PERFORMANCE OF A/C SPLIT UNITS WORKING BY (R 134a) REPLACING (R 22)

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Submitted in Partial Fulfillment of the Requirements for the
Degree of Master of Science in
Mechanical Engineering

Faculty of Graduate Studies

University of Jordan

May 2000

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Dedication

To soul of my father, to my mother who

gives me love and

hope, to my fiancee who helped and

encouraged me to complete my

graduate studies, to my brothers

and sisters

Acknowledgements

I would like to thank my supervisor Professor Mahmoud Hammad for his valuable encouragement and help to complete this work.

I would like to thank professor Mohammad AL- saad, Dr. Burhan Tashtoush, and Dr. Handry Ammary for their efforts in the defense of this research.

Also, I would like to thank my family and my friends for their help and encouragement.

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Nomenclature

T : temperature(°C)

h : Enthalpy(KJ/Kg)

$\dot{m}$: mass flow rate(Kg/sec)

q_{ref} : Refrigerating Effect(KJ/Kg)

$\mathbf{Q_{ref}}$: Refrigeration Capacity(Kw)

q_w : compression work

P : Electric Power Consumption(W).

COP : Coefficient Of Performance.

Subscripts:

e : Evaporator
c : Condenser

Abstract

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The purpose of this research is to study the performance of air conditioning split unit of 2.5 tons refrigeration capacity operating on R 134a as a replacement for R22.

It is known that R22 posses a degree of Ozone Depletion Potential (ODP), and so, we began to research about another refrigerant that is a friend to the environment. In this research, R 134a was selected to replace R-22.

The capillary tube was replaced by a manual control valve. This was conducted to control the evaporation temperature and pressure which are

the main independent parameters of the cycle. After that, experiments were performed on R22.

Before charging the system with R134a, it is required to replace the mineral oil which is used with R22 by a polyol ester oil which is suitable for R 134a. It has good miscibility with it, and does not react with it.

After that, suitable charge of R 134a that gives the optimum coefficient of performance was selected, it was (1500g). Experiments then were performed using R134a, by Te variation tests and Tc variation tests.

Performance curves for R22 and R134a were presented, and a comparison between both performances was, also, presented.

The air conditioner gave a good refrigeration capacity and coefficient of performance for R22 but it gave a lower refrigeration capacity and coefficient of performance for R134a. The coefficient of performance reached was (3.0) and the refrigeration capacity (1.9 kW) for evaporating temperature of (12°C) and condensing temperature of (43°C)for R134a, while for the same conditions the Coefficient of Performance reached about (5.1) and the refrigeration capacity about (6.2 kW) for R22.

From the experiments, It can be concluded that, R134a is not a suitable alternative for R 22 in the split unit air conditioner and it is not recommended to be used in air conditioning systems.

Chapter One

INTRODUCTION

In recent years the most pressing research issue in the field of refrigeration and air conditioning systems has been the search for new and environmentally acceptable working fluids which can replace CFCs and HCFCs. Most of the substances considered are new synthetic compounds, namely the Hydrofluoro Carbons (HFCs).

It is known that CFCs and HCFCs have been used in refrigeration and air conditioning systems, these compounds have a good operating performance, but every thing can't be used without disadvantages. These compounds destroy the Ozone layer which prevent the earth from the dangerous rays, such as, Ultra Violet rays.

The Montreal protocol of 1987, called for the phasing out of chlorofluoro carbons (CFCs) and hydrochlorofluoro carbons HCFCs by the end of last century. Besides the good performance of HCFCs and CFCs, they are low in toxicity, non-flammable, non corrosive, and compatible with other materials, they are destroying the ozone layer.

The most common refrigerant which is used in air conditioning systems is HCFC-22, this substance has a very good performance in air conditioning systems, non toxic, non flammable and has very good thermodynamic and physical properties which make it an ideal refrigerant for air conditioning systems.

HCFC-22 is one of the hydrochlorofluoro carbon compounds, and so, it has a dangerous effect on the Ozone layer, and so, the Ozone layer will be affected by this compound, also this compound participates in global warming of the earth.

For the above reasons, and in accordance with Montreal protocol, researchers began looking for alternatives for this compound. Several compounds and mixtures have been tested on the air conditioning systems.

The alternative for R22 should have acceptable thermodynamic and physical properties, compatibility with materials, lower Ozone depletion potential, lower potential source of global warming and high stability. These properties are found in several compounds and mixtures of compounds, and so, experiments were conducted to find the performance and compare them with those of R22 under the same operating conditions. In this research, R134a, which is a compound from HFC family is used as a replacement to R22. R134a is a free of chlorine atom, and so, it has a zero depletion potential and very small global warming potential compared to HCFC-22. Besides the above good property of HFC 134a, it has good thermodynamic and physical properties, non toxic, non corrosive, non flammable, and so, attention should be paid to it to study its performance under the same operating conditions as R22.

This research was performed on a split Air Conditioner Unit. The main purpose is to study the performance of split unit air conditioner by using R-134a as a replacement to R22, and comparison of power consumption , refrigeration capacity, heat rejection rate and the coefficient of performance, under the same operating conditions as R22. These experiments were performed at different condition of evaporating and condensing temperatures. This performance will be studied in two parts:

1- Evaporating Temperature (Te) variation test:

Changing the evaporating temperature at constant condensing temperature.

2- Condensing Temperature (Tc) variation test:

Changing the condensing temperature at constant evaporating temperature.

A comparison with the same unit using R22 is conducted.

Yajima, et. al., (1994), presented the performance of HFC 134a, HFC 32/134a, HFC-32/125/134a and HFC-32/125 as alternative refrigerants for HCFC-22. Their work was divided into two branches, the first was making experiments on a 0.8 Ref-ton split type air conditioning unit, the second was a simulation process for these experiments. They concluded that, HFC-32/134a (30/70%) shows the highest performance of the other proposed alternatives. Also, they discovered that, the addition of HFC-125 to HFC-32/134a will lower the system C.O.P because of the smaller latent heat of HFC-125. Also, they concluded from their experiments that HFC-32 gives the highest system COP because of small pressure drop and high heat transfer performance.

Muir,(1994), studied the possible alternatives for R22, and he showed some advantages and disadvantages of these alternatives. These alternative refrigerants are R134a, R407c, and R410A. He found that by using R134a as an alternative for R22 in an air conditioning systems, R-134a has the lowest capacity and pressure of the other two possible alternative R-407c and R410A. He found that, also, if we want to use R134a as an alternative for R22, we must redesign all R-22 equipment in order to get a good efficiency compared to R22. This redesign includes making the tubes in the systems larger, in order to minimize the pressure drops and so getting reasonable operating efficiency. Another redesign requirements is using greatest compressor displacements which will increase the capital cost of the system, and so, he concluded that R-134a is the least likely of the other two alternatives to be utilized for residential and smaller commercial systems. And so, R134a can be used in large air conditioning systems because of large tubes and large compressors are used. R-407C is the simplest alternative than the other two, because it requires the minimal changes to the current R22 operating equipment. The only major change required is the use of polyol ester lubricants which are hydroscopic materials (have a greater tendency to absorb moisture).

It was concluded that, the use of R407C will give a slightly less efficiency than R-22, and the cost of using R407c is slightly greater than R-22.

R410A operates at very high pressure, approximately 50% higher than R-22, and requires much lower displacement compressors. The higher pressure and density of R-410A will allow to use much smaller diameter tubes. The use of R-410A still gives us a lower efficiency than R-22.

It was ,also, resulted that, it is necessary to completely redesign the system in order to handle the higher pressures and to optimize the heat exchangers for the use of R-410A, and so, higher efficiency than the other two alternatives by 5% for the same cost can be obtained. Also, he put a disadvantage to R410A which is a direct global warming. But he said that, the higher efficiency of R410A may offset its higher direct global warming in the systems of low leak rate, while for high leakage systems, this would not be the case.

Xiao Feng, et. al., (1994), discussed some potential alternatives for HCFC 22 from two sides: Coefficient Of Performance and Volumetric Capacity, these alternatives are:

HFC 134a, Propane, HFC 32/HFC 125, HFC 32/HFC 152a, HFC 32/HFC 134a, HFC 32/HFC 125/HFC 134a, HFC 125/HFC 143a/HFC 134a and HFC 152a/HFC 134a/HFC 32. They concluded that, the possible alternative for HCFC 22 depends on the target of this replacement process. For example, if we want to protect the environment and not to change the existing system, we can use HFC 32/HFC 125, HFC 32/HFC 152a, HFC 32/HFC 134a, HFC 32/HFC 125/HFC 134a, HFC 125/HFC 143a/HFC 134a, and HFC 152a/HFC 134a/HFC 32 mixtures. Also, they concluded that, if the flammable problem is considered, we can use, HFC 32/HFC 125, HFC 32/HFC 134a, HFC 32/HFC 125/HFC 134a, and HFC 125/HFC 143a/HFC 134a, and if coefficient of performance is required to be not less than that of HCFC 22, none of the above mixtures can be used as possible alternative for HCFC 22. The final conclusion of them is that, the mixture HFC 32/HFC 125/HFC 134a is the best alternative for HCFC 22 from the mixtures mentioned above, but we should seek new better alternatives for HCFC 22.

Nengzhao Jiang, et. al., (1994), examined the use of HFC 32/HFC 134a instead of HCFC 22 in an air conditioner. They used the carnahan-starling-Desantis (CSD) equation of state and appropriate mixing rule to calculate the thermodynamic properties for variable mixture ratios and the theoretical refrigeration cycle performance for HFC 32/HFC 134a, then they selected the optimum mixture ratio and they began to make experiments on window type air conditioner. From the theoretical work, they concluded that the performance of the refrigeration cycle using HFC 32/HFC 134a has a close approach to that of HFC22.

From the experimental work, they concluded that, the room air conditioner using a mixture of HFC 32/HFC 134a has a less charge, but needs a longer capillary tube compared to the room air conditioner using HCFC 22 to achieve a performance that is near from that of HCFC 22.

Also, they concluded that when we use the mixture HFC 32/HFC 134a (25/75%) instead of HCFC 22 in an air conditioner we can achieve an improved performance, and the mixture HFC 32/HFC 134a is a potential alternative refrigerant to HCFC 22 used in room air conditioners.

Adamson , M. Eng. Sc, IEAust, (1998), proposed that dimethylether as a single-component, and it drop-in replacement for R-12 in flooded systems. Also, they found that its saturation pressure/temperature relationship is very close to R-12, heat transfer properties are significantly better and energy costs are slightly lower. Compressor capacity is close to R-12 capacity at medium temperature but slightly lower than R-12 capacity at low temperature. It is non-toxic in normal usage, low cost, widely available and environmentally safe, although flammable.

Rogstam, (1998), showed that cyclopropane (RC 270) is more energy efficient than R-12 and R600a. Further, RC 270 is a natural working fluid, which a long with benign thermodynamic properties makes it an interesting refrigerant.

The stability tests showed that there is no any decomposition of cyclo propane, but they showed a slight growth of simple hydrocarbons, such as methane and ethane. These hydrocarbons were stable for long period of time.

Also, RC 270 and R 600a performances were tested in household freezers, and from these tests, it is seen that both RC270 and R600a increase the energy consumption compared to R12 by 1.5% for RC270, and by 10% for R600a. Also, from the experiments, it is seen that, RC270 seems to be satisfactory stable and the system performance is generally better than for both R12 and R600a.

Ismail, et. al., (1998), studied the behavior of a medium power vapor compression system operating in the heating and refrigeration modes with refrigerants R22 and R290. A computer code based on energy balances was developed to simulate the behavior of the system operation with the two fluids. They showed that the mass flow, the density, the refrigeration and heating capacity and the discharge temperature were higher for R22 than for R290, and the coefficient of performance remained the same for both R22 and R290, also, they showed that the mass of R22 in the system is 155% higher than R290.

Purkayastha, and Bansal. (1998), presented an experimental study on the performance of hydrocarbon refrigerants such as propane and liquefied petroleum gas (LPG) mix as suitable replacements for the widely used refrigerant HCFC 22 in refrigerant and heat pump applications. They said that the hydrocarbon refrigerants performed better than HCFC 22 but with a small less of condenser capacity. They concluded that LPG of the tested composition which is a mixture of propane, ethane, and iso-butane can be excellent refrigerant in heat pump or refrigeration applications.

Dongsoo Jung, et. al. (1999), examined the thermodynamic performance of supplementary/retrofit refrigerant mixtures for CFC used in existing automobile air-conditioners. They used a thermodynamic computer analysis of an automobile air-condition and they proposed some refrigerants mixture to be used as alternative to CFC 12 composed of HCFC 22, HFC 134a, HCFC 142b, RE170 (dimethylether) HC 290, and HC 600a. They resulted that HFC 134a/RE170 mixture with zero ozone depletion potential is the best long term candidate to replace CFC 12. Also, HCFC 22/HFC 134a/RE 170 and HCFC 22/HFC 134a/HCFC 142b mixtures are good only as short term supplementary/retrofit alternatives because they contain HCFC 22. Finally they showed us that a hydrocarbon mixture of HC 290/HC 600a has a good performance but its use in existing automobile air-conditioners should be carefully considered due to its flammability.

Kim and O'Neal, (1995),performed an experimental study to investigate the critical flow of refrigerants through short tube orifice by measuring the mass flow rates and pressure profiles a long the short tube orifice. They studied eight critical flow models and they compared them with experimental data for HCFC 22 and HFC 134a. These models included four homogeneous equilibrium models, two homogenous frozen models, and two non-homogenous equilibrium models. The flow was chocked when down stream pressures were lower than the saturation pressure corresponding to the upstream temperature. After the comparison between existing critical flow models and experimental data, they found that, the homogeneous frozen models showed the best agreement with the measured data except for exit qualities below 0.06.

Hambraeus, (1995), studied the effect of the new oils on the heat transfer in evaporators and condensers. He presented the results from an experimental investigation of the effect of three different ester-based oils on heat transfer of HFC 134a in a horizontal evaporator. The heat transfer coefficient decreased in most of the cases, this decrease depend on the viscosity of the oil. He found that the heat transfer increase can occur in special cases, these cases are when the flow rate of the refrigerant is low and the viscosity is low.

The researcher concluded that:

1- Oil can increase or decrease the heat transfer rate.

2- The increase of heat transfer rate is due to increased tube wetting which is an effect of the increased surface tension.

3- The decrease in heat transfer depend on the viscosity of the oil, where a high viscosity yields a great decrease than a low viscosity oil.

Bansal, et. al., (1991), studied the performance characteristics of HFC 134a in an industrial (water to water) heat pump test facility with a twin-screw compressor. They studied many parameters relating to heat pump performance such as volumetric efficiency, coefficient of performance and volumetric heating capacity for low to medium temperature (<70 C). Also, they studied the influence of degree of superheat on the miscibility of HFC 134a with ester oil and on the viscosity of the oil-refrigerant mixture for various discharge pressures.

From these studies they concluded that in spite of HFC 134a is environmentally safe and has good thermal properties but it has some disadvantages. From these disadvantages, if we want replace CFC 12 by HFC 134a in this heat pump, cleaning a heat pump system is cumbersome and it is expensive. Also, HFC 134a cannot offer the full operating range of CFC 12, particularly beyond 70 C.

They, also, showed some advantages of HFC 134a, from these advantages the following. The oil presented no problems regarding its viscosity, miscibility, chemical stability and its return to the compressor. They, also, concluded that the compressor used for other refrigerants (CFCs, HCFCs) still achieve good performance when HFC 134a is used. And so, from that, they concluded that HFC 134a is a good alternative for CFC 12 up to its limiting temperature of 67.5 C at 2MPa.

Luzzatto, et. al., (1994), presented the efforts carried out in Delchi Carrier, Villasanta plant on application of R134a and the mixture R32/R125/R134a of the composition 23%-25%-52% in weight as substituted of R22 on a portable room air conditioning system.

They pointed out that, by using R134a as a substitute for R22, some modifications should be performed on the systems. These modifications include, the compressor, lubricant oil, expansion device, and the filter. Also, they showed that by using the mixture R32/R125/R134a, no modifications needed.

Finally, they concluded that, by using R134a, the system needs a compressor with a displacement 50% bigger than the compressor for R22, and the cost of R 22 is higher than that of R134a, also, R134a system requires a drier filter, and so, these modifications will increase the cost of the complete system by 7%, but, for the system which uses the above mixture, there is an increase of the cost by 2% because the cost of this mixture is higher than that of R22.

Devotta, and Gopicand, (1992), presented the performance of R-134a as compared to R-22, R-152a, and R-134. The study included the pressure ratio, specific compressor displacement, theoritical Rankine coefficient of performance , shaft power per ton of refrigeration. They also, presented a discussion of the practical implifications of the choice of the alternatives to R-12. They concluded that the refrigeration effect is highest using R-22, while R-134a and R-152a would perform closer to R-12. They concluded that the designed components for R-12 do not require substantial modifications so as to be used with R-134a and R-152a, while some major modifications have to be incorporated when replacing R-22 by R-134a and R-152a.

Zoubi, (1998), examined a locally manufactured domestic refrigerator using R-134a as an alternative to R-12. He did not change or modify any design of the used refrigerator components. He concluded that R-134a gives a good performance as replacement to R-12 in domestic refrigerators. He obtained coefficients of performance up to 6.1. This was obtained at Te=5C, Tc=47C, and Ta=29C.

Eckels, and Pate, (1991), reported an experimental heat transfer coefficients for R-134a and R-12 during in-tube single phase flow, evaporation and condensation. They concluded that in single –phase flow, heat transfer coefficients for R-134a were 33 percent higher when compared to those of R-12 .For evaporation at similar mass fluxes, R-134a heat transfer coefficients were 35 to 45 percent higher than those of R-12. For condensation at similar mass fluxes, R-134a heat transfer coefficients were 25 to 35 percent higher than those of R-12.

Preisegger, and Henrici, (1992), summarized the requirements for a suitable replacement for R12. They described the criteria leading to the selection of R-134a, the developmental efforts that have been made and the results of this process. Also, they described chemical properties , material compatibility and thermodynamic properties of R134a. Because of different chemistry in comparison with CFC refrigerants, special requirements for suitable compressor lubricants and system cleanliness are mentioned. These requirements are tolerable residues of oily and fatty impurities in tubes, evaporators, condensers and compressors remaining from the manufacturing processes. The reason of this is to avoid problems that could occur if these impurities are dissolved in refrigerant or lubricant and distributed in the system.

Alnobani, (1997), studied the performance of the vapor compression cycles operate with new environmentally safe alternatives to refrigerant R-12 namely R-134a and R-152a. He found that, R-134a and R-152a are suitable and attractive alternatives to R-12. He, also, said that, from energy point of view, R-152a is the best and its COP is higher than that of both, but there are some resrictions in the application range of using it for very high condensing

(Tc>60℃) and very low evaporating temperatures(Te<-40℃). R-134a has a slightly lower COP compared to that of R-12 for moderate evaporating and condensing temperatures(Tc<40℃, and Te>-25). R-134a has higher COP than R-12, but at higher condensing and lower evaporating temperatures, the performance of R-134a deteriorates and its COP decreases.

Carpenter, (1991), presented a brief outline of ICI developmental work on the new range of ester oils suitable for use with alternative refrigerants. He described the simple procedure developed to enable the refrigeration industry to convert from R-12 to R-134a. Also, he described the flushing procedure and the determination of residual mineral-oil contents. He concluded that R-134a and ester lubricants can be retrofitted into many of the existing refrigeration and air-conditioning systems currently running on R-12.

Wei, et. al., (1991) presented vapor pressure curves for R-134a and three kinds of representative oil for different oil percentages, and for the temperature range from –20 to +40C.

AL-Tarawnah, (1996), studied the performance of A/C split unit by using mixtures of propane, butane and Iso butane. Also, he used a computer algorithm based on Aspen library to calculate the enthalpy values of the mixture.

He found that, increasing the propane ratio in the mixture will increase its Coefficient Of Performance to a value greater than that of R22.

This research will concentrate on the performance of a 2.5 tons A/C Split Unit working by R-134a refrigerant. Comparison with the performance of the unit when R-22 is used will also be addressed.

Chapter Three

COMPARATIVE STUDY

3.1 Introduction

Several important characteristics should be studied for any good refrigerating fluid. A good working fluid means many things, such as, suitable thermodynamic characteristics, Physical and chemical characteristics and its safety for the application under study. Also, there is no refrigerant which is suitable for all applications. This means that the type of the application determines the type of the refrigerant used.

Some characteristics that should be taken into consideration when a refrigerant is selected as a working fluid in an air conditioner or in a refrigerator or any other device that needs a refrigerant will be addressed.

3.2 Thermodynamic characteristics

3.2.1- Latent heat of vaporization

The refrigerant should have high latent heat of vaporization, because this means, high refrigerating effect per unit mass of the refrigerant which is a preferable characteristic of refrigerant. This gives low mass rate of flow and consequently low losses.

3.2.2- Evaporating pressure:

Positive evaporating pressure, above atmospheric pressure, to prevent air leakage from the outside atmosphere, must be maintained.

3.2.3- Condensing Pressure:

It should have a low condensing pressure refrigerant, because this means a low cost piping system is needed.

3.2.4- Freezing Temperature:

The refrigerant should have a low freezing temperature in order to prevent solidification during normal operating conditions.

3.2.5- Critical Temperature:

The refrigerant should have high critical temperature, because this means low work of compression.

3.3 Physical and chemical characteristics

3.3.1- Heat transfer characteristics

Good heat transfer characteristics should be found for good refrigerant.

3.3.2-Miscibility with oil

For the used refrigerant in a system, we should select a suitable oil which has good solubility with the refrigerant. Good solubility means, good heat transfer characteristics, and good return of oil to the compressor.

3.3.3- Water Solubility:

If a refrigerant or oil has good solubility in water, or water has good solubility in them, freezing of water in the expansion device may occur, or, acids will be produced which will make corrosion of piping system, and so, the refrigerant should have low water solubility.

3.4 safety :

3.4.1- Toxicity:

When we select a refrigerant, we should take into consideration, its toxicity that is, it is dangerous through food and drinks or not.

3.4.2- Flammability:

The good refrigerant, the non flammable one, that is, no burning occur when mixed with air.

3.5 Cost and Availability:

The selected refrigerant should not be expensive and it should be available.

3.6 Effect on the Environment:

The effect on the environment includes the effect on the ozone layer, also on the human atmosphere. The refrigerant should have a very low effect on the ozone layer (very low potential to the ozone layer) or zero ozone layer depletion (ODP).

3.7 Comparison between R22 and R134a:

3.7.1 Physical Properties:

1. Freezing Point:

For the refrigerants, low freezing point is required in order to prevent solidification in system. We can see from table (3.1) that R22 has lower freezing point than R134a, but the freezing point of R134a (-96.6) is enough low to be used in air conditioning applications, and so, R134a is suitable for air conditioning from this point.

Table (3.1) Thermodynamic Properties of Refrigerants (ASHRAE Handbook of Fundamentals, 1993)

Property(unit)	R22	R134a
Freezing Point(˚C)	-160	-96.6
Boiling Point at Atmospheric Pressure(˚ C)	-40.76	-26.16
Critical Temperature(˚ C)	96	101.1
Critical Pressure(kPa)	4974	4067
Critical Volume(L/kg)	1.904	1.81
Molecular Mass (kmol/kg)	86.48	102.03

2. Boiling Point:

In the air conditioning or any refrigerating system, we want a refrigerant of low boiling point, because high boiling point temperature means operating the compressor at high vacuums, which reduces the capacity of the system. Zoubi, (1998) We can see from table (3.1), that R134a has higher boiling point at atmospheric pressure than R22, but it is sufficiently low (-26.16).

3. Critical Temperature and Critical Pressure:

The condenser temperature must be kept under the critical temperature of the refrigerant, because no condensation can occur above the critical temperature regardless of the pressure applied. Zoubi, (1998).

From table (3.1) we can see that, both of two refrigerants R22 and R134a have close values of critical temperatures, and they are higher than the condensing temperature in the system. Also, the critical pressures of them are higher enough than the condensing pressure in the system.

4. Specific Heat:

Low specific heat of liquid and high specific heat of vapor are desired because, if the specific heat of the liquid is low, then this will increase the subcooling state of liquid, and if the specific heat of the vapor is high, this will decrease the superheating and so, all of that will increase the refrigerating effect. As shown from table (3.2), the specific heat of R134a is higher than that of R22 in two states liquid and vapor state.

Table (3.2) Physical Properties Of R22 and R134a (ASHRAE Handbook of Fundamentals, 1993)*

R22	Liquid	Vapor	R134a	Liquid	Vapor
Specific Heat(KJ/Kg.K)	1.202	0.792		1.367	0.93
Viscosity(μpa.s)	188.5	12.2		254.3	11.42

*At 10 °C

5.Viscosity:

As the viscosity of the refrigerant decreases, its heat transfer characteristics will improve, and low pumping power needed. We can see from table (3.2) that in the liquid state R134a has higher viscosity value than R22, and they have close values in the vapor state.

3.7.2Thermodynamic performance

1. Evaporating, condensing pressure and compression ratio:

Evaporating and condensing pressure means the pressure at which the liquid will evaporate in the evaporator, and the pressure at which the vapor will condense in the condenser, respectively. It is desirable to select the refrigerant of low compression ratio (condenser pressure/evaporator pressure) because this means low power consumption. Also, the pressure in the evaporator and in the condenser should be positive and above atmospheric pressure in order to prevent air leakage from the outside atmosphere, and this pressure also, should not be too high to prevent using pipe of high strength and high thickness and so high cost. Zoubi, (1998).

From table (3.3) we can see that, R134a has a compression ratio of higher than that of R22, and so, we can expect that using R134a will need higher power consumption than R22.

2. Coefficient of Performance:

Coefficient of performance **(COP)** expresses the useful work of the vapor compression cycle. It indicates the ratio between the refrigerating effect and the work of compression. If (COP) is high then we can say that the refrigerant performance used is suitable.

3. Net Refrigerating Effect:

Net refrigerating effect means the quantity of heat that each unit mass of refrigerant absorbs from the refrigerated space. Dossat (principles of refrigeration).

Table(3.3)Comparative Refrigerant performance per kilowatt(ASHRAE Handbook of Fundamentals, 1993)*

Property(unit)	R22	R134a
Evaporator Pressure (Mpa)	0.566	0.335
Condensing Pressure (Mpa)	1.39	0.933
Compression Ratio	2.46	2.78
Net Ref. Effect(kJ/kg)	160.57	152.5
Refrigerant Circulated(kg/s)	0.00623	0.00656
Volume of Suction Gas(m^3/kg)	0.0415	0.0223
Compressor Displacement(L/s)	0.258	0.146
Power (kW)	0.142	0.054
Suction Temperature (°C)	4.0	4.0

*** At Evaporating Temperature of (4°C) and Condensing Temperature Of 37°C.**

The refrigerating effect is an expression of the latent heat of vaporization of the refrigerant. To get a good performance or a good refrigerating effect, the latent heat of vaporization should be high, and consequently lower refrigerant quantity and smaller compressor, condenser and evaporator can be used. Zoubi (1998).

From table (3.3) we can see that R134a has a close value of refrigerating effect to that of R22.

4. Specific Volume of Suction Gas:

If the specific volume of the refrigerant is high, the mass circulated is low. And so, smaller compressor can be used. From table (3.3) we can see that R134a has lower specific volume than R22.

3.7.3 Chemical Properties:

1. Miscibility with oil:

The lubricant oil which is used with (HCFCs) is a mineral oil, but this oil can't be used with (HFCs) due to low solubility of it in HFCs. Synthetic oil is a suitable oil for HFCs, in this work polyol ester oil was used. This lubricant oil has some disadvantages, such as, its miscibility to the moisture is very high, and so, this moisture may close the narrow tubes such as capillary tube if it reached the point of freezing. But, in this work the capillary tube was canceled, and replaced by a manual control valve, and so, there is no problem from this point.

2. Reaction of Refrigerant with water:

Any refrigerant may react with water, but the reaction products may vary from refrigerant to another., and so, we should take this point into consideration. The presence of water in the system may cause a reaction with the refrigerant, and so, this reaction may produce acids which cause corrosion in the pipes, or refrigerant decomposition. Also, if the water present in the system was higher than the solubility of it in the refrigerant, ice will be formed which will close the narrow tubes, if they are present.

Finally, we should say that, the solubility of water in the selected refrigerant, should be as low as possible. Solubility of water in R22 is very low but the solubility of water in R134a at 25°C is 0.11% by weight. Zoubi(1998), Petra Engineering Industries Company(2000).

3.7.4 Safety

1. Toxicity:

Toxicity is an important property of any material that is used in day life, and so, this property should be studied. Any refrigerating system has parts, and these parts may leak, and so, this refrigerant may be breathed or touched by any body, and so, any refrigerant used should be low in toxicity.

R22 is considered a non toxic material, also, R134a is a non toxic for duration of exposure of about 8 to 12 hour .Zoubi(1998), Petra Engineering Industries Company(1998).

2. Flammability:

As mentioned above, any refrigerant system may leak, and some amount of the refrigerant may mix with air, and so, if there is a source of heat, this mixture must not be flammable to complete the requirements of safety of the used refrigerant. R22 and R134a are non-flammable, and so, their use is not dangerous from this side.

3. Thermal Decomposition

If refrigerants reached very high temperature, it may decompose and this decomposition may produce some toxic compounds which will be dangerous to us, but in air conditioning or in any refrigeration cycle, we don't reach this very high temperature(600° C).Zoubi(1998), Habash(1994), Petra Enginering Industries Company(2000).

3.7.5 Cost and Availability :

Cost is a very important parameter in refrigerant selection. R134a has a price of 7 JD/kg. This refrigerant needs a special type of lubricant oil (polyol ester oil) which costs (9JD/liter). But R22 has a price only 3.5 JD/kg, also, the lubricant oil has a lower price of 3 JD/liter.

Chapter Four

EXPERIMENTAL RIG AND EXPERIMENTAL WORK PROCEDURE

4.1 Introduction

The subject of this research is to study the performance of a split air conditioner unit by replacing HCFC 22 by HFC 134a. This A/C split unit was manufactured in Petra industries for manufacturing refrigerators and air conditioners.

The original compressor of this device was type (Copland). Due to restrictions on using other than R22 and R12 with this type of compressors, it was replaced by a Hitachi compressor, and a resizing on the coils dimensions was done, (AL-Tarawnah, 1998).

The specifications of the unit used are:

Trade mark: Petra

Manufactured by: Petra Ind. 1994.

Compressor type: Hitachi

Cond. Coil type :DX-12 FPI-3 row. Aluminum Finned Copper tube.

Evap. Coil type:DX-12 FPI-2 row. Aluminum Finned Copper tube.

Gross Capacity : 2.5 Tons.

4 Way Valve : Sporland

FD20 Flow Control: Aeroquip

Important modifications were performed. These modifications are:

- Suction Accumulator.
- Strainer, Hitachi.
- Filter Dryer, Sporland.
- High Pressure gage.
- Low Pressure gage.
- Sight glass on liquid line.
- Six charge and check points.

A very important modification was made. This modification replaced the expansion valve by a manual valve to control the evaporating temperature at any required setting.

For the purpose of this work, the lubricant oil which is used with R22 was removed and replaced by polyol ester oil (suniso) which is used with R134a and has special characteristics such as good miscibility with R134a.

4.2 A/C Split Unit Installation:

The A/C split unit consists of the following parts:

4.2.1 Compressor:

The compressor used here is of type Hitachi, which has the following characteristics:

-Compressor cooling: Forced Air.

- Capacity : 25400 BTU/Hr.
- Amps :15.1A.

Mechanism: Reciprocating connection Rod, 2cylinders.

Bore: 44.5mm.

Stroke: 17.5mm.

Displacement: 54.4cm^3/rev.

Oil Charge: 1600cm^3.

- The motor which leads the compressor has the following specifications:

Permanent split capacitor type, single phase 220-240V, 50Hz, and the max current is 58A.

4.2.2 Condenser:

Condenser is a device used to condense the vapor which is discharged from the compressor, this condensation occurs by forced air which is blown by an electric blower. The condensation process is performed by heat transfer from the vapor to the condensing medium that is here an air.

4.2.3 Evaporator:

It is a part of the split unit system that is placed in the air conditioned space. Its function is to remove the heat from the space in order to decrease the space temperature, and this temperature will evaporate the condensed vapor which comes from the condenser.

4.2.4 Suction Accumulator:

The liquid refrigerant is temporarily held in the suction accumulator and metered back to the compressor at a controlled rate through the metering orifice,(AL-Tarawnah, 1996).

Also, another function of the accumulator is to reduce the transmission of noise to the low side.

4.2.5 Filter drier and Strainer:

This part is very important because it collects moisture that is miscible in the working fluid. This moisture may close some liquid lines, if we reach a point of freezing water. Also, this water will react with working fluid, and so, acid will be formed which will destroy the tubes of the system.

4.3 Experimental Work Procedure:

4.3.1 Introduction

This work is divided into two divisions. The first part is performing the experiments on the air conditioner when the Refrigerant is an R-22, and the second part is when the refrigerant is an R134a.

In the two divisions of this work, experiments were conducted by varying the evaporating temperature at constant ambient and condensing temperatures. Then varying the condensing temperature and maintaining the evaporating and ambient temperatures constant .

4.3.2 Variables to be measured

The following variables were:

1- Temperature:

The temperature was measured by thermocouples of type 'T' that were connected to a Micro processor of type (Comark).

The thermocouples were fixed in certain places in the system, by a tape, then by (rocky wool) and then another piece of tape to ensure good insulation of the thermocouples from the outside conditions other than system conditions.

They were placed in these places in order to measure the following temperatures:

1- Suction and discharge of the compressor.

2- Inlet and outlet of the condenser.

3- Inlet and Outlet of the evaporator.

4- The ambient temperature.

5- The temperature of the cooled air by the evaporator.

6- Surfaces of the condenser and evaporator.

2- Pressure:

Two pressure gauges were used, one on the suction line of the compressor, which is a low pressure gage and the other on the discharge line which is a high pressure gauge. The low pressure gauge range is from -30 to 250 psi, and the high pressure gauge is from 0 to 500 psi. Also, in the evacuation and discharging process a pressure gauge manifold was used.

3- Electric Power Consumption:

The electric power consumed by the compressor and the evaporator fan and the condenser fan were measured by a single phase watt-hour meter. The power consumed by the compressor can be calculated by subtracting the power consumed by two fans from the total power consumption. The power consumed by two fans can be measured, because in the first only, two fans will operate, and so, we can find their power consumption from the single-phase watt- hour meter. The power consumption was measured with time and so we can find the actual electric power consumption of the compressor in a unit time.

For the purpose of having acceptable results, the system should be evacuated and then charged with the gases under study. Before that, the mineral oil which is suitable for R22 should be replaced by polyol ester oil which is suitable for R134a.

4.3.3 The Experimental Steps

The Experimental Procedure consists of:

A- Evacuation Process:

The purpose of the evacuation of the system, is to ensure removing the air from the system, and to ensure also, removing the moisture and the R22 refrigerant, in order to charge the system with pure R134a.

The evacuation process can be performed as the following:

Connect the hose of the gauge manifold between the vacuum pump and the suction line of the compressor, then start the vacuum pump, continue the evacuation unit the desired pressure, under the atmospheric pressure, is obtained.

After that, the charging process will be performed, but, what is the amount of R134a charge which is the optimum ?

Three methods can be used to find the optimum charge of R134a:

1- Using a Sight Glass:

During the charging process, if we see through a sight glass a clean stream of liquid refrigerant visible, this will indicate a suitable charge of R 134a. But, if bubbles have been found, this will indicate a shortage of refrigerant, but these bubbles may be seen from the sight glass even when the system if fully charged, because these bubbles may be formed when there is a restriction in the system before the sight glass.

2- The formation of dew on the inlet of the evaporator:

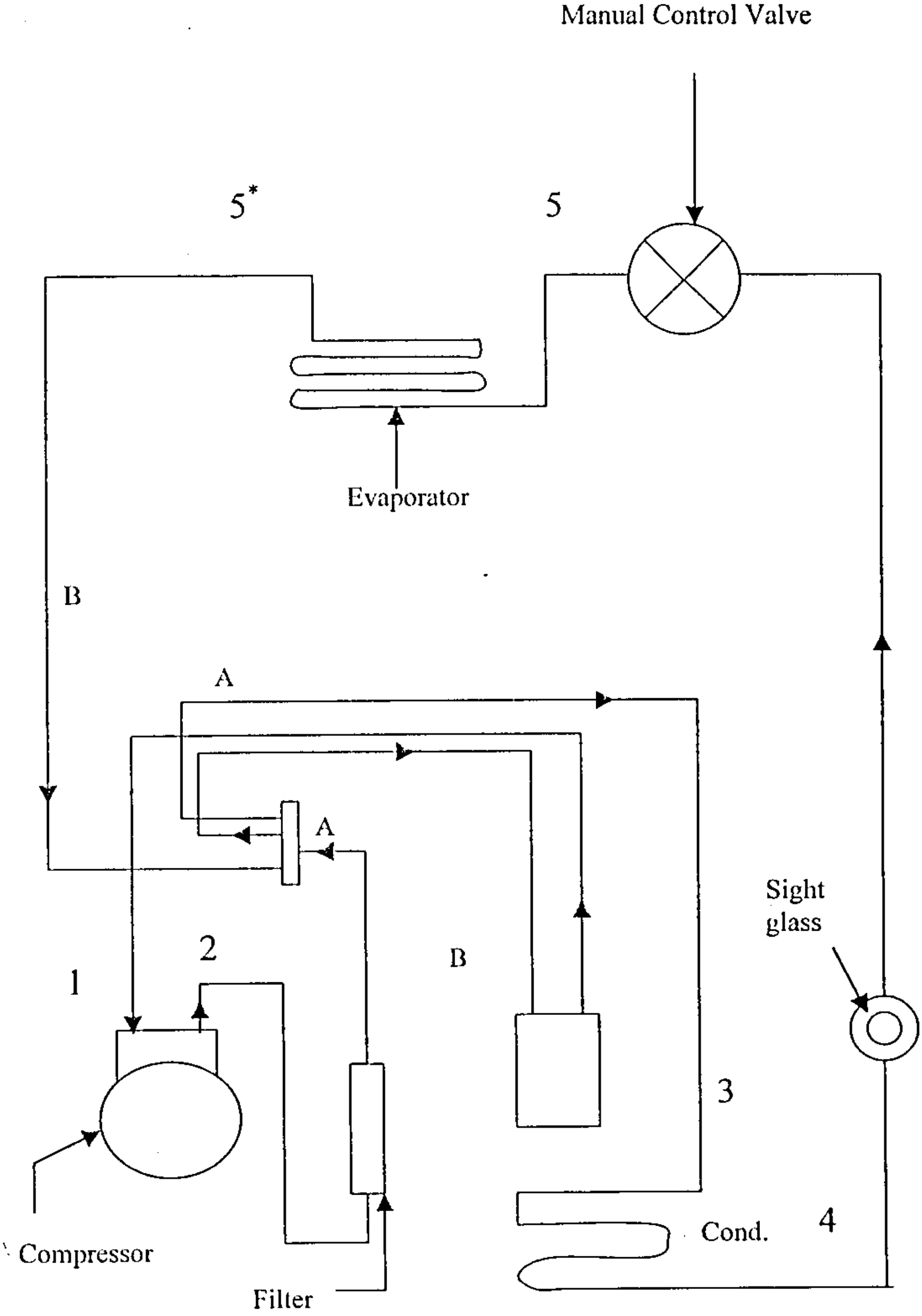
This will indicate a good performance of the system and so, this is the possible charge for optimum performance.

3- Charging the system with several charges

The system was charged with several charges : 1300g, 1500g, 1800g, and 2000g, and then it is possible to plot the coefficient of performance for every charge at a given evaporating, condensing and ambient temperature, and from this figure we can find the best charge which is corresponding to the highest coefficient of performance, which is in the experiment was (1500g).

B- Charging Process:

After determining the proper charge of optimum coefficient of performance, the system was charged with (1500g) of R 134a and the experiments were performed by evaporating temperatures (Te)variation tests and condensing temperatures(Tc) variation tests.



Figure(4.1) Schematic diagram of A/C Split Unit

Chapter Five

MATHEMATICAL ANALYSIS

5.1 Introduction

In this work, the Te variation tests and Tc variation tests on R22 and on R134a were performed. Refrigerating effect, compression work, COP, mass flow rate, electric power consumption, condenser duty, volumetric efficiency, and isentropic efficiency were evaluated for two refrigerants, and a comparison between both refrigerants were carried out.

Methods of calculating the above parameters, and the mathematical equations to find some values under study, are introduced here.

5.2 Parameters Under Study

5.2.1- Refrigerating Effect :

As mentioned before, the refrigerating effect(q_{ref}) is the quantity of heat each unit mass of refrigerant absorbs from the refrigerated space.

$$q_{ref}=h^*{}_5-h_4=h_5^*-h_5 \quad \text{..} (5.1)$$

Where:

h_5^*: is the enthalpy of the saturated vapor at the exit of the evaporator .

h_5 : is the enthalpy of the two phase liquid vapor mixture which enters the evaporator.

h_4 : is the enthalpy of the liquid which is at the exit of the condenser.

5.2.2 Mass Flow Rate:

The total power consumed by two fans and compressor was measured by a single phase watt meter-hour, the power consumed by the two blowers when they are driven in the first for 3 minutes before the compressor operation, also, was measured.

Assume that, the total power consumption is P_1, and the power consumed by the blowers is P_2, then, the net power consumed by the compressor is (P) , and so :

$$P=P_1-P_2 \quad \ldots\ldots(5.2)$$

$$P=\frac{\dot{m}}{\eta_{is}}(h_2-h_1) \quad \ldots\ldots(5.3)$$

$$\eta_{is}=(h_{2s}-h_1)/(h_2-h_1) \quad \ldots\ldots(5.4)$$

Where:

h_2: enthalpy of the super heated vapor at the exit of compressor.

h_1: enthalpy of the super heated vapor at the inlet of the compressor.

η_{is}: isentropic efficiency, where

h_{2s}: enthalpy of the super heated vapor at the exit of compressor if the compression process is isentropic..

and so from eq. (5.3) we can find that

$$\dot{m} = (\eta_{is} * P)/(h_2 - h_1) \quad \text{.....(5.5)}$$

5.2.3- Refrigeration Capacity:

Refrigerating capacity is the rate of heat removed in (W) from the refrigerated space. It is given by:

$$Q_{ref} = \dot{m} * q_{ref} \quad \text{.....(5.6)}$$

Where:

Q_{ref} : refrigeration capacity in kW.

$\dot{m}$: refrigerant mass flow rate in kg/s.

q_{ref} : refrigerating effect in kJ/kg.

5.2.4 Compression Work:

It is the work consumed by the compressor in (kJ/kg) to compress one kilogram of the vapor from the inlet to the outlet, and it is given by:

$$q_w = h_2 - h_1 \quad \text{..... (5.7)}$$

5.2.5 Condenser Duty:

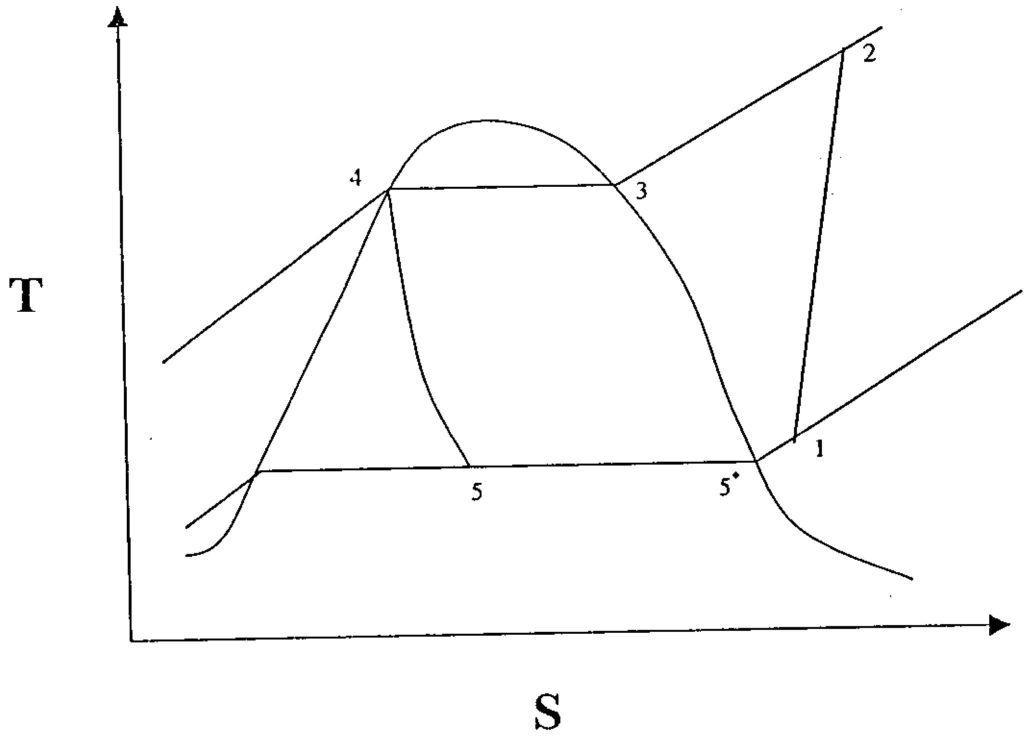
It is an expression of the rate of heat rejection in the condenser to the condensing medium. It can be expressed as the following:

$q_c=\dot{m}(h_2-h_4)$ ....(5.8)

5.2.6 Coefficient of Performance:

It is an expression of the efficiency of the system, and it can be given by:

$COP = (h_1-h_5)/(h_2-h_1)=(h_1-h_4)/(h_2-h_1)$ .... (5.9)



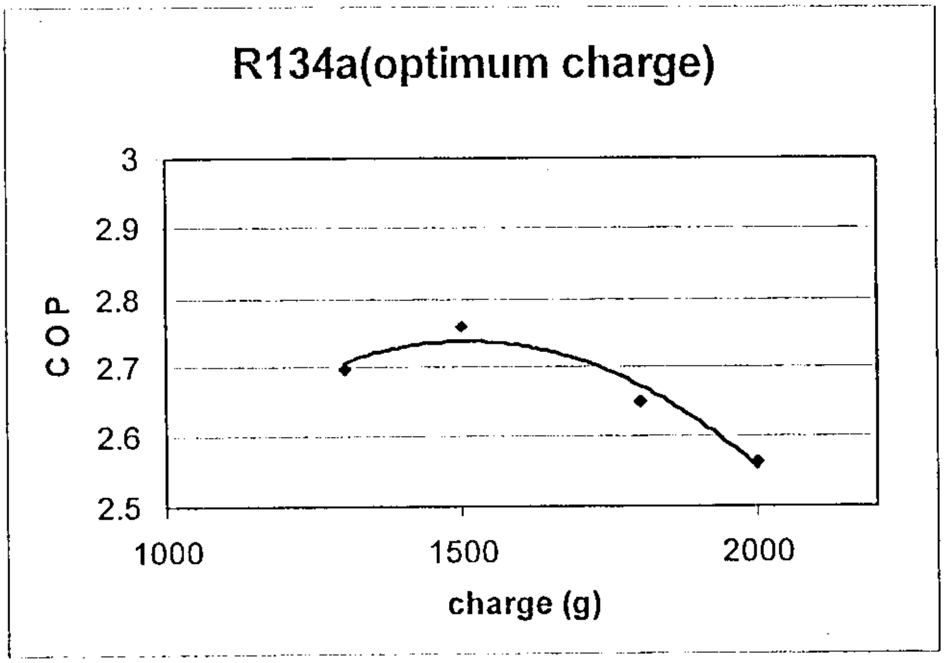
Figure(5.1) T-S diagram

Chapter Six

RESULTS AND DISCUSSION

6.1 Introduction

Te variation tests and Tc variation tests for R-22 were first carried out. Experiments on R134a were then carried out. Firstly, the optimum charge of R134a that gives the best coefficient of performance was found, the A/c split unit was charged with different charges starting from 1300g, then 1500g, 1800g, and finally 2000g. The optimum charge will found was about 1500g, as shown in figure(6.1). Then, Te variation tests and Tc variation tests were carried out on R-134a.



Figure(6.1) Optimum Charge Of R134a

6.2 Steps of Work

This section is divided into two parts:

I- Te and Tc variation tests for R-22 and for R134a individually.

II- R134a Te and Tc variation tests compared to that of R22.

6.2.1 Te Variation Tests for R22 and for R-134a:

This part was performed at condensing temperature of (43 °C), and ambient temperature of (22 °C) and at various evaporating temperatures which were (5,6,8,11,12) °C.

The effect of the evaporating temperature on several parameters is discussed as follows:-

1. Refrigerating Effect:

From Figures (6.2)and (6.16), it can be seen that refrigerating effect increases by increasing the evaporating temperature at constant condensing temperature. The greater refrigerating effect per unit mass of refrigerant circulated obtained at the higher vaporizing temperature is accounted for by the fact that, there is a small temperature differential between the vaporizing temperature and the temperature of the liquid approaching the refrigerant control, and so, at the higher evaporating temperature, a smaller fraction of the refrigerant vaporized in the control and a greater portion vaporized in the evaporator and produced useful cooling, (Dossat ,1991).

2. Compression Work :

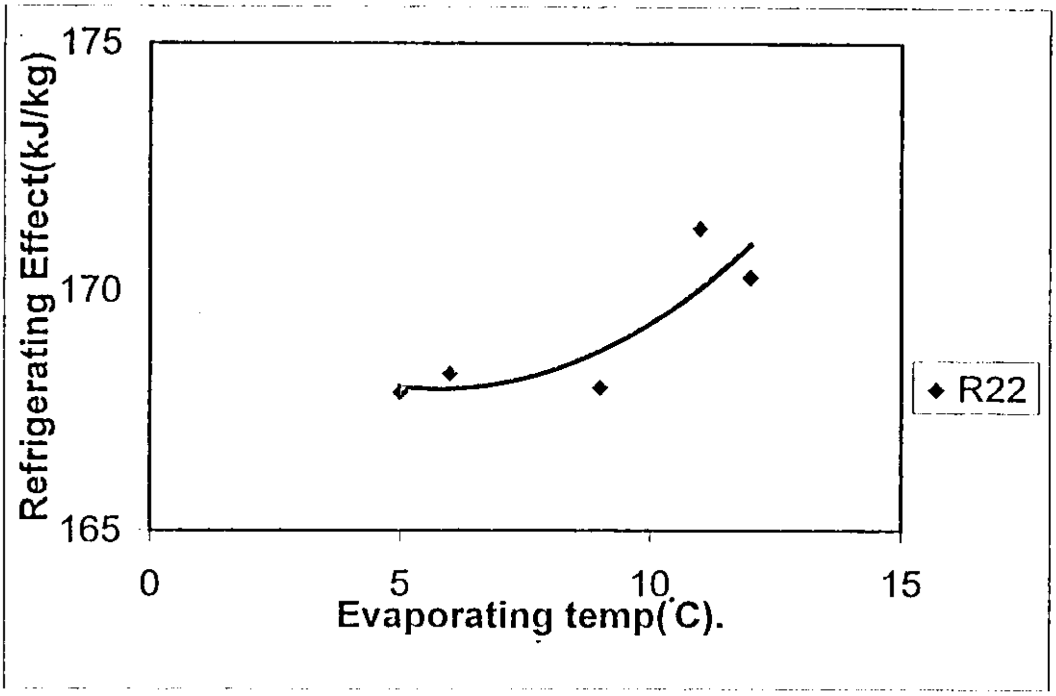
From Figures (6.3) and (6.17), one can see that increasing the evaporating temperature, will decrease the work of compression, this is due to equation (5.7), which shows that the work of compression will decrease if the enthalpy of the suction vapor increase, and this can be achieved by increasing the temperature of the suction vapor, i.e., increasing the evaporating temperature.

3. Coefficient of Performance:

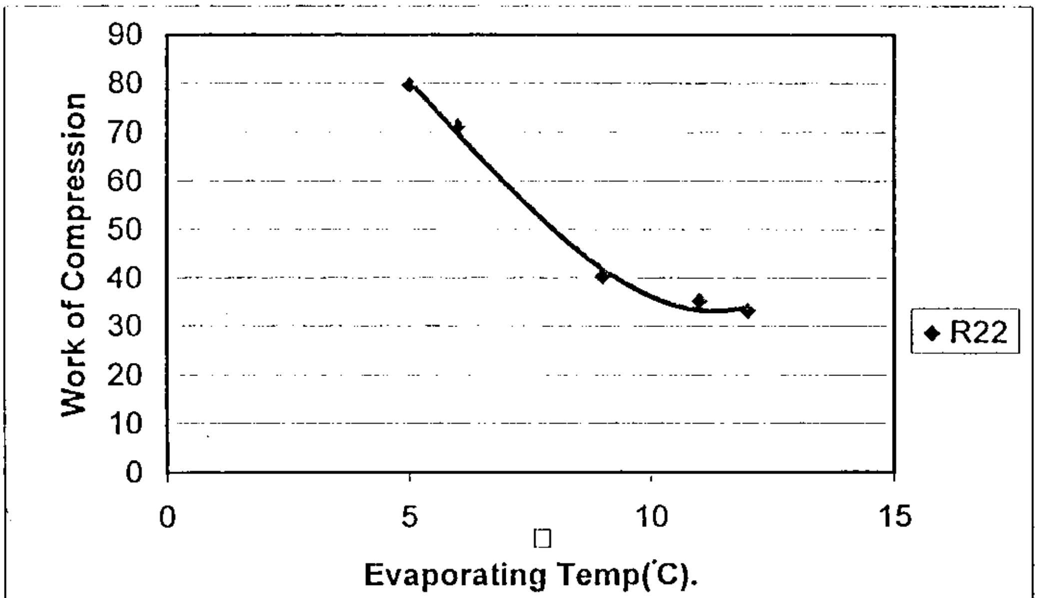
It is known that the coefficient of performance can be expressed by:

COP =refrigerating effect / work of compression ....(6.1)

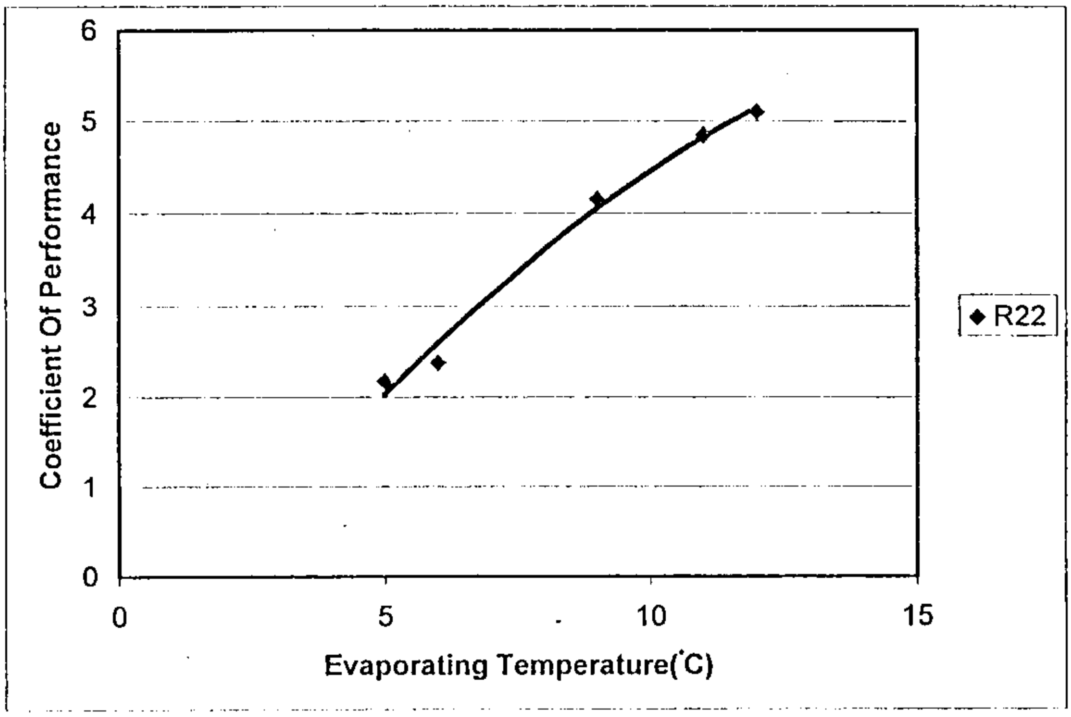
and so, one can say that increasing the refrigerating effect and/or decreasing the work of compression with increasing evaporating temperature will increase the coefficient of performance with increasing the evaporating temperature. This can be shown in Figures (6.4) and (6.18).



Figure(6.2) Refrigerating Effect Vs. Evaporating Temp



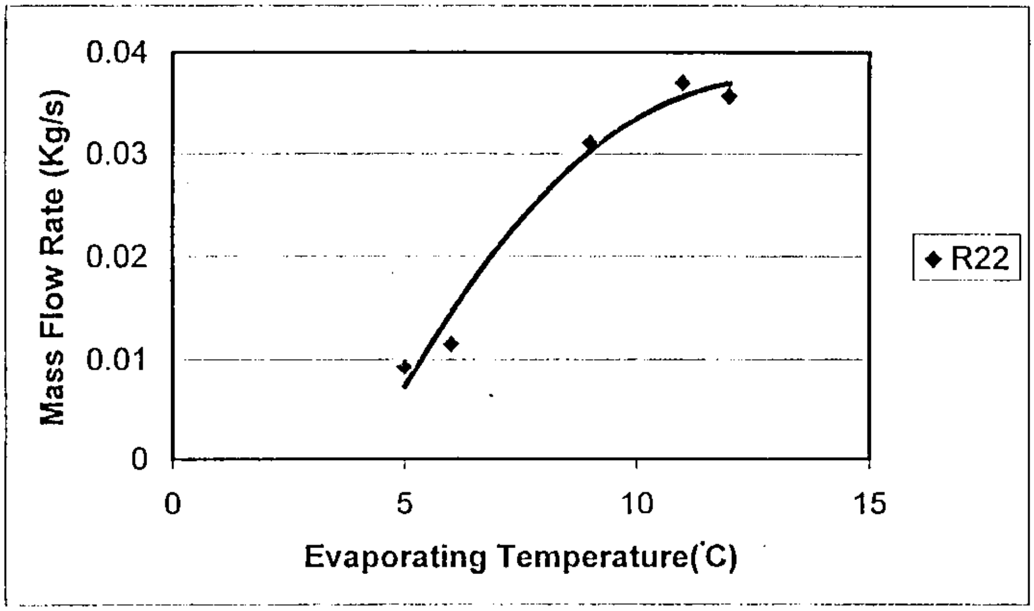
Figure(6.3) Work of Compression Vs. Te



Figure(6.4) Coefficient of Performance Vs. Te

4. Mass Flow Rate:

It is obvious from Figures (6.5) and (6.19) that increasing the evaporating temperature will increase the mass flow rate of the refrigerant. This is because , increasing the evaporating temperature will increase the temperature and the pressure of the suction vapor of the compressor, and this will decrease the specific volume of the suction vapors, and so, the compressor capacity of the refrigerant will increase, and so, this will increase the mass flow rate of the refrigerant.

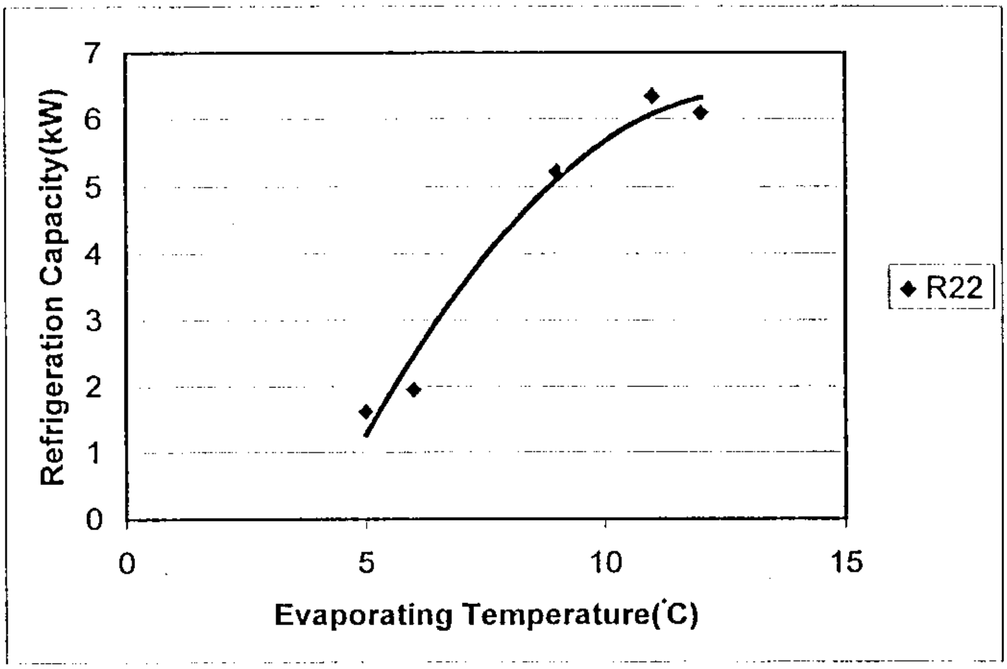


Figure(6.5) Mass Flow Rate Vs. Te

5. Refrigeration Capacity:

From Figures (6.6) and (6.20) we see that, increasing the evaporating temperature will increase the refrigeration capacity. This can be justified as the following:

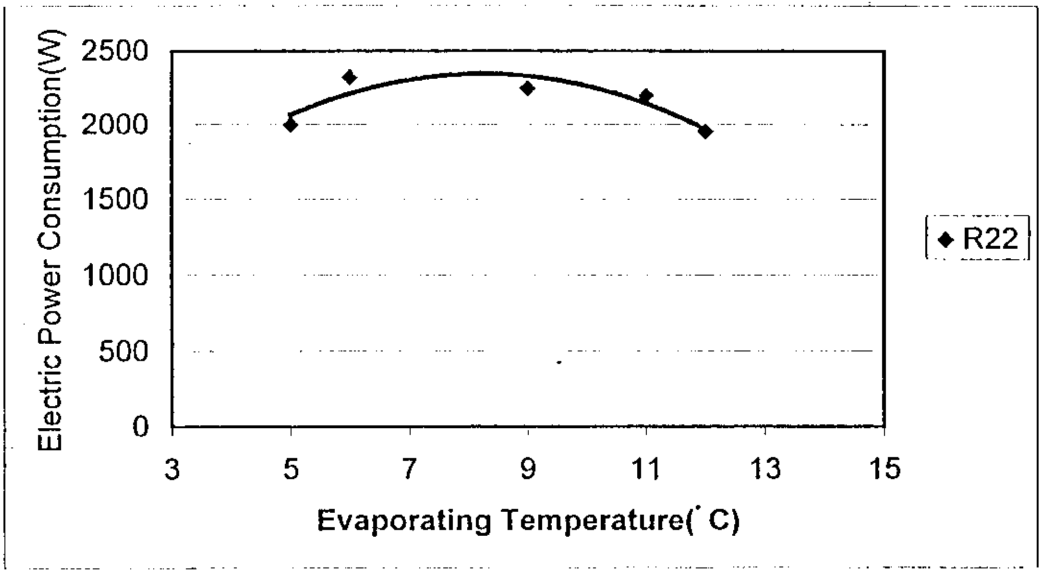
We can conclude from figure (6.5) and figure (6.2) that, increasing the evaporating temperature will increase the refrigerant mass flow rate and the refrigerating effect, respectively, and so, from that and from equation(5.6), one can find that increasing the evaporating temperature will increase the refrigeration capacity.



Figure(6.6) Refrigeration Capacity Vs. Te

6. Electric Power Consumption:

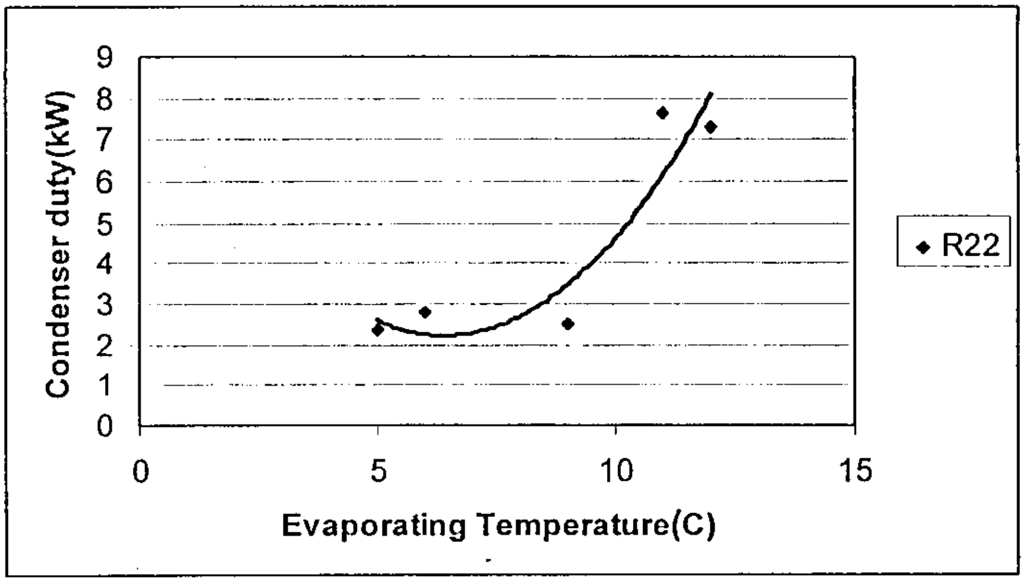
As shown in Figures (6.7) and (6.21), increasing the evaporating temperature will increase the electric power consumption to a peak value, then it will decrease by increasing the evaporating temperature, this can be justified by equation (5.3), and if we know that, by increasing the evaporating temperature the mass flow rate will increase and the work of compression will decrease, but the rate of increasing the mass flow rate is higher than that of decreasing the work of compression, and so, this will increase the power consumption by increasing the evaporating temperature. Then, the electric power consumption will decrease for higher evaporating temperature, because the rate of decreasing the work of compression will become higher than that of increasing the mass flow rate.



Figure(6.7) Electric Power Consumption Vs. Te

7. Condenser duty :

As shown in Figures (6.8) and(6.22), the condenser duty increases by increasing the evaporating temperature. It can be shown from equation (5.8) that increasing the mass flow rate which increases by increasing evaporating temperature, will increase the condenser duty.



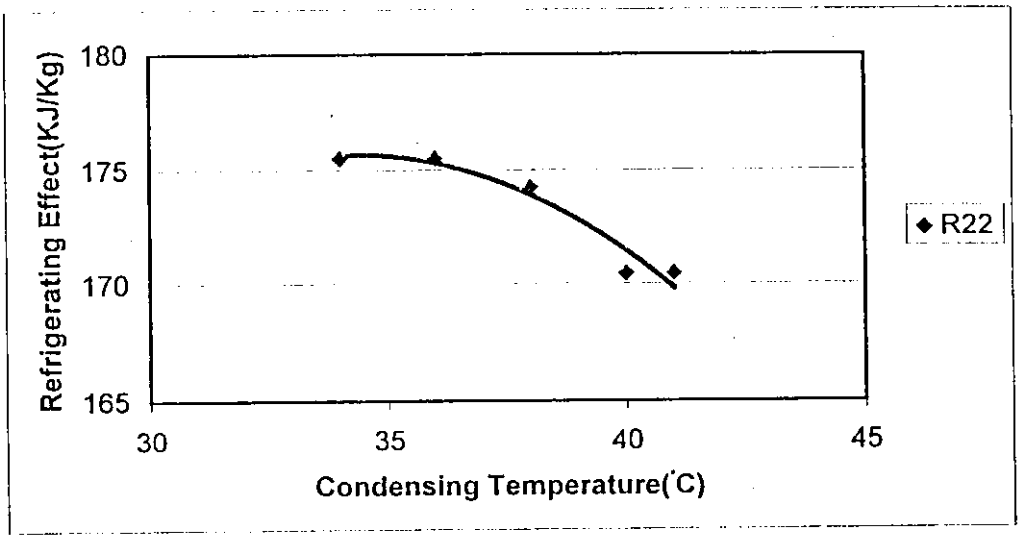
Figure(6.8)Condenser Duty Vs. Evaporating Temp.(˚C)

6.2.2 Tc Variation Tests for R-22 and for R-134a:

This part was performed at evaporating temperature of 5°C, and ambient temperature of 22°C, and at various condensing temperatures which were (34,36,38,40,41)°C.

1. Refrigerating Effect:

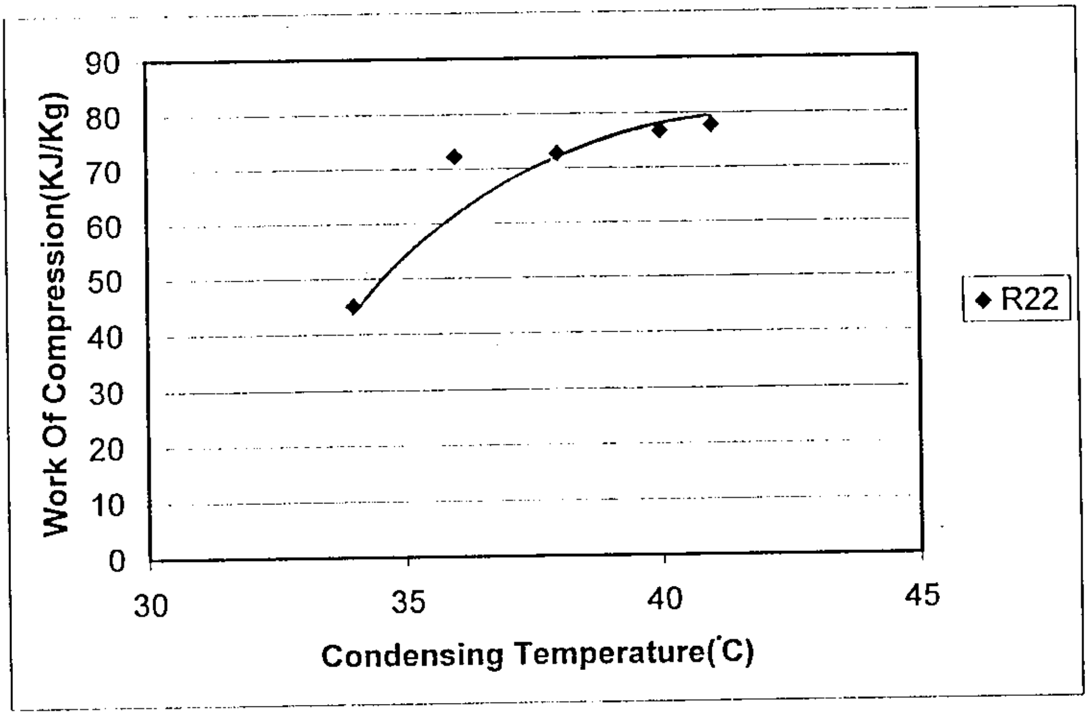
Figures (6.9) shows that, by increasing the condensing temperature, the refrigerating effect will decrease. From equation (5.1) and in Tc variation tests, maintaining the evaporating temperature at constant value, keeps h_5^* constant, but the condensing temperature will vary, and so, increasing the condensing temperature will increase the enthalpy (h4), so the refrigerating effect will decrease.



Figure(6.9) Refrigerating Effect Vs. Condensing Temp.

2. Compression Work:

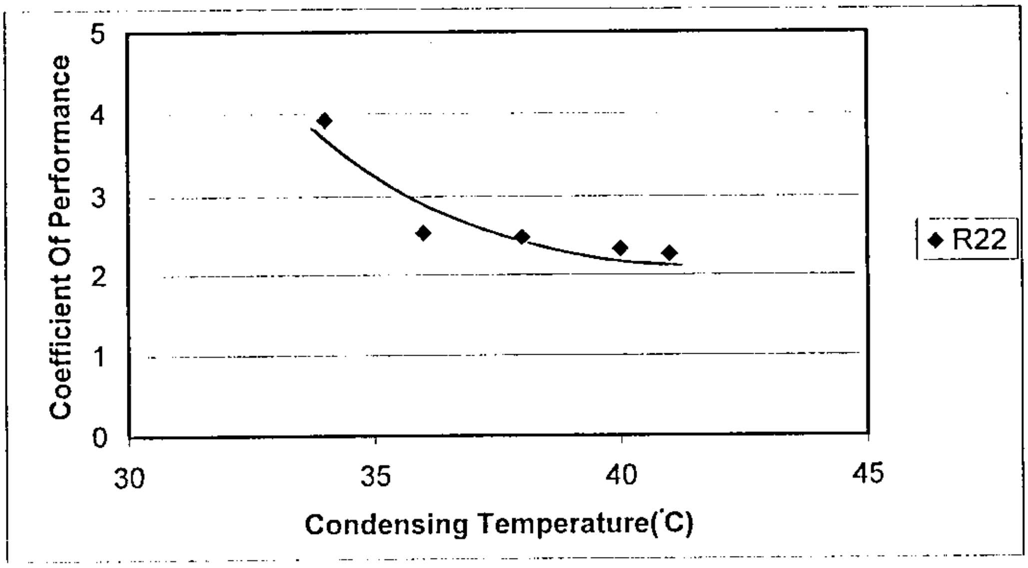
As shown in Figures (6.10) and (6.23), increasing the condensing temperature will increase the work of compression. From equation (5.7), if (h2) increases, which is the enthalpy of the discharge vapor, the work of compression will increase at constant evaporating temperature.



Figure(6.10) Work Of Compression Vs. Condensing Temp.

3. Coefficient of Performance:

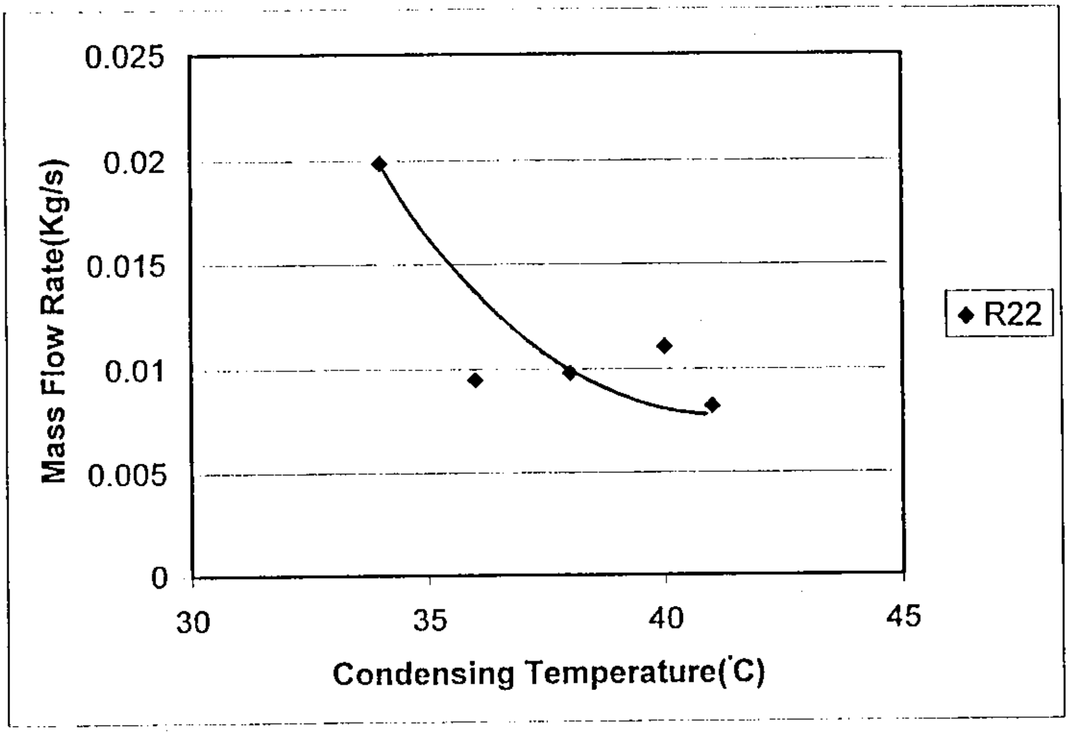
Equation (6.1) can give the definition of the coefficient of performance. And so, decreasing the refrigerating effect by increasing the condensing temperature, and increasing the work of compression by increasing the condensing temperature, all of that will decrease the coefficient of performance by increasing the condensing temperature, as shown in Figures (6.11) and (6.24).



Figure(6.11) Coefficient of Performance Vs. Cond. Temp.

4. Mass Flow Rate:

It is shown from Figure (6.12) that, increasing the condensing temperature will decrease the mass flow rate of the refrigerant.

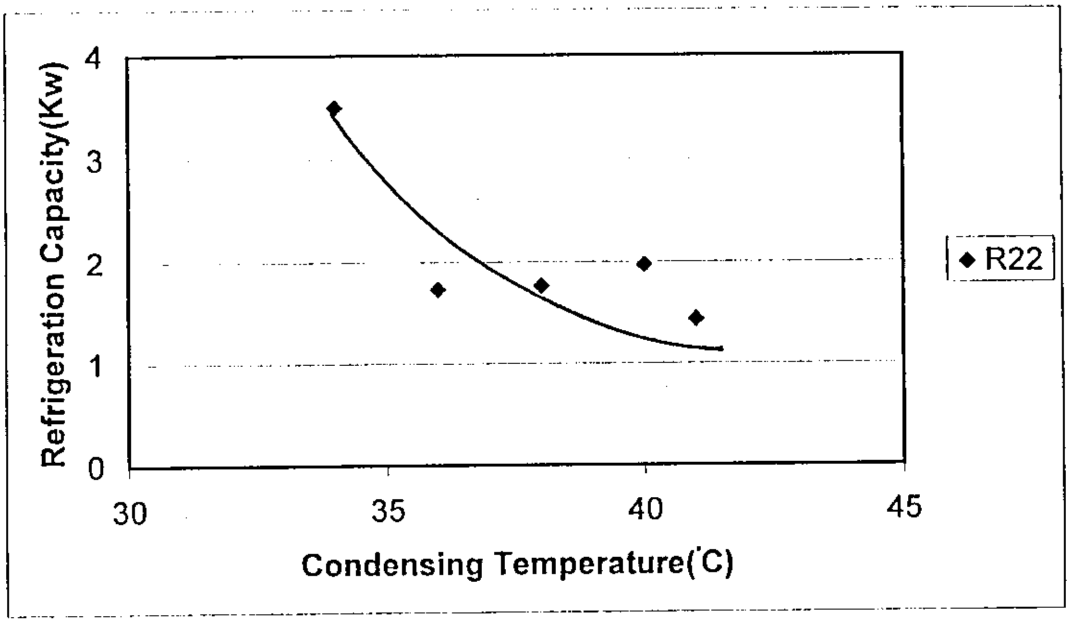


Figure(6.12)Mass Flow Rate Vs. Condensing Temperature

5. Refrigeration Capacity:

It can be noticed from figure (6.13) that, increasing the condensing temperature will decrease the refrigeration Capacity.

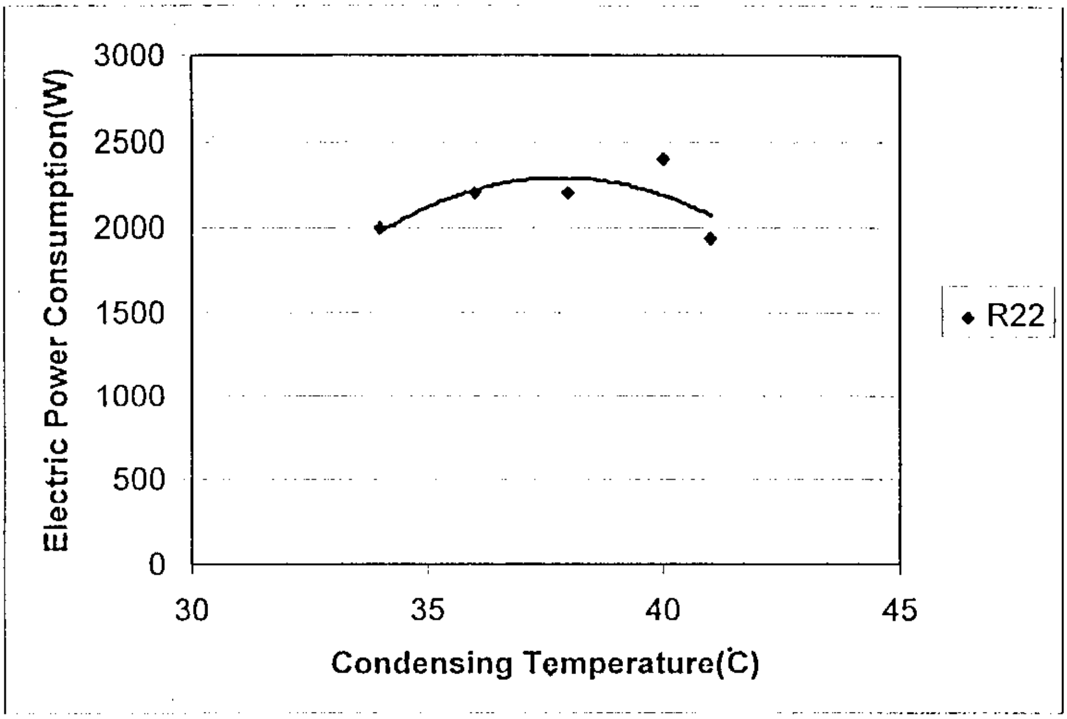
From figure (6.9) and figure (6.12), both the refrigerating effect (qe) and the mass flow rate ($\dot{m}$) will decrease by increasing the condensing temperature. So, from the equation(5.6) one can guess why the refrigeration capacity (Qe) decreases by increasing the condensing temperature.



Figure(6.13) Refrigeration Capacity Vs. Condensing Temp.

6. Electric Power Consumption:

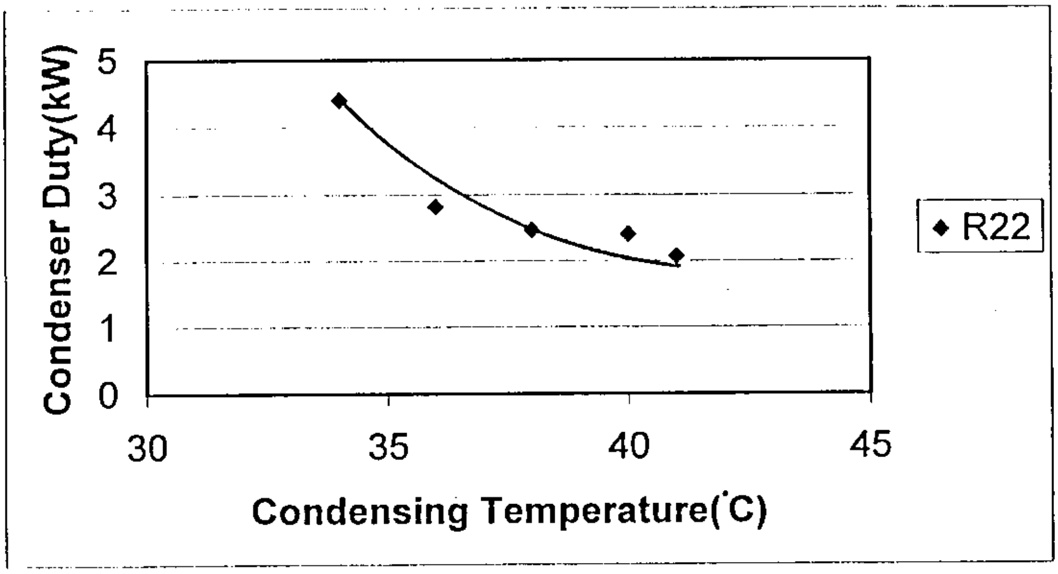
It is seen from figure (6.14) that increasing the condensing temperature will increase the power consumption. This can be justified by using equation(5.3) and figure (6.12). As shown from this figure, increasing the condensing temperature will decrease the mass flow rate, and from figure (6.11), increasing the condensing temperature will increase the work of compression, also, one can see from the two figures that the rate of increasing the mass flow rate is higher than that of work of compression, and so, the electric power consumption will increase to a peak value of (2400 W) and then decreases by increasing the condensing temperature.



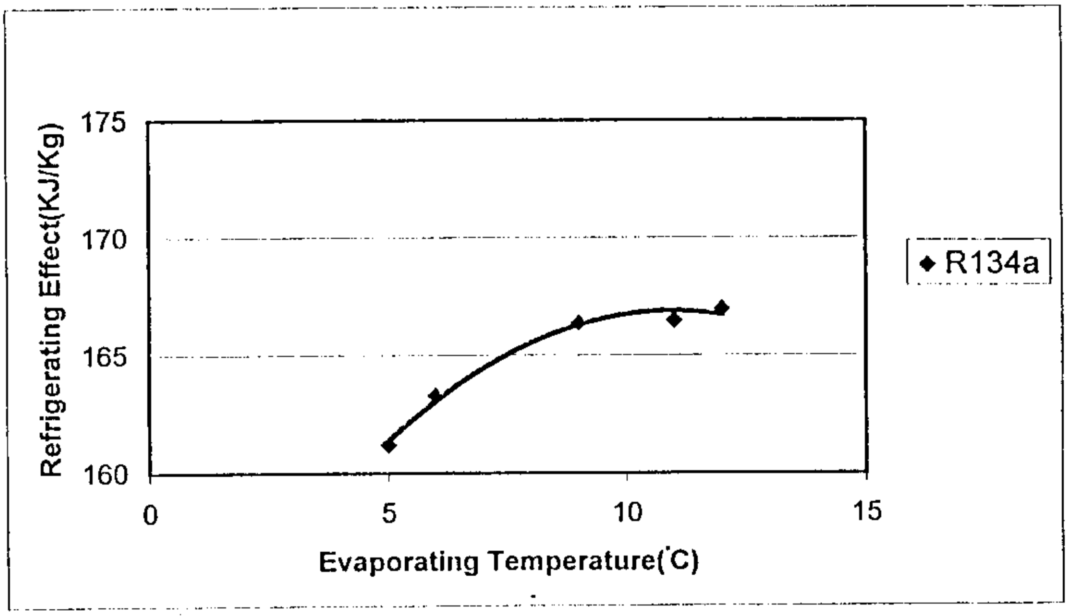
Figure(6.14) Electric Power Consumption Vs. Cond. Temp.

7. Condenser Duty :

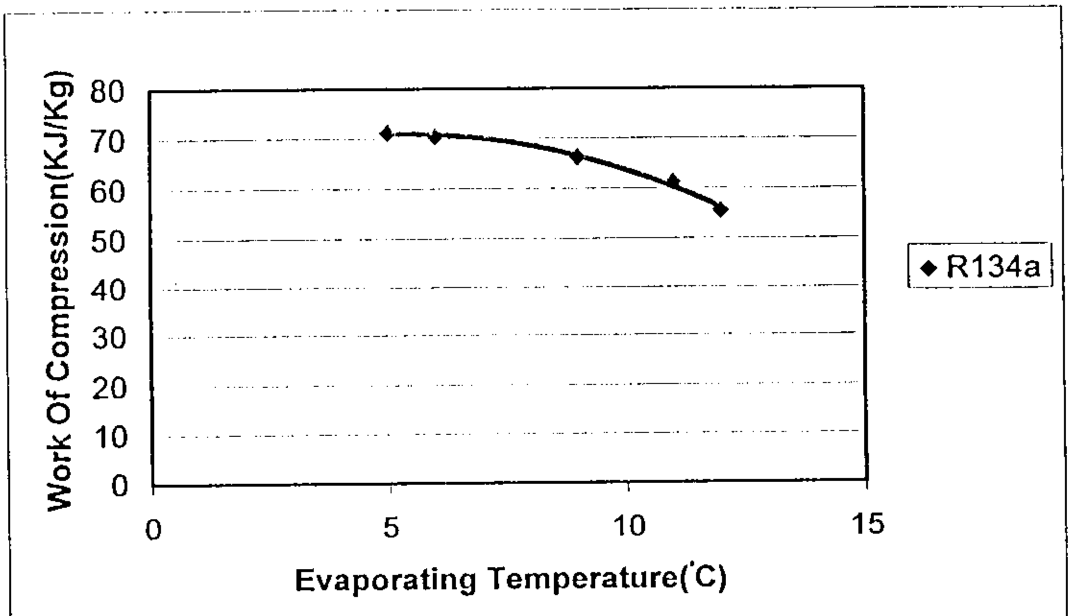
As shown from figure (6.15) the condenser duty decreases by increasing the condensing temperature, because it is known that the mass flow rate decreases by increasing the condensing temperature. From equation (5.8), Decreasing the mass flow rate by increasing the condensing temperature will decrease the condenser duty with condensing temperature.



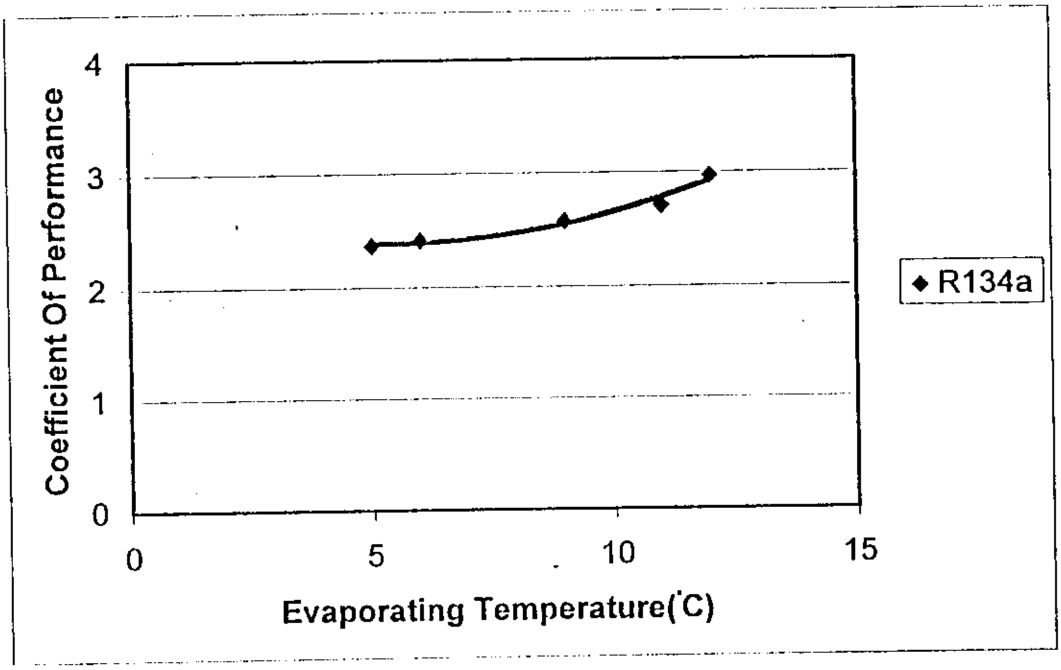
Figure(6. 15) Condenser Duty Vs. Cond. Temp.



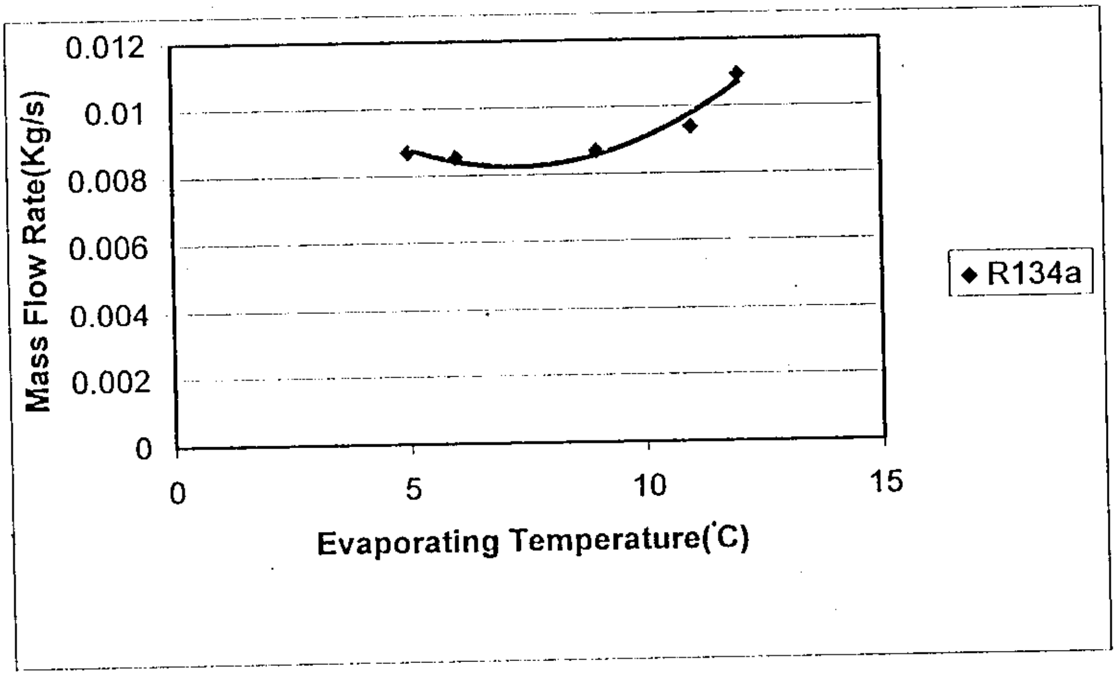
Figure(6.16) Refrigerating Effect Vs. Evaporating Temp.



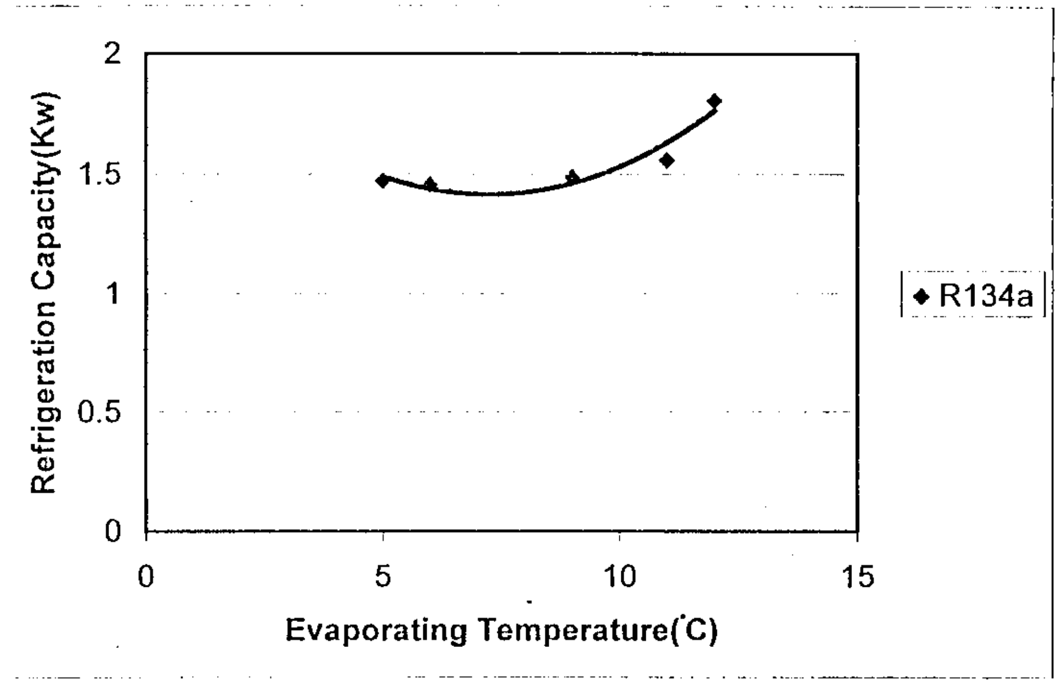
Figure(6.17) Work Of Compression Vs. Evaporating Temp.



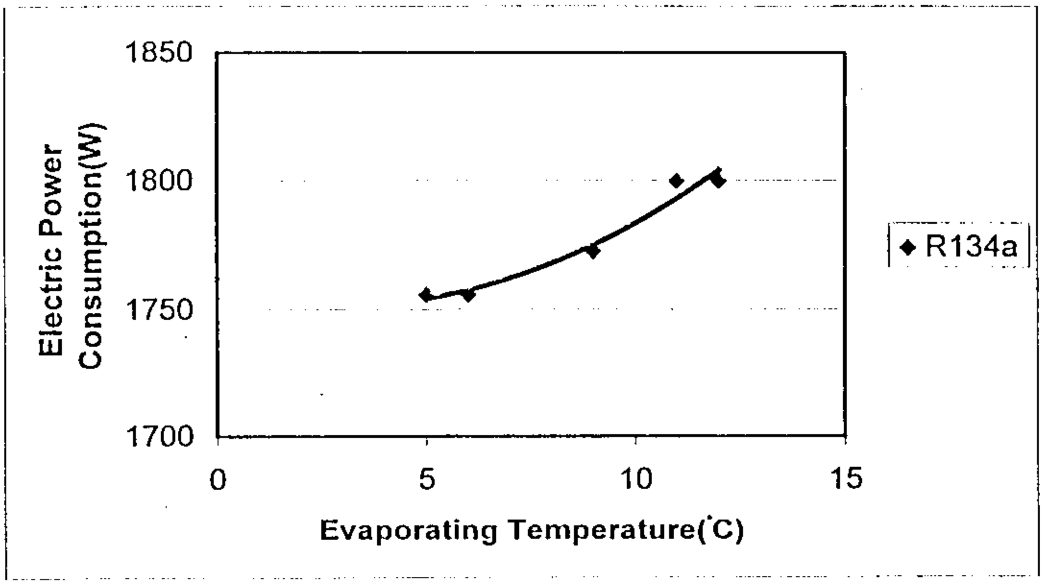
Figure(6.18) Coefficient Of Performance Vs. Evaporating Temp.



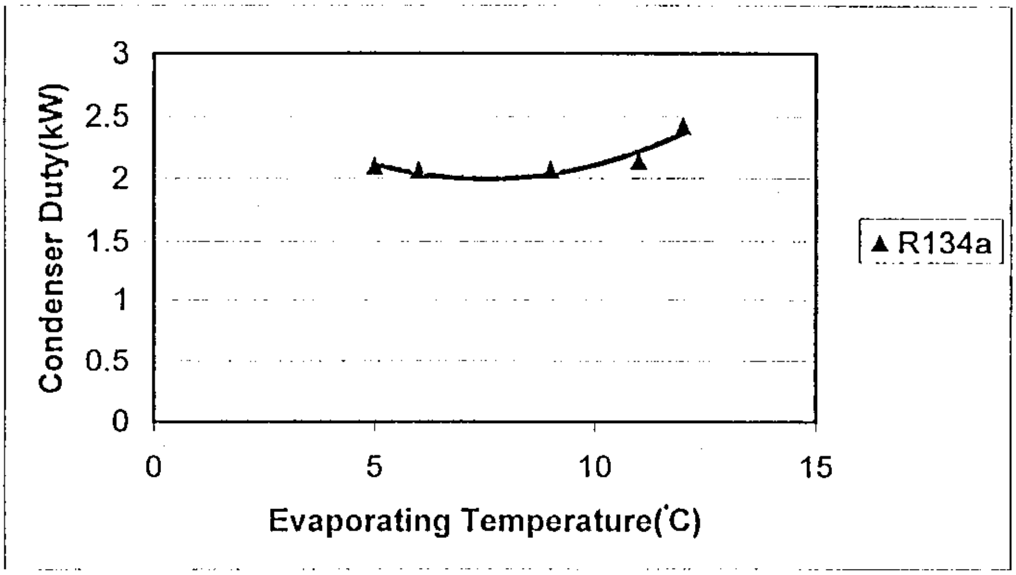
Figure(6.19) Mass Flow Rate Vs. Evaporating Temp.



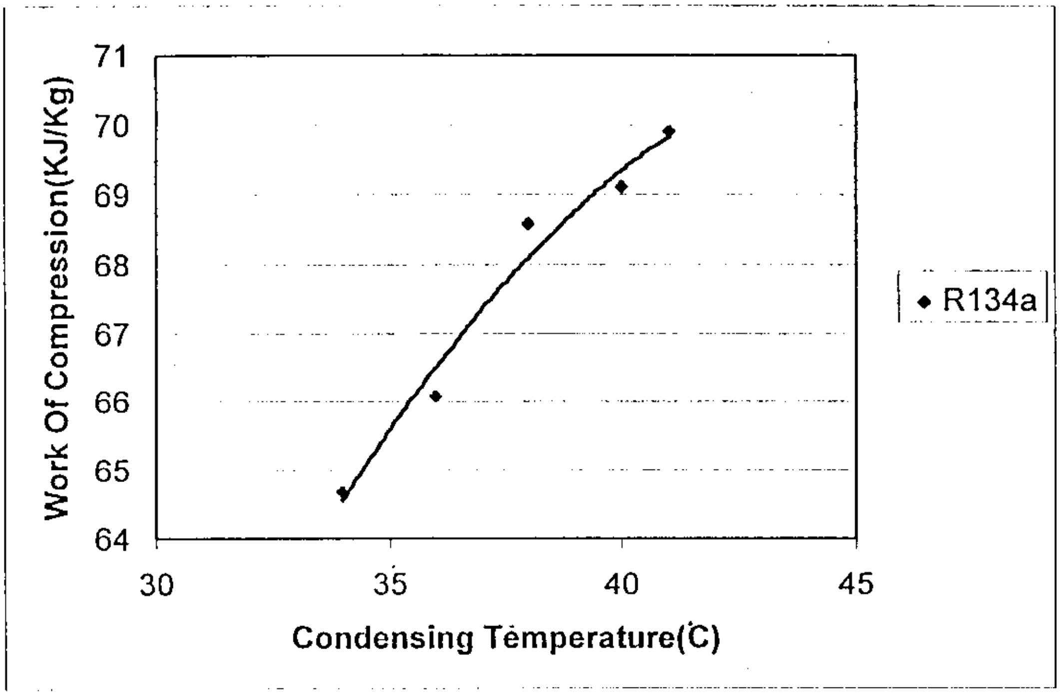
Figure(6.20) Refrigeration Capacity Vs. Evaporating Temp.



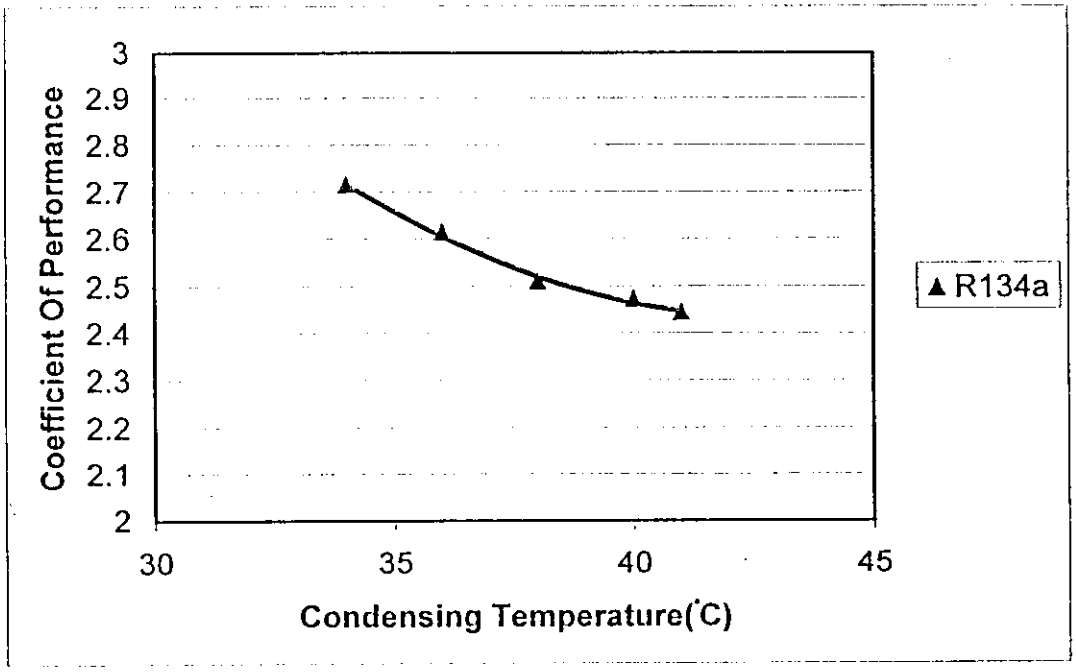
Figure(6.21)Electric Power Consumption Vs. Evap. Temp.



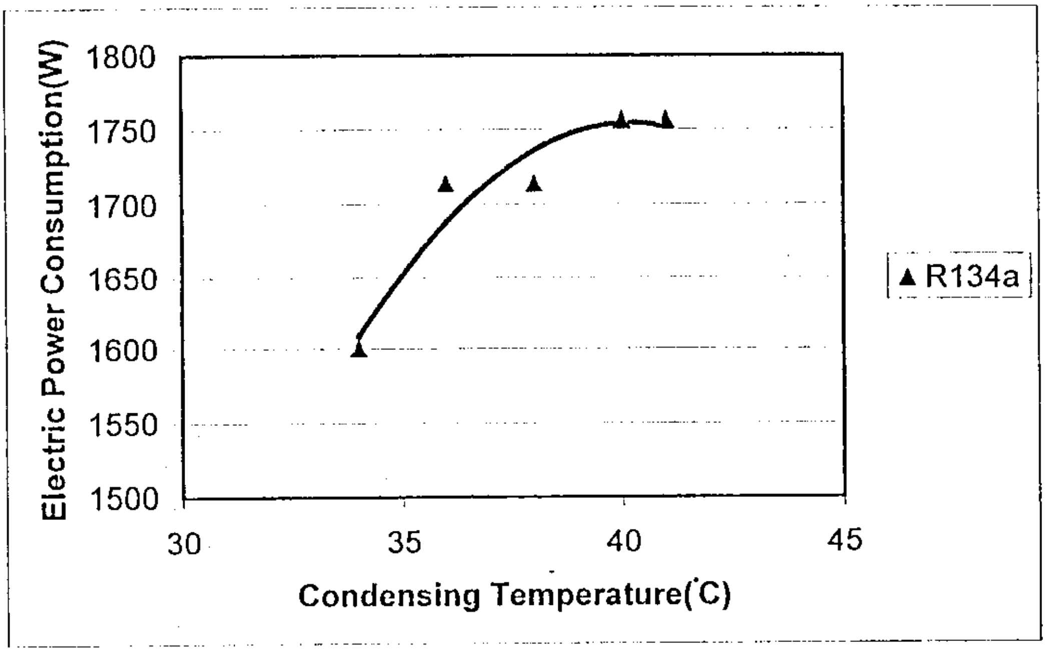
Figure(6.22) Condenser Duty Vs. Te



Figure(6.23) Work Of Compression Vs. Condensing Temp.



Figure(6.24) Coefficient Of Performance Vs. cond. Temp.



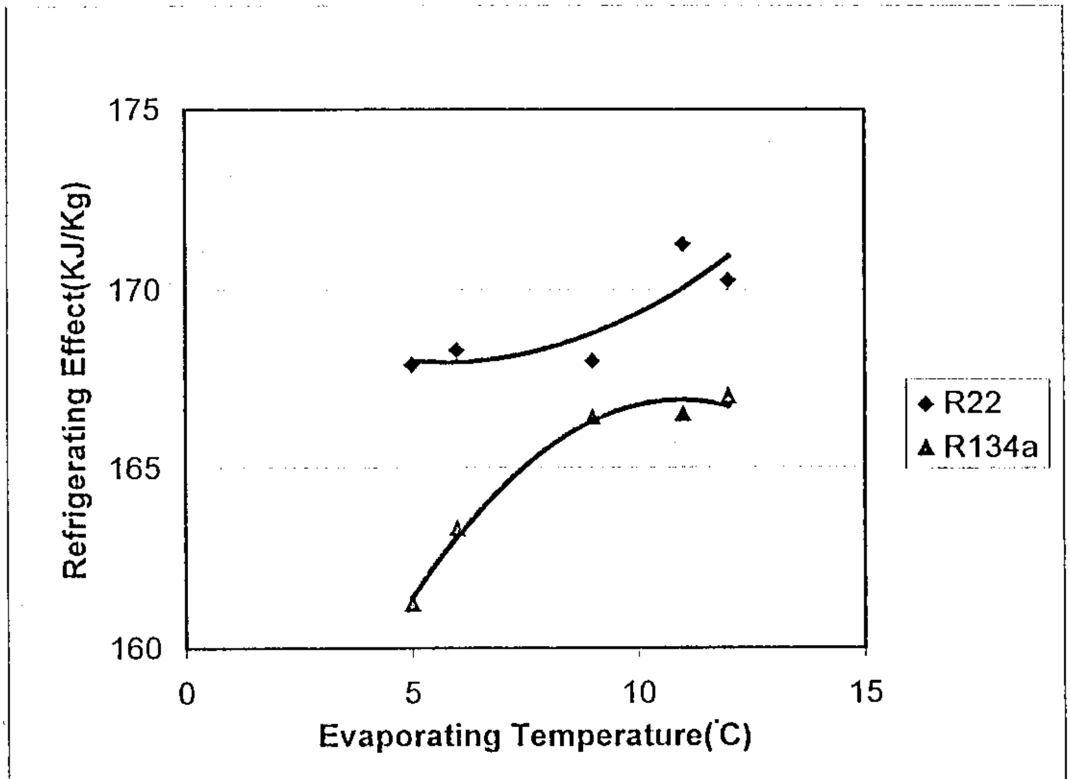
Figure(6.25) Electric Power Consumption Vs. Cond. Temp.

6.2.3 R134a Te and Tc variation tests compared to that of R22.

Here, I will present the comparison between R134a and R22 in some aspects such as coefficient of performance, refrigerating effect and other important parameters.

1. Refrigerating Effect:

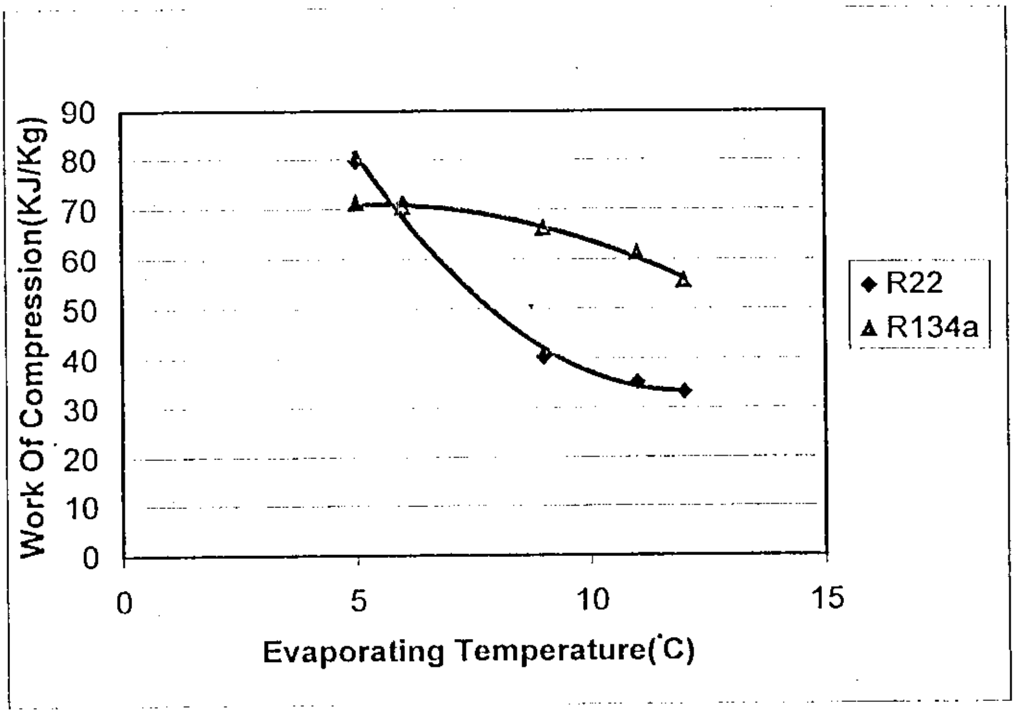
It can be seen from figure (6.26) that the refrigerating effect of R22 is higher than that of R134a by (4%) at the maximum, and about (1.5%) at the minimum difference.



Figure(6.26) Refrigerating Effect Of R134a and R22 Vs.Te

2. Work of Compression:

It can be seen from figure (6.27) that the work of compression of R134a is higher than that of R22 by percentage of(40%) at the maximum, and they are equal at some points.



Figure(6.27) Work Of Compression for R134a and R22 Vs. Te

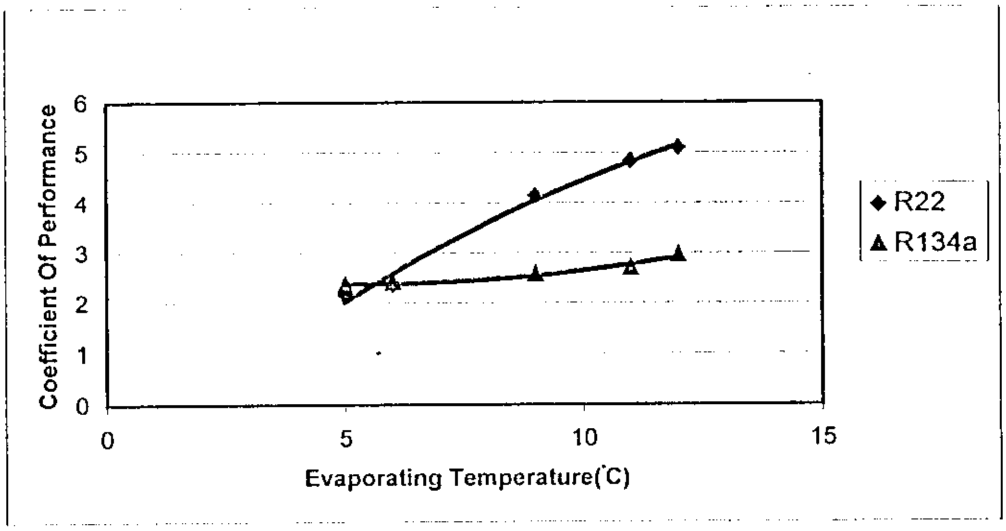
3. Coefficient of Performance:

It is shown from figure (6.28) that the coefficient of performance of R22 is higher than that of R134a.

COP = refrigerating effect / work of compression

and as shown in figure (6.26), the refrigerating effect of R22 is higher than that of R134a. And, from, figure (6.27) the work of compression of

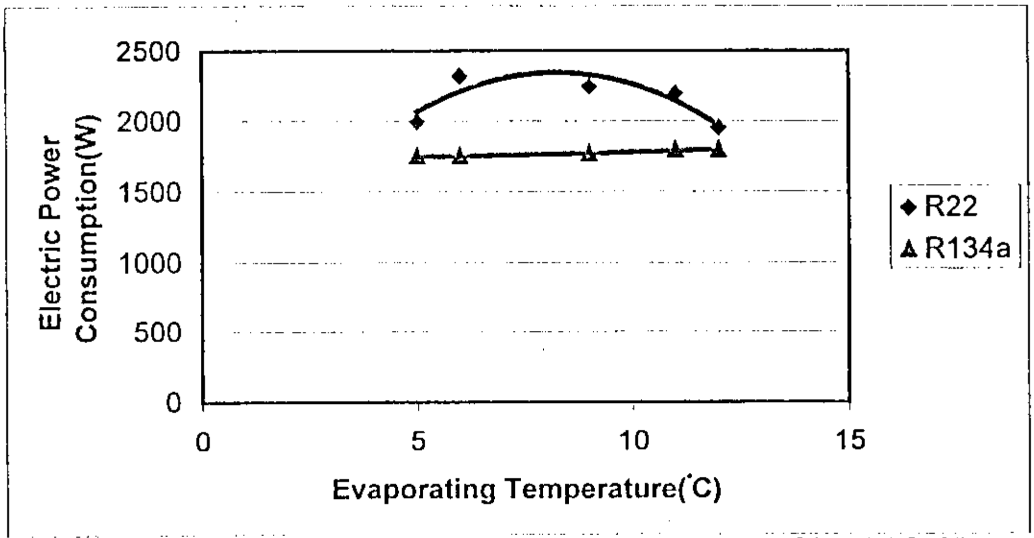
R134a is higher than that of R22, and so, we can say that the coefficient o performance of R22 is higher than that of R134a. Maximum COP for R2 reached (5), while it was only (3) for R134a. The reduction about (40%)



Figure(6.28) C. O. P for R134a and R22 Vs. Te

4. Electric Power Consumption:

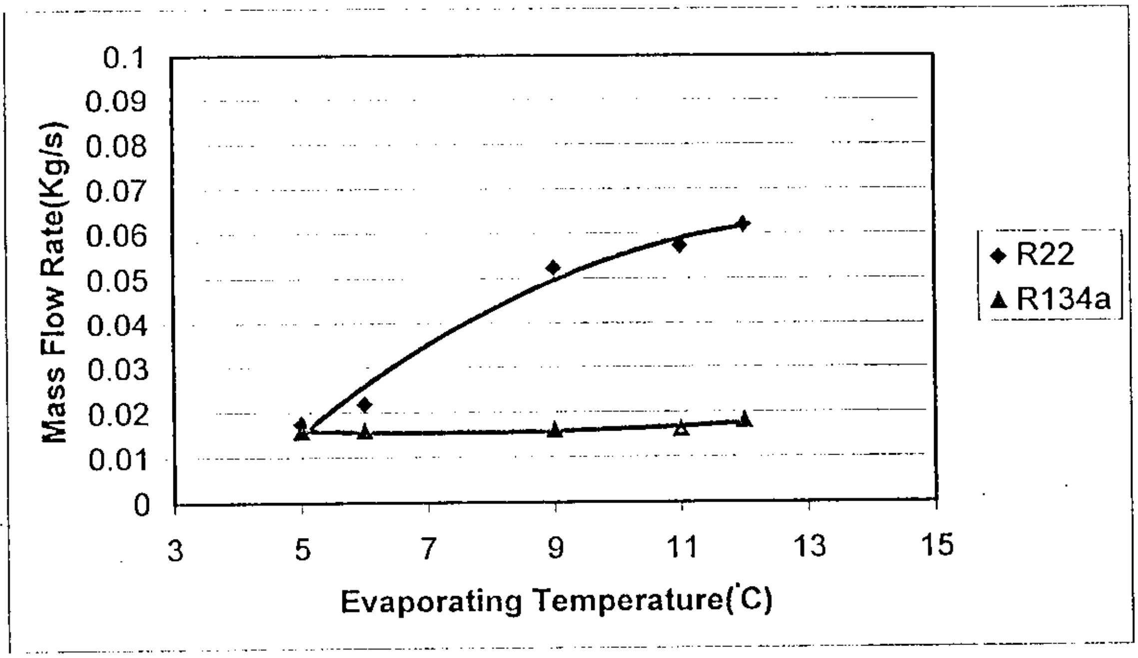
Also as shown from figure (6.29), the electric power consumption of 22 is higher than that of R 134a by a percentage of(22%) at the maximum.



Figure(6.29) Elec. Power Consumption for R134a &R22 Vs.Te

5. Mass Flow Rate:

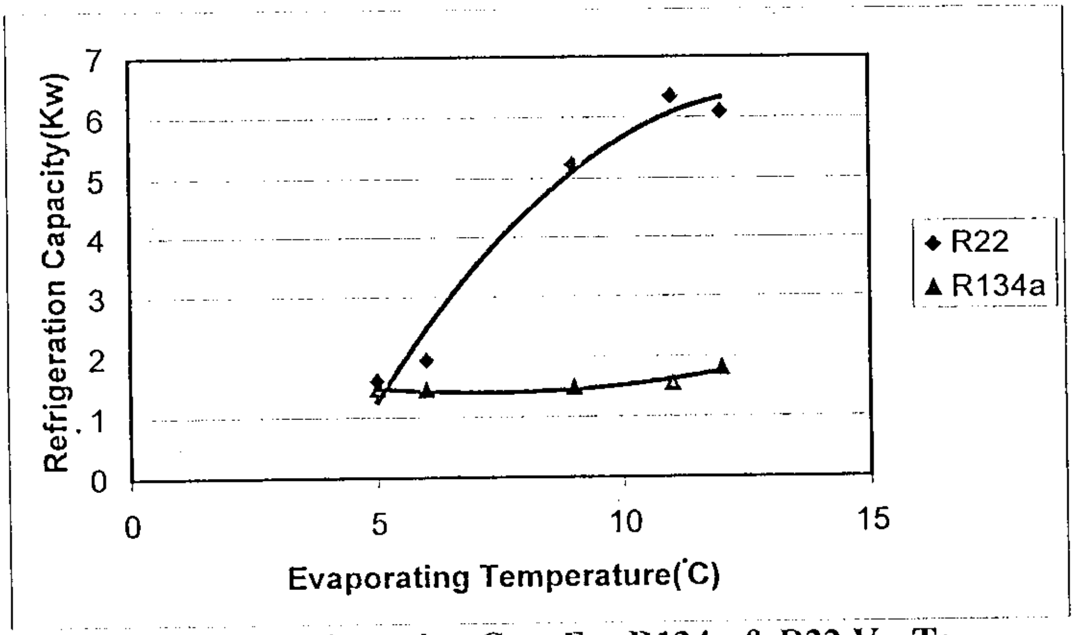
As shown in figure (6.30), the mass flow rate of R 22 is higher than that of R 134a. The reduction about (70%).



Figure(6.30) Mass Flow Rate For R134a &R22 Vs. Te

6. Refrigeration Capacity:

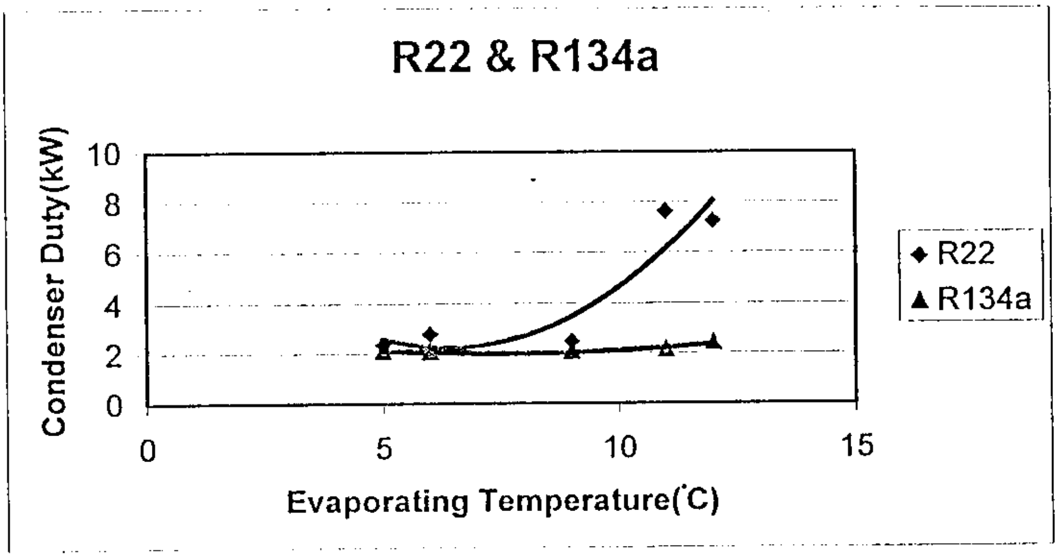
Figure (6.31) shows that, the refrigeration capacity of R22 is higher than that of R134a. This can be justified by referring to equation(5.6), and we know from figure (6.30) that the mass flow rate of R22 is higher than that of R134a, and we can see from figure (6.26) that the refrigerating effect of R22 is higher than that of R134a, and so we can say that the refrigeration capacity of R22 is higher than that of R134a. Refrigeration capacity for R22 reached about(6.2)Kw. While it is about (1.9)Kw for R134a. this gives a reduction over (70%) of the capacity as maximum reduction.



Figure(6.31) Refrigeration Cap. For R134a & R22 Vs. Te

7. Condenser Duty :

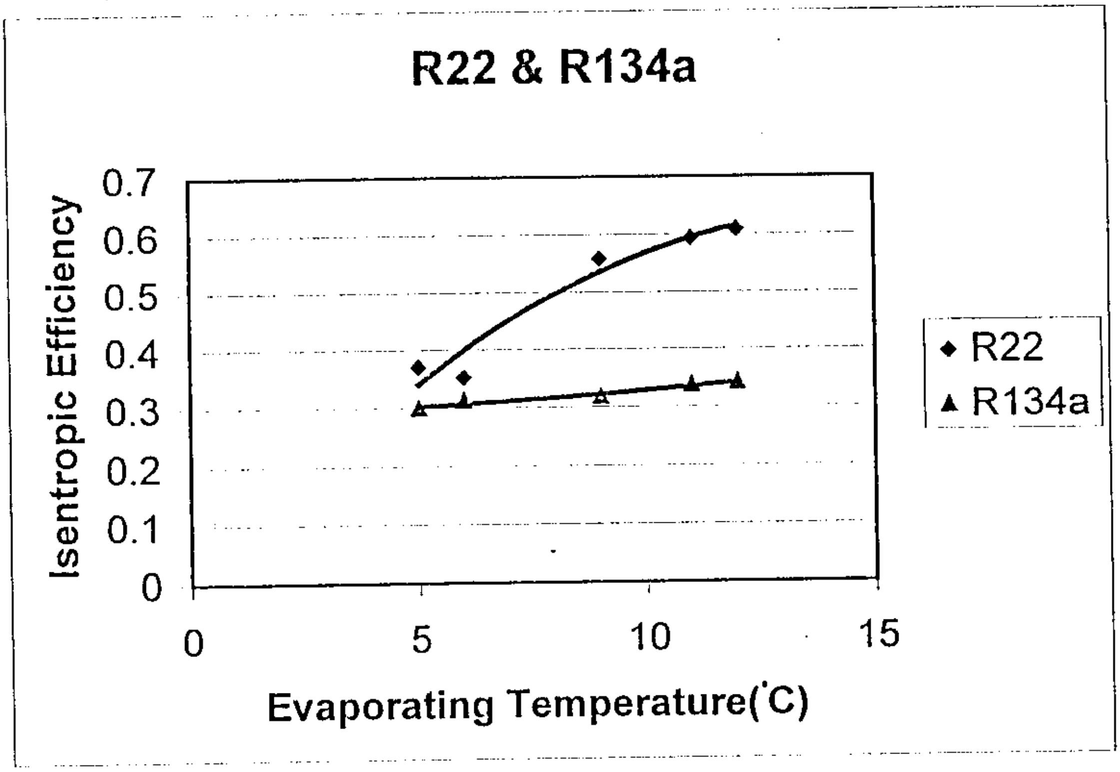
As shown in figure(6.32), the condenser duty, if R-134a is used is less than that of R-22 by a value of about(50%). It can be concluded that the condenser is unsuitable in this split unit A/C and it is needed to be changed if R134a is used an alternative for R22.



Figure(6.32) Condenser Duty Vs. Te for R22 and R134a

8. Isentropic Efficiency:

It is shown from figure(6.33) that the isentropic efficiency is very low by using R134a, and it has a percentage decrease of about(40%). And so, it can be concluded that this compressor is not suitable when R134a is used.



Figure(6.33) Isentropic Efficiency Vs.Te for R134a and R22

Chapter seven

CONCLUSIONS AND RECOMMENDATIONS

7.1Conclusions:

From the experiments which were performed, several conclusions can be introduced:-

1- R134a can give a coefficient of performance as R22 at low loads or at low evaporating temperatures.

2- The low coefficient of performance and refrigeration capacity of R134a in the A/C split unit can be justified by that, the isentropic efficiency of the compressor using R134a was very low, about 30%, whereas it is high using R22, about in average 60 %.

3- The coefficient of performance was reduced by using R 134a by a maximum value of (42%), and the refrigeration capacity by a maximum value of about (70%).

4- The condenser is unsuitable in this A/C split unit by using R 134a and it should be changed if it is desired to use R134a in this air conditioner.

5- R134a is not a suitable replacement for R22 in Air Conditioning Split Units.

7.2 Recommendations:

1- Another alternative for R22 other than R134a.

2-The compressor should be changed if it is required to use R134a as a refrigerant to replace R22 in this A/C split unit.

4-The oil which is used with R134a should be selected carefully, and we must not use mineral oil, but must use polyol ester oil.

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ملخص

أداء وحدات التبريد المنفصلة العاملة على غاز(R-134a)كبديل للغاز(R-22)

إعداد: سليمان محمود سليمان عبيدات

إشراف

أ.د. محمود حماد

الهدف من هذا البحث هو دراسة الأداء لوحدة تكييف منفصلة(A/C Split Unit) قدرتها الإسمية (2.5)طن عاملة على غاز R22 باستبداله بغاز R134a.

والسبب في اختيار R134a هو أنه صديق للبيئة ولا يضر بطبقة الأوزون بعكس R22.

في البداية تمت إزالة(محبس التمدد) واستبداله بآخر يمكن التحكم فيه يدوياً حتى نتمكن من التحكم في درجة حرارة التبخر لسائل وبالتالي حتى نتمكن من إجراء البحث المتضمن تغيير درجة حرارة التبخر عند درجة حرارة تكثيف معينة، ومن ثم تغيير حرارة التكثيف عند درجة تبخر ثابتة.

بعد ذلك تم اجراء التجارب على غاز R22، ثم تغيير الزيت المستخدم والذي كان عبارة عن زيت معدني ملائم لـ R22، حيث تم استبداله بزيت آخر ملائم لـ R134a

والمسمى (Polyol ester Oil) حيث أن له ذائبية جيدة معه بالإضافة إلى أنه لا يتفاعل معه تفاعلاً كيميائياً.

تم البحث اولا عن الشحنة الملائمة من R134a والتي تعطي أحسن معامل اداء للجهاز، حيث قمت بشحن الجهاز بعدة شحنات هي 1300غم، 1500غم، 1800غم، 2000غم، حيث وجد أن الشحنة التي تعطي أفضل أداء للجهاز هي 1500غم.

بعد ذلك تمت التجارب بتغيير درجة حرارة التبخير عند درجة تكثيف معينة، ومن ثم بتغيير حرارة التكثيف عند درجة حرارة تبخير ثابتة.

لقد تضمن هذا البحث علاقات تبين سلوك الغازين عند نفس الظروف وكذلك عمل مقارنة بينهما، حيث تبين أن R134a يعطي معامل اداء قليل يصل تقريباً إلى حوالي COP=3 عند درجة تبخر 12°م ودرجة حرارة تكثيف 43°، بينما كان COP = 5.0 عند نفس الظروف باستخدام R22 ومن هذه التجارب تبين أن R134a ليس بديلاً مناسباً لـ R22 في وحدات التبريد المنفصلة (A/C Split Unit).