COMPARATIVE PERFORMANCE STUDY OF VAPOUR COMPRESSION REFRIGERATION SYSTEM WITH REFRIGERANT R134a,R404A,R407C,R410A,R507A,R600a

A project report submitted in partial fulfilment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

MECHANICAL ENGINEERING

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CERTIFICATE

This is to certify that the project titled "**COMPARATIVE PERFORMANCE STUDY OF VAPOUR COMPRESSION REFRIGERATION SYSTEM WITH REFRIGERANT R134a,R404A,R407C,R410A,R507A,R600a**"*describes the bonafide work done by* ***K.KESAVA, K.PHANI KUMAR, Y.RAVI TEJA, K.HIMA SINDHU*** *and* ***R.ANUDEEP*** *in partial fulfilment for the award of B.TECH in Mechanical Engineering under the supervision and guidance of* ***P.SRINIVASARAO*** *during the academic year 2018-2019.*

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ACKNOWLEDGEMENT

We are happy to present this report on **Comparative Performance Study Of Vapour Compression Refrigeratiom System with Refrigerants R134a, R404A, R4074C, R410A, R507A, R600a** in Partial fulfilment of the requirement for the award of B.Tech, Degree in Mechanical Engineering.

We take this opportunity to express our deep and sincere indebtedness to our esteemed guide Mr.P.Srinivasa Rao, Assistant Professor, ANITS, a source of constant motivation in successfully completing our project.

We intend to express our thanks with sincere obedience to Prof.B.NagaRaju, Head of Mechanical Engineering department and Prof.T.Subramanyam, Principal for facilitating the execution of this work.

Lastly, we are grateful to one and all who have contributed either or indirectly in completion of this project.

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LIST OF FIGURES

List of tables :

INDEX

CHAPTERS **PAGE NO**

Abstract

Refrigeration may be defined as the process of achieving and maintaining a temperature below that the surroundings the air being to freeze ice,cool some product or space to the required temperature.The aim of modern refrigeration is the zero ozone depletion potential, low global warming potential and ability of liquids to absorb more quantities of heat when boil&evaporate. Refrigeration have more no of applications.one of the important applications of refrigeration is in ice plant.

We have considered this application because in future ice plant can be the more preferable cooling device for long term protection of goods for the supply and sales.Ice plant uses simple vapour compression cycle for producing refrigeration effect we have considered this cycle for analysis by different eco friendly refrigerents.Several refrigerantes have emerged as substitutes to replace R134a the most widely used fluorocarbon refrigerantes.These include the environmentally eco-friendly hydrocarbon refrigerants like R410A,R407C,R404A and R507A and environmentaly eco friendly natural refrigerantes like R600a. R134a is a pure refrigerant where as R410A,R134A,R404A,R507A are blends of refrigerantes.The advantages of blend refrigerants are that properties such as flammability,capacity,discharge temperature.

In the project study the effects of the main parameters such as refrigerant type ,degree of subcooling , super heating, effect of condenser pressure and evaporator pressures on the refrigeration effect,coefficient of performance and compression work.Considering the recent trends of replacement of ozone depleting and global warming refrigerants and improvement in refrigerating effect, in present study ,R600a refrigerant replacement for new and exisiting systems presently using R134a.

CHAPTER-1

1. INTRODUCTION

1.1 Refrigeration:

The job of a refrigeration plant is to cool articles or substances down to, and maintain them at a temperature lower than the ambient temperature. The refrigeration system works on vapour compression refrigeration system. The vapour-compression uses a circulating liquid refrigerant as the medium which absorbs and removes heat from the space to be cooled and subsequently rejects that heat. Generally refrigerant enters the compressor in the Thermodynamic state known as a saturated vapour and is compressed to a higher pressure, resulting in a higher temperature as well. The hot, compressed vapour is then in the thermodynamic state known as a superheated vapour and it is at a temperature and pressure at which it can be condensed with either cooling water or cooling air. That hot Vapour is cooled Condensed into a liquid by flowing through a coil or tubes. In condenser Circulating Refrigerant rejects heat from the system. The condensed liquid refrigerant, in the thermodynamic state known as a saturated liquid. Then refrigerant entered in the expansion valve where it reduction in pressure. Finally enter in into evaporator and absorb amount of heat from the products.

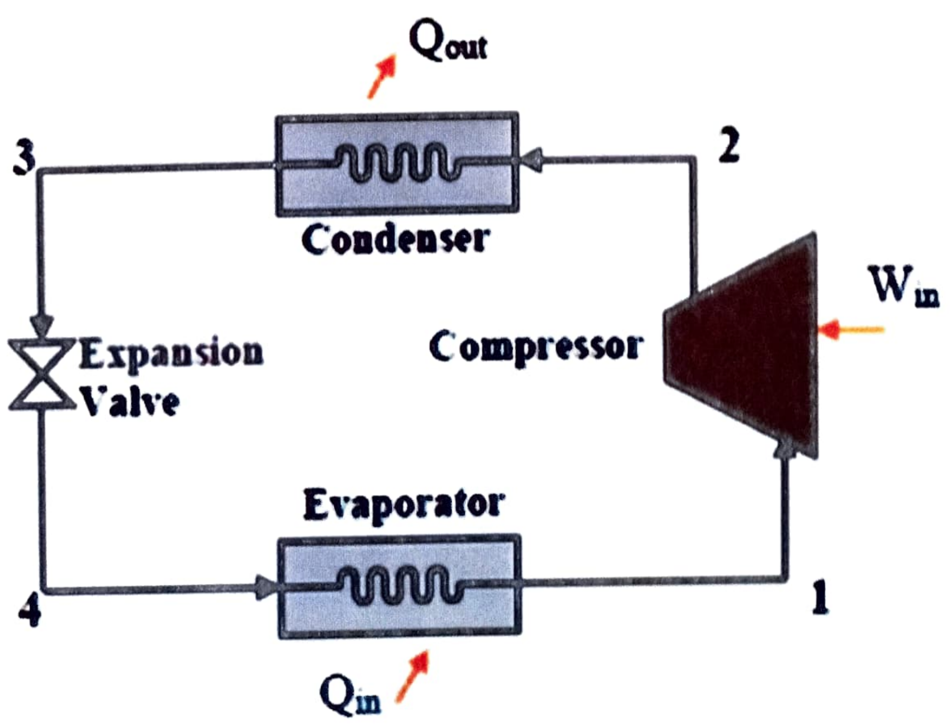


Fig 1.1 Vapour compression refrigerating system

1.2 Refrigeration systems have four components:

A. Compressor

It compresses the refrigerant. The compressor receives low pressure gas from the evaporator and converts it to high pressure gas. As the gas is compressed, the temperature rises. The hot refrigerant gas then flows to the condenser.

B. Condenser

A condenser is a device or unit used to condense a substance from its gaseous to its liquid state, by cooling it. In so doing, the latent heat is given up by the substance, and will transfer to the condenser coolant.

C. Expansion Valve

Its function is to meter the amount of refrigerant to be supplied to evaporator and to reduce the pressure up to evaporator pressure such that liquid can vaporise at the evaporator coil.

D. Evaporator

An evaporator is used in an air-conditioning system to allow a compressed cooling refrigerant, to evaporate from liquid to gas while absorbing heat in the process. It can also be used to remove water or other liquids from mixtures.

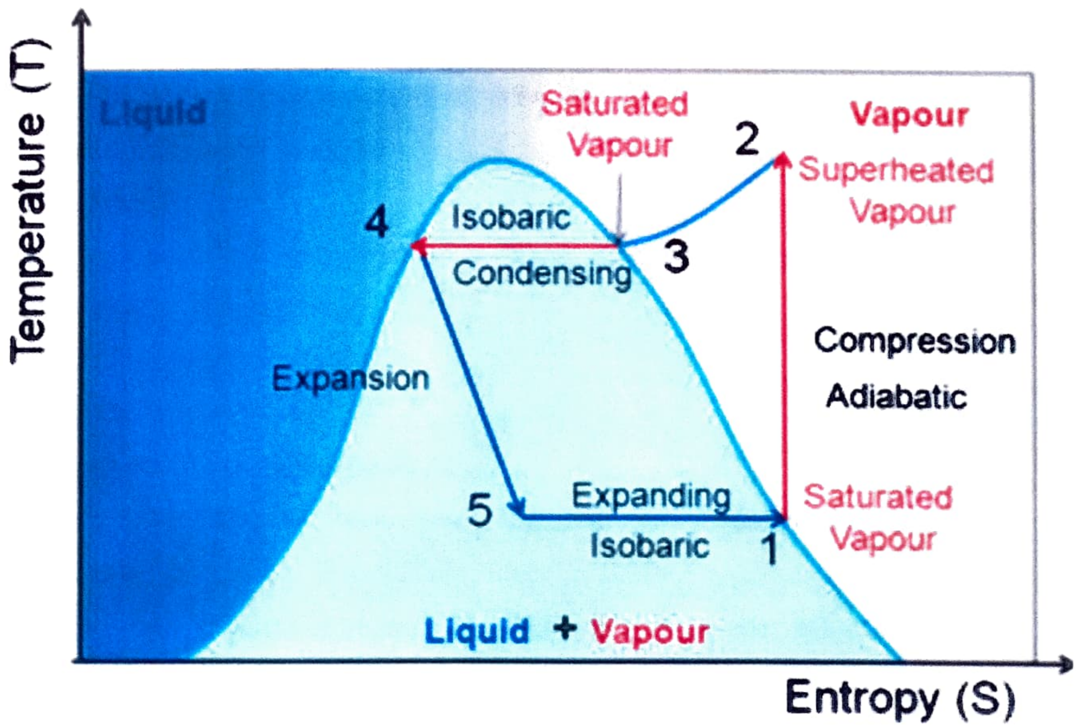


Fig 1.2 TS diagram

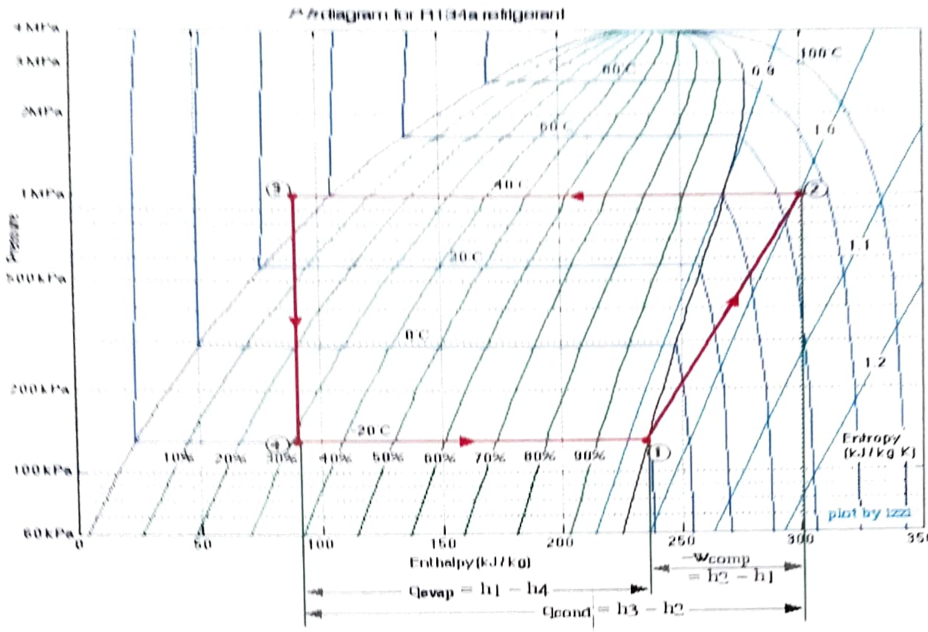


Fig 1.3 Ph diagram

Process 1-2: Isentropic compression of saturated vapour in compressor

Process 2-3: Isobaric heat rejection in condenser

Process 3-4: Isenthalpic expansion of saturated liquid in expansion device

Process 4-1: Isobaric heat extraction in the evaporator

1.3 Application of Refrigeration:

The major application of refrigeration can be classified into major important areas.

1. Food processing, preservation and distribution
2. Chemical and process industries
3. Special Applications

1.3.1 Application of refrigeration in Food processing, preservation and distribution:

Storage of Raw Fruits and Vegetables

Meat and poultry

Dairy Products: Ice cream,buttermilk etc..

Beverages: Production of beer, wine and concentrated fruit juices require refrigeration.

Processing and distribution of frozen food: Many vegetables, meat, fish and poultry are frozen to sustain the taste, which nearly duplicates that of the fresh product.

1.3.2 Applications of refrigeration in chemical and process industries:

The industries like petroleum refineries, petrochemical plants and paper pulp industries etc. require very large cooling capacities.

Separation of gases

Condensation of Gases

Dehumidification of Air

Solidification of Solute

Storage as liquid at low pressure

Removal of Heat of Reaction

Cooling for preservation

Recovery of Solvents

1.3.3 Special applications of refrigeration:

These are in manufacturing processes, applications in medicine, construction units etc.

Cold Treatment of Metals

Medical storage

Ice Skating Rinks

Construction

Desalination of Water

Ice Manufacture

1.4 Methods of Refrigeration:

There are number of methods by which the refrigeration can be achieved. They are broadly classified into two categories.

1. Non cyclic method of refrigeration
2. Cyclic method of refrigeration

1.4.1 1.Non cyclic method of Refrigeration:

In the non-cyclic method of refrigeration there is no thermodynamic cycle followed for creating the cooling effect. There are two methods of non-cyclic refrigeration process as described below:

Ice Refrigeration: In this method the ordinary ice is used for keeping the space at temperature below the surrounding temperature. The temperature of ice is considered to be 0 degree Celsius hence it can be used to maintain the temperatures of about 5 to 10 degree Celsius. This method of cooling is still being used for cooling the cold drinks, keeping the water chilled in thermos, etc.

Dry ice refrigeration: Dry ice is the solid carbon dioxide having the temperature of -78 degree Celsius. Dry ice converts directly from solid state to gaseous; this process is called as sublimation. The process of dry ice refrigeration is now-a-days being used for freezing the food in aircraft transportation.

1.4.2 2 Cyclic method of refrigeration

This consists of a refrigeration cycle, where heat is removed from a low-temperature space or source and rejected to a high-temperature sink with the help of external work, and its inverse, the thermodynamic power cycle.

Cyclic refrigeration can be classified as:

Vapor cycle

Gas cycle

Vapour cycle refrigeration can further be classified as:

(a) Vapour compression refrigeration

(b) Vapour absorption system

Vapour absorption cycle

The most common combinations are ammonia (refrigerant) with water (absorbent), and water (refrigerant) with lithium bromide (absorbent).

Gas cycle

When the working fluid is a gas that is compressed and expanded but doesn't change phase, the refrigeration cycle is called a *gas cycle*. Air is most often this working fluid. As there is no condensation and evaporation intended in a gas cycle, components corresponding to the condenser and evaporator in a vapour compression cycle are the hot and cold gas-to-gas heat exchangers in gas cycles.

The gas cycle is less efficient than the vapour compression cycle because the gas cycle works on the reverse Brayton cycle instead of the reverse Rankine cycle. As such the working fluid does not receive and reject heat at constant temperature.

1.5 CLASSIFICATION OF REFRIGERANTS

- Primary refrigerants (Refrigerants that directly take part in the refrigeration process)
- Secondary refrigerants (refrigerants that are first cooled by the primary refrigerants and then further used for cooling purpose

1.5.1 Classification of primary refrigerants

1.5.1.1 Halocarbon compounds :

Number	Chemical Name	Chemical Formula
R-11	Trichloro Monofluoro Methane	CCl_3F
R-12	Dichloro Difluoro Methane	CCl_2F_2
R-13	Monochloro Trifluoro Methane	$CClF_3$
R-22	Monochloro Difluoro Methane	$CHClF_2$
R-113	Trichloro Difluoro Ethane	$C_2Cl_3F_3$

Table 1.1 Halocarbon compounds chemical formula

Azeotropes :

Consists of mixtures of different refrigerants which don't separate into their compounds with the change in pressure or temperature or both. They have fixed thermodynamic properties.

Name	Mixture by weight
R-500	73.8% of R-12 & 26.2% of R-152a
R-502	48.8% of R-22 & 51.2% of R-115
R-503	40.1% of R-23 & 59.9% of R-13

Table 1.2 Azeotropes mixture by weight

Azeotropic mixture is a mixture of two or more liquids which, when mixed in precise proportion, form a compound having a boiling temperature which is independent of the boiling temperature of the individual liquids.

Hydrocarbons:

Most of the organic compounds are considered as refrigerant under this group. Most of them possess satisfactory thermodynamic-properties but are highly flammable.

Number	Chemical Name	Chemical Formula
R 134a	Tetrafluoroethane	CH2FCF3
R 404a	Mixture of tetrafluoroethane, Pentafluoroethane-trifluoroethane	CF3CH2F/CF3CH2F/ CF3CH3
R 407c	Mixture of Difluoromethane ,pentafluoroethane,tetrafluoroethane	CHF2CF3
R 410A	Mixture of puron and suva	R 32/ R 125
R 507A	Forfane	R 125/ R 143a
R 600a	Isobutane	C4H10

Table 1.3 Refrigerants chemical formula

1.5.1.2 Inorganic compounds:

The refrigerants under this group were universally used for all purposes before the introduction of halo-carbon, refrigerants. Earlier they were used for different purposes due to their inherent thermo-dynamic and physical properties, for example:

Number	Chemical Name	Chemical Formula	Specific use
R-717	Ammonia	NH_3	Ice plants
R-718	Water	H_2O	In steam production system
R-729	Air	–	For aeroplanes
R-744	Carbon Dioxide	CO_2	For ship refrigeration

Table 1.4 Inorganic refrigerants specific use

1.5.1.3 Unsaturated Organic Compounds :

Comprising of mainly hydrocarbon group with ethylene and propylene bases, for example:

Number	Chemical Name	Chemical Formula
R-1120	Trichloro Ethylene	$C_2H_4Cl_4$
R-1130	Dichloro Ethylene	$C_2H_4Cl_2$
R-1150	Ethylene	C_2H_4
R-1270	Propylene	C_3H_6

Table 1.5 Unsaturated organic compounds

1.6 Secondary refrigerants:

- Secondary refrigerants (refrigerants that are first cooled by the primary refrigerants and then further used for cooling purpose

a) water-glycol solutions

b) water-ethanol solutions

c) acetate solutions.

1.7 DESIRABLE PROPERTIES OF REFRIGERANTS:

1.7.1 THERMODYNAMIC PROPERTIES

(A) Boiling Point:

Low boiling temperature at atmospheric of the refrigerant is desirable. Compressor has to be operated at high vacuum if the boiling point of the refrigerant is high at atmospheric pressure.

Refrigerant Name	Boiling Point at 760mm of Hg
R 134a	-26.3°C
R 404a	-46.45°C
R 407C	-43.6°C
R 410A	-51.6°C
R 507A	-52.8°C
R 600a	-11.7°C

Table 1.6 Refrigerants boiling point

(B) Freezing point:

Freezing point of the refrigerant is important because the refrigerant should not freeze under required evaporator temperature. The refrigerant must have a freezing temperature well below the evaporator operating temperature.

Refrigerant Name	Freezing Point at 760mm of Hg
R 134a	-142°C
R 404a	-101°C
R 407c	-160°C
R 410A	-155°C
R 600a	-159.6°C

Table 1.7 Refrigerants freezing point

(C) Evaporator and condenser pressure:

It is always desirable to have positive pressure in evaporator and condenser for the required temperatures. However, the pressures should not be too high above atmospheric pressures. Too high pressure require very robust construction of the refrigeration system which require high initial cost and high operating cost also. Positive pressures in the evaporator are necessary to prevent leakage of air and mixture into refrigeration system.

The operating range is one of the major and important considerations in the selection of refrigerant for the economical functioning of the refrigeration system.

The extreme pressure of CO_2 for the normal working temperature range, as is evident from the above table, make it suitable refrigerant.

High difference between the evaporator and condenser pressure results in high compression ratio. The power required to run the compressor increases with increasing ratio. High pressure ratio also requires more power and gives low volumetric efficiency.

(D) Critical temperature and pressure:

The critical temperature of a vapour is defined as the temperature above which the vapour cannot be condensed irrespective of increased pressure, The critical temperature of the refrigerant used should be higher then the temperature occurring within the condenser for easy condensation of the refrigerant vapor.

Refrigerant Name	**Critical Temperature (^{0}C)**	**Critical Pressure (kpa)**
NH_3	132.8°C	1636
R 134a	122°C	4060.3
R 404a	161.18°C	54083
R 410a	72.8°C	4926.1
R 407C	86.74°C	4619.10
R 507 A	70.9°C	3793.6
R 600a	135°C	3660

Table 1.8 Refrigerants critical pressure and temperature

(E) Latent heat of refrigerant:

High latent heat of refrigerant at evaporator temperature is desirable. The weight of the refrigerant required to be circulated in the system per unit of refrigerating effect will be low if the latent heat of refrigerant is high. This also reduces the initial cost of the refrigerant used in the system.

refrigerant	latent heat of vapourisation (KJ/Kg)
R 134a	216
R 404a	200
R 407c	250
R 410A	256.7
R 507A	196.8
R 600a	366.5

Table 1.9 Refrigerants latent heat of vapourisation

1.7.2 SAFE WORKING PROPERTIES OF REFRIGERANTS

(A)Toxicity:

The toxic effect of the refrigerant on the human body is one of the major considerations in the selection of the refrigerant. This is because of the possibility of leakage of the refrigerant from the refrigerant system. Toxicity of the refrigerant may cause the injury to the human body or even death depending upon its percentage in air. It increase suffocation and poisons the air used for breathing.

(B) Flammability:

An ideal refrigerant should not have any danger of explosion in the presence of air or when exposed to lubricating oil. Most of the commonly used refrigerants such as freons are non flammable. Ammonia and methyl chloride burn with certain concentrations in the air. The refrigerants from the family of hydrocarbon are highly flammable.

(C) Corrosive Properties:

The chemical reaction of the refrigerant on the materials used in the refrigeration system is not the prime consideration in the selection of the refrigerant, but the selected refrigerant decides the material to be used for construction of the system.

The refrigerant must be chemically inert with the materials used for the refrigeration system.

At the same time these materials must also be chemically inert in the presence of water or air. The Freon refrigerant are non corrosive with all commonly used materials in the construction of refrigeration system such as brass, copper, zinc, iron, tin,lead & aluminium.However these refrigerants become acidic in presence of air and water.

Therefore aluminium and magnesium must not be used with freon refrigerants as they are readily attacked by acids. Freons also have high solvent action on natural rubber so that synthetic rubber is used for gaskets.

Iron and steel are commonly used with ammonia refrigerant as it reacts with copper, brass and other copper alloys in the presence of water.

(D) Chemical Stability:

An ideal refrigerant should be chemically stable and should not decompose at temperatures normal encountered in the refrigeration system.

Freon refrigerant are unstable above 600°C but such temperature are never reached in a refrigeration system under normal working conditions.

(E) Effect On Stored Products:

The refrigerants used are specially for cold storage plants and for domestic fridge systems should not affect the quality (i.e. color, taste etc.) of stored products when these stored substances come in contact with the refrigerant.

Ammonia gets readily dissolved in water and become alkaline in nature. Most vegetables, fruits and meat products are slightly acidic in nature and when exposed ammonia reacts with these products and spoils the taste.

Freons have no effect on food, meats, vegetables, flowers and dairy products. There will not be any change in color taste or texture of stored products which is exposed to Freon.

1.7.3 PHYSICAL PROPERTIES:

(A) Specific volume:

Low specific volume of the refrigerant at the suction into compressor is always desirable, because it reduces the size of the compressor for the same refrigeration capacity. The reciprocating compressors are always used for refrigerants with low specific volume at suction whereas the centrifugal compressors are desirable for refrigerants with high specific volume. .

(B)Specific Heat of Liquid And Vapour:

Low specific heat of liquid refrigerant & high specific heat of vapour refrigerant are desirable because both tend to increase the refrigerating effect per kg of refrigerant.

The low specific heat of liquid refrigerants helps in increasing the sub cooling of liquid and high specific heat of vapour helps in decreasing the super heating of vapour.

A refrigerant having both above properties gives considerably high refrigerating effect per kg of refrigerant.

(C) Thermal Conductivity:

The thermal conductivity of refrigerants in liquid & gaseous phase are required for finding the heat transfer coefficient in evaporators and condensers.

High conductivity of refrigerant in both states are desirable.

(D) Viscosity:

This property of refrigerant in both states carries importance for calculating heat transfer coefficients in evaporators and condensers. This data is necessary for designing the pumping units of the system. Low viscosity of the refrigerant in both states are desirable. For better heat transfer and low power requirement for pumping operation.

(E) Dielectric Strength:

It becomes an important factor when it is used in hermetically sealed unit where the motor is exposed to the refrigerant.

The dielectric strength of different refrigerant vapours is compared with the dielectric strength of nitrogen and ratio of two is termed as relative dielectric strength.

1.7.4 OTHER PROPERTIES:

(A) Odour :

Odour of a refrigerant may be an advantageous or disadvantageous. Distinct odour of the refrigerant helps in detecting the leak of the refrigerant.

Some refrigerant having specific odour spoils the refrigerated products when they come in contact with them. Some eatables such as meat and butter which are highly sensitive to odour lose their taste when exposed to NH_3 and SO_2.

In small concentration, NH3 has a pleasant odour but it becomes irritating with an increase in concentration.

SO_2 has very irritating and obnoxious odour even with very small concentrations.

The freons R-12, R-22, R-113 are more or less odourless.

(B) Tendency To Leak:

The leakage of the refrigerant from the system or leakage of air into the system is due to failure of the joints or couplings. This may also be due to flaws in the material used for construction. A dense fluid has less tendency to leak than a fluid with lesser density the possibilities of the leakage is more with high discharge pressure and low density refrigerant.

(C) C.O.P & H.P. Requirement:

The requirement of the H.P. per ton of the refrigeration is the most important considerations from the economic point of View. Low power consumption per ton of refrigeration is desirable. The theoretical values of C.O.P & H.P per ton for different refrigerants are listed below when the evaporating temperature is -15°C and condensing temp is +30°C.

(D) Relationship Between Oil & Refrigerant:

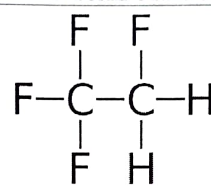
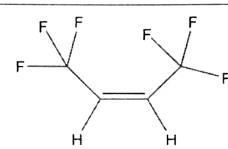
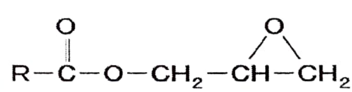
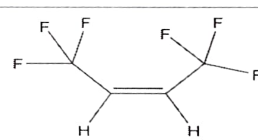
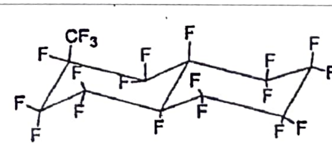
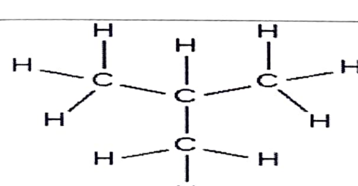
The refrigerant should not react with lubricating oil as the lube oil gets exposed to refrigerant in the compressor. The miscibility of the lube oil and the refrigerant (ability of the refrigerant to mix with oil) is the important criteria in selection of the refrigerant. This property is also important for smooth running of the system.

The refrigerants NH_3 & CO_2 are immiscible refrigerants. All Freons and most refrigerants from hydrocarbon group are miscible. High viscous oil must be used with miscible refrigerants as the effect of miscibility is to reduce the viscosity.

(E) Cost & Availability: The refrigerant must be readily available and at a reasonable price. The cost of the refrigerant is not very important in small units as the amount of refrigerant required for make up, in the event of leakage occurring in the system is small.

The cost of the refrigerant, a high capacity refrigerating system is very important. The relatively cost of the three commonly used refrigerants are as follows:

NH_3 CHEAPEST, R-12 MORE EXPENSIVE AND R-22 MOST EXPENSIVE

REFRIGERANT NAME	**CHEMICAL STRUCTURE**
R 134a	
R 404A	
R 407c	[Chemical Formula 2] 
R 410A	
R 507 A	
R 600 a	

1.7.6 SELECTION OF REFRIGERANT

There is not a single best refrigerant which can be used for all refrigeration purpose. Different application requires different characteristics. The thermodynamic, physical as well as safe working properties should be taken into account before selecting a refrigerant for a particular purpose. .However, following properties range more atte tion for selecting a refrigerant and compressor

(a) Working-pressure range and pressure ratio

(b) Corrosiveness and flammability,

(c) Space limitations

(d) Temperature required in evaporators

1.8 Performance analysis of vapour compression refrigeration system:

Effect of evaporator temperature

Effect of condenser temperature

Effect of sub cooling

Effect of superheating

1.8.1 Effect of evaporator temperature:

The effect of evaporator temperature on performance of the system is obtained by keeping the condenser temperature (pressure) and compressor displacement rate and clearance ratio fixed.

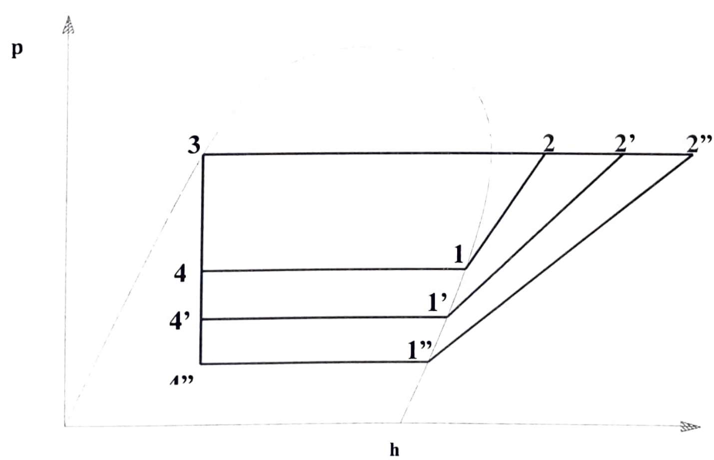


Fig 1.4 *Effect of evaporator temperature on refrigeration effect on P-h diagram*

On refrigeration effect and refrigeration capacity:

A compressor alone cannot provide refrigeration capacity. By refrigeration capacity of compressor what we mean is the capacity of a refrigeration system that uses the compressor under discussion. cycle on P-h diagram at different evaporator temperatures. It can be seen from the figure that the refrigeration effect, q_e ($q_e = h_1 - h_4$) increases marginally as the evaporator temperature is increased.

On work of compression and power requirement:

At a constant condenser temperature as evaporator temperature increases the work of compression,($w = h_2 - h_1$) decreases. This is due to the divergent nature of isentropes in the superheated region. The work of compression becomes zero when the evaporator temperature becomes equal to the condenser temperature ($T_e = T_c$).

The power input to the compressor is given by:

$$W = h_2 - h_1$$

As discussed before, for a given clearance ratio and condenser temperature, the volumetric efficiency and hence the mass flow rate becomes zero at a lower limiting value of evaporator temperature ($Te = T_{lim}$). Since the work of compression becomes zero when the evaporator temperature equals the condenser temperature, the power input to the compressor, which is a product of mass flow rate and work of compression is zero at a low evaporator temperature (at which the mass flow rate is zero). And the power input also becomes zero when evaporator temperature equals condenser temperature (at which the work of compression becomes zero

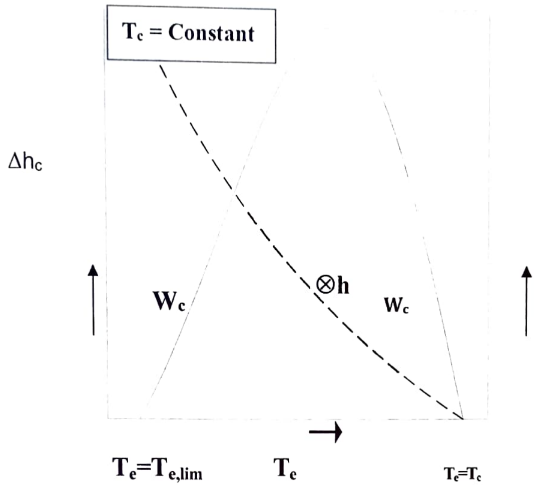


Fig 1.5

Effect of evaporator temperature on work of compression (Δh_c) and power input to compressor (W_c)

On COP

The COP of the system is defined as:

COP=Refrigeration effect/work of compression

COP=N/W

As discussed before, as the evaporator temperature increases the refrigeration effect, q_e increases marginally and the work of compression, w_c reduces sharply. As a result the COP of the system increases rapidly as the evaporator temperature increases.

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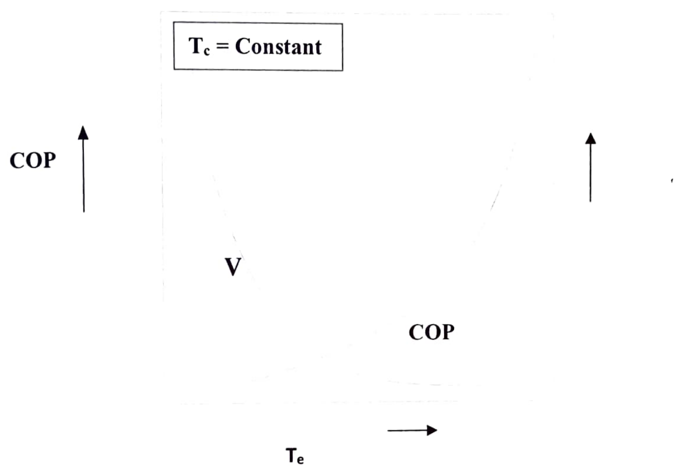

Fig 1.6 **Effect of evaporator temperature on COP**

1.8.2 Effect of condenser temperature:

Atmospheric air is the cooling medium for most of the refrigeration systems. Since the ambient temperature at a location can vary over a wide range, the heat rejection temperature (i.e., the condensing temperature) may also vary widely. This affects the performance of the compressor and hence the refrigeration system. The effect of condensing temperature on compressor performance can be studied by keeping evaporator temperature constant.

On refrigeration effect and refrigeration capacity:

At a constant evaporator temperature as the condensing temperature increases, then the enthalpy of refrigerant at the inlet to the evaporator increases. Since the evaporator enthalpy remains constant at a constant evaporator temperature, the refrigeration effect decreases with increase in condensing temperature as shown in Fig. The refrigeration capacity (Qe) also reduces with increase in condensing temperature as both the mass flow rate and refrigeration effect decrease as shown in below Fig.

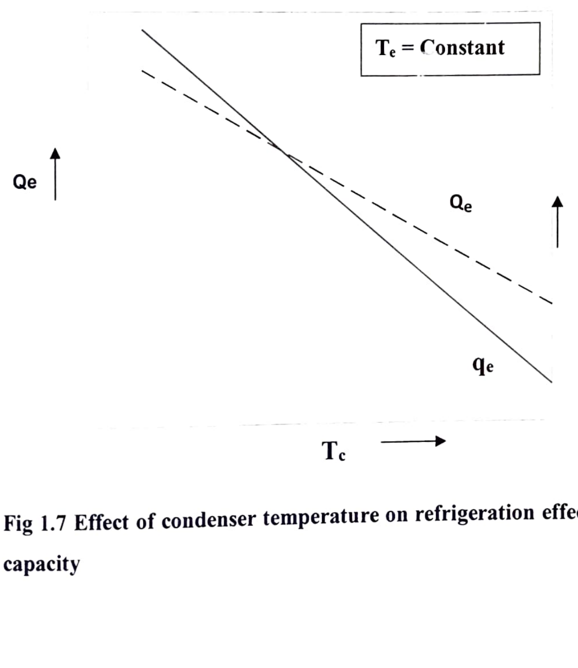

Fig 1.7 Effect of condenser temperature on refrigeration effect and refrigeration capacity

On work of compression and power requirement:

The work of compression is zero when the condenser temperature is equal to the evaporator temperature, on the other hand at a limiting condensing temperature the mass flow rate of refrigerant becomes zero as the clearance volumetric efficiency becomes zero. Hence, similar to the effect of evaporator temperature on power curve, the compressor power input increases from zero (work of compression is zero), reaches a peak and then again becomes zero at a high value of condensing temperature as shown in below Fig. However, the peak power in this case is not as critical as with evaporator temperature since the chances of condenser operating at such a high temperatures are rare

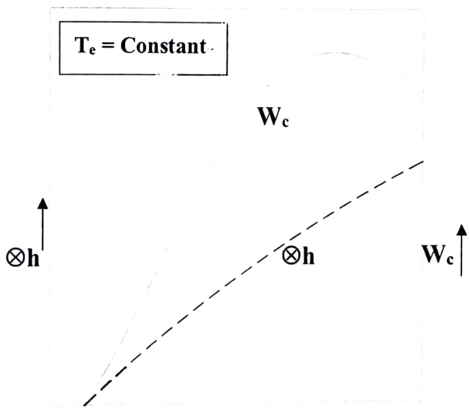

Fig 1.8 **Effect of condenser temperature on work of compression and power input to compressor**

On COP

As condensing temperature increases the refrigeration effect reduces marginally and work of compression increases, as a result the COP reduces as shown in Fig. Even though the specific volume at compressor inlet is independent of condensing temperature, since the refrigeration effect decreases with increase in condensing temperature, the volume flow rate of refrigerant per unit capacity increases as condenser temperature increases as shown in below Fig.

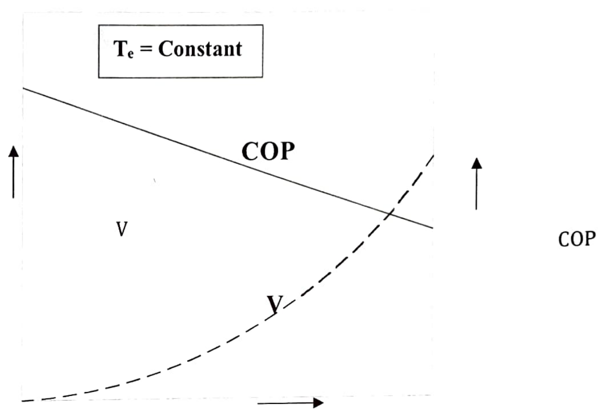

Fig 1.9 Effect of condensing temperature on COP

The above discussion shows that the performance of the system degrades as the evaporator temperature decreases and condensing temperature increases, i.e., the temperature lift increases. This is in line with the effect of these temperatures on reverse Carnot refrigeration system. It is seen that compared to the condensing temperature, the effect of evaporator temperature is quiet significant. When the heat sink temperature does not vary too much then the effect of condensing temperature may not be significant.

1.8.3 Effect of sub cooling:

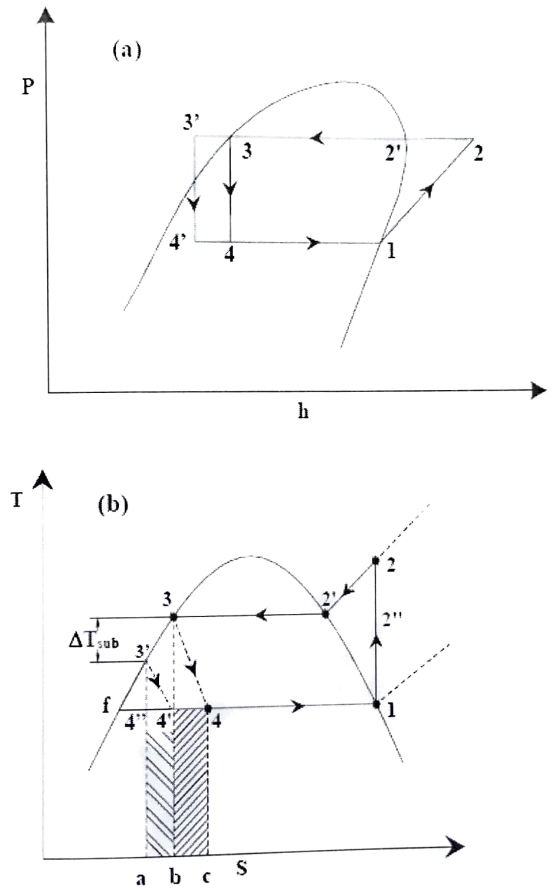

Fig 1.10(a),Fig 1.10(b) Ts diagram with and without subcooling

On work of compression: The amount of work input to the compressor is same doesn't change with the degree of subcooling.

On refrigeration effect:

It can be seen from the T-s diagram that without subcooling the throtling loss is equal to the hatched are b-4' 4-c whereas with subcooling the throttling los is given by the area a-4"-4'-b. thus the refrigeration effect increases by an amount equal to $h4-h4'=h3-h3'$

On cop:

Cop of the refrigeration system will be increases with degree of sub cooling. Because work of compression remains same.

1.8.4 Effect of superheating:

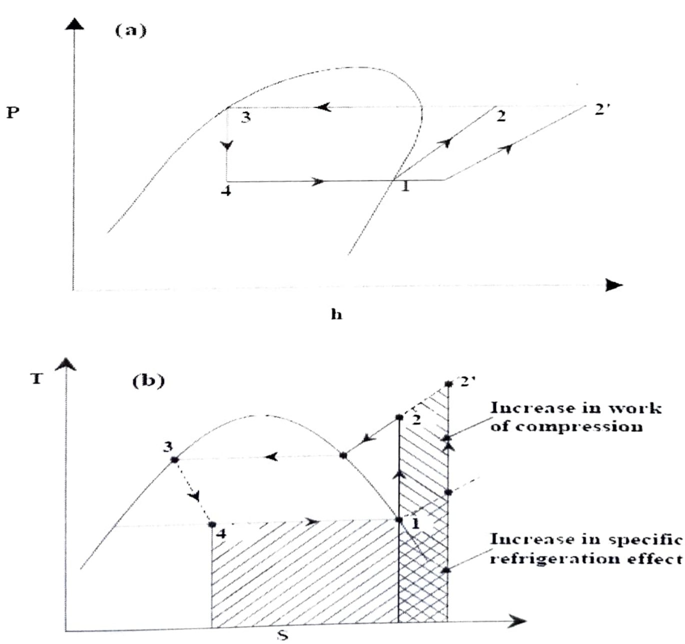

Fig 1.11(a),Fig 1.11(b) Ts chart with superheating

As shown in figure, with useful superheating, the refrigeration effect, specific volume at the inlet to the compressor and work done of compression increase. COP increase or not depends upon the relative increase in refrigeration effect and work of compression, which in turn depends upon the nature of the refrigerant used. the temperature of refrigerant at the exit of the compressor increases with superheat as the isentropes in the vapour region gradually diverge.

CHAPTER-2

Literature review

1. **N austin :**

The main aim of this project is to compare the performance of vapour compression refrigeration systems with diverse refrigerant mixtures like R152a, R32, R290, R1270, R600a and RE170 to that of vapour compression refrigeration systems using R134a, CFC22, CFC12, and R134a. This is done in order to find the possibility of an alternative or replacement to the traditional refrigerants. The outcomes proved that among the replacement refrigerants studied in the analysis, R152a, RE170and R600a possess a commendable performance coefficient (COP) compared to CFC12, CFC22 and R134a. In the experiment condensation temperature is kept at 50°C while the evaporating temperature ranged from -30°C to 10°C. Results showed better performance coefficient values (COP) for the alternative refrigerants.

2. **E G Saturday et al :**

This work presents the computer aided comparative analysis of the effects of subcooling and superheating on the performance of R134a and R717 in simple vapour compression refrigeration systems. The results obtained show that subcooling and superheating refrigerant R134a improve the performance of the system as the COP increases with the subcooling and superheating temperatures .For R717, subcooling the refrigerant will give in improvement in the COP. These were presented graphically using the MATLAB programming language.

3.A Baskaran et al :

A performance analysis on a vapour compression refrigeration system with various refrigerants mixture of R152a, RE170, R600a, and R290 were done for various mixture ratios and their results were compared with R134a as possible alternative replacement. The results showed that all of the alternative refrigerants investigated in the analysis except R431A, [R 152a (29%), R290 (71%)] have a slightly higher performance coefficient (COP) than R134a for the condensation temperature of 500C and evaporating temperatures ranging between -300C and 100C. The effects of the main parameters of performance analysis such as refrigerant type, degree of sub cooling and super heating on the refrigerating effect, coefficient of performance and volumetric refrigeration capacity were also investigated for various evaporating temperatures. refrigerant blend R435A [RE170 (80%), R152a (20%)] were found to be the most suitable alternative among refrigerants tested for R134a.

4.Ashish kumar paharia et al :

This paper presents performance of three hydroflurocarbon (HFC) refrigerants (R-410A, R-507A, R-407C) selected to replace R-22 in a vapour compression refrigeration system using thermodynamic simulation. The result showed that R-410A and R-407C have thermodynamic performance similar to R-22 and R-410a has slightly lower coefficient of performance (COP), higher refrigerating capacity than R-22. And also the main Environmental impacts of ozone layer depletion and global warming, refrigerant R410-A and R407-C are found to be the most suitable alternatives refrigerants to refrigerant R-22.

5.Gulshan sachadev et al :

In the present paper, the performance of alternative refrigerants is compared to find the substitute of R-22 which is widely used hydrochlorofluorocarbon refrigerant. These alternative refrigerants such as R-134A, R-410A, R-407C and M-20, which are eco-friendly. From comparison of performance parameters of different alternative refrigerants , came to know that R-407C has the potential to replace R-22 with minimum investment, eco-friendly and less efforts.

6.A.baskaran et al :

Performance analysis on a vapour compression refrigeration system of R-134a with various eco-friendly refrigerants of HFC-152a, HFC -32, HC-290, HC-1270, HC-600a and RE-170 for a possible alternative replacement. The results showed that RE-170 has a slightly higher performance coefficient than R-134as for condensation temperatures of 50°C and evaporating temperature ranging between -30°C to 10°C.

The performance coefficient of the system (COP) increases with increase in evaporating temperature for a constant condensing temperature in the analysis.

7.Hadya*et al

This paper presents the comparision of performance of three refrigerants R22,R410 & R32 by stimulated results of VCR system with subcooling & superheating by comparing refrigerants R410 and R12 with R32,R32 yields 7.34% & 36% higher COP.For same operating temperature & pressure the cooling capacity for R32 is higher than the R22 refrigerant.

8.Mr.Pankaj Pandey * et.al

Manufacturers to meet the challenges of higher efficiency and the environmental responsibility while keeping their system affordable.In present research study a refrigerant property dependent thermodynamic model of a simple reciprocating system,which can stimulate the performance of actual system as closely as possible,has been used to compare the characteristics of various refrigerants [R22,R134a,R410A and R407C] used by world.By considering constrains like ozone depution,efficiency improvement in this paper,R407 can be potential HFC refrigerant replacement for new and existing systems presently using R22 with minimum investment.

9.James M.Calm *

The present research study deals with evolution of refrigerant generations.According to the improvement in refrigerant requriments,evolution is done in four refrigerant generation

First generation (1830 – 1930S) :

Moto : Whatever worked

Refrigerants : etheis,CO_2,NH_3 SO_2,$HCOOCH_3$,HCs,H_2O,CCl_4,CHc's......

Second generation (1931 – 1990S):

Moto: safety and durability

Refrigeration: CFc's,HCFc,s,HFc's,NH_3,H_2O......

Third generation (1990 -2010S):

Moto: ozone protection

Refrigeration: (HCFC'S), HFCs,NH_3,H_2O, ...

Fourth generation (2010-till now)

Moto: Zero/low ODP, low GWP, short T atm, high efficiency

10.Abdullah A.A.A. Al-Rashed :

This paper presents a comparable evaluation of R600a (isobutane), R-290 (propane), R-134a, R-22, for R-410A, and R-32 an optimized finned-tube evaporator, and analyzes the evaporator effect on the system coefficient of performance (COP) The exception to this was R-290, whose COP was better than that of R-22 by approximately 3% due to a set of favorable thermo physical properties. The condensing and evaporating temperatures used in this study correspond to the comfort cooling application.

11.Atilla gencer devecioglua et al :

In the present study, a comparison was considered about some characteristics of new generation low GWP value gases most of which are at the trial stage. Hydrofluoro-olefin (HFO) based mixed gases having low GWP value were investigated as alternatives to different four refrigerants used commonly in refrigerating and air conditioning equipments. In the study, R450A, R513A, R1234yf and R1234ze(E) gases were used instead of R134a; DR-33, L40, DR-7 and R448A were used instead of R404A; DR-5 and R447A were used instead of R410A; and N20 and R444B refrigerants were used as alternatives to R22. Although they have some differences in terms of energy parameters, it can be stated that R1234yf, L40, DR-5 and R444B refrigerants can be good alternatives to R134a, R404A, R410A and R22, respectively.

12.M.R.Braun et al :

This hypothesis was studied with a simple equation relating this coefficient to the coefficient of system performance (*COSP*), and with software model based on an R404A refrigeration system installed in a supermarket in north east England. In both approaches the condenser fan power usage was excluded from the

COP but included in the *COSP*. This approach was implemented in the Matlab model with an estimated energy reduction of 4.5% for the six month data set.

13.Vaibhav Jain et al :

In the present research study a refrigerant property dependent thermodynamic model of a simple reciprocating system, which can simulate the performance of actual system as closely as possible, has been used to compare the characteristics of various refrigerants [R22, R134a, R410A, R407C and M20] used by world manufacturers to meet the challenges of higher efficiency and environmental responsibility while keeping their system affordable. Considering the recent trends of replacement of ozone depleting refrigerants and improvement in system efficiency, in the present study, R407C can be a potential HFC refrigerant replacement for new and existing systems presently using R22 with minimum investment and efforts.

CHAPTER-3

3. Problem formulation:

Paper(13)

This paper represents comparative performance study of vapour compression refrigeration system with environmentally eco friendly hydrocarbon refrigerants R22/R134a/R410A/R407C/M20 in the airconditioning applications. Considering the recent trends of replacement of ozone depleting refrigerants and improvement in system efficiency,in the present study,R407C can be potential HFC refrigerant replacement for new and exciting systems presently using R22 refrigerant.

Paper(8)

Performance analysis of ice plant using Ecofriendly hydrocarbon refrigerants R134a ,R410A and R407C. In this paper the calculations have been carried out for two different situations

Evaporation temperature -10°C

Evaporation temperature 5°C

Statement of problem

Comparative performance of a vapour compression refrigeration system by using different ecofriendly hydrocarbon refrigerants. As a part of this objective the effect of evaporator temperature,condenser temperature,subcooling and super heating on the vapour compression cycle on the performance parameters like refrigeration effect,work of compression and coefficient of performance are studied.

3.1 Statement of problem

Comparative performance of a vapour compression refrigeration system by using different refrigerants. As a part of this objective the effect of evaporator temperature,condenser temperature,subcooling and super heating on the vapour compression cycle on the performance parameters like refrigeration effect,work of compression and coefficient of performance are studied.

Assumptions

Evaporature temperature-- -20°C

Condenser temperature-- 50°C

Considered Mass flow rate per kg

All the thermodynamic process are considered as reversiable

The refrigerants are R134a,R600a,R410A,R404A,R407C and R507A

3.2 Energy calculations

Compressor

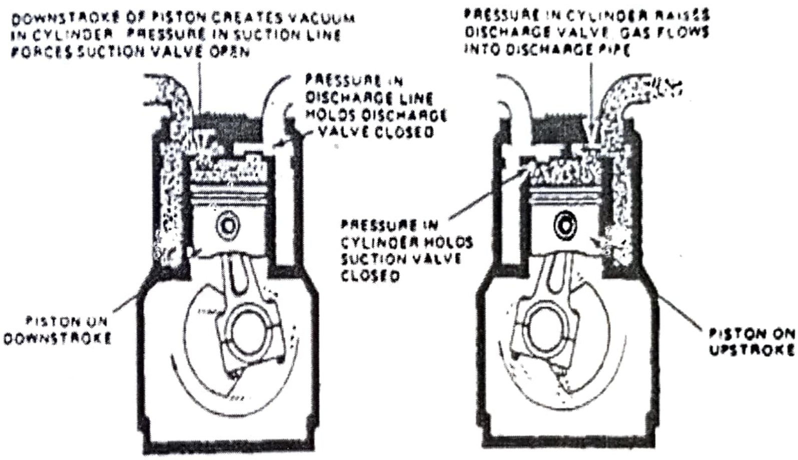

Fig 3.1 compressor

Work of compression (wc) = $m(h_1 - h_2)$ kJ

Condensor :

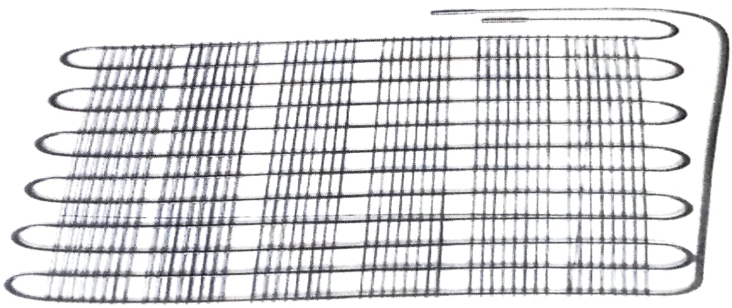

Fig 3.2 condenser

heat rejection (Qr) = $m(h_2 - h_3)$ kJ

Evaporator

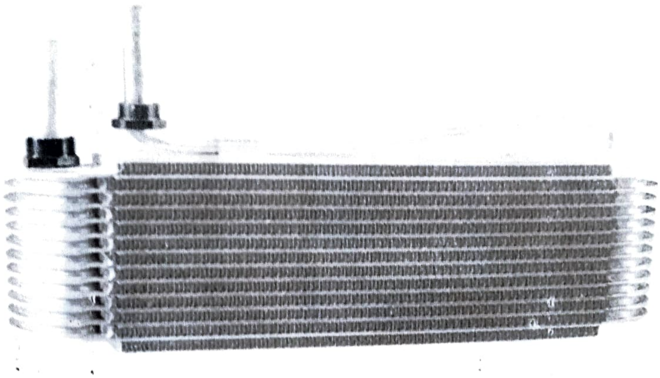

Fig 3.3 Evaporator

Heat absorbed (Q) = $m(h_1 - h_4)$ kJ

Expansion valve

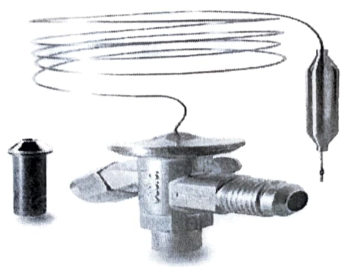

Fig 3.4 Expansicn valve

Enthalpy is constant $h_3 = h_4$

3.3 calculation procedure

1-2 Isentropic compression ; $S_1 = S_2$

$W = -\int vdp = -\int dh = -(h_2 - h_1)$

2-3 : Condensation: P = constant

$q = h_2 - h_3$

3-4 : Isenthalpic expansion : $h_3 = h_4$

4-1 : Evaporation: P_o=const

Refrigerating effect $q_o = h_1 - h_4$

h_1=specific enthalpy at the inlet of compressor (kJ/kg)

h_2=specific enthalpy at the outlet of compressor (kJ/kg)

h_3=specific enthalpy at the outlet of condenser

h_4=specific enthalpy at the inlet of evaporator

COP= Refrigeration effect/compressor work

$N/W = h_1 - h_4 / h_2 - h_1$

1)First initially fix the evaporator temperature. The evaporator temperature depends on the temperature of the storage/application.

Evaporator temperature = -20℃

2) Fix the condenser temperature which depends upon the atmospheric temperature therefore condenser temperature is taken more than the atmospheric temperature.

Condenser temperature = 50℃

3.4 Effect of evaporator temperature

For refrigenrant R-134a

At -20°C

$P = 0.13299$Mpa

$H_f = 24.26$KJ/Kg

$H_{fg} = 211.05$KJ/Kg

$H_g = 235.31$KJ/Kg

$S_f = 0.0996$KJ/Kg

$S_g = 0.9332$KJ/Kg

At -0°C

$p = 1.33$mpa

$H_f = 121.46$KJ/Kg

$H_{fg} = 150.995$KJ/Kg

$H_g = 272.46$KJ/Kg

$S_f = 0.43375$KJ/Kg

$S_g = 0.90105$ KJ/Kg

$C_{pf}=1.56$[illegible] KJ/Kgk

$C_{pg}=1.246$ KJ/Kgk

from graphs

refrigeration effect=113 KJ/Kg

work of compression=52 KJ/Kg

cop=2.2

REFRIGERANT R134a

enthalpys

$h_1 = h_g$ at $-20°C$

$= 235.31\ kJ/kg$

$S_1 = S_2$

$S_1 = S_g$ at $-20°C$

$= 0.9332$

$$S_1 = S_g + C_p \ln\left(\frac{T_{sup}}{T_{sat}}\right)$$

$$0.9332 = 0.901 + 1.2 \ln\left(\frac{T_{sup}}{50+273}\right)$$

$T_{sup} = 331.77\,k = 58.77°C$

$h_2 = h_g + C_p(T_{sup} - T_{sat})$

$h_2 = 272.46 + 1.2\ (58.77 - 50)$

$= 283.3\ kJ/kg$

$h_3 = h_4 = h_f$ at $50°C = 121.46\ kJ/kg$

refrigeration effect $(N) = h_1 - h_4$

$= 235.31 - 121.46$

$= 113.85\ kJ/kg$

work of compression $(W) = h_2 - h_1$

$= 283.98 - 235.31$

$= 49.67\ kJ/kg$

$cop = \frac{N}{W}$

$= 2.27$

TYPE OF REFRIGERANT	REFRIGERATION EFFECT				
	-20°C	-15°C	-10°C	-5°C	0°C
R 507A	70	74	78	82	84
R 404A	75	79	81	87	89
R 134a	113	117	119	123	126
R 407c	118	121	124	127	130
R 410A	128	129	130	133	135
R 600a	208	213	219	227	233

TYPE OF REFRIGERANT	WORK OF COMPRESSION			
	-20°C	-15°C	-10°C	0°C
R 507A	44	38	27	22
R 404A	45	40	29	22
R 134a	52	46	36	31
R 407c	57	51	40	33
R 410A	61	54	41	35
R 600a	98	91	71	61

TYPE OF REFRIGERANT	COP				
	-20°C	-15°C	-10°C	-5°C	0°C
R410A	2.1	2.4	2.7	3	3.9
R600A	2.1	2.3	2.7	3.2	3.8
R-134a	2.2	2.5	2.8	3.4	4
R-407C	2.1	2.4	2.7	3	3.9
R-404A	1.6	2	2.3	3.2	4
R-507A	1.6	2	2.4	3	3.8

Table 4.1 Effect of evaporator temperature on parameters

3.5 Effect of condenser temperature

Condenser temperature=45°C

Evaporator temperature= -20°C

Temperature = 45°C

H_f = 112.32 KJ/Kg

H_g = 272.40 KJ/Kg

S_g = 0.9026 KJ/Kg

C_p = 1.192 KJ/Kg

From the graphs

from graphs

refrigeration effect=122 KJ/Kg

work of compression=46 KJ/Kg

cop =2.65

Effect of superheating

Condenser temperature = 50°C

Evaporator temperature = -10°C

Degree of superheating = 5°C

from graphs

Refrigeration effect=122 KJ/Kg

work of compression= 50 KJ/Kg

cop=2.44

Effect of condenser temperature

REFRIGERANT R134a

enthalpys

$h_1 = h_g$ at - 20°C

$= 235.31 \ kJ/kg$

$S_1 = S_2$

$S_1 = S_g$ at - 20°C

$= 0.9332$

$$S_1 = S_g + C_p \ \ln\left(\frac{T_{sup}}{T_{sat}}\right)$$

$$0.9332 = 0.9026 + 1.18 \ \ln\left(\frac{T_{sup}}{45+273}\right)$$

$T_{sup} = 326.6k = 53.30°C$

$h_2 = h_g + C_p(T_{sup} - T_{sat})$

$h_2 = 272.46 + 1.218\ (53.30 - 45)$

$= 282.70 \ kJ/kg$

$h_3 = h_4 = h_f$ at $45°C = 121.32 \ kJ/kg$

refrigeration effect $(N) = h_1 - h_4$

$= 235.31 - 112.32$

$= 122.99 \ kJ/kg$

work of compression $(W) = h_2 - h_1$

$= 282.7 - 235.31$

$= 47.4 \ kJ/kg$

$$cop = \frac{N}{W}$$

$= 2.6$

TYPE OF REFRIGERANT	WORK OF COMPRESSION(KJ/KG)				
	50°C	45°(	40°C	35°C	30°C
R410A	61	58	55	49	41
R600A	98	92	89	81	70
R-134a	52	46	44	41	39
R-407C	57	53	49	45	41
R-404A	45	43	41	37	34
R-507A	44	42	40	37	34

TYPE OF REFRIGERANT	REFRIGERATION EFFECT(KJ/KG)				
	50°C	45°C	40°C	35°C	30°C
R410A	128	137	145	156	166
R600A	208	219	231	259	279
R-134a	113	122	129	137	144
R-407C	118	127	137	145	153
R-404A	75	88	95	105	115
R-507A	70	79	88	98	104

TYPE OF REFRIGERANT	COP				
	50°C	45°C	40°C	35°C	30°C
R410A	2.1	2.4	2.6	3.2	4.1
R600A	2.1	2.4	2.6	3.2	4
R-134a	2.2	2.7	3	3.3	3.7
R-407C	2.1	2.4	2.8	3.2	3.7
R-404A	1.6	2.1	2.3	2.8	3.4
R-507A	1.6	1.9	2.2	2.7	3.1

Table 4.2 Effect of condenser temperature on parameters

TYPE OF REFRIGERANT	WORK OF COMPRESSION				
	-20°C	-15°C	-10°C	-5°C	0°C
R 50 'A	44	43	42	31	24
R 404A	45	42	44	43	45
R 134a	52	50	50	52	53
R 407c	57	50	53	43	63
R 410A	61	58	65	67	76
R 600a	98	93	96	90	90

TYPE OF REFRIGERANT	REFRIGERATION EFFECT126				
	-20°C	-15°C	-10°C	-5°C	0°C
R 507A	70	77	82	88	92
R 404A	75	80	84	89	92
R 134a	113	117	122	126	131
R 407c	118	126	129	132	137
R 410A	128	132	136	143	146
R 600a	208	217	222	231	239

TYPE OF REFRIGERANT	COP				
	-20°C	-15°C	-10°C	-5°C	0°C
R 507A	1.6	1.8	2	2.8	3.8
R 404A	1.6	1.9	1.9	1.9	2.1
R 134a	2.2	2.3	2.4	2.6	2.7
R 407c	2.1	2.5	2.4	3.1	2.2
R 410A	2.1	2.3	2.1	2.1	1.9
R 600a	2.1	2.3	2.3	2.6	2.7

Table 4.3 Effect of superheating on parameters

3.7 Effect of subcooling

Condenser temperature = 50°C

Evaporator temperature = -20°C

Degree of subcooling = 5°C

from graphs

Refrigeration effect=121 KJ/Kg

work of compression= 52 KJ/Kg

cop=2.32

REFRIGERANT R134a

enthalpys

$h_1 = h_g$ at - 20°C

$= 235.31 \ kJ/kg$

$h_2 = 283.3 \ kJ/kg$

$h_3 = h_3^1 - C_p(T_3^1 - T_3)$

$h_3^1 = 121.45 \ kJ/kg \ at \ 50°C$

$h_3 = 121.45 - 1.566(50 - 45)$

$h_3 = h_4 = 13.62 \ kJ/kg$

refrigeration effect $(N) = h_1 - h_4$

$= 235.31 - 113.62$

$= 121.69 \ kJ/kg$

work of compression $(W) = h_2 - h_1$

$= 283.3 - 235.31$

$= 49.67 \ kJ/kg$

$cop = \frac{N}{W}$

$= 2.4$

TYPE OF REFRIGERANT	REFRIGERATION EFFECT(KJ/KG)				
	50°C	45°C	40°C	35°C	30°C
R410A	128	137	146	156	169
R600A	208	220	231	239	257
R-134a	113	121	130	136	144
R-407C	118	128	139	144	158
R-404A	75	87	95	104	113
R-507A	70	81	88	98	106

TYPE OF REFRIGERANT	WORK OF COMPRESSION(KJ/KG)				
	50°C	45°C	40°C	35°C	30°C
R410A	61	61	61	61	61
R600A	98	98	98	98	98
R-134a	52	52	52	52	52
R-407C	57	57	57	57	57
R-404A	45	45	45	45	45
R-507A	44	44	44	44	44

TYPE OF REFRIGERANT	COP				
	50°C	45°C	40°C	35°C	30°C
R 134a	2.2	2.3	2.5	2.6	2.8
R 407c	2.1	2.2	2.4	2.5	2.8
R 410A	2.1	2.3	2.4	2.6	2.7
R 600a	2.1	2.2	2.4	2.4	2.6
R 404A	1.6	1.9	2.1	2.3	2.5
R 507A	1.6	1.9	2	2.2	2.4

Table 4.4 Effect of subcooling on parameters

CHAPTER-4

4. Results and discussions:

4.1 Effect of Evaporator temperature :

4.1.1 On refrigeration effect

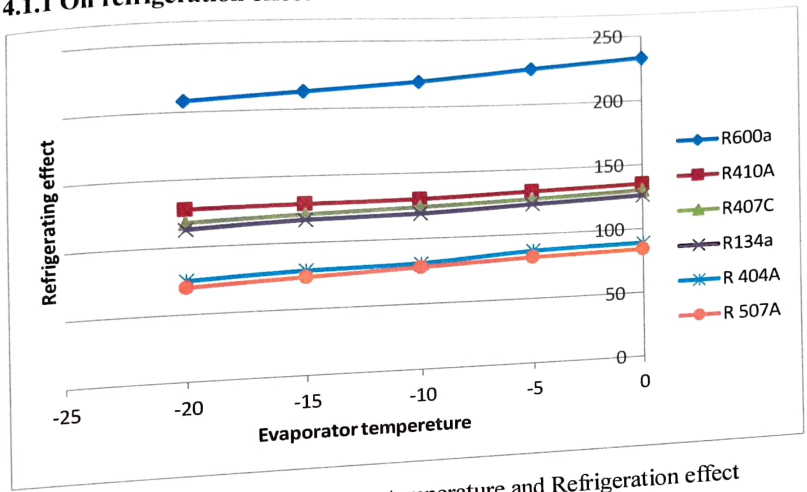

Fig 4.1 Graph between Evaporator temperature and Refrigeration effect

From the graph Refrigerant R600a has higher refrigeration effect than the remaining refrigerants at evaporative temperature from -20°C to 0°C.

Refrigerants R410A,R407C have higher refrigeration effect when compared with the refrigerant R134a.

At evaporator temperature 0°C the difference in refrigeration effect of the refrigerants R134a,R410A and R407C is very small. But at 20°C these refrigerants have some significant difference.

The refrigerants R507A and R404A have small difference of refrigeration effect at evaporator temperature from -20°C to 0°C and these refrigerants have lower value of refrigeration effect when compared to remaining refrigerants.

The refrigerant R600a at 0°C have higher difference of refrigeration effect than temperature at -20°C.

4.1.2 On work of compression

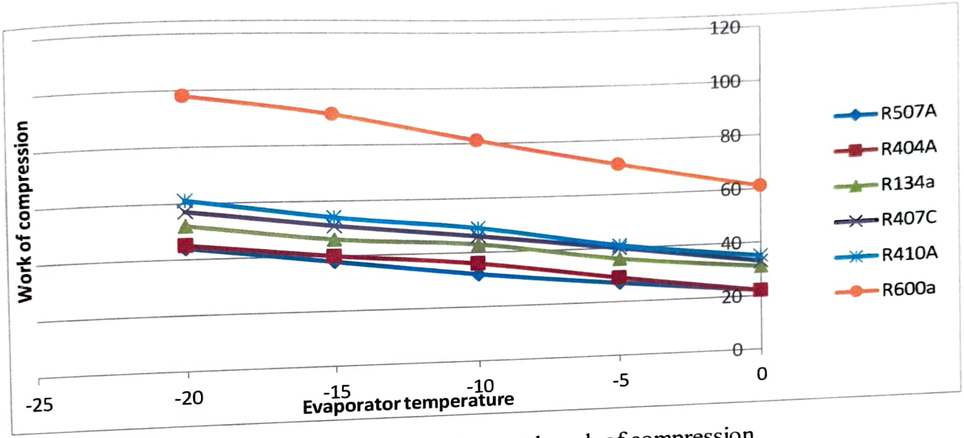

Fig 4.2 Graph between evaporator temperature and work of compression

The refrigerant R600a has higher work of compression than the other refrigerants from evaporative temperature -20°C to 0°C.

The refrigerants R507A and R404A have lower work of compression when compared with the other refrigerants in between the given evaporator temperatures.

The refrigerants R507A and R404A have same work of compression at evaporator temperature -20°C and 0°C. But have small difference at the -10°C.

The refrigerant R600a at 0°C have lower difference of work of compression than the temperature at -20°C.

4.1.3 On COP

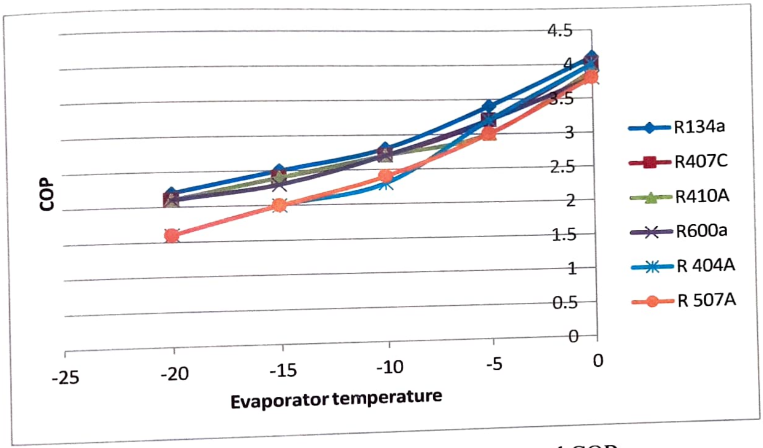

Fig 4.3 Graph between evaporator temperature and COP

The refrigerant R134a has higher coefficient of performance than the other refrigerants from evaporative temperature -20°C to 0°C.

The refrigerants R600a,R407C and R410A have very small difference of COP at the 0°C and -20°C.

At evaporator temperature -20°C the refrigerants R507A and R404A have lower equal COP.

At evaporator temperature 0°C the refrigerants R134a,R600a,R410A and R407C have very small difference in COP.

4.2 Effect of condenser temperature:

4.2.1 On refrigerating effect

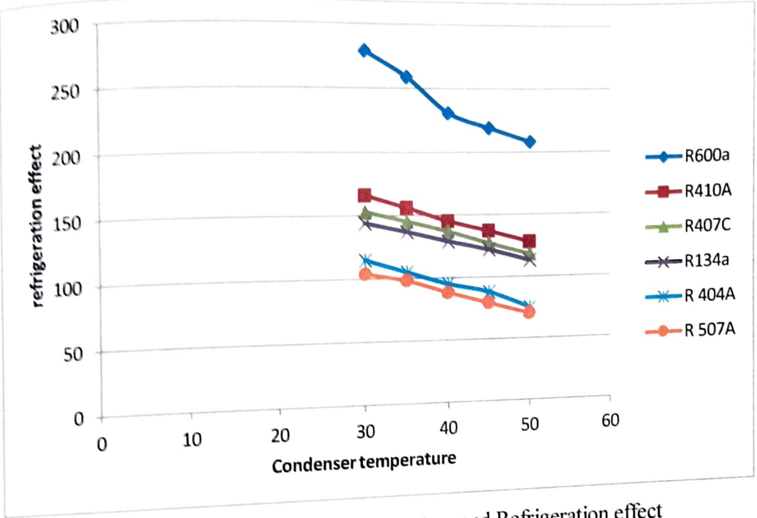

Fig 4.4 Graph between Condenser temperature and Refrigeration effect

From the graph Refrigerant R600a has higher refrigeration effect than the remaining refrigerants at condenser temperature from 50°C to 30°C.

Refrigerants R410A,R407C have higher refrigeration effect when compared with the refrigerant R134a.

The refrigerant R507A has lower refrigerating effect when compared to the remaining refrigerants.

At condenser temperature 50°C the difference in refrigeration effect of the refrigerants R134a,R410A and R407C is very small. But at 20°C these refrigerants have some significant difference.

If the condenser temperature decreases from 50°C the difference of refrigeration effect increases between these refrigerants.

4.2.2 On work of compression:

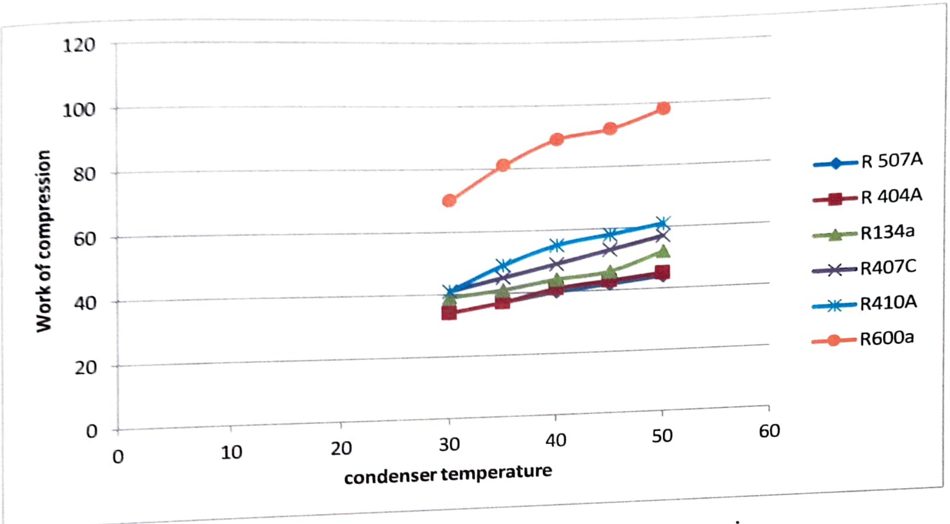

Fig 4.5 Graph between Condenser temperature and work of compression

The refrigerants R507A and R404A have lower work of compression when compared with the other refrigerants in between the given condenser temperatures.

The refrigerant R600a has higher work of compression than the other refrigerants at condenser temperature from 30°C to 50°C.

At condenser temperature 30°C the difference of work of compression of the refrigerants R134a,R410A and R407C is very small. But at 50°C these refrigerants have some significant difference.

The refrigerants R507A and R404A have same work of compression at the condenser temperature 30°C and 50°C and in middle have some small amount of work of compression.

If the condenser temperature decreases from 50°C the difference of work of compression decreases between these refrigerants.

4.2.3 ON COP:

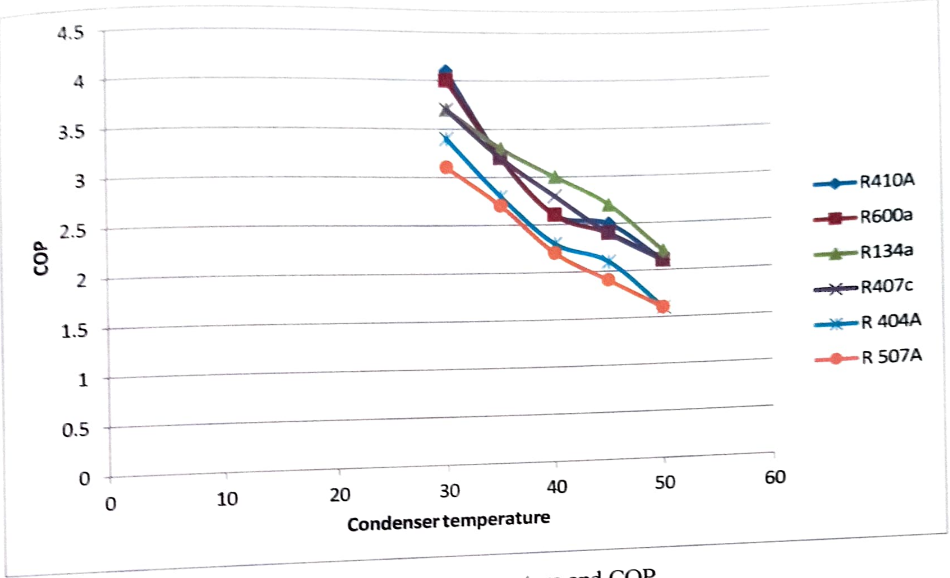

Fig 4.6 Graph between Condenser temperature and COP

The refrigerants R600a and R410A have higher coefficient of performance at the condenser temperature 30°C when compared with the remaining refrigerants.

The refrigerant R134a has higher COP value at the condenser temperature in between 35°C to 50°C when compared with the remaining refrigerants.

The difference in COP of the refrigerants R410A,R600a,R134a and R407C at the condenser temperature 50°C is very small but at 30°C some significant difference between them.

The refrigerant R507A has lowest COP value between the given condenser temperature when compared with the remaining refrigerants.

The refrigerants R507A and R404A have lowest value of COP at the condenser temperature 50°C.

4.3 Effect of Degree of sub cooling:

4.3.1 On refrigeration effect

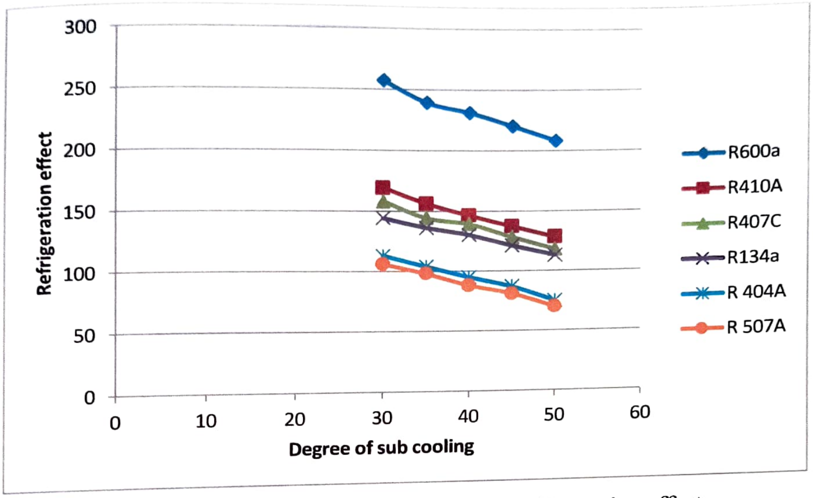

Fig 4.7 Graph between Degree of subcooling and Refrigeration effect

From the graph Refrigerant R600a has higher refrigeration effect than the remaining refrigerants in degree of sub cooling at degree of subcool is 5°C.

The refrigerant R507A has lower refrigeration effect than the remaining refrigerants in degree of sub cooling.

At the starting of degree of subcooling the difference in refrigeration effect between the refrigerants R410A,R407C and R134a is very low. But refrigeration effect increases with the degree of subcooling.

4.3.2 On work of compression

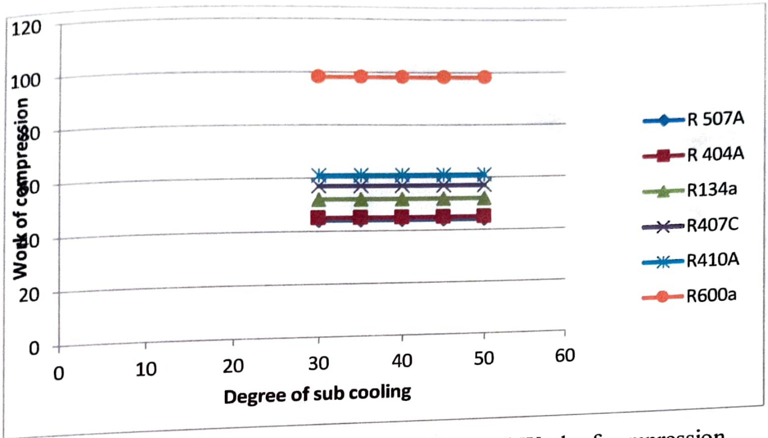

Fig 4.8 Graph between Degree of subcooling and Work of compression

The refrigerants R507A and R404A have lower work of compression when compared with the other refrigerants in degree of subcooling at degree of subcool is 5°C. At the starting and ending of the subcooling the refrigerants R507A and R404A have same work of compression but very small difference in between sub cooling. The refrigerant R600a has higher work of compression than the other refrigerants in degree of subcooling.

4.3.3 On COP

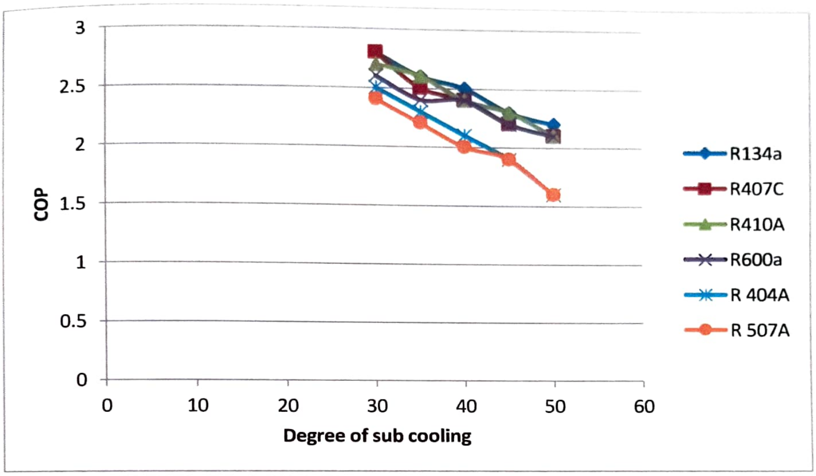

Fig 4.9 Graph between Degree of subcooling and COP

The refrigerant R134a has higher COP value at the starting of the degree of subcooling at 50°C.

The refrigerant R407C has higher COP value at the end of degree of subcooling at temperature 30°C.

The difference in COP value of the refrigerants R134a,R407C,R410A and R600a at the starting of the degree of subcooling at 50°C is very small but at the end of process have some significant difference in cop value.

The refrigerants R507A has lower COP value than compared with other refrigerants.

4.4 Effect of superheating:

4.4.1 On refrigeration effect

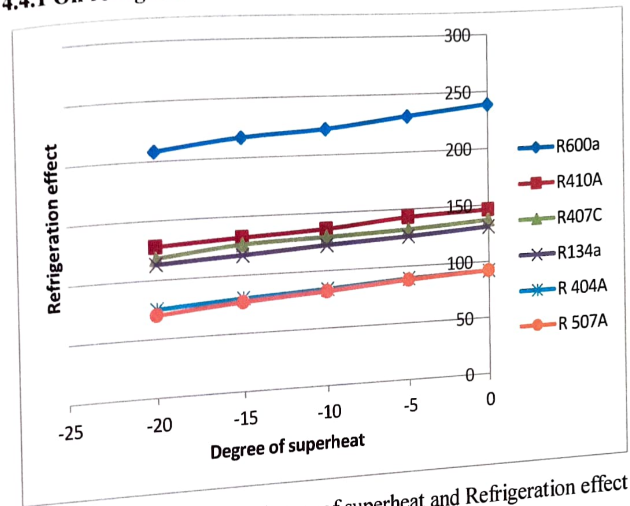

Fig 4.10 Graph between degree of superheat and Refrigeration effect

From the graph Refrigerant R600a has higher refrigeration effect than the remaining refrigerants in degree of superheating at degree of superheat is 5°C.

The refrigerant R507A has lower refrigeration effect than the remaining refrigerants in degree of superheat.

At the starting of degree of superheat the difference in refrigeration effect between the refrigerants R410A,R407C and R134a is very low at the starting and ending of the superheating.

The refrigerant R600a at 0°C have higher difference of refrigeration effect than temperature at -20°C in degree of superheating process.

4.4.2 On work of compression

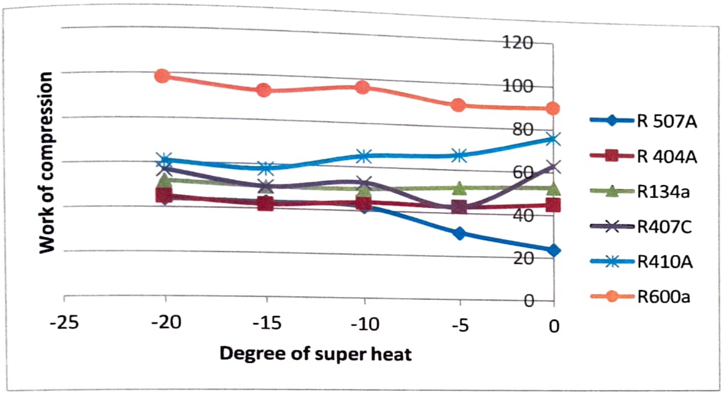

Fig 4.11 Graph between degree of superheat and Work of compression

The refrigerants R507A and R404A have lower work of compression than compared with remaining refrigerants in degree of super heating.

At the starting of degree of super heating at temperature -20°C refrigerants R404A and R507A have same work of compression but at temperature 0°C have some difference between them.

The refrigerant R600a has higher work of compression than the other refrigerants in degree of superheating.

At the starting of degree of superheat the difference in work of compression between the refrigerants R410A,R407C and R134a is very low and at the end of superheating have some significant difference.

4.4.3 On COP

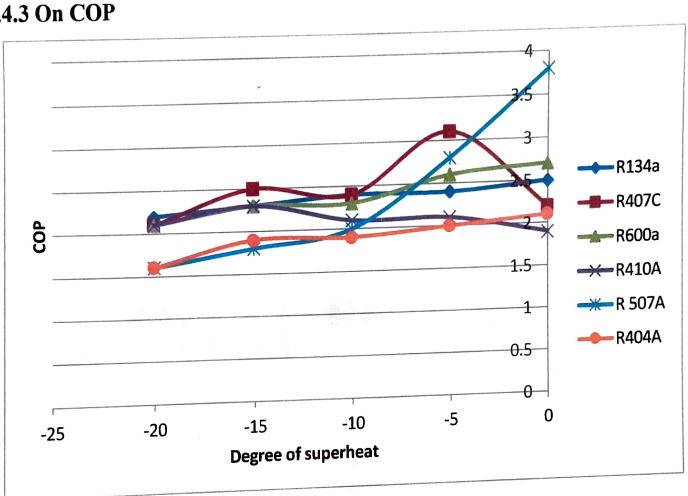

Fig 4.12 Graph between degree of superheat and Work of compression

The degree of super heating at -20°C the refrigerant R134a has higher COP value than the remaining refrigerants.

The degree of super heating at 0°C the refrigerant R507A has higher COP value than the remaining refrigerants.

The refrigerant R407c has higher COP value in degree of superheating at the temperatures in between the -15°C and -5°C.

CHAPTER-5

5. Conclusion:

Comparative performance study of vapour compression refrigeration system with can make a concluded that

The refrigerant R600a has higher refrigeration effect than remaining refrigerants under all operating conditions of the refrigeration system.

By comparing with refrigerant R134a the refrigerants R600a,R410A and R407C have higher refrigeration effect.

The refrigerants R507A and R404A have lower compression work than than remaining refrigerants under all operating conditions of the refrigeration system.

By comparing with refrigerant R134a the refrigerants R507A and R404A have lower power input required under all operating conditions.

5.1 Future scope:

Exergy analysis on vapour compression refrigeration system with under operating working conditions.

CHAPTER-6

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