2911
-2	2895	2873	3021
-1	2999	2982	3134
0	3107	3094	3250

Table 18. Comparison of volumetric cooling capacity with varying evaporator temperature (Tc= 48ºC)

Te (ºC)	R502	R404A	R507A
-50	327.3	281.1	303.5
-49	345.2	297.5	321
-48	363.8	314.7	339.3
-47	383.3	332.7	358.4
-46	403.5	351.5	378.3
-45	424.7	371.2	399.2
-44	446.8	391.8	421
-43	469.8	413.3	443.8
-42	493.7	435.8	467.5

-41	518.7	459.2	492.3
-40	544.6	483.7	518.1
-39	571.6	509.2	545.1
-38	599.7	535.8	573.1
-37	629	563.6	602.4
-36	659.3	592.4	632.8
-35	690.9	622.5	664.5
-34	723.6	653.8	697.4
-33	757.6	686.4	731.7
-32	792.9	720.3	767.3
-31	829.5	755.5	804.3
-30	867.5	792.2	842.7
-29	906.9	830.2	882.7
-28	947.7	869.7	924.1
-27	990	910.8	967.1
-26	1034	953.4	1012
-25	1079	997.6	1058
-24	1126	1043	1106
-23	1175	1091	1156
-22	1225	1140	1207
-21	1277	1191	1261
-20	1331	1244	1316
-19	1386	1299	1373
-18	1444	1356	1432
-17	1503	1415	1494
-16	1564	1476	1557
-15	1628	1539	1623
-14	1693	1604	1691
-13	1761	1671	1761
-12	1830	1741	1833
-11	1902	1813	1908
-10	1976	1887	1985
-9	2052	1964	2065
-8	2131	2044	2148
-7	2212	2126	2233
-6	2296	2210	2321
-5	2382	2298	2412
-4	2471	2388	2505
-3	2562	2481	2602
-2	2656	2578	2702
-1	2753	2677	2804
0	2853	2779	2910

Table 19. Comparison of volumetric cooling capacity with varying evaporator temperature (Tc= 54ºC)

Te (ºC)	R502	R404A	R507A

-50	286.5	231.9	247
-49	302.5	245.9	261.8
-48	319.1	260.7	277.3
-47	336.6	276.1	293.5
-46	354.7	292.3	310.5
-45	373.7	309.3	328.3
-44	393.5	327	346.9
-43	414.2	345.6	366.3
-42	435.8	365	386.7
-41	458.2	385.3	407.9
-40	481.6	406.5	430.1
-39	505.9	428.7	453.2
-38	531.3	451.8	477.4
-37	557.7	475.9	502.6
-36	585.1	501.1	528.9
-35	613.6	527.4	556.2
-34	643.2	554.7	584.7
-33	674	583.2	614.4
-32	706	612.9	645.3
-31	739.2	643.7	677.4
-30	773.7	675.9	710.8
-29	809.4	709.3	745.6
-28	846.5	744	781.7
-27	884.9	780.2	819.2
-26	924.8	817.7	858.1
-25	966	856.7	898.6
-24	1009	897.1	940.5
-23	1053	939.1	984.1
-22	1099	982.7	1029
-21	1146	1028	1076
-20	1195	1075	1125
-19	1246	1123	1175
-18	1299	1174	1227
-17	1353	1226	1281
-16	1409	1280	1337
-15	1467	1336	1395
-14	1527	1394	1455
-13	1588	1454	1517
-12	1652	1516	1581
-11	1718	1580	1647
-10	1786	1647	1715
-9	1856	1715	1786
-8	1928	1786	1859
-7	2003	1860	1935
-6	2079	1936	2013
-5	2159	2014	2093
-4	2240	2095	2177
-3	2324	2178	2263
-2	2411	2265	2351
-1	2500	2354	2443

0	2592	2446	2537

Table 20. Comparison of volumetric cooling capacity with varying evaporator temperature (Tc= 60ºC)

Te (ºC)	R502	R404A	R507A
-50	244.1	178.2	182
-49	258.1	189.7	193.7
-48	272.7	201.8	206
-47	288	214.4	218.9
-46	304	227.7	232.5
-45	320.7	241.7	246.7
-44	338.2	256.4	261.7
-43	356.5	271.7	277.3
-42	375.5	287.9	293.7
-41	395.4	304.7	310.9
-40	416.1	322.4	328.9
-39	437.6	340.9	347.7
-38	460.1	360.2	367.4
-37	483.6	380.4	387.9
-36	507.9	401.6	409.4
-35	533.3	423.6	431.8
-34	559.7	446.7	455.2
-33	587.2	470.7	479.6
-32	615.7	495.8	505
-31	645.3	521.9	531.6
-30	676.1	549.1	559.2
-29	708.1	577.5	588
-28	741.3	607	618
-27	775.7	637.8	649.1
-26	811.4	669.8	681.6
-25	848.5	703.1	715.3
-24	886.8	737.7	750.4
-23	926.6	773.6	786.8
-22	967.8	811	824.6
-21	1010	849.8	863.9
-20	1055	890.1	904.7
-19	1100	931.9	947
-18	1148	975.3	990.9
-17	1197	1020	1036
-16	1247	1067	1084
-15	1300	1115	1133
-14	1354	1166	1183

-13	1409	1217	1236
-12	1467	1271	1290
-11	1527	1327	1346
-10	1588	1385	1405
-9	1652	1444	1465
-8	1717	1506	1527
-7	1785	1570	1592
-6	1855	1636	1659
-5	1926	1705	1728
-4	2001	1775	1799
-3	2077	1848	1872
-2	2156	1924	1949
-1	2237	2002	2027
0	2320	2082	2108

Table 21. Variation of coefficient of performance with varying evaporator temperature (R-502)

Te (ºC)	Tc=30ºC	Tc=36ºC	Tc=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	1.291	1.117	0.9609	0.8186	0.687	0.563
-49	1.322	1.144	0.9836	0.8381	0.7038	0.5773
-48	1.354	1.171	1.007	0.8581	0.721	0.592
-47	1.386	1.198	1.031	0.8786	0.7386	0.6071
-46	1.42	1.227	1.055	0.8996	0.7566	0.6225
-45	1.454	1.256	1.08	0.9211	0.775	0.6382
-44	1.49	1.287	1.106	0.9432	0.7939	0.6543
-43	1.527	1.318	1.132	0.9658	0.8132	0.6708
-42	1.564	1.35	1.16	0.9889	0.833	0.6877
-41	1.603	1.382	1.187	1.013	0.8533	0.705
-40	1.643	1.416	1.216	1.037	0.8741	0.7227
-39	1.685	1.451	1.245	1.062	0.8954	0.7408
-38	1.727	1.487	1.276	1.088	0.9173	0.7594
-37	1.771	1.523	1.307	1.114	0.9397	0.7784
-36	1.817	1.561	1.339	1.141	0.9627	0.7978
-35	1.863	1.6	1.371	1.169	0.9862	0.8178
-34	1.912	1.641	1.405	1.197	1.01	0.8383
-33	1.962	1.682	1.44	1.227	1.035	0.8592
-32	2.014	1.725	1.476	1.257	1.061	0.8807
-31	2.067	1.769	1.513	1.288	1.087	0.9027
-30	2.123	1.815	1.551	1.32	1.114	0.9253
-29	2.18	1.862	1.59	1.352	1.141	0.9485
-28	2.239	1.91	1.63	1.386	1.169	0.9723
-27	2.301	1.961	1.672	1.421	1.198	0.9966
-26	2.365	2.013	1.714	1.456	1.228	1.022

-25	2.431	2.066	1.759	1.493	1.259	1.047
-24	2.5	2.122	1.804	1.531	1.291	1.074
-23	2.572	2.18	1.852	1.57	1.323	1.101
-22	2.646	2.24	1.9	1.61	1.356	1.129
-21	2.724	2.301	1.951	1.652	1.391	1.157
-20	2.805	2.366	2.003	1.694	1.426	1.187
-19	2.889	2.432	2.057	1.739	1.463	1.217
-18	2.977	2.502	2.112	1.784	1.5	1.248
-17	3.068	2.574	2.17	1.831	1.539	1.28
-16	3.164	2.649	2.23	1.88	1.579	1.313
-15	3.264	2.727	2.292	1.93	1.62	1.346
-14	3.369	2.808	2.356	1.982	1.662	1.381
-13	3.479	2.892	2.423	2.036	1.706	1.417
-12	3.594	2.981	2.493	2.091	1.751	1.454
-11	3.715	3.073	2.565	2.149	1.798	1.492
-10	3.842	3.169	2.64	2.209	1.846	1.531
-9	3.975	3.269	2.718	2.271	1.896	1.572
-8	4.116	3.375	2.799	2.335	1.947	1.613
-7	4.265	3.485	2.884	2.401	2.001	1.656
-6	4.422	3.601	2.972	2.471	2.056	1.701
-5	4.588	3.722	3.065	2.543	2.113	1.747
-4	4.764	3.85	3.161	2.617	2.172	1.794
-3	4.951	3.985	3.262	2.695	2.233	1.843
-2	5.15	4.126	3.367	2.776	2.297	1.894
-1	5.362	4.276	3.478	2.861	2.363	1.946
0	5.588	4.434	3.594	2.949	2.432	2.001

Table 22. Variation of coefficient of performance with varying evaporator temperature (R-404A)

Te (ºC)	Tc=30ºC	Tc=36ºC	Tc=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	1.189	1.012	0.849	0.6975	0.5528	0.4095
-49	1.219	1.037	0.8705	0.7157	0.5681	0.4222
-48	1.25	1.063	0.8926	0.7344	0.5838	0.4352
-47	1.281	1.09	0.9152	0.7536	0.5999	0.4485
-46	1.314	1.117	0.9385	0.7732	0.6164	0.4621
-45	1.347	1.145	0.9623	0.7934	0.6333	0.476
-44	1.381	1.174	0.9868	0.814	0.6506	0.4903
-43	1.417	1.204	1.012	0.8352	0.6684	0.5049
-42	1.453	1.234	1.038	0.8569	0.6866	0.5199
-41	1.491	1.266	1.064	0.8792	0.7052	0.5353
-40	1.529	1.298	1.091	0.9021	0.7243	0.551
-39	1.569	1.332	1.119	0.9256	0.7439	0.5671
-38	1.61	1.366	1.148	0.9497	0.764	0.5837

-37	1.653	1.401	1.178	0.9744	0.7847	0.6006
-36	1.696	1.438	1.208	0.9998	0.8058	0.618
-35	1.742	1.475	1.239	1.026	0.8275	0.6358
-34	1.788	1.514	1.271	1.053	0.8498	0.654
-33	1.837	1.553	1.305	1.08	0.8727	0.6728
-32	1.886	1.595	1.339	1.109	0.8961	0.692
-31	1.938	1.637	1.374	1.138	0.9202	0.7117
-30	1.992	1.681	1.41	1.168	0.945	0.7319
-29	2.047	1.726	1.447	1.198	0.9704	0.7527
-28	2.104	1.773	1.485	1.23	0.9965	0.7739
-27	2.164	1.821	1.525	1.263	1.023	0.7958
-26	2.225	1.871	1.566	1.296	1.051	0.8183
-25	2.289	1.922	1.608	1.331	1.079	0.8413
-24	2.356	1.976	1.651	1.367	1.109	0.865
-23	2.425	2.031	1.696	1.403	1.139	0.8893
-22	2.496	2.088	1.743	1.441	1.169	0.9143
-21	2.571	2.148	1.791	1.48	1.201	0.94
-20	2.649	2.209	1.84	1.52	1.234	0.9664
-19	2.73	2.273	1.892	1.562	1.268	0.9936
-18	2.814	2.34	1.945	1.605	1.302	1.021
-17	2.902	2.409	2	1.649	1.338	1.05
-16	2.994	2.48	2.057	1.695	1.375	1.08
-15	3.09	2.555	2.116	1.742	1.413	1.11
-14	3.191	2.633	2.177	1.791	1.452	1.142
-13	3.296	2.714	2.24	1.842	1.493	1.174
-12	3.407	2.798	2.307	1.894	1.535	1.207
-11	3.523	2.886	2.375	1.948	1.578	1.241
-10	3.644	2.978	2.446	2.005	1.623	1.277
-9	3.772	3.074	2.521	2.063	1.669	1.313
-8	3.907	3.175	2.598	2.123	1.717	1.351
-7	4.05	3.281	2.679	2.186	1.766	1.39
-6	4.2	3.391	2.763	2.251	1.817	1.43
-5	4.359	3.507	2.85	2.319	1.87	1.471
-4	4.527	3.629	2.942	2.389	1.925	1.514
-3	4.706	3.757	3.038	2.463	1.982	1.558
-2	4.895	3.892	3.138	2.539	2.041	1.604
-1	5.097	4.035	3.243	2.619	2.102	1.651
0	5.313	4.185	3.353	2.701	2.166	1.7

Table 23. Variation coefficient of performance with varying evaporator temperature (R-507A)

Te (ºC)	Tc=30ºC	Tc=36ºC	Tc=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	1.225	1.043	0.8753	0.716	0.5596	0.3975

-49	1.256	1.069	0.8973	0.7346	0.5751	0.41
-48	1.287	1.096	0.9199	0.7536	0.5909	0.4228
-47	1.32	1.123	0.943	0.7731	0.6072	0.436
-46	1.353	1.151	0.9667	0.7931	0.6238	0.4494
-45	1.387	1.18	0.991	0.8136	0.6408	0.4632
-44	1.422	1.21	1.016	0.8346	0.6583	0.4773
-43	1.458	1.24	1.042	0.8561	0.6762	0.4917
-42	1.495	1.271	1.068	0.8782	0.6945	0.5065
-41	1.534	1.303	1.095	0.9009	0.7133	0.5217
-40	1.573	1.337	1.123	0.9241	0.7325	0.5372
-39	1.614	1.371	1.151	0.948	0.7523	0.5532
-38	1.656	1.406	1.181	0.9724	0.7725	0.5695
-37	1.7	1.442	1.211	0.9976	0.7933	0.5862
-36	1.745	1.479	1.242	1.023	0.8146	0.6033
-35	1.791	1.517	1.274	1.05	0.8364	0.6209
-34	1.839	1.557	1.306	1.077	0.8588	0.6389
-33	1.888	1.598	1.34	1.105	0.8818	0.6574
-32	1.939	1.64	1.375	1.134	0.9054	0.6764
-31	1.992	1.683	1.411	1.163	0.9297	0.6958
-30	2.047	1.728	1.448	1.194	0.9546	0.7158
-29	2.104	1.774	1.486	1.225	0.9802	0.7363
-28	2.162	1.822	1.525	1.257	1.006	0.7573
-27	2.223	1.871	1.565	1.29	1.033	0.7788
-26	2.286	1.922	1.607	1.324	1.061	0.801
-25	2.352	1.975	1.65	1.36	1.09	0.8237
-24	2.42	2.029	1.694	1.396	1.119	0.8471
-23	2.491	2.086	1.74	1.433	1.149	0.8711
-22	2.564	2.144	1.787	1.471	1.18	0.8958
-21	2.641	2.205	1.836	1.511	1.212	0.9211
-20	2.72	2.268	1.887	1.552	1.245	0.9472
-19	2.803	2.334	1.939	1.594	1.279	0.974
-18	2.89	2.402	1.993	1.637	1.314	1.002
-17	2.98	2.472	2.049	1.682	1.35	1.03
-16	3.075	2.546	2.107	1.729	1.387	1.059
-15	3.174	2.622	2.168	1.777	1.425	1.089
-14	3.277	2.702	2.23	1.827	1.465	1.12
-13	3.385	2.785	2.295	1.878	1.506	1.152
-12	3.499	2.871	2.362	1.931	1.548	1.185
-11	3.618	2.961	2.432	1.986	1.591	1.219
-10	3.743	3.056	2.505	2.043	1.636	1.254
-9	3.875	3.154	2.581	2.102	1.683	1.29
-8	4.014	3.258	2.66	2.164	1.731	1.327
-7	4.161	3.366	2.742	2.228	1.78	1.365
-6	4.316	3.479	2.828	2.294	1.832	1.405
-5	4.48	3.598	2.918	2.363	1.885	1.445
-4	4.653	3.723	3.011	2.434	1.94	1.488
-3	4.838	3.855	3.109	2.509	1.997	1.531
-2	5.034	3.994	3.211	2.586	2.057	1.577
-1	5.242	4.141	3.319	2.667	2.118	1.623
0	5.465	4.295	3.431	2.751	2.183	1.672

Table 24. Comparison of coefficient of performance with varying evaporator temperature(Tc= 30ºC)

Te (ºC)	R502	R404A	R507A
-50	1.291	1.189	1.225
-49	1.322	1.219	1.256
-48	1.354	1.25	1.287
-47	1.386	1.281	1.32
-46	1.42	1.314	1.353
-45	1.454	1.347	1.387
-44	1.49	1.381	1.422
-43	1.527	1.417	1.458
-42	1.564	1.453	1.495
-41	1.603	1.491	1.534
-40	1.643	1.529	1.573
-39	1.685	1.569	1.614
-38	1.727	1.61	1.656
-37	1.771	1.653	1.7
-36	1.817	1.696	1.745
-35	1.863	1.742	1.791
-34	1.912	1.788	1.839
-33	1.962	1.837	1.888
-32	2.014	1.886	1.939
-31	2.067	1.938	1.992
-30	2.123	1.992	2.047
-29	2.18	2.047	2.104
-28	2.239	2.104	2.162
-27	2.301	2.164	2.223
-26	2.365	2.225	2.286
-25	2.431	2.289	2.352
-24	2.5	2.356	2.42
-23	2.572	2.425	2.491
-22	2.646	2.496	2.564
-21	2.724	2.571	2.641
-20	2.805	2.649	2.72
-19	2.889	2.73	2.803
-18	2.977	2.814	2.89
-17	3.068	2.902	2.98
-16	3.164	2.994	3.075
-15	3.264	3.09	3.174
-14	3.369	3.191	3.277
-13	3.479	3.296	3.385
-12	3.594	3.407	3.499
-11	3.715	3.523	3.618
-10	3.842	3.644	3.743
-9	3.975	3.772	3.875
-8	4.116	3.907	4.014
-7	4.265	4.05	4.161
-6	4.422	4.2	4.316
-5	4.588	4.359	4.48
-4	4.764	4.527	4.653

-3	4.951	4.706	4.838
-2	5.15	4.895	5.034
-1	5.362	5.097	5.242
0	5.588	5.313	5.465

Table 25. Comparison of coefficient of performance with varying evaporator temperature (Tc= 36ºC)

Te (ºC)	R502	R404A	R507A
-50	1.117	1.012	1.043
-49	1.144	1.037	1.069
-48	1.171	1.063	1.096
-47	1.198	1.09	1.123
-46	1.227	1.117	1.151
-45	1.256	1.145	1.18
-44	1.287	1.174	1.21
-43	1.318	1.204	1.24
-42	1.35	1.234	1.271
-41	1.382	1.266	1.303
-40	1.416	1.298	1.337
-39	1.451	1.332	1.371
-38	1.487	1.366	1.406
-37	1.523	1.401	1.442
-36	1.561	1.438	1.479
-35	1.6	1.475	1.517
-34	1.641	1.514	1.557
-33	1.682	1.553	1.598
-32	1.725	1.595	1.64
-31	1.769	1.637	1.683
-30	1.815	1.681	1.728
-29	1.862	1.726	1.774
-28	1.91	1.773	1.822
-27	1.961	1.821	1.871
-26	2.013	1.871	1.922
-25	2.066	1.922	1.975
-24	2.122	1.976	2.029
-23	2.18	2.031	2.086
-22	2.24	2.088	2.144
-21	2.301	2.148	2.205
-20	2.366	2.209	2.268
-19	2.432	2.273	2.334
-18	2.502	2.34	2.402
-17	2.574	2.409	2.472
-16	2.649	2.48	2.546
-15	2.727	2.555	2.622

-14	2.808	2.633	2.702
-13	2.892	2.714	2.785
-12	2.981	2.798	2.871
-11	3.073	2.886	2.961
-10	3.169	2.978	3.056
-9	3.269	3.074	3.154
-8	3.375	3.175	3.258
-7	3.485	3.281	3.366
-6	3.601	3.391	3.479
-5	3.722	3.507	3.598
-4	3.85	3.629	3.723
-3	3.985	3.757	3.855
-2	4.126	3.892	3.994
-1	4.276	4.035	4.141
0	4.434	4.185	4.295

Table 26. Comparison of coefficient of performance with varying evaporator temperature (Tc=42ºC)

Te (ºC)	R502	R404A	R507A
-50	0.9609	0.849	0.8753
-49	0.9836	0.8705	0.8973
-48	1.007	0.8926	0.9199
-47	1.031	0.9152	0.943
-46	1.055	0.9385	0.9667
-45	1.08	0.9623	0.991
-44	1.106	0.9868	1.016
-43	1.132	1.012	1.042
-42	1.16	1.038	1.068
-41	1.187	1.064	1.095
-40	1.216	1.091	1.123
-39	1.245	1.119	1.151
-38	1.276	1.148	1.181
-37	1.307	1.178	1.211
-36	1.339	1.208	1.242
-35	1.371	1.239	1.274
-34	1.405	1.271	1.306
-33	1.44	1.305	1.34
-32	1.476	1.339	1.375
-31	1.513	1.374	1.411
-30	1.551	1.41	1.448
-29	1.59	1.447	1.486

-28	1.63	1.485	1.525
-27	1.672	1.525	1.565
-26	1.714	1.566	1.607
-25	1.759	1.608	1.65
-24	1.804	1.651	1.694
-23	1.852	1.696	1.74
-22	1.9	1.743	1.787
-21	1.951	1.791	1.836
-20	2.003	1.84	1.887
-19	2.057	1.892	1.939
-18	2.112	1.945	1.993
-17	2.17	2	2.049
-16	2.23	2.057	2.107
-15	2.292	2.116	2.168
-14	2.356	2.177	2.23
-13	2.423	2.24	2.295
-12	2.493	2.307	2.362
-11	2.565	2.375	2.432
-10	2.64	2.446	2.505
-9	2.718	2.521	2.581
-8	2.799	2.598	2.66
-7	2.884	2.679	2.742
-6	2.972	2.763	2.828
-5	3.065	2.85	2.918
-4	3.161	2.942	3.011
-3	3.262	3.038	3.109
-2	3.367	3.138	3.211
-1	3.478	3.243	3.319
0	3.594	3.353	3.431

Table 27. Comparison of coefficient of performance with varying evaporator temperature (Tc=48ºC)

Te (ºC)	R502	R404A	R507A
-50	0.8186	0.6975	0.716
-49	0.8381	0.7157	0.7346
-48	0.8581	0.7344	0.7536
-47	0.8786	0.7536	0.7731
-46	0.8996	0.7732	0.7931
-45	0.9211	0.7934	0.8136
-44	0.9432	0.814	0.8346
-43	0.9658	0.8352	0.8561
-42	0.9889	0.8569	0.8782

-41	1.013	0.8792	0.9009
-40	1.037	0.9021	0.9241
-39	1.062	0.9256	0.948
-38	1.088	0.9497	0.9724
-37	1.114	0.9744	0.9976
-36	1.141	0.9998	1.023
-35	1.169	1.026	1.05
-34	1.197	1.053	1.077
-33	1.227	1.08	1.105
-32	1.257	1.109	1.134
-31	1.288	1.138	1.163
-30	1.32	1.168	1.194
-29	1.352	1.198	1.225
-28	1.386	1.23	1.257
-27	1.421	1.263	1.29
-26	1.456	1.296	1.324
-25	1.493	1.331	1.36
-24	1.531	1.367	1.396
-23	1.57	1.403	1.433
-22	1.61	1.441	1.471
-21	1.652	1.48	1.511
-20	1.694	1.52	1.552
-19	1.739	1.562	1.594
-18	1.784	1.605	1.637
-17	1.831	1.649	1.682
-16	1.88	1.695	1.729
-15	1.93	1.742	1.777
-14	1.982	1.791	1.827
-13	2.036	1.842	1.878
-12	2.091	1.894	1.931
-11	2.149	1.948	1.986
-10	2.209	2.005	2.043
-9	2.271	2.063	2.102
-8	2.335	2.123	2.164
-7	2.401	2.186	2.228
-6	2.471	2.251	2.294
-5	2.543	2.319	2.363
-4	2.617	2.389	2.434
-3	2.695	2.463	2.509
-2	2.776	2.539	2.586
-1	2.861	2.619	2.667
0	2.949	2.701	2.751

Table 28. Comparison of coefficient of performance with varying evaporator temperature (Tc=54ºC)

Te (ºC)	R502	R404A	R507A
-50	0.687	0.5528	0.5596
-49	0.7038	0.5681	0.5751
-48	0.721	0.5838	0.5909
-47	0.7386	0.5999	0.6072
-46	0.7566	0.6164	0.6238
-45	0.775	0.6333	0.6408
-44	0.7939	0.6506	0.6583
-43	0.8132	0.6684	0.6762
-42	0.833	0.6866	0.6945
-41	0.8533	0.7052	0.7133
-40	0.8741	0.7243	0.7325
-39	0.8954	0.7439	0.7523
-38	0.9173	0.764	0.7725
-37	0.9397	0.7847	0.7933
-36	0.9627	0.8058	0.8146
-35	0.9862	0.8275	0.8364
-34	1.01	0.8498	0.8588
-33	1.035	0.8727	0.8818
-32	1.061	0.8961	0.9054
-31	1.087	0.9202	0.9297
-30	1.114	0.945	0.9546
-29	1.141	0.9704	0.9802
-28	1.169	0.9965	1.006
-27	1.198	1.023	1.033
-26	1.228	1.051	1.061
-25	1.259	1.079	1.09
-24	1.291	1.109	1.119
-23	1.323	1.139	1.149
-22	1.356	1.169	1.18
-21	1.391	1.201	1.212
-20	1.426	1.234	1.245
-19	1.463	1.268	1.279
-18	1.5	1.302	1.314
-17	1.539	1.338	1.35
-16	1.579	1.375	1.387
-15	1.62	1.413	1.425
-14	1.662	1.452	1.465
-13	1.706	1.493	1.506
-12	1.751	1.535	1.548
-11	1.798	1.578	1.591
-10	1.846	1.623	1.636
-9	1.896	1.669	1.683
-8	1.947	1.717	1.731
-7	2.001	1.766	1.78
-6	2.056	1.817	1.832
-5	2.113	1.87	1.885
-4	2.172	1.925	1.94
-3	2.233	1.982	1.997

-2	2.297	2.041	2.057
-1	2.363	2.102	2.118
0	2.432	2.166	2.183

Table 29. Comparison of coefficient of performance with varying evaporator temperature (Tc=60ºC)

Te (ºC)	R502	R404A	R507A
-50	0.563	0.4095	0.3975
-49	0.5773	0.4222	0.41
-48	0.592	0.4352	0.4228
-47	0.6071	0.4485	0.436
-46	0.6225	0.4621	0.4494
-45	0.6382	0.476	0.4632
-44	0.6543	0.4903	0.4773
-43	0.6708	0.5049	0.4917
-42	0.6877	0.5199	0.5065
-41	0.705	0.5353	0.5217
-40	0.7227	0.551	0.5372
-39	0.7408	0.5671	0.5532
-38	0.7594	0.5837	0.5695
-37	0.7784	0.6006	0.5862
-36	0.7978	0.618	0.6033
-35	0.8178	0.6358	0.6209
-34	0.8383	0.654	0.6389
-33	0.8592	0.6728	0.6574
-32	0.8807	0.692	0.6764
-31	0.9027	0.7117	0.6958
-30	0.9253	0.7319	0.7158
-29	0.9485	0.7527	0.7363
-28	0.9723	0.7739	0.7573
-27	0.9966	0.7958	0.7788
-26	1.022	0.8183	0.801
-25	1.047	0.8413	0.8237
-24	1.074	0.865	0.8471
-23	1.101	0.8893	0.8711
-22	1.129	0.9143	0.8958
-21	1.157	0.94	0.9211
-20	1.187	0.9664	0.9472
-19	1.217	0.9936	0.974
-18	1.248	1.021	1.002
-17	1.28	1.05	1.03
-16	1.313	1.08	1.059
-15	1.346	1.11	1.089

-14	1.381	1.142	1.12
-13	1.417	1.174	1.152
-12	1.454	1.207	1.185
-11	1.492	1.241	1.219
-10	1.531	1.277	1.254
-9	1.572	1.313	1.29
-8	1.613	1.351	1.327
-7	1.656	1.39	1.365
-6	1.701	1.43	1.405
-5	1.747	1.471	1.445
-4	1.794	1.514	1.488
-3	1.843	1.558	1.531
-2	1.894	1.604	1.577
-1	1.946	1.651	1.623
0	2.001	1.7	1.672

Table 30. Variation of exergy destruction ratio with varying evaporator temperature (R-502)

Te (ºC)	Tc=30ºC	Tc=36ºC	Tc=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	1.523	1.916	2.389	2.979	3.741	4.785
-49	1.51	1.902	2.374	2.959	3.715	4.748
-48	1.498	1.889	2.359	2.941	3.691	4.713
-47	1.487	1.877	2.345	2.924	3.668	4.679
-46	1.475	1.864	2.331	2.907	3.646	4.646
-45	1.464	1.853	2.318	2.891	3.625	4.616
-44	1.453	1.841	2.305	2.876	3.605	4.587
-43	1.443	1.831	2.293	2.862	3.586	4.56
-42	1.433	1.82	2.282	2.848	3.569	4.534
-41	1.423	1.81	2.271	2.836	3.552	4.51
-40	1.413	1.801	2.261	2.824	3.537	4.488
-39	1.404	1.792	2.252	2.813	3.523	4.467
-38	1.395	1.783	2.243	2.803	3.51	4.448
-37	1.386	1.775	2.235	2.794	3.498	4.431
-36	1.378	1.767	2.227	2.786	3.488	4.415
-35	1.37	1.76	2.221	2.779	3.479	4.401
-34	1.363	1.753	2.214	2.772	3.471	4.389
-33	1.355	1.747	2.209	2.767	3.464	4.378
-32	1.349	1.742	2.204	2.763	3.459	4.37
-31	1.342	1.737	2.201	2.759	3.455	4.363
-30	1.336	1.732	2.198	2.757	3.452	4.358
-29	1.33	1.728	2.195	2.756	3.451	4.355
-28	1.325	1.725	2.194	2.756	3.452	4.355
-27	1.32	1.723	2.193	2.757	3.454	4.356

-26	1.315	1.721	2.194	2.76	3.458	4.359
-25	1.311	1.719	2.195	2.763	3.463	4.365
-24	1.308	1.719	2.198	2.768	3.471	4.373
-23	1.304	1.719	2.201	2.775	3.48	4.384
-22	1.302	1.72	2.206	2.783	3.491	4.397
-21	1.3	1.722	2.211	2.793	3.504	4.413
-20	1.298	1.725	2.219	2.804	3.52	4.432
-19	1.297	1.728	2.227	2.817	3.537	4.454
-18	1.297	1.733	2.237	2.832	3.558	4.479
-17	1.297	1.739	2.248	2.849	3.581	4.508
-16	1.298	1.745	2.261	2.869	3.606	4.54
-15	1.3	1.754	2.276	2.89	3.635	4.576
-14	1.303	1.763	2.292	2.914	3.667	4.616
-13	1.306	1.774	2.311	2.941	3.703	4.661
-12	1.311	1.786	2.331	2.971	3.742	4.711
-11	1.316	1.8	2.355	3.004	3.786	4.766
-10	1.323	1.816	2.38	3.04	3.834	4.827
-9	1.331	1.834	2.409	3.081	3.887	4.895
-8	1.34	1.854	2.441	3.125	3.946	4.969
-7	1.35	1.876	2.476	3.174	4.011	5.051
-6	1.363	1.901	2.515	3.229	4.082	5.142
-5	1.377	1.929	2.558	3.289	4.161	5.242
-4	1.393	1.961	2.606	3.355	4.248	5.353
-3	1.411	1.996	2.66	3.429	4.345	5.476
-2	1.432	2.035	2.719	3.511	4.452	5.613
-1	1.456	2.079	2.786	3.602	4.571	5.765
0	1.483	2.129	2.86	3.704	4.705	5.935

Table 31. Variation of exergy destruction ratio with varying evaporator temperature (R-404A)

Te (ºC)	Tc=30ºC	Tc=36ºC	Tc=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	1.739	2.22	2.836	3.67	4.892	6.953
-49	1.722	2.201	2.812	3.637	4.842	6.86
-48	1.706	2.182	2.789	3.605	4.793	6.772
-47	1.691	2.164	2.767	3.575	4.746	6.687
-46	1.676	2.147	2.745	3.546	4.702	6.606
-45	1.661	2.13	2.725	3.518	4.659	6.529
-44	1.647	2.114	2.705	3.491	4.619	6.456
-43	1.633	2.098	2.686	3.465	4.58	6.386
-42	1.619	2.083	2.668	3.441	4.543	6.32
-41	1.606	2.069	2.65	3.418	4.508	6.257
-40	1.593	2.055	2.634	3.396	4.475	6.197
-39	1.581	2.042	2.618	3.376	4.444	6.141
-38	1.569	2.029	2.603	3.356	4.415	6.088

-37	1.558	2.017	2.589	3.338	4.387	6.038
-36	1.547	2.005	2.576	3.321	4.361	5.991
-35	1.536	1.995	2.564	3.305	4.338	5.947
-34	1.526	1.984	2.553	3.291	4.316	5.906
-33	1.516	1.975	2.542	3.278	4.295	5.869
-32	1.507	1.966	2.533	3.266	4.277	5.834
-31	1.498	1.958	2.524	3.255	4.261	5.803
-30	1.49	1.95	2.517	3.246	4.247	5.774
-29	1.482	1.943	2.51	3.238	4.234	5.749
-28	1.474	1.937	2.505	3.232	4.224	5.727
-27	1.467	1.932	2.5	3.227	4.216	5.708
-26	1.461	1.927	2.497	3.224	4.21	5.692
-25	1.455	1.923	2.495	3.222	4.206	5.679
-24	1.449	1.92	2.494	3.222	4.205	5.67
-23	1.445	1.918	2.494	3.224	4.206	5.665
-22	1.44	1.917	2.495	3.227	4.209	5.663
-21	1.437	1.917	2.498	3.232	4.215	5.664
-20	1.434	1.918	2.503	3.239	4.224	5.67
-19	1.431	1.919	2.508	3.249	4.235	5.679
-18	1.43	1.922	2.516	3.26	4.249	5.693
-17	1.429	1.926	2.525	3.274	4.267	5.711
-16	1.429	1.932	2.536	3.29	4.288	5.734
-15	1.43	1.939	2.549	3.309	4.313	5.762
-14	1.431	1.947	2.564	3.331	4.341	5.795
-13	1.434	1.956	2.581	3.356	4.374	5.834
-12	1.438	1.968	2.6	3.384	4.41	5.879
-11	1.443	1.981	2.622	3.416	4.452	5.931
-10	1.449	1.996	2.647	3.451	4.499	5.989
-9	1.456	2.014	2.676	3.491	4.552	6.055
-8	1.465	2.033	2.707	3.536	4.611	6.13
-7	1.475	2.056	2.742	3.585	4.676	6.213
-6	1.487	2.081	2.782	3.641	4.749	6.307
-5	1.502	2.109	2.826	3.702	4.831	6.412
-4	1.518	2.141	2.875	3.771	4.922	6.529
-3	1.537	2.177	2.93	3.847	5.023	6.661
-2	1.558	2.218	2.991	3.933	5.137	6.808
-1	1.583	2.263	3.06	4.028	5.264	6.974
0	1.611	2.315	3.138	4.135	5.406	7.16

Table 32. Variation exergy destruction ratio with varying evaporator temperature (R-507A)

Te (ºC)	Tc=30ºC	Tc=36ºC	Tc=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	1.658	2.122	2.721	3.549	4.82	7.194

-49	1.642	2.104	2.698	3.518	4.771	7.094
-48	1.627	2.086	2.677	3.488	4.723	6.999
-47	1.613	2.069	2.656	3.459	4.678	6.908
-46	1.598	2.053	2.636	3.432	4.634	6.821
-45	1.584	2.037	2.617	3.405	4.593	6.738
-44	1.571	2.022	2.598	3.38	4.553	6.66
-43	1.558	2.008	2.58	3.356	4.516	6.585
-42	1.545	1.994	2.564	3.334	4.48	6.513
-41	1.533	1.98	2.547	3.312	4.446	6.446
-40	1.521	1.967	2.532	3.292	4.414	6.382
-39	1.509	1.955	2.518	3.272	4.384	6.322
-38	1.498	1.943	2.504	3.254	4.355	6.265
-37	1.487	1.932	2.491	3.237	4.329	6.211
-36	1.476	1.921	2.479	3.222	4.304	6.161
-35	1.466	1.911	2.468	3.207	4.281	6.113
-34	1.457	1.901	2.458	3.194	4.26	6.07
-33	1.447	1.893	2.448	3.182	4.24	6.029
-32	1.439	1.884	2.439	3.171	4.223	5.992
-31	1.43	1.877	2.432	3.161	4.208	5.958
-30	1.422	1.87	2.425	3.153	4.194	5.927
-29	1.415	1.864	2.419	3.146	4.182	5.899
-28	1.408	1.858	2.415	3.141	4.173	5.875
-27	1.401	1.853	2.411	3.137	4.165	5.854
-26	1.395	1.849	2.408	3.134	4.16	5.836
-25	1.389	1.846	2.406	3.133	4.157	5.822
-24	1.384	1.843	2.406	3.134	4.156	5.811
-23	1.38	1.841	2.407	3.136	4.157	5.804
-22	1.376	1.841	2.409	3.14	4.161	5.8
-21	1.372	1.841	2.412	3.146	4.167	5.801
-20	1.369	1.842	2.417	3.154	4.176	5.805
-19	1.367	1.844	2.423	3.163	4.188	5.814
-18	1.366	1.847	2.43	3.175	4.203	5.827
-17	1.365	1.851	2.44	3.19	4.221	5.844
-16	1.365	1.857	2.451	3.206	4.242	5.866
-15	1.366	1.863	2.464	3.225	4.267	5.893
-14	1.367	1.871	2.479	3.247	4.296	5.926
-13	1.37	1.881	2.496	3.272	4.328	5.964
-12	1.373	1.892	2.515	3.3	4.365	6.009
-11	1.378	1.905	2.537	3.332	4.407	6.06
-10	1.384	1.92	2.562	3.367	4.454	6.119
-9	1.391	1.937	2.59	3.407	4.506	6.185
-8	1.399	1.956	2.621	3.451	4.565	6.26
-7	1.409	1.978	2.656	3.5	4.631	6.344
-6	1.421	2.003	2.694	3.555	4.704	6.438
-5	1.434	2.03	2.737	3.615	4.785	6.544
-4	1.45	2.061	2.786	3.683	4.875	6.662
-3	1.468	2.096	2.84	3.759	4.976	6.795
-2	1.488	2.136	2.9	3.843	5.089	6.944
-1	1.511	2.18	2.967	3.937	5.215	7.111
0	1.538	2.23	3.043	4.042	5.356	7.298

Table 33. Comparison of exergy destruction ratio with varying evaporator temperature(Tc= 30ºC)

Te (ºC)	R502	R404A	R507A
-50	1.523	1.739	1.658
-49	1.51	1.722	1.642
-48	1.498	1.706	1.627
-47	1.487	1.691	1.613
-46	1.475	1.676	1.598
-45	1.464	1.661	1.584
-44	1.453	1.647	1.571
-43	1.443	1.633	1.558
-42	1.433	1.619	1.545
-41	1.423	1.606	1.533
-40	1.413	1.593	1.521
-39	1.404	1.581	1.509
-38	1.395	1.569	1.498
-37	1.386	1.558	1.487
-36	1.378	1.547	1.476
-35	1.37	1.536	1.466
-34	1.363	1.526	1.457
-33	1.355	1.516	1.447
-32	1.349	1.507	1.439
-31	1.342	1.498	1.43
-30	1.336	1.49	1.422
-29	1.33	1.482	1.415
-28	1.325	1.474	1.408
-27	1.32	1.467	1.401
-26	1.315	1.461	1.395
-25	1.311	1.455	1.389
-24	1.308	1.449	1.384
-23	1.304	1.445	1.38
-22	1.302	1.44	1.376
-21	1.3	1.437	1.372
-20	1.298	1.434	1.369
-19	1.297	1.431	1.367
-18	1.297	1.43	1.366
-17	1.297	1.429	1.365
-16	1.298	1.429	1.365
-15	1.3	1.43	1.366
-14	1.303	1.431	1.367
-13	1.306	1.434	1.37
-12	1.311	1.438	1.373
-11	1.316	1.443	1.378
-10	1.323	1.449	1.384
-9	1.331	1.456	1.391
-8	1.34	1.465	1.399
-7	1.35	1.475	1.409
-6	1.363	1.487	1.421
-5	1.377	1.502	1.434

-4	1.393	1.518	1.45
-3	1.411	1.537	1.468
-2	1.432	1.558	1.488
-1	1.456	1.583	1.511
0	1.483	1.611	1.538

Table 34. Comparison of exergy destruction ratio with varying evaporator temperature (Tc= 36ºC)

Te (ºC)	R502	R404A	R507A
-50	1.916	2.22	2.122
-49	1.902	2.201	2.104
-48	1.889	2.182	2.086
-47	1.877	2.164	2.069
-46	1.864	2.147	2.053
-45	1.853	2.13	2.037
-44	1.841	2.114	2.022
-43	1.831	2.098	2.008
-42	1.82	2.083	1.994
-41	1.81	2.069	1.98
-40	1.801	2.055	1.967
-39	1.792	2.042	1.955
-38	1.783	2.029	1.943
-37	1.775	2.017	1.932
-36	1.767	2.005	1.921
-35	1.76	1.995	1.911
-34	1.753	1.984	1.901
-33	1.747	1.975	1.893
-32	1.742	1.966	1.884
-31	1.737	1.958	1.877
-30	1.732	1.95	1.87
-29	1.728	1.943	1.864
-28	1.725	1.937	1.858
-27	1.723	1.932	1.853
-26	1.721	1.927	1.849
-25	1.719	1.923	1.846
-24	1.719	1.92	1.843
-23	1.719	1.918	1.841
-22	1.72	1.917	1.841
-21	1.722	1.917	1.841
-20	1.725	1.918	1.842
-19	1.728	1.919	1.844
-18	1.733	1.922	1.847

-17	1.739	1.926	1.851
-16	1.745	1.932	1.857
-15	1.754	1.939	1.863
-14	1.763	1.947	1.871
-13	1.774	1.956	1.881
-12	1.786	1.968	1.892
-11	1.8	1.981	1.905
-10	1.816	1.996	1.92
-9	1.834	2.014	1.937
-8	1.854	2.033	1.956
-7	1.876	2.056	1.978
-6	1.901	2.081	2.003
-5	1.929	2.109	2.03
-4	1.961	2.141	2.061
-3	1.996	2.177	2.096
-2	2.035	2.218	2.136
-1	2.079	2.263	2.18
0	2.129	2.315	2.23

Table 35. Comparison of exergy destruction ratio with varying evaporator temperature (Tc= 42ºC)

Te (ºC)	R502	R404A	R507A
-50	2.389	2.836	2.721
-49	2.374	2.812	2.698
-48	2.359	2.789	2.677
-47	2.345	2.767	2.656
-46	2.331	2.745	2.636
-45	2.318	2.725	2.617
-44	2.305	2.705	2.598
-43	2.293	2.686	2.58
-42	2.282	2.668	2.564
-41	2.271	2.65	2.547
-40	2.261	2.634	2.532
-39	2.252	2.618	2.518
-38	2.243	2.603	2.504
-37	2.235	2.589	2.491
-36	2.227	2.576	2.479
-35	2.221	2.564	2.468
-34	2.214	2.553	2.458
-33	2.209	2.542	2.448
-32	2.204	2.533	2.439
-31	2.201	2.524	2.432
-30	2.198	2.517	2.425
-29	2.195	2.51	2.419
-28	2.194	2.505	2.415
-27	2.193	2.5	2.411
-26	2.194	2.497	2.408

-25	2.195	2.495	2.406
-24	2.198	2.494	2.406
-23	2.201	2.494	2.407
-22	2.206	2.495	2.409
-21	2.211	2.498	2.412
-20	2.219	2.503	2.417
-19	2.227	2.508	2.423
-18	2.237	2.516	2.43
-17	2.248	2.525	2.44
-16	2.261	2.536	2.451
-15	2.276	2.549	2.464
-14	2.292	2.564	2.479
-13	2.311	2.581	2.496
-12	2.331	2.6	2.515
-11	2.355	2.622	2.537
-10	2.38	2.647	2.562
-9	2.409	2.676	2.59
-8	2.441	2.707	2.621
-7	2.476	2.742	2.656
-6	2.515	2.782	2.694
-5	2.558	2.826	2.737
-4	2.606	2.875	2.786
-3	2.66	2.93	2.84
-2	2.719	2.991	2.9
-1	2.786	3.06	2.967
0	2.86	3.138	3.043

Table 36. Comparison of exergy destruction ratio with varying evaporator temperature (Tc= 48ºC)

Te (ºC)	R502	R404A	R507A
-50	2.979	3.67	3.549
-49	2.959	3.637	3.518
-48	2.941	3.605	3.488
-47	2.924	3.575	3.459
-46	2.907	3.546	3.432
-45	2.891	3.518	3.405
-44	2.876	3.491	3.38
-43	2.862	3.465	3.356
-42	2.848	3.441	3.334
-41	2.836	3.418	3.312
-40	2.824	3.396	3.292
-39	2.813	3.376	3.272
-38	2.803	3.356	3.254
-37	2.794	3.338	3.237
-36	2.786	3.321	3.222

-35	2.779	3.305	3.207
-34	2.772	3.291	3.194
-33	2.767	3.278	3.182
-32	2.763	3.266	3.171
-31	2.759	3.255	3.161
-30	2.757	3.246	3.153
-29	2.756	3.238	3.146
-28	2.756	3.232	3.141
-27	2.757	3.227	3.137
-26	2.76	3.224	3.134
-25	2.763	3.222	3.133
-24	2.768	3.222	3.134
-23	2.775	3.224	3.136
-22	2.783	3.227	3.14
-21	2.793	3.232	3.146
-20	2.804	3.239	3.154
-19	2.817	3.249	3.163
-18	2.832	3.26	3.175
-17	2.849	3.274	3.19
-16	2.869	3.29	3.206
-15	2.89	3.309	3.225
-14	2.914	3.331	3.247
-13	2.941	3.356	3.272
-12	2.971	3.384	3.3
-11	3.004	3.416	3.332
-10	3.04	3.451	3.367
-9	3.081	3.491	3.407
-8	3.125	3.536	3.451
-7	3.174	3.585	3.5
-6	3.229	3.641	3.555
-5	3.289	3.702	3.615
-4	3.355	3.771	3.683
-3	3.429	3.847	3.759
-2	3.511	3.933	3.843
-1	3.602	4.028	3.937
0	3.704	4.135	4.042

Table 37. Comparison of exergy destruction ratio with varying evaporator temperature (Tc= 54ºC)

Te (ºC)	R502	R404A	R507A
-50	3.741	4.892	4.82
-49	3.715	4.842	4.771
-48	3.691	4.793	4.723
-47	3.668	4.746	4.678
-46	3.646	4.702	4.634

-45	3.625	4.659	4.593
-44	3.605	4.619	4.553
-43	3.586	4.58	4.516
-42	3.569	4.543	4.48
-41	3.552	4.508	4.446
-40	3.537	4.475	4.414
-39	3.523	4.444	4.384
-38	3.51	4.415	4.355
-37	3.498	4.387	4.329
-36	3.488	4.361	4.304
-35	3.479	4.338	4.281
-34	3.471	4.316	4.26
-33	3.464	4.295	4.24
-32	3.459	4.277	4.223
-31	3.455	4.261	4.208
-30	3.452	4.247	4.194
-29	3.451	4.234	4.182
-28	3.452	4.224	4.173
-27	3.454	4.216	4.165
-26	3.458	4.21	4.16
-25	3.463	4.206	4.157
-24	3.471	4.205	4.156
-23	3.48	4.206	4.157
-22	3.491	4.209	4.161
-21	3.504	4.215	4.167
-20	3.52	4.224	4.176
-19	3.537	4.235	4.188
-18	3.558	4.249	4.203
-17	3.581	4.267	4.221
-16	3.606	4.288	4.242
-15	3.635	4.313	4.267
-14	3.667	4.341	4.296
-13	3.703	4.374	4.328
-12	3.742	4.41	4.365
-11	3.786	4.452	4.407
-10	3.834	4.499	4.454
-9	3.887	4.552	4.506
-8	3.946	4.611	4.565
-7	4.011	4.676	4.631
-6	4.082	4.749	4.704
-5	4.161	4.831	4.785
-4	4.248	4.922	4.875
-3	4.345	5.023	4.976
-2	4.452	5.137	5.089
-1	4.571	5.264	5.215
0	4.705	5.406	5.356

Table 38. Comparison of exergy destruction ratio with varying evaporator temperature (Tc= 60ºC)

Te (ºC)	R502	R404A	R507A
-50	4.785	6.953	7.194
-49	4.748	6.86	7.094
-48	4.713	6.772	6.999
-47	4.679	6.687	6.908
-46	4.646	6.606	6.821
-45	4.616	6.529	6.738
-44	4.587	6.456	6.66
-43	4.56	6.386	6.585
-42	4.534	6.32	6.513
-41	4.51	6.257	6.446
-40	4.488	6.197	6.382
-39	4.467	6.141	6.322
-38	4.448	6.088	6.265
-37	4.431	6.038	6.211
-36	4.415	5.991	6.161
-35	4.401	5.947	6.113
-34	4.389	5.906	6.07
-33	4.378	5.869	6.029
-32	4.37	5.834	5.992
-31	4.363	5.803	5.958
-30	4.358	5.774	5.927
-29	4.355	5.749	5.899
-28	4.355	5.727	5.875
-27	4.356	5.708	5.854
-26	4.359	5.692	5.836
-25	4.365	5.679	5.822
-24	4.373	5.67	5.811
-23	4.384	5.665	5.804
-22	4.397	5.663	5.8
-21	4.413	5.664	5.801
-20	4.432	5.67	5.805
-19	4.454	5.679	5.814
-18	4.479	5.693	5.827
-17	4.508	5.711	5.844
-16	4.54	5.734	5.866
-15	4.576	5.762	5.893
-14	4.616	5.795	5.926
-13	4.661	5.834	5.964
-12	4.711	5.879	6.009
-11	4.766	5.931	6.06
-10	4.827	5.989	6.119
-9	4.895	6.055	6.185
-8	4.969	6.13	6.26
-7	5.051	6.213	6.344
-6	5.142	6.307	6.438
-5	5.242	6.412	6.544

-4	5.353	6.529	6.662
-3	5.476	6.661	6.795
-2	5.613	6.808	6.944
-1	5.765	6.974	7.111
0	5.935	7.16	7.298

Table 39. Variation of exergetic efficiency with varying evaporator temperature (R-502)

Te (ºC)	Tc=30ºC	Tc=36ºC	TC=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	0.3964	0.343	0.295	0.2513	0.2109	0.1729
-49	0.3983	0.3446	0.2964	0.2526	0.2121	0.174
-48	0.4002	0.3461	0.2977	0.2537	0.2132	0.1751
-47	0.4021	0.3476	0.299	0.2549	0.2142	0.1761
-46	0.404	0.3491	0.3002	0.256	0.2153	0.1771
-45	0.4058	0.3505	0.3014	0.257	0.2162	0.1781
-44	0.4076	0.3519	0.3025	0.258	0.2172	0.179
-43	0.4093	0.3533	0.3036	0.2589	0.218	0.1799
-42	0.4111	0.3546	0.3047	0.2598	0.2189	0.1807
-41	0.4127	0.3559	0.3057	0.2607	0.2197	0.1815
-40	0.4144	0.3571	0.3066	0.2615	0.2204	0.1822
-39	0.416	0.3582	0.3075	0.2622	0.2211	0.1829
-38	0.4175	0.3593	0.3084	0.2629	0.2217	0.1836
-37	0.419	0.3604	0.3091	0.2636	0.2223	0.1841
-36	0.4205	0.3614	0.3099	0.2641	0.2228	0.1847
-35	0.4219	0.3623	0.3105	0.2646	0.2233	0.1852
-34	0.4233	0.3632	0.3111	0.2651	0.2237	0.1856
-33	0.4246	0.364	0.3116	0.2655	0.224	0.1859
-32	0.4258	0.3647	0.3121	0.2658	0.2243	0.1862
-31	0.427	0.3654	0.3124	0.266	0.2245	0.1865
-30	0.4281	0.366	0.3127	0.2662	0.2246	0.1866
-29	0.4292	0.3665	0.313	0.2662	0.2246	0.1867
-28	0.4302	0.3669	0.3131	0.2662	0.2246	0.1868
-27	0.4311	0.3673	0.3131	0.2662	0.2245	0.1867
-26	0.4319	0.3676	0.3131	0.266	0.2243	0.1866
-25	0.4327	0.3677	0.313	0.2657	0.224	0.1864
-24	0.4334	0.3678	0.3127	0.2654	0.2237	0.1861
-23	0.434	0.3678	0.3124	0.2649	0.2232	0.1857
-22	0.4345	0.3676	0.3119	0.2643	0.2227	0.1853
-21	0.4348	0.3674	0.3114	0.2637	0.222	0.1847
-20	0.4351	0.367	0.3107	0.2629	0.2213	0.1841
-19	0.4353	0.3665	0.3099	0.262	0.2204	0.1834
-18	0.4354	0.3659	0.309	0.2609	0.2194	0.1825
-17	0.4353	0.3651	0.3079	0.2598	0.2183	0.1816

-16	0.4351	0.3642	0.3067	0.2585	0.2171	0.1805
-15	0.4348	0.3632	0.3053	0.2571	0.2157	0.1793
-14	0.4343	0.3619	0.3038	0.2555	0.2143	0.1781
-13	0.4336	0.3605	0.302	0.2537	0.2126	0.1766
-12	0.4328	0.3589	0.3002	0.2518	0.2109	0.1751
-11	0.4317	0.3571	0.2981	0.2498	0.2089	0.1734
-10	0.4305	0.3551	0.2958	0.2475	0.2069	0.1716
-9	0.4291	0.3529	0.2933	0.2451	0.2046	0.1696
-8	0.4274	0.3504	0.2906	0.2424	0.2022	0.1675
-7	0.4255	0.3477	0.2877	0.2396	0.1996	0.1652
-6	0.4233	0.3447	0.2845	0.2365	0.1968	0.1628
-5	0.4208	0.3414	0.281	0.2332	0.1938	0.1602
-4	0.418	0.3378	0.2773	0.2296	0.1905	0.1574
-3	0.4148	0.3338	0.2732	0.2258	0.1871	0.1544
-2	0.4112	0.3295	0.2689	0.2217	0.1834	0.1512
-1	0.4072	0.3247	0.2641	0.2173	0.1795	0.1478
0	0.4028	0.3196	0.2591	0.2126	0.1753	0.1442

Table 40. Variation of exergetic efficiency with varying evaporator temperature (R-404A)

Te (ºC)	Tc=30ºC	Tc=36ºC	TC=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	0.3651	0.3106	0.2607	0.2141	0.1697	0.1257
-49	0.3673	0.3124	0.2623	0.2157	0.1712	0.1272
-48	0.3695	0.3143	0.2639	0.2171	0.1726	0.1287
-47	0.3716	0.316	0.2655	0.2186	0.174	0.1301
-46	0.3737	0.3178	0.267	0.22	0.1754	0.1315
-45	0.3758	0.3195	0.2685	0.2214	0.1767	0.1328
-44	0.3778	0.3212	0.2699	0.2227	0.178	0.1341
-43	0.3798	0.3228	0.2713	0.2239	0.1792	0.1354
-42	0.3818	0.3243	0.2727	0.2252	0.1804	0.1366
-41	0.3837	0.3259	0.274	0.2263	0.1815	0.1378
-40	0.3856	0.3274	0.2752	0.2275	0.1826	0.1389
-39	0.3874	0.3288	0.2764	0.2285	0.1837	0.14
-38	0.3892	0.3302	0.2775	0.2296	0.1847	0.1411
-37	0.391	0.3315	0.2786	0.2305	0.1856	0.1421
-36	0.3927	0.3327	0.2796	0.2314	0.1865	0.143
-35	0.3943	0.3339	0.2806	0.2323	0.1874	0.1439
-34	0.3959	0.3351	0.2815	0.2331	0.1881	0.1448
-33	0.3974	0.3362	0.2823	0.2338	0.1888	0.1456
-32	0.3989	0.3372	0.2831	0.2344	0.1895	0.1463
-31	0.4003	0.3381	0.2837	0.235	0.1901	0.147
-30	0.4017	0.339	0.2843	0.2355	0.1906	0.1476

-29	0.403	0.3398	0.2849	0.2359	0.191	0.1482
-28	0.4042	0.3405	0.2853	0.2363	0.1914	0.1487
-27	0.4053	0.3411	0.2857	0.2366	0.1917	0.1491
-26	0.4064	0.3416	0.286	0.2368	0.1919	0.1494
-25	0.4074	0.3421	0.2861	0.2368	0.1921	0.1497
-24	0.4083	0.3424	0.2862	0.2369	0.1921	0.1499
-23	0.4091	0.3427	0.2862	0.2368	0.1921	0.15
-22	0.4098	0.3428	0.2861	0.2366	0.192	0.1501
-21	0.4104	0.3428	0.2858	0.2363	0.1918	0.1501
-20	0.4109	0.3428	0.2855	0.2359	0.1914	0.1499
-19	0.4113	0.3425	0.285	0.2354	0.191	0.1497
-18	0.4116	0.3422	0.2844	0.2347	0.1905	0.1494
-17	0.4117	0.3417	0.2837	0.234	0.1899	0.149
-16	0.4117	0.3411	0.2828	0.2331	0.1891	0.1485
-15	0.4116	0.3403	0.2818	0.2321	0.1882	0.1479
-14	0.4113	0.3394	0.2806	0.2309	0.1872	0.1472
-13	0.4109	0.3382	0.2793	0.2296	0.1861	0.1463
-12	0.4102	0.3369	0.2778	0.2281	0.1848	0.1454
-11	0.4094	0.3355	0.2761	0.2265	0.1834	0.1443
-10	0.4084	0.3337	0.2742	0.2246	0.1818	0.1431
-9	0.4072	0.3318	0.2721	0.2227	0.1801	0.1417
-8	0.4057	0.3297	0.2698	0.2205	0.1782	0.1403
-7	0.404	0.3273	0.2672	0.2181	0.1762	0.1386
-6	0.402	0.3246	0.2644	0.2155	0.1739	0.1369
-5	0.3997	0.3216	0.2614	0.2127	0.1715	0.1349
-4	0.3971	0.3184	0.2581	0.2096	0.1689	0.1328
-3	0.3942	0.3148	0.2545	0.2063	0.166	0.1305
-2	0.3909	0.3108	0.2505	0.2027	0.163	0.1281
-1	0.3872	0.3064	0.2463	0.1989	0.1597	0.1254
0	0.383	0.3017	0.2417	0.1947	0.1561	0.1226

Table 41. Variation of exergetic efficiency with varying evaporator temperature (R-507A)

Te (ºC)	Tc=30ºC	Tc=36ºC	TC=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	0.3762	0.3203	0.2688	0.2198	0.1718	0.122
-49	0.3784	0.3222	0.2704	0.2214	0.1733	0.1235
-48	0.3806	0.324	0.272	0.2228	0.1747	0.125
-47	0.3828	0.3258	0.2735	0.2243	0.1761	0.1265
-46	0.3849	0.3275	0.275	0.2257	0.1775	0.1279
-45	0.3869	0.3292	0.2765	0.227	0.1788	0.1292
-44	0.389	0.3309	0.2779	0.2283	0.1801	0.1306

-43	0.391	0.3325	0.2793	0.2296	0.1813	0.1318
-42	0.3929	0.334	0.2806	0.2308	0.1825	0.1331
-41	0.3949	0.3356	0.2819	0.2319	0.1836	0.1343
-40	0.3967	0.337	0.2831	0.233	0.1847	0.1355
-39	0.3986	0.3384	0.2843	0.2341	0.1857	0.1366
-38	0.4004	0.3398	0.2854	0.2351	0.1867	0.1377
-37	0.4021	0.3411	0.2864	0.236	0.1877	0.1387
-36	0.4038	0.3423	0.2874	0.2369	0.1885	0.1397
-35	0.4055	0.3435	0.2884	0.2377	0.1894	0.1406
-34	0.4071	0.3447	0.2892	0.2385	0.1901	0.1414
-33	0.4086	0.3457	0.29	0.2391	0.1908	0.1423
-32	0.4101	0.3467	0.2907	0.2398	0.1915	0.143
-31	0.4115	0.3476	0.2914	0.2403	0.192	0.1437
-30	0.4128	0.3484	0.292	0.2408	0.1925	0.1444
-29	0.4141	0.3492	0.2925	0.2412	0.193	0.1449
-28	0.4153	0.3499	0.2929	0.2415	0.1933	0.1455
-27	0.4165	0.3505	0.2932	0.2417	0.1936	0.1459
-26	0.4175	0.351	0.2934	0.2419	0.1938	0.1463
-25	0.4185	0.3514	0.2936	0.2419	0.1939	0.1466
-24	0.4194	0.3517	0.2936	0.2419	0.194	0.1468
-23	0.4202	0.3519	0.2935	0.2418	0.1939	0.147
-22	0.4209	0.352	0.2934	0.2415	0.1938	0.1471
-21	0.4215	0.352	0.2931	0.2412	0.1935	0.147
-20	0.422	0.3519	0.2927	0.2407	0.1932	0.1469
-19	0.4224	0.3517	0.2922	0.2402	0.1927	0.1468
-18	0.4227	0.3513	0.2915	0.2395	0.1922	0.1465
-17	0.4228	0.3507	0.2907	0.2387	0.1915	0.1461
-16	0.4228	0.3501	0.2898	0.2377	0.1908	0.1456
-15	0.4227	0.3493	0.2887	0.2367	0.1899	0.1451
-14	0.4224	0.3483	0.2875	0.2354	0.1888	0.1444
-13	0.422	0.3471	0.2861	0.2341	0.1877	0.1436
-12	0.4213	0.3457	0.2845	0.2325	0.1864	0.1427
-11	0.4205	0.3442	0.2827	0.2308	0.1849	0.1416
-10	0.4195	0.3424	0.2807	0.229	0.1834	0.1405
-9	0.4183	0.3405	0.2786	0.2269	0.1816	0.1392
-8	0.4168	0.3382	0.2762	0.2247	0.1797	0.1377
-7	0.4151	0.3358	0.2736	0.2222	0.1776	0.1362
-6	0.4131	0.333	0.2707	0.2196	0.1753	0.1344
-5	0.4108	0.33	0.2676	0.2167	0.1729	0.1326
-4	0.4082	0.3266	0.2642	0.2135	0.1702	0.1305
-3	0.4053	0.323	0.2604	0.2101	0.1673	0.1283
-2	0.4019	0.3189	0.2564	0.2065	0.1642	0.1259
-1	0.3982	0.3145	0.2521	0.2026	0.1609	0.1233
0	0.394	0.3096	0.2473	0.1983	0.1573	0.1205

Table 42. Comparison of exergetic efficiency with varying evaporator temperature (Tc= 30ºC)

Te (ºC)	R502	R404A	R507A
-50	0.3964	0.3651	0.3762
-49	0.3983	0.3673	0.3784
-48	0.4002	0.3695	0.3806
-47	0.4021	0.3716	0.3828
-46	0.404	0.3737	0.3849
-45	0.4058	0.3758	0.3869
-44	0.4076	0.3778	0.389
-43	0.4093	0.3798	0.391
-42	0.4111	0.3818	0.3929
-41	0.4127	0.3837	0.3949
-40	0.4144	0.3856	0.3967
-39	0.416	0.3874	0.3986
-38	0.4175	0.3892	0.4004
-37	0.419	0.391	0.4021
-36	0.4205	0.3927	0.4038
-35	0.4219	0.3943	0.4055
-34	0.4233	0.3959	0.4071
-33	0.4246	0.3974	0.4086
-32	0.4258	0.3989	0.4101
-31	0.427	0.4003	0.4115
-30	0.4281	0.4017	0.4128
-29	0.4292	0.403	0.4141
-28	0.4302	0.4042	0.4153
-27	0.4311	0.4053	0.4165
-26	0.4319	0.4064	0.4175
-25	0.4327	0.4074	0.4185
-24	0.4334	0.4083	0.4194
-23	0.434	0.4091	0.4202
-22	0.4345	0.4098	0.4209
-21	0.4348	0.4104	0.4215
-20	0.4351	0.4109	0.422
-19	0.4353	0.4113	0.4224
-18	0.4354	0.4116	0.4227
-17	0.4353	0.4117	0.4228
-16	0.4351	0.4117	0.4228
-15	0.4348	0.4116	0.4227
-14	0.4343	0.4113	0.4224
-13	0.4336	0.4109	0.422
-12	0.4328	0.4102	0.4213
-11	0.4317	0.4094	0.4205
-10	0.4305	0.4084	0.4195
-9	0.4291	0.4072	0.4183
-8	0.4274	0.4057	0.4168
-7	0.4255	0.404	0.4151
-6	0.4233	0.402	0.4131

-5	0.4208	0.3997	0.4108
-4	0.418	0.3971	0.4082
-3	0.4148	0.3942	0.4053
-2	0.4112	0.3909	0.4019
-1	0.4072	0.3872	0.3982
0	0.4028	0.383	0.394

Table 43. Comparison of exergetic efficiency with varying evaporator temperature (Tc= 36ºC)

Te (ºC)	R502	R404A	R507A
-50	0.343	0.3106	0.3203
-49	0.3446	0.3124	0.3222
-48	0.3461	0.3143	0.324
-47	0.3476	0.316	0.3258
-46	0.3491	0.3178	0.3275
-45	0.3505	0.3195	0.3292
-44	0.3519	0.3212	0.3309
-43	0.3533	0.3228	0.3325
-42	0.3546	0.3243	0.334
-41	0.3559	0.3259	0.3356
-40	0.3571	0.3274	0.337
-39	0.3582	0.3288	0.3384
-38	0.3593	0.3302	0.3398
-37	0.3604	0.3315	0.3411
-36	0.3614	0.3327	0.3423
-35	0.3623	0.3339	0.3435
-34	0.3632	0.3351	0.3447
-33	0.364	0.3362	0.3457
-32	0.3647	0.3372	0.3467
-31	0.3654	0.3381	0.3476
-30	0.366	0.339	0.3484
-29	0.3665	0.3398	0.3492
-28	0.3669	0.3405	0.3499
-27	0.3673	0.3411	0.3505
-26	0.3676	0.3416	0.351

-25	0.3677	0.3421	0.3514
-24	0.3678	0.3424	0.3517
-23	0.3678	0.3427	0.3519
-22	0.3676	0.3428	0.352
-21	0.3674	0.3428	0.352
-20	0.367	0.3428	0.3519
-19	0.3665	0.3425	0.3517
-18	0.3659	0.3422	0.3513
-17	0.3651	0.3417	0.3507
-16	0.3642	0.3411	0.3501
-15	0.3632	0.3403	0.3493
-14	0.3619	0.3394	0.3483
-13	0.3605	0.3382	0.3471
-12	0.3589	0.3369	0.3457
-11	0.3571	0.3355	0.3442
-10	0.3551	0.3337	0.3424
-9	0.3529	0.3318	0.3405
-8	0.3504	0.3297	0.3382
-7	0.3477	0.3273	0.3358
-6	0.3447	0.3246	0.333
-5	0.3414	0.3216	0.33
-4	0.3378	0.3184	0.3266
-3	0.3338	0.3148	0.323
-2	0.3295	0.3108	0.3189
-1	0.3247	0.3064	0.3145
0	0.3196	0.3017	0.3096

Table 44. Comparison of exergetic efficiency with varying evaporator temperature (Tc= 42ºC)

Te (ºC)	R502	R404A	R507A
-50	0.295	0.2607	0.2688
-49	0.2964	0.2623	0.2704
-48	0.2977	0.2639	0.272
-47	0.299	0.2655	0.2735
-46	0.3002	0.267	0.275
-45	0.3014	0.2685	0.2765
-44	0.3025	0.2699	0.2779
-43	0.3036	0.2713	0.2793
-42	0.3047	0.2727	0.2806
-41	0.3057	0.274	0.2819
-40	0.3066	0.2752	0.2831
-39	0.3075	0.2764	0.2843
-38	0.3084	0.2775	0.2854
-37	0.3091	0.2786	0.2864
-36	0.3099	0.2796	0.2874

-35	0.3105	0.2806	0.2884
-34	0.3111	0.2815	0.2892
-33	0.3116	0.2823	0.29
-32	0.3121	0.2831	0.2907
-31	0.3124	0.2837	0.2914
-30	0.3127	0.2843	0.292
-29	0.313	0.2849	0.2925
-28	0.3131	0.2853	0.2929
-27	0.3131	0.2857	0.2932
-26	0.3131	0.286	0.2934
-25	0.313	0.2861	0.2936
-24	0.3127	0.2862	0.2936
-23	0.3124	0.2862	0.2935
-22	0.3119	0.2861	0.2934
-21	0.3114	0.2858	0.2931
-20	0.3107	0.2855	0.2927
-19	0.3099	0.285	0.2922
-18	0.309	0.2844	0.2915
-17	0.3079	0.2837	0.2907
-16	0.3067	0.2828	0.2898
-15	0.3053	0.2818	0.2887
-14	0.3038	0.2806	0.2875
-13	0.302	0.2793	0.2861
-12	0.3002	0.2778	0.2845
-11	0.2981	0.2761	0.2827
-10	0.2958	0.2742	0.2807
-9	0.2933	0.2721	0.2786
-8	0.2906	0.2698	0.2762
-7	0.2877	0.2672	0.2736
-6	0.2845	0.2644	0.2707
-5	0.281	0.2614	0.2676
-4	0.2773	0.2581	0.2642
-3	0.2732	0.2545	0.2604
-2	0.2689	0.2505	0.2564
-1	0.2641	0.2463	0.2521
0	0.2591	0.2417	0.2473

Table 45. Comparison of exergetic efficiency with varying evaporator temperature (Tc= 48ºC)

Te (ºC)	R502	R404A	R507A
-50	0.2513	0.2141	0.2198
-49	0.2526	0.2157	0.2214
-48	0.2537	0.2171	0.2228
-47	0.2549	0.2186	0.2243
-46	0.256	0.22	0.2257

-45	0.257	0.2214	0.227
-44	0.258	0.2227	0.2283
-43	0.2589	0.2239	0.2296
-42	0.2598	0.2252	0.2308
-41	0.2607	0.2263	0.2319
-40	0.2615	0.2275	0.233
-39	0.2622	0.2285	0.2341
-38	0.2629	0.2296	0.2351
-37	0.2636	0.2305	0.236
-36	0.2641	0.2314	0.2369
-35	0.2646	0.2323	0.2377
-34	0.2651	0.2331	0.2385
-33	0.2655	0.2338	0.2391
-32	0.2658	0.2344	0.2398
-31	0.266	0.235	0.2403
-30	0.2662	0.2355	0.2408
-29	0.2662	0.2359	0.2412
-28	0.2662	0.2363	0.2415
-27	0.2662	0.2366	0.2417
-26	0.266	0.2368	0.2419
-25	0.2657	0.2368	0.2419
-24	0.2654	0.2369	0.2419
-23	0.2649	0.2368	0.2418
-22	0.2643	0.2366	0.2415
-21	0.2637	0.2363	0.2412
-20	0.2629	0.2359	0.2407
-19	0.262	0.2354	0.2402
-18	0.2609	0.2347	0.2395
-17	0.2598	0.234	0.2387
-16	0.2585	0.2331	0.2377
-15	0.2571	0.2321	0.2367
-14	0.2555	0.2309	0.2354
-13	0.2537	0.2296	0.2341
-12	0.2518	0.2281	0.2325
-11	0.2498	0.2265	0.2308
-10	0.2475	0.2246	0.229
-9	0.2451	0.2227	0.2269
-8	0.2424	0.2205	0.2247
-7	0.2396	0.2181	0.2222
-6	0.2365	0.2155	0.2196
-5	0.2332	0.2127	0.2167
-4	0.2296	0.2096	0.2135
-3	0.2258	0.2063	0.2101
-2	0.2217	0.2027	0.2065
-1	0.2173	0.1989	0.2026
0	0.2126	0.1947	0.1983

Table 46. Comparison of exergetic efficiency with varying evaporator temperature (Tc= 54ºC)

Te (ºC)	R502	R404A	R507A
-50	0.2109	0.1697	0.1718
-49	0.2121	0.1712	0.1733
-48	0.2132	0.1726	0.1747
-47	0.2142	0.174	0.1761
-46	0.2153	0.1754	0.1775
-45	0.2162	0.1767	0.1788
-44	0.2172	0.178	0.1801
-43	0.218	0.1792	0.1813
-42	0.2189	0.1804	0.1825
-41	0.2197	0.1815	0.1836
-40	0.2204	0.1826	0.1847
-39	0.2211	0.1837	0.1857
-38	0.2217	0.1847	0.1867
-37	0.2223	0.1856	0.1877
-36	0.2228	0.1865	0.1885
-35	0.2233	0.1874	0.1894
-34	0.2237	0.1881	0.1901
-33	0.224	0.1888	0.1908
-32	0.2243	0.1895	0.1915
-31	0.2245	0.1901	0.192
-30	0.2246	0.1906	0.1925
-29	0.2246	0.191	0.193
-28	0.2246	0.1914	0.1933
-27	0.2245	0.1917	0.1936
-26	0.2243	0.1919	0.1938
-25	0.224	0.1921	0.1939
-24	0.2237	0.1921	0.194
-23	0.2232	0.1921	0.1939
-22	0.2227	0.192	0.1938
-21	0.222	0.1918	0.1935
-20	0.2213	0.1914	0.1932
-19	0.2204	0.191	0.1927
-18	0.2194	0.1905	0.1922
-17	0.2183	0.1899	0.1915
-16	0.2171	0.1891	0.1908
-15	0.2157	0.1882	0.1899
-14	0.2143	0.1872	0.1888
-13	0.2126	0.1861	0.1877
-12	0.2109	0.1848	0.1864
-11	0.2089	0.1834	0.1849
-10	0.2069	0.1818	0.1834
-9	0.2046	0.1801	0.1816
-8	0.2022	0.1782	0.1797
-7	0.1996	0.1762	0.1776
-6	0.1968	0.1739	0.1753
-5	0.1938	0.1715	0.1729

-4	0.1905	0.1689	0.1702
-3	0.1871	0.166	0.1673
-2	0.1834	0.163	0.1642
-1	0.1795	0.1597	0.1609
0	0.1753	0.1561	0.1573

Table 47. Comparison of exergetic efficiency with varying evaporator temperature (Tc= 60ºC)

Te (ºC)	R502	R404A	R507A
-50	0.1729	0.1257	0.122
-49	0.174	0.1272	0.1235
-48	0.1751	0.1287	0.125
-47	0.1761	0.1301	0.1265
-46	0.1771	0.1315	0.1279
-45	0.1781	0.1328	0.1292
-44	0.179	0.1341	0.1306
-43	0.1799	0.1354	0.1318
-42	0.1807	0.1366	0.1331
-41	0.1815	0.1378	0.1343
-40	0.1822	0.1389	0.1355
-39	0.1829	0.14	0.1366
-38	0.1836	0.1411	0.1377
-37	0.1841	0.1421	0.1387
-36	0.1847	0.143	0.1397
-35	0.1852	0.1439	0.1406
-34	0.1856	0.1448	0.1414
-33	0.1859	0.1456	0.1423
-32	0.1862	0.1463	0.143
-31	0.1865	0.147	0.1437
-30	0.1866	0.1476	0.1444
-29	0.1867	0.1482	0.1449
-28	0.1868	0.1487	0.1455
-27	0.1867	0.1491	0.1459
-26	0.1866	0.1494	0.1463
-25	0.1864	0.1497	0.1466
-24	0.1861	0.1499	0.1468
-23	0.1857	0.15	0.147
-22	0.1853	0.1501	0.1471
-21	0.1847	0.1501	0.147

-20	0.1841	0.1499	0.1469
-19	0.1834	0.1497	0.1468
-18	0.1825	0.1494	0.1465
-17	0.1816	0.149	0.1461
-16	0.1805	0.1485	0.1456
-15	0.1793	0.1479	0.1451
-14	0.1781	0.1472	0.1444
-13	0.1766	0.1463	0.1436
-12	0.1751	0.1454	0.1427
-11	0.1734	0.1443	0.1416
-10	0.1716	0.1431	0.1405
-9	0.1696	0.1417	0.1392
-8	0.1675	0.1403	0.1377
-7	0.1652	0.1386	0.1362
-6	0.1628	0.1369	0.1344
-5	0.1602	0.1349	0.1326
-4	0.1574	0.1328	0.1305
-3	0.1544	0.1305	0.1283
-2	0.1512	0.1281	0.1259
-1	0.1478	0.1254	0.1233
0	0.1442	0.1226	0.1205

Table 48. Effect of varying evaporator temperature on efficiency defect in compressor (R-502)

Te (ºC)	Tc=30ºC	Tc=36ºC	Tc=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	0.2245	0.22	0.2157	0.2116	0.2077	0.2039
-49	0.225	0.2204	0.2161	0.212	0.2081	0.2043
-48	0.2254	0.2208	0.2165	0.2124	0.2084	0.2046
-47	0.2258	0.2213	0.2169	0.2127	0.2088	0.2049
-46	0.2263	0.2217	0.2173	0.2131	0.2091	0.2053
-45	0.2267	0.2221	0.2177	0.2135	0.2094	0.2056
-44	0.2271	0.2224	0.218	0.2138	0.2098	0.2059
-43	0.2275	0.2228	0.2184	0.2142	0.2101	0.2062
-42	0.2279	0.2232	0.2188	0.2145	0.2104	0.2065
-41	0.2283	0.2236	0.2191	0.2148	0.2107	0.2068
-40	0.2287	0.2239	0.2195	0.2152	0.2111	0.2071
-39	0.2291	0.2243	0.2198	0.2155	0.2114	0.2074
-38	0.2294	0.2247	0.2201	0.2158	0.2117	0.2077
-37	0.2298	0.225	0.2205	0.2161	0.212	0.2079
-36	0.2302	0.2254	0.2208	0.2164	0.2122	0.2082
-35	0.2305	0.2257	0.2211	0.2167	0.2125	0.2085
-34	0.2309	0.226	0.2214	0.217	0.2128	0.2088
-33	0.2312	0.2264	0.2217	0.2173	0.2131	0.209
-32	0.2316	0.2267	0.222	0.2176	0.2134	0.2093
-31	0.2319	0.227	0.2223	0.2179	0.2136	0.2095
-30	0.2322	0.2273	0.2226	0.2182	0.2139	0.2098
-29	0.2326	0.2276	0.2229	0.2184	0.2141	0.21

-28	0.2329	0.2279	0.2232	0.2187	0.2144	0.2102
-27	0.2332	0.2282	0.2235	0.219	0.2146	0.2105
-26	0.2335	0.2285	0.2238	0.2192	0.2149	0.2107
-25	0.2338	0.2288	0.224	0.2195	0.2151	0.2109
-24	0.2341	0.2291	0.2243	0.2197	0.2154	0.2112
-23	0.2344	0.2294	0.2246	0.22	0.2156	0.2114
-22	0.2347	0.2296	0.2248	0.2202	0.2158	0.2116
-21	0.235	0.2299	0.2251	0.2205	0.2161	0.2118
-20	0.2353	0.2302	0.2253	0.2207	0.2163	0.212
-19	0.2356	0.2304	0.2256	0.2209	0.2165	0.2122
-18	0.2358	0.2307	0.2258	0.2212	0.2167	0.2124
-17	0.2361	0.231	0.2261	0.2214	0.2169	0.2126
-16	0.2364	0.2312	0.2263	0.2216	0.2171	0.2128
-15	0.2366	0.2315	0.2265	0.2218	0.2173	0.213
-14	0.2369	0.2317	0.2268	0.2221	0.2175	0.2132
-13	0.2372	0.2319	0.227	0.2223	0.2177	0.2134
-12	0.2374	0.2322	0.2272	0.2225	0.2179	0.2135
-11	0.2377	0.2324	0.2274	0.2227	0.2181	0.2137
-10	0.2379	0.2326	0.2276	0.2229	0.2183	0.2139
-9	0.2381	0.2329	0.2279	0.2231	0.2185	0.2141
-8	0.2384	0.2331	0.2281	0.2233	0.2187	0.2142
-7	0.2386	0.2333	0.2283	0.2235	0.2189	0.2144
-6	0.2389	0.2335	0.2285	0.2237	0.219	0.2146
-5	0.2391	0.2338	0.2287	0.2238	0.2192	0.2147
-4	0.2393	0.234	0.2289	0.224	0.2194	0.2149
-3	0.2395	0.2342	0.2291	0.2242	0.2195	0.215
-2	0.2398	0.2344	0.2293	0.2244	0.2197	0.2152
-1	0.24	0.2346	0.2295	0.2246	0.2199	0.2154
0	0.2402	0.2348	0.2297	0.2247	0.22	0.2155

Table 49. Effect of varying evaporator temperature on efficiency defect in compressor (R-404A)

Te (ºC)	Tc=30ºC	Tc=36ºC	Tc=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	0.2286	0.2241	0.2198	0.2156	0.2115	0.2076
-49	0.229	0.2245	0.2201	0.2159	0.2118	0.2079
-48	0.2294	0.2248	0.2204	0.2162	0.2121	0.2082
-47	0.2297	0.2252	0.2208	0.2165	0.2124	0.2085
-46	0.2301	0.2255	0.2211	0.2168	0.2127	0.2087
-45	0.2304	0.2258	0.2214	0.2171	0.213	0.209
-44	0.2308	0.2262	0.2217	0.2174	0.2133	0.2092
-43	0.2311	0.2265	0.222	0.2177	0.2135	0.2095
-42	0.2315	0.2268	0.2223	0.218	0.2138	0.2097
-41	0.2318	0.2271	0.2226	0.2182	0.214	0.21
-40	0.2321	0.2274	0.2229	0.2185	0.2143	0.2102
-39	0.2324	0.2277	0.2231	0.2188	0.2145	0.2104

-38	0.2327	0.228	0.2234	0.219	0.2148	0.2106
-37	0.233	0.2283	0.2237	0.2193	0.215	0.2108
-36	0.2333	0.2285	0.2239	0.2195	0.2152	0.2111
-35	0.2336	0.2288	0.2242	0.2197	0.2154	0.2113
-34	0.2339	0.2291	0.2244	0.22	0.2157	0.2115
-33	0.2342	0.2293	0.2247	0.2202	0.2159	0.2117
-32	0.2345	0.2296	0.2249	0.2204	0.2161	0.2119
-31	0.2347	0.2299	0.2252	0.2206	0.2163	0.212
-30	0.235	0.2301	0.2254	0.2209	0.2165	0.2122
-29	0.2353	0.2303	0.2256	0.2211	0.2167	0.2124
-28	0.2355	0.2306	0.2258	0.2213	0.2169	0.2126
-27	0.2358	0.2308	0.2261	0.2215	0.2171	0.2128
-26	0.236	0.231	0.2263	0.2217	0.2172	0.2129
-25	0.2362	0.2313	0.2265	0.2219	0.2174	0.2131
-24	0.2365	0.2315	0.2267	0.2221	0.2176	0.2133
-23	0.2367	0.2317	0.2269	0.2223	0.2178	0.2134
-22	0.2369	0.2319	0.2271	0.2224	0.2179	0.2136
-21	0.2372	0.2321	0.2273	0.2226	0.2181	0.2137
-20	0.2374	0.2323	0.2275	0.2228	0.2183	0.2139
-19	0.2376	0.2325	0.2277	0.223	0.2184	0.214
-18	0.2378	0.2327	0.2278	0.2231	0.2186	0.2142
-17	0.238	0.2329	0.228	0.2233	0.2187	0.2143
-16	0.2382	0.2331	0.2282	0.2235	0.2189	0.2144
-15	0.2384	0.2333	0.2284	0.2236	0.219	0.2146
-14	0.2386	0.2335	0.2285	0.2238	0.2192	0.2147
-13	0.2388	0.2337	0.2287	0.2239	0.2193	0.2148
-12	0.239	0.2338	0.2289	0.2241	0.2195	0.215
-11	0.2392	0.234	0.229	0.2242	0.2196	0.2151
-10	0.2394	0.2342	0.2292	0.2244	0.2197	0.2152
-9	0.2396	0.2343	0.2293	0.2245	0.2199	0.2153
-8	0.2397	0.2345	0.2295	0.2247	0.22	0.2154
-7	0.2399	0.2347	0.2296	0.2248	0.2201	0.2156
-6	0.2401	0.2348	0.2298	0.2249	0.2202	0.2157
-5	0.2402	0.235	0.2299	0.2251	0.2204	0.2158
-4	0.2404	0.2351	0.2301	0.2252	0.2205	0.2159
-3	0.2406	0.2353	0.2302	0.2253	0.2206	0.216
-2	0.2407	0.2355	0.2304	0.2255	0.2207	0.2161
-1	0.2409	0.2356	0.2305	0.2256	0.2208	0.2162
0	0.2411	0.2358	0.2306	0.2257	0.2209	0.2163

Table 50. Effect of varying evaporator temperature on efficiency defect in compressor (R-507A)

Te (ºC)	Tc=30ºC	Tc=36ºC	Tc=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	0.2301	0.2256	0.2213	0.2171	0.2131	0.2092

-49	0.2305	0.2259	0.2216	0.2174	0.2134	0.2095
-48	0.2308	0.2263	0.2219	0.2177	0.2137	0.2097
-47	0.2312	0.2266	0.2222	0.218	0.214	0.21
-46	0.2315	0.2269	0.2225	0.2183	0.2142	0.2103
-45	0.2319	0.2273	0.2228	0.2186	0.2145	0.2105
-44	0.2322	0.2276	0.2231	0.2189	0.2148	0.2107
-43	0.2325	0.2279	0.2234	0.2191	0.215	0.211
-42	0.2328	0.2282	0.2237	0.2194	0.2153	0.2112
-41	0.2331	0.2285	0.224	0.2197	0.2155	0.2114
-40	0.2334	0.2287	0.2243	0.2199	0.2157	0.2117
-39	0.2337	0.229	0.2245	0.2202	0.216	0.2119
-38	0.234	0.2293	0.2248	0.2204	0.2162	0.2121
-37	0.2343	0.2296	0.225	0.2207	0.2164	0.2123
-36	0.2346	0.2298	0.2253	0.2209	0.2166	0.2125
-35	0.2349	0.2301	0.2255	0.2211	0.2169	0.2127
-34	0.2352	0.2304	0.2258	0.2213	0.2171	0.2129
-33	0.2354	0.2306	0.226	0.2216	0.2173	0.2131
-32	0.2357	0.2309	0.2262	0.2218	0.2175	0.2133
-31	0.2359	0.2311	0.2265	0.222	0.2177	0.2135
-30	0.2362	0.2313	0.2267	0.2222	0.2179	0.2136
-29	0.2364	0.2316	0.2269	0.2224	0.218	0.2138
-28	0.2367	0.2318	0.2271	0.2226	0.2182	0.214
-27	0.2369	0.232	0.2273	0.2228	0.2184	0.2142
-26	0.2371	0.2322	0.2275	0.223	0.2186	0.2143
-25	0.2374	0.2324	0.2277	0.2232	0.2188	0.2145
-24	0.2376	0.2327	0.2279	0.2233	0.2189	0.2146
-23	0.2378	0.2329	0.2281	0.2235	0.2191	0.2148
-22	0.238	0.2331	0.2283	0.2237	0.2193	0.2149
-21	0.2382	0.2333	0.2285	0.2239	0.2194	0.2151
-20	0.2385	0.2335	0.2287	0.224	0.2196	0.2152
-19	0.2387	0.2336	0.2288	0.2242	0.2197	0.2154
-18	0.2389	0.2338	0.229	0.2244	0.2199	0.2155
-17	0.2391	0.234	0.2292	0.2245	0.22	0.2157
-16	0.2393	0.2342	0.2294	0.2247	0.2202	0.2158
-15	0.2394	0.2344	0.2295	0.2248	0.2203	0.2159
-14	0.2396	0.2345	0.2297	0.225	0.2205	0.216
-13	0.2398	0.2347	0.2298	0.2251	0.2206	0.2162
-12	0.24	0.2349	0.23	0.2253	0.2207	0.2163
-11	0.2402	0.235	0.2301	0.2254	0.2209	0.2164
-10	0.2403	0.2352	0.2303	0.2256	0.221	0.2165
-9	0.2405	0.2354	0.2304	0.2257	0.2211	0.2167
-8	0.2407	0.2355	0.2306	0.2258	0.2212	0.2168
-7	0.2408	0.2357	0.2307	0.226	0.2214	0.2169
-6	0.241	0.2358	0.2309	0.2261	0.2215	0.217
-5	0.2412	0.236	0.231	0.2262	0.2216	0.2171
-4	0.2413	0.2361	0.2311	0.2264	0.2217	0.2172
-3	0.2415	0.2363	0.2313	0.2265	0.2218	0.2173
-2	0.2416	0.2364	0.2314	0.2266	0.2219	0.2174
-1	0.2418	0.2366	0.2315	0.2267	0.2221	0.2175
0	0.2419	0.2367	0.2317	0.2268	0.2222	0.2176

Table 51. Comparison of efficiency defect in compressor with varying evaporator temperature (Tc= 30ºC)

Te (ºC)	R502	R404A	R507A
-50	0.2245	0.2286	0.2301
-49	0.225	0.229	0.2305
-48	0.2254	0.2294	0.2308
-47	0.2258	0.2297	0.2312
-46	0.2263	0.2301	0.2315
-45	0.2267	0.2304	0.2319
-44	0.2271	0.2308	0.2322
-43	0.2275	0.2311	0.2325
-42	0.2279	0.2315	0.2328
-41	0.2283	0.2318	0.2331
-40	0.2287	0.2321	0.2334
-39	0.2291	0.2324	0.2337
-38	0.2294	0.2327	0.234
-37	0.2298	0.233	0.2343
-36	0.2302	0.2333	0.2346
-35	0.2305	0.2336	0.2349
-34	0.2309	0.2339	0.2352
-33	0.2312	0.2342	0.2354
-32	0.2316	0.2345	0.2357
-31	0.2319	0.2347	0.2359
-30	0.2322	0.235	0.2362
-29	0.2326	0.2353	0.2364
-28	0.2329	0.2355	0.2367
-27	0.2332	0.2358	0.2369
-26	0.2335	0.236	0.2371
-25	0.2338	0.2362	0.2374
-24	0.2341	0.2365	0.2376
-23	0.2344	0.2367	0.2378
-22	0.2347	0.2369	0.238
-21	0.235	0.2372	0.2382
-20	0.2353	0.2374	0.2385
-19	0.2356	0.2376	0.2387
-18	0.2358	0.2378	0.2389
-17	0.2361	0.238	0.2391
-16	0.2364	0.2382	0.2393
-15	0.2366	0.2384	0.2394
-14	0.2369	0.2386	0.2396
-13	0.2372	0.2388	0.2398
-12	0.2374	0.239	0.24
-11	0.2377	0.2392	0.2402
-10	0.2379	0.2394	0.2403
-9	0.2381	0.2396	0.2405
-8	0.2384	0.2397	0.2407
-7	0.2386	0.2399	0.2408
-6	0.2389	0.2401	0.241
-5	0.2391	0.2402	0.2412
-4	0.2393	0.2404	0.2413

-3	0.2395	0.2406	0.2415
-2	0.2398	0.2407	0.2416
-1	0.24	0.2409	0.2418
0	0.2402	0.2411	0.2419

Table 52. Comparison of efficiency defect in compressor with varying evaporator temperature (Tc= 36ºC)

Te (ºC)	R502	R404A	R507A
-50	0.22	0.2241	0.2256
-49	0.2204	0.2245	0.2259
-48	0.2208	0.2248	0.2263
-47	0.2213	0.2252	0.2266
-46	0.2217	0.2255	0.2269
-45	0.2221	0.2258	0.2273
-44	0.2224	0.2262	0.2276
-43	0.2228	0.2265	0.2279
-42	0.2232	0.2268	0.2282
-41	0.2236	0.2271	0.2285
-40	0.2239	0.2274	0.2287
-39	0.2243	0.2277	0.229
-38	0.2247	0.228	0.2293
-37	0.225	0.2283	0.2296
-36	0.2254	0.2285	0.2298
-35	0.2257	0.2288	0.2301
-34	0.226	0.2291	0.2304
-33	0.2264	0.2293	0.2306
-32	0.2267	0.2296	0.2309
-31	0.227	0.2299	0.2311
-30	0.2273	0.2301	0.2313
-29	0.2276	0.2303	0.2316
-28	0.2279	0.2306	0.2318
-27	0.2282	0.2308	0.232
-26	0.2285	0.231	0.2322
-25	0.2288	0.2313	0.2324
-24	0.2291	0.2315	0.2327
-23	0.2294	0.2317	0.2329
-22	0.2296	0.2319	0.2331
-21	0.2299	0.2321	0.2333
-20	0.2302	0.2323	0.2335
-19	0.2304	0.2325	0.2336
-18	0.2307	0.2327	0.2338

-17	0.231	0.2329	0.234
-16	0.2312	0.2331	0.2342
-15	0.2315	0.2333	0.2344
-14	0.2317	0.2335	0.2345
-13	0.2319	0.2337	0.2347
-12	0.2322	0.2338	0.2349
-11	0.2324	0.234	0.235
-10	0.2326	0.2342	0.2352
-9	0.2329	0.2343	0.2354
-8	0.2331	0.2345	0.2355
-7	0.2333	0.2347	0.2357
-6	0.2335	0.2348	0.2358
-5	0.2338	0.235	0.236
-4	0.234	0.2351	0.2361
-3	0.2342	0.2353	0.2363
-2	0.2344	0.2355	0.2364
-1	0.2346	0.2356	0.2366
0	0.2348	0.2358	0.2367

Table 53. Comparison of efficiency defect in compressor with varying evaporator temperature (Tc= 42ºC)

Te (ºC)	R502	R404A	R507A
-50	0.2157	0.2198	0.2213
-49	0.2161	0.2201	0.2216
-48	0.2165	0.2204	0.2219
-47	0.2169	0.2208	0.2222
-46	0.2173	0.2211	0.2225
-45	0.2177	0.2214	0.2228
-44	0.218	0.2217	0.2231
-43	0.2184	0.222	0.2234
-42	0.2188	0.2223	0.2237
-41	0.2191	0.2226	0.224
-40	0.2195	0.2229	0.2243
-39	0.2198	0.2231	0.2245
-38	0.2201	0.2234	0.2248
-37	0.2205	0.2237	0.225
-36	0.2208	0.2239	0.2253
-35	0.2211	0.2242	0.2255
-34	0.2214	0.2244	0.2258
-33	0.2217	0.2247	0.226
-32	0.222	0.2249	0.2262
-31	0.2223	0.2252	0.2265
-30	0.2226	0.2254	0.2267
-29	0.2229	0.2256	0.2269

-28	0.2232	0.2258	0.2271
-27	0.2235	0.2261	0.2273
-26	0.2238	0.2263	0.2275
-25	0.224	0.2265	0.2277
-24	0.2243	0.2267	0.2279
-23	0.2246	0.2269	0.2281
-22	0.2248	0.2271	0.2283
-21	0.2251	0.2273	0.2285
-20	0.2253	0.2275	0.2287
-19	0.2256	0.2277	0.2288
-18	0.2258	0.2278	0.229
-17	0.2261	0.228	0.2292
-16	0.2263	0.2282	0.2294
-15	0.2265	0.2284	0.2295
-14	0.2268	0.2285	0.2297
-13	0.227	0.2287	0.2298
-12	0.2272	0.2289	0.23
-11	0.2274	0.229	0.2301
-10	0.2276	0.2292	0.2303
-9	0.2279	0.2293	0.2304
-8	0.2281	0.2295	0.2306
-7	0.2283	0.2296	0.2307
-6	0.2285	0.2298	0.2309
-5	0.2287	0.2299	0.231
-4	0.2289	0.2301	0.2311
-3	0.2291	0.2302	0.2313
-2	0.2293	0.2304	0.2314
-1	0.2295	0.2305	0.2315
0	0.2297	0.2306	0.2317

Table 54. Comparison of efficiency defect in compressor with varying evaporator temperature (Tc= 48ºC)

Te (ºC)	R502	R404A	R507A
-50	0.2116	0.2156	0.2171
-49	0.212	0.2159	0.2174
-48	0.2124	0.2162	0.2177
-47	0.2127	0.2165	0.218
-46	0.2131	0.2168	0.2183
-45	0.2135	0.2171	0.2186
-44	0.2138	0.2174	0.2189
-43	0.2142	0.2177	0.2191
-42	0.2145	0.218	0.2194

-41	0.2148	0.2182	0.2197
-40	0.2152	0.2185	0.2199
-39	0.2155	0.2188	0.2202
-38	0.2158	0.219	0.2204
-37	0.2161	0.2193	0.2207
-36	0.2164	0.2195	0.2209
-35	0.2167	0.2197	0.2211
-34	0.217	0.22	0.2213
-33	0.2173	0.2202	0.2216
-32	0.2176	0.2204	0.2218
-31	0.2179	0.2206	0.222
-30	0.2182	0.2209	0.2222
-29	0.2184	0.2211	0.2224
-28	0.2187	0.2213	0.2226
-27	0.219	0.2215	0.2228
-26	0.2192	0.2217	0.223
-25	0.2195	0.2219	0.2232
-24	0.2197	0.2221	0.2233
-23	0.22	0.2223	0.2235
-22	0.2202	0.2224	0.2237
-21	0.2205	0.2226	0.2239
-20	0.2207	0.2228	0.224
-19	0.2209	0.223	0.2242
-18	0.2212	0.2231	0.2244
-17	0.2214	0.2233	0.2245
-16	0.2216	0.2235	0.2247
-15	0.2218	0.2236	0.2248
-14	0.2221	0.2238	0.225
-13	0.2223	0.2239	0.2251
-12	0.2225	0.2241	0.2253
-11	0.2227	0.2242	0.2254
-10	0.2229	0.2244	0.2256
-9	0.2231	0.2245	0.2257
-8	0.2233	0.2247	0.2258
-7	0.2235	0.2248	0.226
-6	0.2237	0.2249	0.2261
-5	0.2238	0.2251	0.2262
-4	0.224	0.2252	0.2264
-3	0.2242	0.2253	0.2265
-2	0.2244	0.2255	0.2266
-1	0.2246	0.2256	0.2267
0	0.2247	0.2257	0.2268

Table 55. Comparison of efficiency defect in compressor with varying evaporator temperature (Tc= 54ºC)

Te (ºC)	R502	R404A	R507A
-50	0.2077	0.2115	0.2131
-49	0.2081	0.2118	0.2134
-48	0.2084	0.2121	0.2137
-47	0.2088	0.2124	0.214
-46	0.2091	0.2127	0.2142
-45	0.2094	0.213	0.2145
-44	0.2098	0.2133	0.2148
-43	0.2101	0.2135	0.215
-42	0.2104	0.2138	0.2153
-41	0.2107	0.214	0.2155
-40	0.2111	0.2143	0.2157
-39	0.2114	0.2145	0.216
-38	0.2117	0.2148	0.2162
-37	0.212	0.215	0.2164
-36	0.2122	0.2152	0.2166
-35	0.2125	0.2154	0.2169
-34	0.2128	0.2157	0.2171
-33	0.2131	0.2159	0.2173
-32	0.2134	0.2161	0.2175
-31	0.2136	0.2163	0.2177
-30	0.2139	0.2165	0.2179
-29	0.2141	0.2167	0.218
-28	0.2144	0.2169	0.2182
-27	0.2146	0.2171	0.2184
-26	0.2149	0.2172	0.2186
-25	0.2151	0.2174	0.2188
-24	0.2154	0.2176	0.2189
-23	0.2156	0.2178	0.2191
-22	0.2158	0.2179	0.2193
-21	0.2161	0.2181	0.2194
-20	0.2163	0.2183	0.2196
-19	0.2165	0.2184	0.2197
-18	0.2167	0.2186	0.2199
-17	0.2169	0.2187	0.22
-16	0.2171	0.2189	0.2202
-15	0.2173	0.219	0.2203
-14	0.2175	0.2192	0.2205
-13	0.2177	0.2193	0.2206
-12	0.2179	0.2195	0.2207
-11	0.2181	0.2196	0.2209
-10	0.2183	0.2197	0.221
-9	0.2185	0.2199	0.2211
-8	0.2187	0.22	0.2212
-7	0.2189	0.2201	0.2214
-6	0.219	0.2202	0.2215
-5	0.2192	0.2204	0.2216
-4	0.2194	0.2205	0.2217
-3	0.2195	0.2206	0.2218
-2	0.2197	0.2207	0.2219

-1	0.2199	0.2208	0.2221
0	0.22	0.2209	0.2222

Table 56. Comparison of efficiency defect in compressor with varying evaporator temperature (Tc= 60ºC)

Te (ºC)	R502	R404A	R507A
-50	0.2039	0.2076	0.2092
-49	0.2043	0.2079	0.2095
-48	0.2046	0.2082	0.2097
-47	0.2049	0.2085	0.21
-46	0.2053	0.2087	0.2103
-45	0.2056	0.209	0.2105
-44	0.2059	0.2092	0.2107
-43	0.2062	0.2095	0.211
-42	0.2065	0.2097	0.2112
-41	0.2068	0.21	0.2114
-40	0.2071	0.2102	0.2117
-39	0.2074	0.2104	0.2119
-38	0.2077	0.2106	0.2121
-37	0.2079	0.2108	0.2123
-36	0.2082	0.2111	0.2125
-35	0.2085	0.2113	0.2127
-34	0.2088	0.2115	0.2129
-33	0.209	0.2117	0.2131
-32	0.2093	0.2119	0.2133
-31	0.2095	0.212	0.2135
-30	0.2098	0.2122	0.2136
-29	0.21	0.2124	0.2138
-28	0.2102	0.2126	0.214
-27	0.2105	0.2128	0.2142
-26	0.2107	0.2129	0.2143
-25	0.2109	0.2131	0.2145
-24	0.2112	0.2133	0.2146
-23	0.2114	0.2134	0.2148
-22	0.2116	0.2136	0.2149
-21	0.2118	0.2137	0.2151
-20	0.212	0.2139	0.2152
-19	0.2122	0.214	0.2154
-18	0.2124	0.2142	0.2155
-17	0.2126	0.2143	0.2157
-16	0.2128	0.2144	0.2158

-15	0.213	0.2146	0.2159
-14	0.2132	0.2147	0.216
-13	0.2134	0.2148	0.2162
-12	0.2135	0.215	0.2163
-11	0.2137	0.2151	0.2164
-10	0.2139	0.2152	0.2165
-9	0.2141	0.2153	0.2167
-8	0.2142	0.2154	0.2168
-7	0.2144	0.2156	0.2169
-6	0.2146	0.2157	0.217
-5	0.2147	0.2158	0.2171
-4	0.2149	0.2159	0.2172
-3	0.215	0.216	0.2173
-2	0.2152	0.2161	0.2174
-1	0.2154	0.2162	0.2175
0	0.2155	0.2163	0.2176

Table 57. Effect of varying evaporator temperature on efficiency defect in condenser (R-502)

Te (ºC)	Tc=30ºC	Tc=36ºC	Tc=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	0.06593	0.1033	0.1335	0.1577	0.1769	0.1916
-49	0.06577	0.1036	0.1341	0.1586	0.1779	0.1925
-48	0.06564	0.1039	0.1348	0.1594	0.1788	0.1936
-47	0.06554	0.1043	0.1355	0.1604	0.1799	0.1947
-46	0.06546	0.1047	0.1362	0.1613	0.181	0.1958
-45	0.06542	0.1052	0.137	0.1623	0.1821	0.197
-44	0.0654	0.1057	0.1379	0.1634	0.1833	0.1982
-43	0.06541	0.1062	0.1387	0.1645	0.1845	0.1995
-42	0.06545	0.1068	0.1397	0.1657	0.1858	0.2008
-41	0.06552	0.1074	0.1407	0.1669	0.1871	0.2022
-40	0.06562	0.1081	0.1417	0.1682	0.1885	0.2036
-39	0.06576	0.1088	0.1428	0.1695	0.19	0.2051
-38	0.06592	0.1096	0.144	0.1709	0.1915	0.2067
-37	0.06612	0.1104	0.1452	0.1723	0.193	0.2083
-36	0.06635	0.1112	0.1464	0.1738	0.1947	0.2099
-35	0.06662	0.1121	0.1477	0.1754	0.1963	0.2116
-34	0.06692	0.1131	0.1491	0.177	0.1981	0.2134
-33	0.06725	0.1141	0.1505	0.1787	0.1999	0.2152
-32	0.06763	0.1152	0.1521	0.1804	0.2018	0.2171
-31	0.06804	0.1163	0.1536	0.1822	0.2037	0.2191
-30	0.06849	0.1175	0.1553	0.1841	0.2057	0.2211
-29	0.06899	0.1187	0.157	0.1861	0.2078	0.2232
-28	0.06952	0.1201	0.1587	0.1881	0.21	0.2254

-27	0.0701	0.1214	0.1606	0.1902	0.2122	0.2276
-26	0.07073	0.1229	0.1625	0.1924	0.2145	0.2299
-25	0.0714	0.1244	0.1645	0.1947	0.2169	0.2323
-24	0.07212	0.126	0.1666	0.1971	0.2194	0.2348
-23	0.0729	0.1277	0.1688	0.1995	0.2219	0.2374
-22	0.07372	0.1294	0.1711	0.2021	0.2246	0.24
-21	0.07461	0.1312	0.1735	0.2047	0.2273	0.2427
-20	0.07555	0.1332	0.1759	0.2075	0.2302	0.2455
-19	0.07656	0.1352	0.1785	0.2103	0.2331	0.2484
-18	0.07763	0.1373	0.1812	0.2133	0.2361	0.2514
-17	0.07877	0.1395	0.184	0.2163	0.2393	0.2545
-16	0.07999	0.1418	0.1869	0.2195	0.2425	0.2577
-15	0.08128	0.1443	0.1899	0.2228	0.2459	0.261
-14	0.08266	0.1468	0.1931	0.2262	0.2494	0.2644
-13	0.08412	0.1495	0.1964	0.2298	0.253	0.2679
-12	0.08568	0.1523	0.1998	0.2335	0.2568	0.2716
-11	0.08733	0.1553	0.2034	0.2374	0.2606	0.2753
-10	0.08909	0.1584	0.2072	0.2414	0.2647	0.2792
-9	0.09097	0.1617	0.2111	0.2455	0.2688	0.2832
-8	0.09296	0.1651	0.2152	0.2499	0.2732	0.2874
-7	0.09509	0.1688	0.2195	0.2544	0.2776	0.2917
-6	0.09736	0.1726	0.224	0.2591	0.2823	0.2962
-5	0.09979	0.1766	0.2287	0.264	0.2871	0.3008
-4	0.1024	0.1809	0.2336	0.2691	0.2922	0.3055
-3	0.1052	0.1854	0.2388	0.2745	0.2974	0.3105
-2	0.1081	0.1901	0.2442	0.28	0.3028	0.3156
-1	0.1113	0.1952	0.25	0.2858	0.3084	0.3209
0	0.1147	0.2005	0.256	0.2919	0.3143	0.3264

Table 58. Effect of varying evaporator temperature on efficiency defect in condenser (R-404A)

Te (ºC)	Tc=30ºC	Tc=36ºC	Tc=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	0.05793	0.09325	0.1214	0.1432	0.1596	0.1705
-49	0.05788	0.09364	0.122	0.1441	0.1605	0.1714
-48	0.05785	0.09406	0.1227	0.145	0.1615	0.1724
-47	0.05785	0.09452	0.1235	0.1459	0.1625	0.1734
-46	0.05788	0.09501	0.1243	0.1469	0.1635	0.1744
-45	0.05793	0.09554	0.1251	0.1479	0.1647	0.1756
-44	0.05801	0.09612	0.126	0.149	0.1658	0.1767
-43	0.05812	0.09673	0.127	0.1501	0.167	0.1779
-42	0.05826	0.09738	0.128	0.1513	0.1683	0.1791
-41	0.05842	0.09807	0.129	0.1525	0.1696	0.1804
-40	0.05862	0.09881	0.1301	0.1538	0.1709	0.1818
-39	0.05885	0.09959	0.1312	0.1551	0.1723	0.1831
-38	0.0591	0.1004	0.1324	0.1565	0.1738	0.1846

-37	0.05939	0.1013	0.1336	0.1579	0.1753	0.1861
-36	0.05971	0.1022	0.1349	0.1594	0.1769	0.1876
-35	0.06006	0.1032	0.1362	0.161	0.1785	0.1892
-34	0.06045	0.1042	0.1376	0.1626	0.1802	0.1909
-33	0.06087	0.1052	0.1391	0.1642	0.1819	0.1926
-32	0.06132	0.1064	0.1406	0.166	0.1837	0.1943
-31	0.06181	0.1075	0.1422	0.1677	0.1856	0.1962
-30	0.06234	0.1088	0.1438	0.1696	0.1875	0.198
-29	0.06291	0.11	0.1455	0.1715	0.1895	0.2
-28	0.06352	0.1114	0.1473	0.1735	0.1916	0.202
-27	0.06417	0.1128	0.1491	0.1756	0.1937	0.2041
-26	0.06486	0.1143	0.151	0.1777	0.1959	0.2062
-25	0.0656	0.1158	0.153	0.18	0.1982	0.2084
-24	0.06639	0.1174	0.1551	0.1823	0.2006	0.2107
-23	0.06722	0.1191	0.1573	0.1847	0.203	0.2131
-22	0.06811	0.1209	0.1595	0.1871	0.2055	0.2155
-21	0.06905	0.1227	0.1619	0.1897	0.2081	0.218
-20	0.07004	0.1246	0.1643	0.1924	0.2108	0.2206
-19	0.0711	0.1267	0.1668	0.1951	0.2136	0.2233
-18	0.07221	0.1288	0.1695	0.198	0.2165	0.2261
-17	0.0734	0.131	0.1722	0.2009	0.2195	0.2289
-16	0.07465	0.1333	0.175	0.204	0.2226	0.2319
-15	0.07597	0.1357	0.178	0.2072	0.2258	0.2349
-14	0.07738	0.1382	0.1811	0.2105	0.2291	0.2381
-13	0.07886	0.1409	0.1843	0.2139	0.2325	0.2413
-12	0.08044	0.1436	0.1877	0.2175	0.236	0.2446
-11	0.08211	0.1466	0.1912	0.2212	0.2397	0.2481
-10	0.08388	0.1496	0.1948	0.225	0.2435	0.2517
-9	0.08575	0.1528	0.1986	0.229	0.2475	0.2554
-8	0.08774	0.1562	0.2026	0.2332	0.2515	0.2592
-7	0.08986	0.1597	0.2068	0.2375	0.2558	0.2632
-6	0.09211	0.1635	0.2111	0.242	0.2602	0.2673
-5	0.0945	0.1674	0.2156	0.2467	0.2647	0.2715
-4	0.09706	0.1715	0.2204	0.2516	0.2694	0.2759
-3	0.09978	0.1759	0.2254	0.2567	0.2743	0.2804
-2	0.1027	0.1805	0.2306	0.262	0.2794	0.2851
-1	0.1058	0.1854	0.2361	0.2675	0.2847	0.29
0	0.1091	0.1905	0.2419	0.2733	0.2903	0.295

Table 59. Effect of varying evaporator temperature on efficiency defect in condenser (R-507A)

Te (ºC)	Tc=30ºC	Tc=36ºC	Tc=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	0.05609	0.09186	0.1201	0.1418	0.1571	0.1659
-49	0.05608	0.0923	0.1209	0.1427	0.1581	0.1668
-48	0.0561	0.09278	0.1216	0.1436	0.1591	0.1678
-47	0.05614	0.09329	0.1225	0.1446	0.1602	0.1688
-46	0.05622	0.09384	0.1233	0.1456	0.1613	0.1699
-45	0.05632	0.09443	0.1242	0.1467	0.1624	0.171
-44	0.05644	0.09505	0.1251	0.1478	0.1636	0.1721
-43	0.0566	0.09572	0.1261	0.149	0.1648	0.1733
-42	0.05678	0.09642	0.1272	0.1502	0.1661	0.1746
-41	0.05699	0.09717	0.1283	0.1515	0.1674	0.1758
-40	0.05723	0.09796	0.1294	0.1528	0.1688	0.1772
-39	0.0575	0.09879	0.1306	0.1542	0.1703	0.1785
-38	0.0578	0.09966	0.1318	0.1556	0.1717	0.18
-37	0.05813	0.1006	0.1331	0.1571	0.1733	0.1815
-36	0.05849	0.1016	0.1344	0.1586	0.1749	0.183
-35	0.05889	0.1026	0.1358	0.1602	0.1765	0.1846
-34	0.05931	0.1036	0.1373	0.1619	0.1782	0.1862
-33	0.05978	0.1048	0.1388	0.1636	0.18	0.1879
-32	0.06028	0.1059	0.1403	0.1653	0.1818	0.1896
-31	0.06081	0.1071	0.142	0.1672	0.1837	0.1914
-30	0.06138	0.1084	0.1437	0.1691	0.1857	0.1933
-29	0.062	0.1098	0.1454	0.1711	0.1877	0.1952
-28	0.06265	0.1112	0.1473	0.1731	0.1898	0.1972
-27	0.06334	0.1126	0.1492	0.1752	0.1919	0.1992
-26	0.06408	0.1142	0.1512	0.1774	0.1942	0.2014
-25	0.06487	0.1158	0.1532	0.1797	0.1965	0.2035
-24	0.0657	0.1174	0.1554	0.182	0.1989	0.2058
-23	0.06658	0.1192	0.1576	0.1845	0.2013	0.2081
-22	0.06751	0.121	0.1599	0.187	0.2039	0.2105
-21	0.0685	0.1229	0.1623	0.1896	0.2065	0.213
-20	0.06955	0.1249	0.1648	0.1923	0.2092	0.2156
-19	0.07066	0.127	0.1674	0.1951	0.212	0.2182
-18	0.07183	0.1292	0.1701	0.198	0.2149	0.2209
-17	0.07306	0.1315	0.1729	0.2011	0.2179	0.2237
-16	0.07437	0.1338	0.1758	0.2042	0.221	0.2266
-15	0.07576	0.1363	0.1788	0.2074	0.2243	0.2296
-14	0.07722	0.1389	0.182	0.2108	0.2276	0.2327
-13	0.07877	0.1417	0.1853	0.2143	0.231	0.2359
-12	0.08041	0.1445	0.1888	0.2179	0.2346	0.2392
-11	0.08215	0.1475	0.1923	0.2217	0.2383	0.2426
-10	0.08399	0.1507	0.1961	0.2256	0.2421	0.2462
-9	0.08594	0.154	0.2	0.2297	0.2461	0.2498
-8	0.08801	0.1575	0.204	0.2339	0.2502	0.2536
-7	0.09021	0.1611	0.2083	0.2383	0.2544	0.2575
-6	0.09255	0.165	0.2128	0.2429	0.2588	0.2615
-5	0.09504	0.169	0.2174	0.2476	0.2634	0.2657

-4	0.09769	0.1733	0.2223	0.2526	0.2682	0.27
-3	0.1005	0.1778	0.2274	0.2578	0.2731	0.2744
-2	0.1035	0.1825	0.2327	0.2632	0.2782	0.2791
-1	0.1068	0.1875	0.2384	0.2688	0.2836	0.2839
0	0.1102	0.1929	0.2443	0.2747	0.2891	0.2888

Table 60. Comparison of efficiency defect in condenser with varying evaporator temperature (Tc= 30ºC)

Te (ºC)	R502	R404A	R507A
-50	0.06593	0.05793	0.05609
-49	0.06577	0.05788	0.05608
-48	0.06564	0.05785	0.0561
-47	0.06554	0.05785	0.05614
-46	0.06546	0.05788	0.05622
-45	0.06542	0.05793	0.05632
-44	0.0654	0.05801	0.05644
-43	0.06541	0.05812	0.0566
-42	0.06545	0.05826	0.05678
-41	0.06552	0.05842	0.05699
-40	0.06562	0.05862	0.05723
-39	0.06576	0.05885	0.0575
-38	0.06592	0.0591	0.0578
-37	0.06612	0.05939	0.05813
-36	0.06635	0.05971	0.05849
-35	0.06662	0.06006	0.05889
-34	0.06692	0.06045	0.05931
-33	0.06725	0.06087	0.05978
-32	0.06763	0.06132	0.06028
-31	0.06804	0.06181	0.06081
-30	0.06849	0.06234	0.06138
-29	0.06899	0.06291	0.062
-28	0.06952	0.06352	0.06265
-27	0.0701	0.06417	0.06334
-26	0.07073	0.06486	0.06408
-25	0.0714	0.0656	0.06487
-24	0.07212	0.06639	0.0657
-23	0.0729	0.06722	0.06658
-22	0.07372	0.06811	0.06751
-21	0.07461	0.06905	0.0685
-20	0.07555	0.07004	0.06955
-19	0.07656	0.0711	0.07066
-18	0.07763	0.07221	0.07183

-17	0.07877	0.0734	0.07306
-16	0.07999	0.07465	0.07437
-15	0.08128	0.07597	0.07576
-14	0.08266	0.07738	0.07722
-13	0.08412	0.07886	0.07877
-12	0.08568	0.08044	0.08041
-11	0.08733	0.08211	0.08215
-10	0.08909	0.08388	0.08399
-9	0.09097	0.08575	0.08594
-8	0.09296	0.08774	0.08801
-7	0.09509	0.08986	0.09021
-6	0.09736	0.09211	0.09255
-5	0.09979	0.0945	0.09504
-4	0.1024	0.09706	0.09769
-3	0.1052	0.09978	0.1005
-2	0.1081	0.1027	0.1035
-1	0.1113	0.1058	0.1068
0	0.1147	0.1091	0.1102

Table 61. Comparison of efficiency defect in condenser with varying evaporator temperature (Tc= 36ºC)

Te (ºC)	R502	R404A	R507A
-50	0.1033	0.09325	0.09186
-49	0.1036	0.09364	0.0923
-48	0.1039	0.09406	0.09278
-47	0.1043	0.09452	0.09329
-46	0.1047	0.09501	0.09384
-45	0.1052	0.09554	0.09443
-44	0.1057	0.09612	0.09505
-43	0.1062	0.09673	0.09572
-42	0.1068	0.09738	0.09642
-41	0.1074	0.09807	0.09717
-40	0.1081	0.09881	0.09796
-39	0.1088	0.09959	0.09879
-38	0.1096	0.1004	0.09966
-37	0.1104	0.1013	0.1006
-36	0.1112	0.1022	0.1016
-35	0.1121	0.1032	0.1026
-34	0.1131	0.1042	0.1036
-33	0.1141	0.1052	0.1048
-32	0.1152	0.1064	0.1059
-31	0.1163	0.1075	0.1071
-30	0.1175	0.1088	0.1084
-29	0.1187	0.11	0.1098
-28	0.1201	0.1114	0.1112

-27	0.1214	0.1128	0.1126
-26	0.1229	0.1143	0.1142
-25	0.1244	0.1158	0.1158
-24	0.126	0.1174	0.1174
-23	0.1277	0.1191	0.1192
-22	0.1294	0.1209	0.121
-21	0.1312	0.1227	0.1229
-20	0.1332	0.1246	0.1249
-19	0.1352	0.1267	0.127
-18	0.1373	0.1288	0.1292
-17	0.1395	0.131	0.1315
-16	0.1418	0.1333	0.1338
-15	0.1443	0.1357	0.1363
-14	0.1468	0.1382	0.1389
-13	0.1495	0.1409	0.1417
-12	0.1523	0.1436	0.1445
-11	0.1553	0.1466	0.1475
-10	0.1584	0.1496	0.1507
-9	0.1617	0.1528	0.154
-8	0.1651	0.1562	0.1575
-7	0.1688	0.1597	0.1611
-6	0.1726	0.1635	0.165
-5	0.1766	0.1674	0.169
-4	0.1809	0.1715	0.1733
-3	0.1854	0.1759	0.1778
-2	0.1901	0.1805	0.1825
-1	0.1952	0.1854	0.1875
0	0.2005	0.1905	0.1929

Table 62. Comparison of efficiency defect in condenser with varying evaporator temperature (Tc= 42ºC)

Te (ºC)	R502	R404A	R507A
-50	0.1335	0.1214	0.1201
-49	0.1341	0.122	0.1209
-48	0.1348	0.1227	0.1216
-47	0.1355	0.1235	0.1225
-46	0.1362	0.1243	0.1233
-45	0.137	0.1251	0.1242
-44	0.1379	0.126	0.1251
-43	0.1387	0.127	0.1261
-42	0.1397	0.128	0.1272
-41	0.1407	0.129	0.1283
-40	0.1417	0.1301	0.1294
-39	0.1428	0.1312	0.1306
-38	0.144	0.1324	0.1318

-37	0.1452	0.1336	0.1331
-36	0.1464	0.1349	0.1344
-35	0.1477	0.1362	0.1358
-34	0.1491	0.1376	0.1373
-33	0.1505	0.1391	0.1388
-32	0.1521	0.1406	0.1403
-31	0.1536	0.1422	0.142
-30	0.1553	0.1438	0.1437
-29	0.157	0.1455	0.1454
-28	0.1587	0.1473	0.1473
-27	0.1606	0.1491	0.1492
-26	0.1625	0.151	0.1512
-25	0.1645	0.153	0.1532
-24	0.1666	0.1551	0.1554
-23	0.1688	0.1573	0.1576
-22	0.1711	0.1595	0.1599
-21	0.1735	0.1619	0.1623
-20	0.1759	0.1643	0.1648
-19	0.1785	0.1668	0.1674
-18	0.1812	0.1695	0.1701
-17	0.184	0.1722	0.1729
-16	0.1869	0.175	0.1758
-15	0.1899	0.178	0.1788
-14	0.1931	0.1811	0.182
-13	0.1964	0.1843	0.1853
-12	0.1998	0.1877	0.1888
-11	0.2034	0.1912	0.1923
-10	0.2072	0.1948	0.1961
-9	0.2111	0.1986	0.2
-8	0.2152	0.2026	0.204
-7	0.2195	0.2068	0.2083
-6	0.224	0.2111	0.2128
-5	0.2287	0.2156	0.2174
-4	0.2336	0.2204	0.2223
-3	0.2388	0.2254	0.2274
-2	0.2442	0.2306	0.2327
-1	0.25	0.2361	0.2384
0	0.256	0.2419	0.2443

Table 63. Comparison of efficiency defect in condenser with varying evaporator temperature (Tc= 48ºC)

Te (ºC)	R502	R404A	R507A
-50	0.1577	0.1432	0.1418
-49	0.1586	0.1441	0.1427

-48	0.1594	0.145	0.1436
-47	0.1604	0.1459	0.1446
-46	0.1613	0.1469	0.1456
-45	0.1623	0.1479	0.1467
-44	0.1634	0.149	0.1478
-43	0.1645	0.1501	0.149
-42	0.1657	0.1513	0.1502
-41	0.1669	0.1525	0.1515
-40	0.1682	0.1538	0.1528
-39	0.1695	0.1551	0.1542
-38	0.1709	0.1565	0.1556
-37	0.1723	0.1579	0.1571
-36	0.1738	0.1594	0.1586
-35	0.1754	0.161	0.1602
-34	0.177	0.1626	0.1619
-33	0.1787	0.1642	0.1636
-32	0.1804	0.166	0.1653
-31	0.1822	0.1677	0.1672
-30	0.1841	0.1696	0.1691
-29	0.1861	0.1715	0.1711
-28	0.1881	0.1735	0.1731
-27	0.1902	0.1756	0.1752
-26	0.1924	0.1777	0.1774
-25	0.1947	0.18	0.1797
-24	0.1971	0.1823	0.182
-23	0.1995	0.1847	0.1845
-22	0.2021	0.1871	0.187
-21	0.2047	0.1897	0.1896
-20	0.2075	0.1924	0.1923
-19	0.2103	0.1951	0.1951
-18	0.2133	0.198	0.198
-17	0.2163	0.2009	0.2011
-16	0.2195	0.204	0.2042
-15	0.2228	0.2072	0.2074
-14	0.2262	0.2105	0.2108
-13	0.2298	0.2139	0.2143
-12	0.2335	0.2175	0.2179
-11	0.2374	0.2212	0.2217
-10	0.2414	0.225	0.2256
-9	0.2455	0.229	0.2297
-8	0.2499	0.2332	0.2339
-7	0.2544	0.2375	0.2383
-6	0.2591	0.242	0.2429
-5	0.264	0.2467	0.2476
-4	0.2691	0.2516	0.2526
-3	0.2745	0.2567	0.2578
-2	0.28	0.262	0.2632
-1	0.2858	0.2675	0.2688
0	0.2919	0.2733	0.2747

Table 64. Comparison of efficiency defect in condenser with varying evaporator temperature (Tc= 54ºC)

Te (ºC)	R502	R404A	R507A
-50	0.1769	0.1596	0.1571
-49	0.1779	0.1605	0.1581
-48	0.1788	0.1615	0.1591
-47	0.1799	0.1625	0.1602
-46	0.181	0.1635	0.1613
-45	0.1821	0.1647	0.1624
-44	0.1833	0.1658	0.1636
-43	0.1845	0.167	0.1648
-42	0.1858	0.1683	0.1661
-41	0.1871	0.1696	0.1674
-40	0.1885	0.1709	0.1688
-39	0.19	0.1723	0.1703
-38	0.1915	0.1738	0.1717
-37	0.193	0.1753	0.1733
-36	0.1947	0.1769	0.1749
-35	0.1963	0.1785	0.1765
-34	0.1981	0.1802	0.1782
-33	0.1999	0.1819	0.18
-32	0.2018	0.1837	0.1818
-31	0.2037	0.1856	0.1837
-30	0.2057	0.1875	0.1857
-29	0.2078	0.1895	0.1877
-28	0.21	0.1916	0.1898
-27	0.2122	0.1937	0.1919
-26	0.2145	0.1959	0.1942
-25	0.2169	0.1982	0.1965
-24	0.2194	0.2006	0.1989
-23	0.2219	0.203	0.2013
-22	0.2246	0.2055	0.2039
-21	0.2273	0.2081	0.2065
-20	0.2302	0.2108	0.2092
-19	0.2331	0.2136	0.212
-18	0.2361	0.2165	0.2149
-17	0.2393	0.2195	0.2179
-16	0.2425	0.2226	0.221
-15	0.2459	0.2258	0.2243
-14	0.2494	0.2291	0.2276
-13	0.253	0.2325	0.231
-12	0.2568	0.236	0.2346
-11	0.2606	0.2397	0.2383
-10	0.2647	0.2435	0.2421
-9	0.2688	0.2475	0.2461
-8	0.2732	0.2515	0.2502
-7	0.2776	0.2558	0.2544
-6	0.2823	0.2602	0.2588
-5	0.2871	0.2647	0.2634
-4	0.2922	0.2694	0.2682

-3	0.2974	0.2743	0.2731
-2	0.3028	0.2794	0.2782
-1	0.3084	0.2847	0.2836
0	0.3143	0.2903	0.2891

Table 65. Comparison of efficiency defect in condenser with varying evaporator temperature (Tc= 60ºC)

Te (ºC)	R502	R404A	R507A
-50	0.1916	0.1705	0.1659
-49	0.1925	0.1714	0.1668
-48	0.1936	0.1724	0.1678
-47	0.1947	0.1734	0.1688
-46	0.1958	0.1744	0.1699
-45	0.197	0.1756	0.171
-44	0.1982	0.1767	0.1721
-43	0.1995	0.1779	0.1733
-42	0.2008	0.1791	0.1746
-41	0.2022	0.1804	0.1758
-40	0.2036	0.1818	0.1772
-39	0.2051	0.1831	0.1785
-38	0.2067	0.1846	0.18
-37	0.2083	0.1861	0.1815
-36	0.2099	0.1876	0.183
-35	0.2116	0.1892	0.1846
-34	0.2134	0.1909	0.1862
-33	0.2152	0.1926	0.1879
-32	0.2171	0.1943	0.1896
-31	0.2191	0.1962	0.1914
-30	0.2211	0.198	0.1933
-29	0.2232	0.2	0.1952
-28	0.2254	0.202	0.1972
-27	0.2276	0.2041	0.1992
-26	0.2299	0.2062	0.2014
-25	0.2323	0.2084	0.2035
-24	0.2348	0.2107	0.2058
-23	0.2374	0.2131	0.2081
-22	0.24	0.2155	0.2105
-21	0.2427	0.218	0.213

-20	0.2455	0.2206	0.2156
-19	0.2484	0.2233	0.2182
-18	0.2514	0.2261	0.2209
-17	0.2545	0.2289	0.2237
-16	0.2577	0.2319	0.2266
-15	0.261	0.2349	0.2296
-14	0.2644	0.2381	0.2327
-13	0.2679	0.2413	0.2359
-12	0.2716	0.2446	0.2392
-11	0.2753	0.2481	0.2426
-10	0.2792	0.2517	0.2462
-9	0.2832	0.2554	0.2498
-8	0.2874	0.2592	0.2536
-7	0.2917	0.2632	0.2575
-6	0.2962	0.2673	0.2615
-5	0.3008	0.2715	0.2657
-4	0.3055	0.2759	0.27
-3	0.3105	0.2804	0.2744
-2	0.3156	0.2851	0.2791
-1	0.3209	0.29	0.2839
0	0.3264	0.295	0.2888

Table 66. Effect of varying evaporator temperature on efficiency defect in throttle valve (R-502)

Te (ºC)	Tc=30ºC	Tc=36ºC	TC=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	0.2754	0.301	0.3276	0.3553	0.3843	0.4152
-49	0.2726	0.2983	0.3249	0.3525	0.3816	0.4125
-48	0.2698	0.2955	0.3221	0.3498	0.3788	0.4097
-47	0.267	0.2926	0.3193	0.347	0.3761	0.407
-46	0.2642	0.2898	0.3165	0.3442	0.3733	0.4042
-45	0.2613	0.287	0.3137	0.3414	0.3705	0.4015
-44	0.2585	0.2842	0.3108	0.3386	0.3677	0.3987
-43	0.2557	0.2814	0.308	0.3358	0.3649	0.396
-42	0.2529	0.2786	0.3052	0.333	0.3621	0.3932
-41	0.25	0.2757	0.3024	0.3302	0.3593	0.3904
-40	0.2472	0.2729	0.2996	0.3273	0.3565	0.3876
-39	0.2444	0.2701	0.2967	0.3245	0.3537	0.3849
-38	0.2415	0.2672	0.2939	0.3217	0.3509	0.3821
-37	0.2387	0.2644	0.291	0.3189	0.3481	0.3793
-36	0.2358	0.2615	0.2882	0.316	0.3453	0.3765
-35	0.233	0.2587	0.2853	0.3132	0.3425	0.3737
-34	0.2301	0.2558	0.2825	0.3103	0.3396	0.3709
-33	0.2273	0.253	0.2796	0.3075	0.3368	0.3681
-32	0.2244	0.2501	0.2768	0.3046	0.334	0.3653

-31	0.2216	0.2472	0.2739	0.3018	0.3311	0.3624
-30	0.2187	0.2444	0.2711	0.2989	0.3283	0.3596
-29	0.2159	0.2415	0.2682	0.2961	0.3254	0.3568
-28	0.213	0.2387	0.2653	0.2932	0.3226	0.354
-27	0.2101	0.2358	0.2625	0.2904	0.3197	0.3512
-26	0.2073	0.2329	0.2596	0.2875	0.3169	0.3483
-25	0.2044	0.23	0.2567	0.2846	0.3141	0.3455
-24	0.2015	0.2272	0.2539	0.2818	0.3112	0.3427
-23	0.1987	0.2243	0.251	0.2789	0.3083	0.3398
-22	0.1958	0.2214	0.2481	0.276	0.3055	0.337
-21	0.1929	0.2185	0.2452	0.2732	0.3026	0.3342
-20	0.1901	0.2157	0.2424	0.2703	0.2998	0.3313
-19	0.1872	0.2128	0.2395	0.2674	0.2969	0.3285
-18	0.1843	0.2099	0.2366	0.2646	0.2941	0.3257
-17	0.1814	0.207	0.2337	0.2617	0.2912	0.3228
-16	0.1786	0.2042	0.2309	0.2588	0.2883	0.32
-15	0.1757	0.2013	0.228	0.2559	0.2855	0.3171
-14	0.1728	0.1984	0.2251	0.2531	0.2826	0.3143
-13	0.17	0.1955	0.2222	0.2502	0.2798	0.3115
-12	0.1671	0.1927	0.2193	0.2473	0.2769	0.3086
-11	0.1642	0.1898	0.2165	0.2445	0.274	0.3058
-10	0.1613	0.1869	0.2136	0.2416	0.2712	0.3029
-9	0.1585	0.184	0.2107	0.2387	0.2683	0.3001
-8	0.1556	0.1811	0.2078	0.2358	0.2655	0.2973
-7	0.1527	0.1783	0.205	0.233	0.2626	0.2944
-6	0.1499	0.1754	0.2021	0.2301	0.2598	0.2916
-5	0.147	0.1725	0.1992	0.2272	0.2569	0.2888
-4	0.1441	0.1696	0.1963	0.2244	0.254	0.2859
-3	0.1413	0.1668	0.1935	0.2215	0.2512	0.2831
-2	0.1384	0.1639	0.1906	0.2186	0.2483	0.2803
-1	0.1355	0.161	0.1877	0.2158	0.2455	0.2774
0	0.1327	0.1582	0.1848	0.2129	0.2426	0.2746

Table 67. Effect of varying evaporator temperature on efficiency defect in throttle valve (R-404A)

Te (ºC)	Tc=30ºC	Tc=36ºC	TC=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	0.313	0.3424	0.3737	0.4071	0.4437	0.4849
-49	0.3099	0.3393	0.3706	0.4041	0.4407	0.4819
-48	0.3068	0.3362	0.3675	0.4011	0.4377	0.479
-47	0.3037	0.3332	0.3645	0.398	0.4347	0.476
-46	0.3006	0.3301	0.3614	0.395	0.4316	0.473
-45	0.2975	0.327	0.3583	0.3919	0.4286	0.4701
-44	0.2943	0.3239	0.3552	0.3889	0.4256	0.4671
-43	0.2912	0.3208	0.3521	0.3858	0.4226	0.4641
-42	0.2881	0.3177	0.349	0.3827	0.4195	0.4611

-41	0.285	0.3145	0.3459	0.3797	0.4165	0.4581
-40	0.2819	0.3114	0.3429	0.3766	0.4135	0.4551
-39	0.2788	0.3083	0.3398	0.3735	0.4104	0.4521
-38	0.2757	0.3052	0.3367	0.3704	0.4074	0.4491
-37	0.2725	0.3021	0.3336	0.3674	0.4043	0.4461
-36	0.2694	0.299	0.3305	0.3643	0.4013	0.4431
-35	0.2663	0.2959	0.3274	0.3612	0.3982	0.4401
-34	0.2632	0.2928	0.3243	0.3581	0.3952	0.4371
-33	0.2601	0.2897	0.3212	0.355	0.3921	0.4341
-32	0.257	0.2866	0.3181	0.352	0.3891	0.431
-31	0.2539	0.2835	0.315	0.3489	0.386	0.428
-30	0.2507	0.2803	0.3119	0.3458	0.3829	0.425
-29	0.2476	0.2772	0.3088	0.3427	0.3799	0.422
-28	0.2445	0.2741	0.3057	0.3396	0.3768	0.4189
-27	0.2414	0.271	0.3026	0.3365	0.3737	0.4159
-26	0.2383	0.2679	0.2995	0.3334	0.3707	0.4129
-25	0.2352	0.2648	0.2964	0.3304	0.3676	0.4098
-24	0.2321	0.2617	0.2933	0.3273	0.3645	0.4068
-23	0.229	0.2586	0.2902	0.3242	0.3615	0.4038
-22	0.2259	0.2555	0.2871	0.3211	0.3584	0.4007
-21	0.2228	0.2524	0.284	0.318	0.3553	0.3977
-20	0.2197	0.2493	0.2809	0.3149	0.3523	0.3947
-19	0.2167	0.2462	0.2778	0.3119	0.3492	0.3916
-18	0.2136	0.2432	0.2747	0.3088	0.3462	0.3886
-17	0.2105	0.2401	0.2716	0.3057	0.3431	0.3856
-16	0.2074	0.237	0.2686	0.3026	0.34	0.3826
-15	0.2043	0.2339	0.2655	0.2996	0.337	0.3795
-14	0.2013	0.2308	0.2624	0.2965	0.3339	0.3765
-13	0.1982	0.2278	0.2593	0.2934	0.3309	0.3735
-12	0.1951	0.2247	0.2563	0.2904	0.3278	0.3704
-11	0.1921	0.2216	0.2532	0.2873	0.3248	0.3674
-10	0.189	0.2186	0.2501	0.2842	0.3217	0.3644
-9	0.186	0.2155	0.2471	0.2812	0.3187	0.3614
-8	0.1829	0.2125	0.244	0.2781	0.3157	0.3584
-7	0.1799	0.2094	0.241	0.2751	0.3126	0.3554
-6	0.1769	0.2064	0.2379	0.272	0.3096	0.3524
-5	0.1738	0.2033	0.2349	0.269	0.3066	0.3494
-4	0.1708	0.2003	0.2318	0.266	0.3035	0.3463
-3	0.1678	0.1972	0.2288	0.2629	0.3005	0.3434
-2	0.1647	0.1942	0.2258	0.2599	0.2975	0.3404
-1	0.1617	0.1912	0.2227	0.2569	0.2945	0.3374
0	0.1587	0.1882	0.2197	0.2539	0.2915	0.3344

Table 68. Effect of varying evaporator temperature on efficiency defect in throttle valve (R-507A)

Te (ºC)	Tc=30ºC	Tc=36ºC	TC=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	0.3017	0.3316	0.3642	0.4003	0.4415	0.4912
-49	0.2986	0.3285	0.3611	0.3972	0.4385	0.4882
-48	0.2954	0.3254	0.358	0.3941	0.4355	0.4853
-47	0.2923	0.3223	0.3549	0.3911	0.4324	0.4823
-46	0.2892	0.3192	0.3518	0.388	0.4294	0.4793
-45	0.286	0.316	0.3487	0.3849	0.4263	0.4763
-44	0.2829	0.3129	0.3456	0.3818	0.4233	0.4733
-43	0.2798	0.3098	0.3425	0.3787	0.4202	0.4703
-42	0.2766	0.3067	0.3393	0.3756	0.4172	0.4673
-41	0.2735	0.3035	0.3362	0.3725	0.4141	0.4643
-40	0.2703	0.3004	0.3331	0.3694	0.4111	0.4613
-39	0.2672	0.2973	0.33	0.3664	0.408	0.4583
-38	0.2641	0.2941	0.3269	0.3633	0.4049	0.4552
-37	0.2609	0.291	0.3238	0.3602	0.4019	0.4522
-36	0.2578	0.2879	0.3206	0.3571	0.3988	0.4492
-35	0.2547	0.2847	0.3175	0.354	0.3957	0.4462
-34	0.2515	0.2816	0.3144	0.3509	0.3927	0.4431
-33	0.2484	0.2785	0.3113	0.3478	0.3896	0.4401
-32	0.2453	0.2754	0.3082	0.3447	0.3865	0.4371
-31	0.2422	0.2722	0.305	0.3416	0.3834	0.434
-30	0.239	0.2691	0.3019	0.3384	0.3804	0.431
-29	0.2359	0.266	0.2988	0.3353	0.3773	0.428
-28	0.2328	0.2629	0.2957	0.3322	0.3742	0.4249
-27	0.2297	0.2598	0.2926	0.3291	0.3711	0.4219
-26	0.2265	0.2566	0.2895	0.3261	0.3681	0.4189
-25	0.2234	0.2535	0.2864	0.323	0.365	0.4158
-24	0.2203	0.2504	0.2833	0.3199	0.3619	0.4128
-23	0.2172	0.2473	0.2801	0.3168	0.3588	0.4098
-22	0.2141	0.2442	0.277	0.3137	0.3558	0.4067
-21	0.211	0.2411	0.2739	0.3106	0.3527	0.4037
-20	0.2079	0.238	0.2708	0.3075	0.3496	0.4007
-19	0.2048	0.2349	0.2677	0.3044	0.3465	0.3976
-18	0.2017	0.2318	0.2646	0.3013	0.3435	0.3946
-17	0.1986	0.2287	0.2616	0.2982	0.3404	0.3916
-16	0.1955	0.2256	0.2585	0.2951	0.3373	0.3885
-15	0.1925	0.2225	0.2554	0.2921	0.3343	0.3855
-14	0.1894	0.2194	0.2523	0.289	0.3312	0.3825
-13	0.1863	0.2163	0.2492	0.2859	0.3282	0.3794
-12	0.1832	0.2133	0.2461	0.2828	0.3251	0.3764
-11	0.1802	0.2102	0.2431	0.2798	0.322	0.3734
-10	0.1771	0.2071	0.24	0.2767	0.319	0.3704
-9	0.174	0.204	0.2369	0.2736	0.3159	0.3673
-8	0.171	0.201	0.2338	0.2706	0.3129	0.3643
-7	0.1679	0.1979	0.2308	0.2675	0.3098	0.3613
-6	0.1649	0.1949	0.2277	0.2644	0.3068	0.3583
-5	0.1618	0.1918	0.2247	0.2614	0.3038	0.3553

-4	0.1588	0.1888	0.2216	0.2583	0.3007	0.3523
-3	0.1557	0.1857	0.2185	0.2553	0.2977	0.3493
-2	0.1527	0.1827	0.2155	0.2522	0.2946	0.3463
-1	0.1497	0.1796	0.2124	0.2492	0.2916	0.3432
0	0.1466	0.1766	0.2094	0.2462	0.2886	0.3402

Table 69. Comparison of efficiency defect in throttle valve with varying evaporator temperature (Tc= 30ºC)

Te (ºC)	R502	R404A	R507A
-50	0.2754	0.313	0.3017
-49	0.2726	0.3099	0.2986
-48	0.2698	0.3068	0.2954
-47	0.267	0.3037	0.2923
-46	0.2642	0.3006	0.2892
-45	0.2613	0.2975	0.286
-44	0.2585	0.2943	0.2829
-43	0.2557	0.2912	0.2798
-42	0.2529	0.2881	0.2766
-41	0.25	0.285	0.2735
-40	0.2472	0.2819	0.2703
-39	0.2444	0.2788	0.2672
-38	0.2415	0.2757	0.2641
-37	0.2387	0.2725	0.2609
-36	0.2358	0.2694	0.2578
-35	0.233	0.2663	0.2547
-34	0.2301	0.2632	0.2515
-33	0.2273	0.2601	0.2484
-32	0.2244	0.257	0.2453
-31	0.2216	0.2539	0.2422
-30	0.2187	0.2507	0.239
-29	0.2159	0.2476	0.2359
-28	0.213	0.2445	0.2328
-27	0.2101	0.2414	0.2297
-26	0.2073	0.2383	0.2265
-25	0.2044	0.2352	0.2234
-24	0.2015	0.2321	0.2203
-23	0.1987	0.229	0.2172
-22	0.1958	0.2259	0.2141
-21	0.1929	0.2228	0.211
-20	0.1901	0.2197	0.2079
-19	0.1872	0.2167	0.2048
-18	0.1843	0.2136	0.2017
-17	0.1814	0.2105	0.1986
-16	0.1786	0.2074	0.1955
-15	0.1757	0.2043	0.1925

-14	0.1728	0.2013	0.1894
-13	0.17	0.1982	0.1863
-12	0.1671	0.1951	0.1832
-11	0.1642	0.1921	0.1802
-10	0.1613	0.189	0.1771
-9	0.1585	0.186	0.174
-8	0.1556	0.1829	0.171
-7	0.1527	0.1799	0.1679
-6	0.1499	0.1769	0.1649
-5	0.147	0.1738	0.1618
-4	0.1441	0.1708	0.1588
-3	0.1413	0.1678	0.1557
-2	0.1384	0.1647	0.1527
-1	0.1355	0.1617	0.1497
0	0.1327	0.1587	0.1466

Table 70. Comparison of efficiency defect in throttle valve with varying evaporator temperature (Tc= 36ºC)

Te (ºC)	R502	R404A	R507A
-50	0.301	0.3424	0.3316
-49	0.2983	0.3393	0.3285
-48	0.2955	0.3362	0.3254
-47	0.2926	0.3332	0.3223
-46	0.2898	0.3301	0.3192
-45	0.287	0.327	0.316
-44	0.2842	0.3239	0.3129
-43	0.2814	0.3208	0.3098
-42	0.2786	0.3177	0.3067
-41	0.2757	0.3145	0.3035
-40	0.2729	0.3114	0.3004
-39	0.2701	0.3083	0.2973
-38	0.2672	0.3052	0.2941
-37	0.2644	0.3021	0.291
-36	0.2615	0.299	0.2879
-35	0.2587	0.2959	0.2847
-34	0.2558	0.2928	0.2816
-33	0.253	0.2897	0.2785
-32	0.2501	0.2866	0.2754
-31	0.2472	0.2835	0.2722
-30	0.2444	0.2803	0.2691
-29	0.2415	0.2772	0.266
-28	0.2387	0.2741	0.2629
-27	0.2358	0.271	0.2598

-26	0.2329	0.2679	0.2566
-25	0.23	0.2648	0.2535
-24	0.2272	0.2617	0.2504
-23	0.2243	0.2586	0.2473
-22	0.2214	0.2555	0.2442
-21	0.2185	0.2524	0.2411
-20	0.2157	0.2493	0.238
-19	0.2128	0.2462	0.2349
-18	0.2099	0.2432	0.2318
-17	0.207	0.2401	0.2287
-16	0.2042	0.237	0.2256
-15	0.2013	0.2339	0.2225
-14	0.1984	0.2308	0.2194
-13	0.1955	0.2278	0.2163
-12	0.1927	0.2247	0.2133
-11	0.1898	0.2216	0.2102
-10	0.1869	0.2186	0.2071
-9	0.184	0.2155	0.204
-8	0.1811	0.2125	0.201
-7	0.1783	0.2094	0.1979
-6	0.1754	0.2064	0.1949
-5	0.1725	0.2033	0.1918
-4	0.1696	0.2003	0.1888
-3	0.1668	0.1972	0.1857
-2	0.1639	0.1942	0.1827
-1	0.161	0.1912	0.1796
0	0.1582	0.1882	0.1766

Table 71. Comparison of efficiency defect in throttle valve with varying evaporator temperature (Tc= 42ºC)

Te (ºC)	R502	R404A	R507A
-50	0.3276	0.3737	0.3642
-49	0.3249	0.3706	0.3611
-48	0.3221	0.3675	0.358
-47	0.3193	0.3645	0.3549
-46	0.3165	0.3614	0.3518
-45	0.3137	0.3583	0.3487
-44	0.3108	0.3552	0.3456
-43	0.308	0.3521	0.3425
-42	0.3052	0.349	0.3393
-41	0.3024	0.3459	0.3362
-40	0.2996	0.3429	0.3331
-39	0.2967	0.3398	0.33
-38	0.2939	0.3367	0.3269

-37	0.291	0.3336	0.3238
-36	0.2882	0.3305	0.3206
-35	0.2853	0.3274	0.3175
-34	0.2825	0.3243	0.3144
-33	0.2796	0.3212	0.3113
-32	0.2768	0.3181	0.3082
-31	0.2739	0.315	0.305
-30	0.2711	0.3119	0.3019
-29	0.2682	0.3088	0.2988
-28	0.2653	0.3057	0.2957
-27	0.2625	0.3026	0.2926
-26	0.2596	0.2995	0.2895
-25	0.2567	0.2964	0.2864
-24	0.2539	0.2933	0.2833
-23	0.251	0.2902	0.2801
-22	0.2481	0.2871	0.277
-21	0.2452	0.284	0.2739
-20	0.2424	0.2809	0.2708
-19	0.2395	0.2778	0.2677
-18	0.2366	0.2747	0.2646
-17	0.2337	0.2716	0.2616
-16	0.2309	0.2686	0.2585
-15	0.228	0.2655	0.2554
-14	0.2251	0.2624	0.2523
-13	0.2222	0.2593	0.2492
-12	0.2193	0.2563	0.2461
-11	0.2165	0.2532	0.2431
-10	0.2136	0.2501	0.24
-9	0.2107	0.2471	0.2369
-8	0.2078	0.244	0.2338
-7	0.205	0.241	0.2308
-6	0.2021	0.2379	0.2277
-5	0.1992	0.2349	0.2247
-4	0.1963	0.2318	0.2216
-3	0.1935	0.2288	0.2185
-2	0.1906	0.2258	0.2155
-1	0.1877	0.2227	0.2124
0	0.1848	0.2197	0.2094

Table 72. Comparison of efficiency defect in throttle valve with varying evaporator temperature (Tc= 48ºC)

Te (ºC)	R502	R404A	R507A
-50	0.3553	0.4071	0.4003
-49	0.3525	0.4041	0.3972

-48	0.3498	0.4011	0.3941
-47	0.347	0.398	0.3911
-46	0.3442	0.395	0.388
-45	0.3414	0.3919	0.3849
-44	0.3386	0.3889	0.3818
-43	0.3358	0.3858	0.3787
-42	0.333	0.3827	0.3756
-41	0.3302	0.3797	0.3725
-40	0.3273	0.3766	0.3694
-39	0.3245	0.3735	0.3664
-38	0.3217	0.3704	0.3633
-37	0.3189	0.3674	0.3602
-36	0.316	0.3643	0.3571
-35	0.3132	0.3612	0.354
-34	0.3103	0.3581	0.3509
-33	0.3075	0.355	0.3478
-32	0.3046	0.352	0.3447
-31	0.3018	0.3489	0.3416
-30	0.2989	0.3458	0.3384
-29	0.2961	0.3427	0.3353
-28	0.2932	0.3396	0.3322
-27	0.2904	0.3365	0.3291
-26	0.2875	0.3334	0.3261
-25	0.2846	0.3304	0.323
-24	0.2818	0.3273	0.3199
-23	0.2789	0.3242	0.3168
-22	0.276	0.3211	0.3137
-21	0.2732	0.318	0.3106
-20	0.2703	0.3149	0.3075
-19	0.2674	0.3119	0.3044
-18	0.2646	0.3088	0.3013
-17	0.2617	0.3057	0.2982
-16	0.2588	0.3026	0.2951
-15	0.2559	0.2996	0.2921
-14	0.2531	0.2965	0.289
-13	0.2502	0.2934	0.2859
-12	0.2473	0.2904	0.2828
-11	0.2445	0.2873	0.2798
-10	0.2416	0.2842	0.2767
-9	0.2387	0.2812	0.2736
-8	0.2358	0.2781	0.2706
-7	0.233	0.2751	0.2675
-6	0.2301	0.272	0.2644
-5	0.2272	0.269	0.2614
-4	0.2244	0.266	0.2583
-3	0.2215	0.2629	0.2553
-2	0.2186	0.2599	0.2522
-1	0.2158	0.2569	0.2492
0	0.2129	0.2539	0.2462

Table 73. Comparison of efficiency defect in throttle valve with varying evaporator temperature (Tc= 54ºC)

Te (ºC)	R502	R404A	R507A
-50	0.3843	0.4437	0.4415
-49	0.3816	0.4407	0.4385
-48	0.3788	0.4377	0.4355
-47	0.3761	0.4347	0.4324
-46	0.3733	0.4316	0.4294
-45	0.3705	0.4286	0.4263
-44	0.3677	0.4256	0.4233
-43	0.3649	0.4226	0.4202
-42	0.3621	0.4195	0.4172
-41	0.3593	0.4165	0.4141
-40	0.3565	0.4135	0.4111
-39	0.3537	0.4104	0.408
-38	0.3509	0.4074	0.4049
-37	0.3481	0.4043	0.4019
-36	0.3453	0.4013	0.3988
-35	0.3425	0.3982	0.3957
-34	0.3396	0.3952	0.3927
-33	0.3368	0.3921	0.3896
-32	0.334	0.3891	0.3865
-31	0.3311	0.386	0.3834
-30	0.3283	0.3829	0.3804
-29	0.3254	0.3799	0.3773
-28	0.3226	0.3768	0.3742
-27	0.3197	0.3737	0.3711
-26	0.3169	0.3707	0.3681
-25	0.3141	0.3676	0.365
-24	0.3112	0.3645	0.3619
-23	0.3083	0.3615	0.3588
-22	0.3055	0.3584	0.3558
-21	0.3026	0.3553	0.3527
-20	0.2998	0.3523	0.3496
-19	0.2969	0.3492	0.3465
-18	0.2941	0.3462	0.3435
-17	0.2912	0.3431	0.3404
-16	0.2883	0.34	0.3373
-15	0.2855	0.337	0.3343
-14	0.2826	0.3339	0.3312
-13	0.2798	0.3309	0.3282
-12	0.2769	0.3278	0.3251
-11	0.274	0.3248	0.322
-10	0.2712	0.3217	0.319
-9	0.2683	0.3187	0.3159
-8	0.2655	0.3157	0.3129

-7	0.2626	0.3126	0.3098
-6	0.2598	0.3096	0.3068
-5	0.2569	0.3066	0.3038
-4	0.254	0.3035	0.3007
-3	0.2512	0.3005	0.2977
-2	0.2483	0.2975	0.2946
-1	0.2455	0.2945	0.2916
0	0.2426	0.2915	0.2886

Table 74. Comparison of efficiency defect in throttle valve with varying evaporator temperature (Tc= 60ºC)

Te (ºC)	R502	R404A	R507A
-50	0.4152	0.4849	0.4912
-49	0.4125	0.4819	0.4882
-48	0.4097	0.479	0.4853
-47	0.407	0.476	0.4823
-46	0.4042	0.473	0.4793
-45	0.4015	0.4701	0.4763
-44	0.3987	0.4671	0.4733
-43	0.396	0.4641	0.4703
-42	0.3932	0.4611	0.4673
-41	0.3904	0.4581	0.4643
-40	0.3876	0.4551	0.4613
-39	0.3849	0.4521	0.4583
-38	0.3821	0.4491	0.4552
-37	0.3793	0.4461	0.4522
-36	0.3765	0.4431	0.4492
-35	0.3737	0.4401	0.4462
-34	0.3709	0.4371	0.4431
-33	0.3681	0.4341	0.4401
-32	0.3653	0.431	0.4371
-31	0.3624	0.428	0.434
-30	0.3596	0.425	0.431
-29	0.3568	0.422	0.428
-28	0.354	0.4189	0.4249
-27	0.3512	0.4159	0.4219
-26	0.3483	0.4129	0.4189
-25	0.3455	0.4098	0.4158
-24	0.3427	0.4068	0.4128
-23	0.3398	0.4038	0.4098
-22	0.337	0.4007	0.4067

-21	0.3342	0.3977	0.4037
-20	0.3313	0.3947	0.4007
-19	0.3285	0.3916	0.3976
-18	0.3257	0.3886	0.3946
-17	0.3228	0.3856	0.3916
-16	0.32	0.3826	0.3885
-15	0.3171	0.3795	0.3855
-14	0.3143	0.3765	0.3825
-13	0.3115	0.3735	0.3794
-12	0.3086	0.3704	0.3764
-11	0.3058	0.3674	0.3734
-10	0.3029	0.3644	0.3704
-9	0.3001	0.3614	0.3673
-8	0.2973	0.3584	0.3643
-7	0.2944	0.3554	0.3613
-6	0.2916	0.3524	0.3583
-5	0.2888	0.3494	0.3553
-4	0.2859	0.3463	0.3523
-3	0.2831	0.3434	0.3493
-2	0.2803	0.3404	0.3463
-1	0.2774	0.3374	0.3432
0	0.2746	0.3344	0.3402

Table 75. Effect of varying evaporator temperature on efficiency defect in evaporator (R-502)

Te (ºC)	Tc=30ºC	Tc=36ºC	Tc=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	0.0378	0.03271	0.02813	0.02397	0.02011	0.01648
-49	0.03836	0.03318	0.02854	0.02432	0.02042	0.01675
-48	0.03894	0.03367	0.02896	0.02468	0.02074	0.01703
-47	0.03953	0.03417	0.02939	0.02505	0.02106	0.01731
-46	0.04014	0.03468	0.02983	0.02543	0.02139	0.01759
-45	0.04076	0.03521	0.03027	0.02581	0.02172	0.01788
-44	0.04139	0.03574	0.03072	0.0262	0.02205	0.01818
-43	0.04205	0.03629	0.03119	0.0266	0.0224	0.01848
-42	0.04272	0.03685	0.03166	0.027	0.02275	0.01878
-41	0.04341	0.03742	0.03215	0.02742	0.0231	0.01909
-40	0.04411	0.03801	0.03264	0.02784	0.02347	0.0194
-39	0.04484	0.03862	0.03315	0.02827	0.02383	0.01972
-38	0.04559	0.03924	0.03367	0.02871	0.02421	0.02004
-37	0.04636	0.03987	0.0342	0.02916	0.0246	0.02037
-36	0.04715	0.04052	0.03475	0.02962	0.02499	0.02071
-35	0.04797	0.04119	0.0353	0.03009	0.02539	0.02105
-34	0.04881	0.04188	0.03587	0.03057	0.02579	0.0214

-33	0.04967	0.04258	0.03646	0.03106	0.02621	0.02175
-32	0.05056	0.04331	0.03706	0.03156	0.02663	0.02211
-31	0.05148	0.04406	0.03767	0.03207	0.02707	0.02248
-30	0.05243	0.04483	0.0383	0.0326	0.02751	0.02286
-29	0.05342	0.04562	0.03895	0.03314	0.02796	0.02324
-28	0.05443	0.04643	0.03962	0.03369	0.02842	0.02363
-27	0.05548	0.04727	0.0403	0.03425	0.02889	0.02403
-26	0.05657	0.04814	0.041	0.03483	0.02938	0.02444
-25	0.05769	0.04903	0.04173	0.03543	0.02987	0.02485
-24	0.05886	0.04995	0.04247	0.03604	0.03038	0.02527
-23	0.06006	0.0509	0.04324	0.03666	0.0309	0.02571
-22	0.06132	0.05189	0.04403	0.03731	0.03143	0.02615
-21	0.06262	0.0529	0.04484	0.03797	0.03197	0.0266
-20	0.06397	0.05396	0.04568	0.03865	0.03253	0.02706
-19	0.06538	0.05505	0.04654	0.03934	0.0331	0.02754
-18	0.06684	0.05618	0.04743	0.04006	0.03369	0.02802
-17	0.06837	0.05735	0.04835	0.0408	0.03429	0.02852
-16	0.06996	0.05856	0.04931	0.04156	0.0349	0.02902
-15	0.07162	0.05982	0.05029	0.04234	0.03554	0.02954
-14	0.07335	0.06113	0.05131	0.04315	0.03619	0.03008
-13	0.07517	0.0625	0.05236	0.04399	0.03686	0.03062
-12	0.07707	0.06392	0.05345	0.04485	0.03755	0.03118
-11	0.07906	0.06539	0.05458	0.04573	0.03826	0.03176
-10	0.08115	0.06693	0.05576	0.04665	0.03899	0.03234
-9	0.08334	0.06854	0.05698	0.0476	0.03974	0.03295
-8	0.08565	0.07022	0.05824	0.04858	0.04052	0.03357
-7	0.08808	0.07198	0.05956	0.0496	0.04132	0.03421
-6	0.09065	0.07382	0.06093	0.05065	0.04214	0.03487
-5	0.09336	0.07575	0.06236	0.05174	0.04299	0.03555
-4	0.09624	0.07777	0.06385	0.05287	0.04387	0.03624
-3	0.09928	0.0799	0.0654	0.05404	0.04478	0.03696
-2	0.1025	0.08213	0.06703	0.05526	0.04572	0.0377
-1	0.106	0.08449	0.06872	0.05653	0.0467	0.03846
0	0.1096	0.08697	0.0705	0.05785	0.04771	0.03924

Table76. Effect of varying evaporator temperature on efficiency defect in evaporator (R-404A)

Te (ºC)	Tc=30ºC	Tc=36ºC	Tc=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	0.03533	0.02966	0.02456	0.01988	0.01551	0.0113
-49	0.03591	0.03015	0.02496	0.02023	0.01581	0.01155
-48	0.0365	0.03064	0.02538	0.02058	0.01611	0.0118
-47	0.0371	0.03114	0.0258	0.02094	0.01641	0.01206
-46	0.03772	0.03166	0.02624	0.0213	0.01672	0.01232
-45	0.03836	0.03218	0.02668	0.02168	0.01703	0.01258

-44	0.039	0.03272	0.02713	0.02205	0.01735	0.01285
-43	0.03967	0.03327	0.02759	0.02244	0.01768	0.01313
-42	0.04036	0.03384	0.02806	0.02283	0.01801	0.0134
-41	0.04106	0.03441	0.02854	0.02323	0.01835	0.01369
-40	0.04178	0.035	0.02903	0.02364	0.01869	0.01397
-39	0.04252	0.03561	0.02953	0.02406	0.01904	0.01426
-38	0.04328	0.03623	0.03004	0.02449	0.01939	0.01456
-37	0.04406	0.03687	0.03056	0.02492	0.01975	0.01486
-36	0.04487	0.03752	0.0311	0.02536	0.02012	0.01516
-35	0.04569	0.03819	0.03165	0.02582	0.0205	0.01548
-34	0.04655	0.03888	0.03221	0.02628	0.02088	0.01579
-33	0.04743	0.03959	0.03279	0.02675	0.02127	0.01611
-32	0.04833	0.04031	0.03338	0.02724	0.02167	0.01644
-31	0.04927	0.04106	0.03398	0.02773	0.02208	0.01677
-30	0.05023	0.04183	0.0346	0.02824	0.02249	0.01711
-29	0.05123	0.04262	0.03524	0.02875	0.02291	0.01746
-28	0.05226	0.04344	0.03589	0.02929	0.02335	0.01781
-27	0.05332	0.04427	0.03656	0.02983	0.02379	0.01817
-26	0.05442	0.04514	0.03725	0.03038	0.02424	0.01854
-25	0.05556	0.04603	0.03796	0.03096	0.0247	0.01891
-24	0.05674	0.04695	0.03869	0.03154	0.02517	0.01929
-23	0.05797	0.0479	0.03944	0.03214	0.02566	0.01968
-22	0.05924	0.04889	0.04022	0.03276	0.02615	0.02008
-21	0.06056	0.0499	0.04101	0.03339	0.02666	0.02048
-20	0.06193	0.05095	0.04183	0.03404	0.02718	0.0209
-19	0.06335	0.05204	0.04268	0.03471	0.02771	0.02132
-18	0.06483	0.05317	0.04355	0.03539	0.02825	0.02175
-17	0.06638	0.05433	0.04446	0.0361	0.02881	0.0222
-16	0.06799	0.05555	0.04539	0.03683	0.02938	0.02265
-15	0.06967	0.0568	0.04635	0.03758	0.02997	0.02311
-14	0.07143	0.05811	0.04735	0.03835	0.03058	0.02359
-13	0.07326	0.05947	0.04838	0.03915	0.0312	0.02407
-12	0.07519	0.06088	0.04945	0.03997	0.03184	0.02457
-11	0.0772	0.06236	0.05055	0.04081	0.03249	0.02508
-10	0.07932	0.06389	0.0517	0.04169	0.03317	0.0256
-9	0.08154	0.0655	0.05289	0.0426	0.03387	0.02614
-8	0.08387	0.06717	0.05413	0.04353	0.03458	0.02669
-7	0.08634	0.06893	0.05542	0.0445	0.03532	0.02726
-6	0.08893	0.07076	0.05676	0.0455	0.03608	0.02784
-5	0.09168	0.07268	0.05816	0.04654	0.03687	0.02844
-4	0.09458	0.0747	0.05961	0.04762	0.03768	0.02905
-3	0.09766	0.07682	0.06113	0.04874	0.03852	0.02969
-2	0.1009	0.07905	0.06272	0.04991	0.03939	0.03034
-1	0.1044	0.0814	0.06438	0.05111	0.04029	0.03101
0	0.1081	0.08388	0.06612	0.05237	0.04122	0.0317

Table 77. Effect of varying evaporator temperature on efficiency defect in evaporator (R-507A)

Te (ºC)	Tc=30ºC	Tc=36ºC	Tc=42ºC	Tc=48ºC	Tc=54ºC	Tc=60ºC
-50	0.03588	0.03055	0.02563	0.02096	0.01638	0.01164
-49	0.03644	0.03103	0.02604	0.02132	0.01669	0.0119
-48	0.03703	0.03152	0.02646	0.02168	0.017	0.01216
-47	0.03762	0.03202	0.02689	0.02204	0.01731	0.01243
-46	0.03824	0.03254	0.02732	0.02242	0.01763	0.0127
-45	0.03886	0.03306	0.02777	0.0228	0.01796	0.01298
-44	0.0395	0.0336	0.02823	0.02318	0.01829	0.01326
-43	0.04016	0.03415	0.02869	0.02358	0.01862	0.01354
-42	0.04084	0.03471	0.02916	0.02398	0.01896	0.01383
-41	0.04153	0.03529	0.02965	0.02439	0.01931	0.01412
-40	0.04224	0.03588	0.03014	0.02481	0.01966	0.01442
-39	0.04297	0.03648	0.03065	0.02523	0.02002	0.01472
-38	0.04372	0.0371	0.03116	0.02567	0.02039	0.01503
-37	0.04449	0.03774	0.03169	0.02611	0.02076	0.01534
-36	0.04528	0.03839	0.03223	0.02656	0.02114	0.01566
-35	0.0461	0.03906	0.03278	0.02702	0.02153	0.01598
-34	0.04694	0.03974	0.03335	0.0275	0.02192	0.01631
-33	0.0478	0.04045	0.03393	0.02798	0.02233	0.01664
-32	0.0487	0.04117	0.03453	0.02847	0.02274	0.01698
-31	0.04961	0.04191	0.03513	0.02897	0.02315	0.01733
-30	0.05056	0.04268	0.03576	0.02949	0.02358	0.01768
-29	0.05154	0.04346	0.0364	0.03002	0.02402	0.01804
-28	0.05255	0.04427	0.03706	0.03056	0.02446	0.01841
-27	0.0536	0.04511	0.03773	0.03111	0.02492	0.01878
-26	0.05468	0.04597	0.03843	0.03168	0.02538	0.01916
-25	0.0558	0.04685	0.03914	0.03226	0.02586	0.01954
-24	0.05696	0.04777	0.03987	0.03285	0.02634	0.01994
-23	0.05816	0.04871	0.04063	0.03346	0.02684	0.02034
-22	0.05941	0.04969	0.0414	0.03409	0.02735	0.02075
-21	0.0607	0.05069	0.0422	0.03473	0.02787	0.02117
-20	0.06204	0.05173	0.04303	0.03539	0.0284	0.0216
-19	0.06344	0.05281	0.04388	0.03607	0.02895	0.02204
-18	0.06489	0.05393	0.04475	0.03677	0.02951	0.02249
-17	0.06641	0.05509	0.04566	0.03749	0.03008	0.02295
-16	0.06799	0.05629	0.04659	0.03823	0.03067	0.02342
-15	0.06963	0.05753	0.04756	0.03899	0.03128	0.0239
-14	0.07135	0.05883	0.04856	0.03977	0.0319	0.02439
-13	0.07315	0.06017	0.04959	0.04058	0.03254	0.02489
-12	0.07503	0.06157	0.05066	0.04141	0.03319	0.02541
-11	0.077	0.06303	0.05177	0.04227	0.03387	0.02594
-10	0.07907	0.06454	0.05292	0.04316	0.03456	0.02648
-9	0.08124	0.06613	0.05411	0.04408	0.03527	0.02703
-8	0.08353	0.06778	0.05535	0.04502	0.03601	0.0276
-7	0.08593	0.06951	0.05663	0.04601	0.03677	0.02819
-6	0.08847	0.07132	0.05797	0.04702	0.03755	0.02879
-5	0.09116	0.07322	0.05937	0.04808	0.03836	0.02941

-4	0.09399	0.07521	0.06082	0.04917	0.03919	0.03005
-3	0.097	0.0773	0.06234	0.0503	0.04005	0.03071
-2	0.1002	0.0795	0.06392	0.05148	0.04094	0.03138
-1	0.1036	0.08182	0.06558	0.0527	0.04186	0.03208
0	0.1072	0.08426	0.06731	0.05397	0.04282	0.0328

Table 78. Comparison of efficiency defect in evaporator with varying evaporator temperature (Tc= 30ºC)

Te (ºC)	R502	R404A	R507A
-50	0.0378	0.03533	0.03588
-49	0.03836	0.03591	0.03644
-48	0.03894	0.0365	0.03703
-47	0.03953	0.0371	0.03762
-46	0.04014	0.03772	0.03824
-45	0.04076	0.03836	0.03886
-44	0.04139	0.039	0.0395
-43	0.04205	0.03967	0.04016
-42	0.04272	0.04036	0.04084
-41	0.04341	0.04106	0.04153
-40	0.04411	0.04178	0.04224
-39	0.04484	0.04252	0.04297
-38	0.04559	0.04328	0.04372
-37	0.04636	0.04406	0.04449
-36	0.04715	0.04487	0.04528
-35	0.04797	0.04569	0.0461
-34	0.04881	0.04655	0.04694
-33	0.04967	0.04743	0.0478
-32	0.05056	0.04833	0.0487
-31	0.05148	0.04927	0.04961
-30	0.05243	0.05023	0.05056
-29	0.05342	0.05123	0.05154
-28	0.05443	0.05226	0.05255
-27	0.05548	0.05332	0.0536
-26	0.05657	0.05442	0.05468
-25	0.05769	0.05556	0.0558
-24	0.05886	0.05674	0.05696
-23	0.06006	0.05797	0.05816
-22	0.06132	0.05924	0.05941
-21	0.06262	0.06056	0.0607

-20	0.06397	0.06193	0.06204
-19	0.06538	0.06335	0.06344
-18	0.06684	0.06483	0.06489
-17	0.06837	0.06638	0.06641
-16	0.06996	0.06799	0.06799
-15	0.07162	0.06967	0.06963
-14	0.07335	0.07143	0.07135
-13	0.07517	0.07326	0.07315
-12	0.07707	0.07519	0.07503
-11	0.07906	0.0772	0.077
-10	0.08115	0.07932	0.07907
-9	0.08334	0.08154	0.08124
-8	0.08565	0.08387	0.08353
-7	0.08808	0.08634	0.08593
-6	0.09065	0.08893	0.08847
-5	0.09336	0.09168	0.09116
-4	0.09624	0.09458	0.09399
-3	0.09928	0.09766	0.097
-2	0.1025	0.1009	0.1002
-1	0.106	0.1044	0.1036
0	0.1096	0.1081	0.1072

Table 79. Comparison of efficiency defect in evaporator with varying evaporator temperature (Tc= 36ºC)

Te (ºC)	R502	R404A	R507A
-50	0.03271	0.02966	0.03055
-49	0.03318	0.03015	0.03103
-48	0.03367	0.03064	0.03152
-47	0.03417	0.03114	0.03202
-46	0.03468	0.03166	0.03254
-45	0.03521	0.03218	0.03306
-44	0.03574	0.03272	0.0336
-43	0.03629	0.03327	0.03415
-42	0.03685	0.03384	0.03471
-41	0.03742	0.03441	0.03529
-40	0.03801	0.035	0.03588
-39	0.03862	0.03561	0.03648
-38	0.03924	0.03623	0.0371
-37	0.03987	0.03687	0.03774
-36	0.04052	0.03752	0.03839
-35	0.04119	0.03819	0.03906
-34	0.04188	0.03888	0.03974
-33	0.04258	0.03959	0.04045
-32	0.04331	0.04031	0.04117
-31	0.04406	0.04106	0.04191
-30	0.04483	0.04183	0.04268

-29	0.04562	0.04262	0.04346
-28	0.04643	0.04344	0.04427
-27	0.04727	0.04427	0.04511
-26	0.04814	0.04514	0.04597
-25	0.04903	0.04603	0.04685
-24	0.04995	0.04695	0.04777
-23	0.0509	0.0479	0.04871
-22	0.05189	0.04889	0.04969
-21	0.0529	0.0499	0.05069
-20	0.05396	0.05095	0.05173
-19	0.05505	0.05204	0.05281
-18	0.05618	0.05317	0.05393
-17	0.05735	0.05433	0.05509
-16	0.05856	0.05555	0.05629
-15	0.05982	0.0568	0.05753
-14	0.06113	0.05811	0.05883
-13	0.0625	0.05947	0.06017
-12	0.06392	0.06088	0.06157
-11	0.06539	0.06236	0.06303
-10	0.06693	0.06389	0.06454
-9	0.06854	0.0655	0.06613
-8	0.07022	0.06717	0.06778
-7	0.07198	0.06893	0.06951
-6	0.07382	0.07076	0.07132
-5	0.07575	0.07268	0.07322
-4	0.07777	0.0747	0.07521
-3	0.0799	0.07682	0.0773
-2	0.08213	0.07905	0.0795
-1	0.08449	0.0814	0.08182
0	0.08697	0.08388	0.08426

Table 80. Comparison of efficiency defect in evaporator with varying evaporator temperature (Tc= 42ºC)

Te (ºC)	R502	R404A	R507A
-50	0.02813	0.02456	0.02563
-49	0.02854	0.02496	0.02604
-48	0.02896	0.02538	0.02646
-47	0.02939	0.0258	0.02689
-46	0.02983	0.02624	0.02732
-45	0.03027	0.02668	0.02777
-44	0.03072	0.02713	0.02823
-43	0.03119	0.02759	0.02869
-42	0.03166	0.02806	0.02916
-41	0.03215	0.02854	0.02965
-40	0.03264	0.02903	0.03014

-39	0.03315	0.02953	0.03065
-38	0.03367	0.03004	0.03116
-37	0.0342	0.03056	0.03169
-36	0.03475	0.0311	0.03223
-35	0.0353	0.03165	0.03278
-34	0.03587	0.03221	0.03335
-33	0.03646	0.03279	0.03393
-32	0.03706	0.03338	0.03453
-31	0.03767	0.03398	0.03513
-30	0.0383	0.0346	0.03576
-29	0.03895	0.03524	0.0364
-28	0.03962	0.03589	0.03706
-27	0.0403	0.03656	0.03773
-26	0.041	0.03725	0.03843
-25	0.04173	0.03796	0.03914
-24	0.04247	0.03869	0.03987
-23	0.04324	0.03944	0.04063
-22	0.04403	0.04022	0.0414
-21	0.04484	0.04101	0.0422
-20	0.04568	0.04183	0.04303
-19	0.04654	0.04268	0.04388
-18	0.04743	0.04355	0.04475
-17	0.04835	0.04446	0.04566
-16	0.04931	0.04539	0.04659
-15	0.05029	0.04635	0.04756
-14	0.05131	0.04735	0.04856
-13	0.05236	0.04838	0.04959
-12	0.05345	0.04945	0.05066
-11	0.05458	0.05055	0.05177
-10	0.05576	0.0517	0.05292
-9	0.05698	0.05289	0.05411
-8	0.05824	0.05413	0.05535
-7	0.05956	0.05542	0.05663
-6	0.06093	0.05676	0.05797
-5	0.06236	0.05816	0.05937
-4	0.06385	0.05961	0.06082
-3	0.0654	0.06113	0.06234
-2	0.06703	0.06272	0.06392
-1	0.06872	0.06438	0.06558
0	0.0705	0.06612	0.06731

Table 81. Comparison of efficiency defect in evaporator with varying evaporator temperature (Tc= 48ºC)

Te (ºC)	R502	R404A	R507A
-50	0.02397	0.01988	0.02096

-49	0.02432	0.02023	0.02132
-48	0.02468	0.02058	0.02168
-47	0.02505	0.02094	0.02204
-46	0.02543	0.0213	0.02242
-45	0.02581	0.02168	0.0228
-44	0.0262	0.02205	0.02318
-43	0.0266	0.02244	0.02358
-42	0.027	0.02283	0.02398
-41	0.02742	0.02323	0.02439
-40	0.02784	0.02364	0.02481
-39	0.02827	0.02406	0.02523
-38	0.02871	0.02449	0.02567
-37	0.02916	0.02492	0.02611
-36	0.02962	0.02536	0.02656
-35	0.03009	0.02582	0.02702
-34	0.03057	0.02628	0.0275
-33	0.03106	0.02675	0.02798
-32	0.03156	0.02724	0.02847
-31	0.03207	0.02773	0.02897
-30	0.0326	0.02824	0.02949
-29	0.03314	0.02875	0.03002
-28	0.03369	0.02929	0.03056
-27	0.03425	0.02983	0.03111
-26	0.03483	0.03038	0.03168
-25	0.03543	0.03096	0.03226
-24	0.03604	0.03154	0.03285
-23	0.03666	0.03214	0.03346
-22	0.03731	0.03276	0.03409
-21	0.03797	0.03339	0.03473
-20	0.03865	0.03404	0.03539
-19	0.03934	0.03471	0.03607
-18	0.04006	0.03539	0.03677
-17	0.0408	0.0361	0.03749
-16	0.04156	0.03683	0.03823
-15	0.04234	0.03758	0.03899
-14	0.04315	0.03835	0.03977
-13	0.04399	0.03915	0.04058
-12	0.04485	0.03997	0.04141
-11	0.04573	0.04081	0.04227
-10	0.04665	0.04169	0.04316
-9	0.0476	0.0426	0.04408
-8	0.04858	0.04353	0.04502
-7	0.0496	0.0445	0.04601
-6	0.05065	0.0455	0.04702
-5	0.05174	0.04654	0.04808
-4	0.05287	0.04762	0.04917
-3	0.05404	0.04874	0.0503
-2	0.05526	0.04991	0.05148
-1	0.05653	0.05111	0.0527
0	0.05785	0.05237	0.05397

Table 82. Comparison of efficiency defect in evaporator with varying evaporator temperature (Tc= 54ºC)

Te (ºC)	R502	R404A	R507A
-50	0.02011	0.01551	0.01638
-49	0.02042	0.01581	0.01669
-48	0.02074	0.01611	0.017
-47	0.02106	0.01641	0.01731
-46	0.02139	0.01672	0.01763
-45	0.02172	0.01703	0.01796
-44	0.02205	0.01735	0.01829
-43	0.0224	0.01768	0.01862
-42	0.02275	0.01801	0.01896
-41	0.0231	0.01835	0.01931
-40	0.02347	0.01869	0.01966
-39	0.02383	0.01904	0.02002
-38	0.02421	0.01939	0.02039
-37	0.0246	0.01975	0.02076
-36	0.02499	0.02012	0.02114
-35	0.02539	0.0205	0.02153
-34	0.02579	0.02088	0.02192
-33	0.02621	0.02127	0.02233
-32	0.02663	0.02167	0.02274
-31	0.02707	0.02208	0.02315
-30	0.02751	0.02249	0.02358
-29	0.02796	0.02291	0.02402
-28	0.02842	0.02335	0.02446
-27	0.02889	0.02379	0.02492
-26	0.02938	0.02424	0.02538
-25	0.02987	0.0247	0.02586
-24	0.03038	0.02517	0.02634
-23	0.0309	0.02566	0.02684
-22	0.03143	0.02615	0.02735
-21	0.03197	0.02666	0.02787
-20	0.03253	0.02718	0.0284
-19	0.0331	0.02771	0.02895
-18	0.03369	0.02825	0.02951
-17	0.03429	0.02881	0.03008
-16	0.0349	0.02938	0.03067
-15	0.03554	0.02997	0.03128
-14	0.03619	0.03058	0.0319
-13	0.03686	0.0312	0.03254
-12	0.03755	0.03184	0.03319
-11	0.03826	0.03249	0.03387
-10	0.03899	0.03317	0.03456
-9	0.03974	0.03387	0.03527
-8	0.04052	0.03458	0.03601
-7	0.04132	0.03532	0.03677
-6	0.04214	0.03608	0.03755
-5	0.04299	0.03687	0.03836
-4	0.04387	0.03768	0.03919

-3	0.04478	0.03852	0.04005
-2	0.04572	0.03939	0.04094
-1	0.0467	0.04029	0.04186
0	0.04771	0.04122	0.04282

Table 83. Comparison of efficiency defect in evaporator with varying evaporator temperature (Tc= 60ºC)

Te (ºC)	R502	R404A	R507A
-50	0.01648	0.0113	0.01164
-49	0.01675	0.01155	0.0119
-48	0.01703	0.0118	0.01216
-47	0.01731	0.01206	0.01243
-46	0.01759	0.01232	0.0127
-45	0.01788	0.01258	0.01298
-44	0.01818	0.01285	0.01326
-43	0.01848	0.01313	0.01354
-42	0.01878	0.0134	0.01383
-41	0.01909	0.01369	0.01412
-40	0.0194	0.01397	0.01442
-39	0.01972	0.01426	0.01472
-38	0.02004	0.01456	0.01503
-37	0.02037	0.01486	0.01534
-36	0.02071	0.01516	0.01566
-35	0.02105	0.01548	0.01598
-34	0.0214	0.01579	0.01631
-33	0.02175	0.01611	0.01664
-32	0.02211	0.01644	0.01698
-31	0.02248	0.01677	0.01733
-30	0.02286	0.01711	0.01768
-29	0.02324	0.01746	0.01804
-28	0.02363	0.01781	0.01841
-27	0.02403	0.01817	0.01878
-26	0.02444	0.01854	0.01916
-25	0.02485	0.01891	0.01954
-24	0.02527	0.01929	0.01994
-23	0.02571	0.01968	0.02034
-22	0.02615	0.02008	0.02075
-21	0.0266	0.02048	0.02117
-20	0.02706	0.0209	0.0216
-19	0.02754	0.02132	0.02204

-18	0.02802	0.02175	0.02249
-17	0.02852	0.0222	0.02295
-16	0.02902	0.02265	0.02342
-15	0.02954	0.02311	0.0239
-14	0.03008	0.02359	0.02439
-13	0.03062	0.02407	0.02489
-12	0.03118	0.02457	0.02541
-11	0.03176	0.02508	0.02594
-10	0.03234	0.0256	0.02648
-9	0.03295	0.02614	0.02703
-8	0.03357	0.02669	0.0276
-7	0.03421	0.02726	0.02819
-6	0.03487	0.02784	0.02879
-5	0.03555	0.02844	0.02941
-4	0.03624	0.02905	0.03005
-3	0.03696	0.02969	0.03071
-2	0.0377	0.03034	0.03138
-1	0.03846	0.03101	0.03208
0	0.03924	0.0317	0.0328

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ANNEXURE 1

Energy and Exergy Analysis Programme in Engineering Equation Solver

(S. A. Klein 2006, academic version V7. 714)

Parameter (Fixed)

Mass flow of refrigerant = 1kg. / second
Room temperature = 5°C higher than evaporator temperature
Environment temperature = 25°C
Isentropic efficiency (Compressor) = 75%

Parameter (Variable)

Evaporator temperature (Te) = -50 °C to 0°C

Condenser temperature (Tc) = 30°C to 60°C

Calculations

Evaporator pressure (Pe)

Pe=PRESSURE(R$,T=Te,x=1)

where R$ =Refrigerant (R22, R407C, R410A and R417A*)

x=dryness fraction

(* Thermodynamic property of R-417A is calculated from REFPROP. version 4.0)

Condenser pressure

Pc=PRESSURE(R$,T=Tc,x=0)

Pressure ratio (R)

R=Pc/Pe

Specific volume (vg)at inlet to compressor

vg=VOLUME(R$,x=1,P=PE)

Voluetric cooling capacity (CC_VOL)

CC_vol=Qe/(mr*vg)

Enthalpy (h)

Compressor inlet

h1=ENTHALPY(R$,X=1,P=Pe)

Compressor outlet

h2s=ENTHALPY(R$,P=Pc,s=s2s)

Condenser outlet

h3=ENTHALPY(R$,P=Pc,x=0)

h4=h3

h2 = (h2s – h1)/isen._eff. + h1

Entropy

s1=ENTROPY(R$,X=1,P=Pe)
s1=s2s
s2=ENTROPY(R$,h=h2,P=Pc)
s3=ENTROPY(R$,x=0,P=Pc)
s4=ENTROPY(R$,x=X4,P=Pe)

Compressor work (wc)
wc=mr*(h2-h1)

Refrigerating effect

Qe=mr*(h1-h4)

Coefficient of performance (COP)

COP =(Qe/wc)

Irreversibility

Compressor (icomp.)

Icomp. =(wc+mr*((h1-t0*s1)-(h2-t0*s2)))

Condenser (i cond.)

icond=(mr*(h2-T0*s2)-mr*(h3-T0*s3))

Throttle valve

it=(mr*((h3-T0*s3)-(h4-T0*s4)))

Evaporator

ie=(mr*(h4-T0*s4)-mr*(h1-T0*s1)+Qe*(1-T0/(Tr+273.15)))

Total Irreversibility (ED_Total)

Ed_Total=(ic+icond+it+ie)

Exergy of the product (EP)

EP=-Qe*(1-T0/(Tr+273.15))

Exergy destruction ratio (EDR)

EDR=Ed_Total/(EP)

Efficiency defect (eff._decect)

Compressor

eff._defect_comp=icomp./(wc)

Condenser

eff._defect _cond=icond/(wc)

Throttle valve

Eff._defec_tthrott=it/(wc)

Evaporator

eff._defecte_vapo=ie/(wc)

Exergetic efficiency

exergetic efficiency =1-(eff._defect_comp. +eff._defect_cond ++eff._defec_tthrott eff._defect_evapo.)