A Novel Approach Vapour Compression Refrigeration System

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Abstract: Most of the early refrigerant materials have been discarded for safety reasons or for lack of chemical or thermal stability. In the present days, many new refrigerants including halo carbon compounds, hydro carbon compounds are used for air conditioning and refrigeration application. CFC's have been identified as the prime and fore most cause of ozone depletion. So they have not given much preference in substitute or above CFC's and HFC's.Several azeotropic mixing refrigerants like R502, R404A and 507A are the best working substances for low temperature vapour compression plants.The main objective of the project was performance analysis of simple vapour compression refrigeration system by using three refrigerants viz., R502, R404A and 507A.the performance of each refrigerant have been found individually and the results were used to evaluate and compare the following performance criteria: coefficient of performance (COP) compressor power, mass flow rate and condenser heat rejection. The analysis was for evaporator and condenser temperature in the range of -30˚C to 0˚C and 40˚C to 55˚C respectively. The characteristics for all the above refrigerants are taken for various parameters which are required for calculating the performance.By comparing the performance values from theoretical analysis, among all three refrigerants, which one is the best suitable for Vapour Compression Refrigeration system was selected.

Keywords:CFC (Chlorofluorocarbons), HCFC(Hydro chlorofluorocarbons), Total equivalent warming impact (TEWI).

I. INTRODUCTION

The refrigerant is a heat carrying medium which during their cycle (Compression, condensation, expansion and evaporation) in the refrigerant system absorb heat from a low temperature system and discard the heat so absorbed to a high temperature system.The natural ice and a mixture of ice and salt were the first refrigerants. In either 1834 ammonia, Sulphur dioxide, Methyl chloride, carbon dioxide came into use as refrigerants in compression cycle refrigeration machines. Most of the early refrigerant materials have been discard for a safety reasons or for a lack of chemical or thermal stability. In the present days, many new refrigerants including Halocarbon compounds are used for air conditioning and refrigeration applications.

(A). Vapour compression refrigeration system:

In this system instead of air, vapours like Ammonia, Carbon Dioxide, and Sulphur dioxide are used as working fluids. Heat carried away by the vapour in the refrigerator isIn the form of latent heat refrigerant. So the capacity of refrigeration of vapour refrigeration system per kg of refrigerant is far superior to the air refrigeration system. The refrigerant vapour is sucked in to the compressor and is compressed by adding the energy in the form of work to increase its thermal level above atmosphere.

(B). Vapour absorption Refrigeration System: It is similar to vapour compression refrigeration system except in the manner in which external heat is added to the vapourized refrigerant to increase the thermal level above atmosphere, which is necessary to reject the heat in the condenser. In vapour absorption system, a working fluid is taken which has high affinity to dissolve in water. The refrigerant is Commonly Used is Ammonia. The liquid strong in ammonia, is heated further by external heat to generate vapour and its temperature is increased above atmospheric temperature.

II.CLASSIFICATION OF REFRIGERANTS

Primary Refrigerants:

Primary refrigerants directly take part in the refrigeration system while secondary refrigerants are first cooled with the help of primary refrigerants and are then used for cooling purpose.

The classification of primary refrigerants is as follows:

(a). Halo-carbon compounds

This group includes refrigerants, which contain one or more of three halogens chlorine, fluorine and bromine. The most of refrigerants used for domestic, commercial and industrial purposes are selected from this group due to their outstanding advantages over the refrigerants from other group.

(b). Azeotropes

The refrigerants under this group consist of mixtures of different refrigerants, which do not separate into their components with the changes in pressure or temperature or both. They have fixed thermodynamic properties ex. R-500 which contains 73.8% R-12and26.2%R-152.

(c). Hydrocarbons

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

(d).Inorganic Compounds

This group was used for all purposes before the introduction of halo-carbon group. They are still used for different purposes due to their inherent thermodynamic and physical properties.

Secondary Refrigerants:

The secondary refrigerants circuit is commonly used in ail big commercial and industrial refrigeration plants. Secondary refrigerants are air, water and brine. Air, water, sodium chloride brine, calcium chloride brine and propylene glycol are commonly used

1. Thermodynamic Properties

Boiling Point:

The boiling temperature of a refrigerant at atmospheric pressure should be low. If the boiling temperature is high at atmospheric pressure, the compressor should be operated at high vacuum. The high boiling temperature reduces the capacity and operating cost of the system.

Freezing point:

The freezing temperature of a refrigerant should be well below the operating evaporator temperature. Since the freezing temperature of most of the refrigerants is below-35°C this property is taken into consideration only in low temperature operation.

Evaporator and Condenser Pressures

It is always desirable to have positive pressures in evaporator and condenser for the required temperatures, for the pressures should not be too high above atmosphere. Too high pressures require the robust construction of the refrigeration system, which requires high initial cost and high operating cost also.

Critical temperature and pressure

The critical temperature of a refrigerant is the highest temperature at which it can be condensed to a liquid, regardless of a higher pressure. It should be above the highest condensing temperature that might be encountered-If the critical temperature of a refrigerant is too near the desired condensing temperature, the excessive power consumption results.

Latent heat of vaporization

A refrigerant should have a high latent of vaporization at the evaporator temperature. The high latent heat results in high refrigerant effect per kg of refrigerant circulated which reduces the mass of refrigerant to be circulated per ton of refrigeration.

Specific volume

The specific volume of the refrigerant vapor at evaporator temperature (i.e., volume of suction vapor to the compressor) indicates the theoretical displacement of the compressor. The reciprocating compressors are used with refrigerants having high pressures and low volumes of the suction vapor. The centrifugal or turbo compressors are with refrigerants having low pressures and high volumes of suction vapor

2.Chemical properties

Flam inability

Ideal refrigerants should not have any danger of explosion in the presence of air in association with lubricating oil. NHa and CHsCl burn with certain concentrations in air. The refrigerants of hydrocarbon family are highly flammable

Toxicity

The toxicity of refrigerant may be of prime or secondary importance, depending upon the application. Some non-toxic refrigerants (i.e., all fluorocarbon refrigerants) when mixed with certain percentage of air become toxic. CO_2 F-12 are particularly used for marine applications because of non-toxic and non-irritating properties.

Solubility of water

Water is only slightly soluble in R-12. At -18°C it will hold 6ppm by weight. If more water is present than can be dissolved by the refrigerant, ice will be formed which chokes the expansion valve or capillary tube used for throttling in the system

3. Physical properties

Stability and inertness

An ideal refrigerant should not decompose at any temperature normally encountered in the refrigerating system. It should not form higher boiling point liquids or solid substances through polymerization. Some refrigerants disintegrate forming non-condensable gases which causes high condensing pressure and vapor lock. In order to avoid this refrigerant should be inert with respect to all materials used in refrigerating system.

Corrosive property

The corrosive property of a refrigerant must be taken in to consideration while selecting the refrigerant, the Freon group of refrigerants is non – corrosive with practically all metals. Ammonia is used only with iron or steel. Sulphur dioxide is non-corrosive to all metals in absence of waterbecause Sulphur dioxide reacts with water and forms Sulphuric acid

Viscosity

The refrigerant in liquid and vapour states should have low viscosity. The low viscosity of the refrigerant is desirable because the pressure drops in passing through liquid and suction lines are small. The heat transfer through condenser and evaporator is improved at low viscosities

Thermal conductivity

The refrigerant in liquid and vapour state should have high thermal conductivity. This property is required in finding the heat transfer coefficient in evaporators and condensersare different.

ABOUT R-502

The R-502 is an azeotropes mixture of 48.8% R-22 ($CHCLF_2$) and 51.2% of R-15 ($CCLF_2CF_3$).It is a nonflammable, non-corrosive, practically non-toxic liquid. It is a good refrigerant for obtaining medium and low temperatures. It is suitable where temperatures from -18◦C to -51◦C are needed. It is only used with reciprocating compressors. The boiling point of this refrigerant at atmospheric pressure is -46◦ C its evaporating pressure at -15◦C is 2.48 bars and the condensing pressure at 30◦C is 12.06 bar. Its latent heat at -29◦C is 168.6 kJ/kg

The R-502 combines many of the good properties of R-12 and R-22. It gives a machine capacity equal to that of R-22 with just about the condensing temperature of a system using R-12. Since this refrigerant has a relatively low condensing pressure and temperature, therefore it increases the life of compressor valves and other parts

About404A

(R-404A) is non-ozone depleting, near azeotropic blend of HFC refrigerants R-125, R-143a and R-134a

Application:

R-404A is formulated to closely match the properties of R-502, making it useful for a variety of medium and low temperature refrigeration applications. R-404A has been approved by many refrigeration compressor and system manufacturers for use in new refrigeration equipment such as food display and storage cases, cold storage rooms, ice machines, transportation, and process refrigeration

Properties & Performance

R-404A is designed to meet the needs of many new and existing refrigeration systems. R-404A is near azeotropic

HFC refrigerant blend rated A1 by ASHRAE (lowest levels of toxicity and flammability) having zero ozone depletion potential.

Lubrication:

R-404A is immiscible with the traditional lubricants used in R-502 systems. As such, the original oil should be replaced with POE when retrofitting to R-404A and the presence of the old oil should be reduced to 5% or less of the original charge. Failure to do so may result in inadequate oil return or other system problems

About 507A

(R-507A) is a non-ozone depleting, azeotropic blend of HFC refrigerants R-125 and R-143a. R-507 is blended to closely match the properties of R-502, making it a good refrigerant for some medium and most low temperature refrigeration applications

Application:

R-507A is approved by compressor and system manufacturers for use in new refrigeration equipment such as food display and storage cases, cold storage rooms, transportation and process refrigeration.

Properties & Performance:

R-507A is designed to meet the needs of many new and existing refrigeration systems. R-507A is an azeotropic HFC refrigerant blend rated A1 by ASHRAE (lowest levels of toxicity and flammability) having zero ozone depletion potential.

Lubrication:

R-507A is immiscible with the traditional lubricants used in R-502 systems. As such, the original oil should be replaced with POE when retrofitting to R-507A, and the presence of the old oil should be reduced to 5% or less of the original charge. Failure to do so may result in inadequate oil return or other system problems.

III.CRITERIA FOR REFRIGERANTS SELECTION

The following is the criteria when evaluating and selecting refrigerants

- Environmentally, refrigerants must have zero-or low ozone-depletion potential. Global warming should be reviewed from the total equivalent warming impact (TEWI) approach. Therefore, the combined direct Global warming which varies with energy efficiency should be thus than the refrigerants being replaced.
- Safety must be maintained. New refrigerants should be non-toxic and nonflammable. Maximum system pressures must be no greater than current acceptable limits for retrofit applications.
- Reliability concerns require that compressor discharge temperatures not to exceed the temperatures of the refrigerant they are replacing.
- Material compatibility between the new refrigerants, lubricants and materials of construction in compressor and system components must be maintained.
- The performance of new refrigerants should be very similar to the refrigerants, which they are replacing. R-502 for low and medium temperature refrigeration, 'R-12 for medium and high temperature applications, and HCFC-22 for high temperature air conditioning.

Effect Of Refrigerants On Atmosphere:

Green House Effect

The earth is designed in such a way that it keeps everything in equilibrium. Earth is known as green house because it looks green with trees and plantation. It is essential to maintain the earth temperature as well as 0: level. Once the mass balance of oxygen and CO: are disturbed, it affects the atmospheric conditions. Large generating thermal power stations and use of large number of automobiles emits CO: on large scale. With a growth in living standard, the power consumption per capita is continuously increasing. In addition to this, the large cuts of forests have increased CO: content in the atmosphere during last one decade. The excess C02 destroys stratospheric Os (ozone) layer, which protects earth, from entering excess heat of the sun. As *Q$* is reduced in thickness or created void in stratosphere, the excess heat falling on the earth will increase the temperature of the earth and totally disturbs the green earth. This effect of reducing O3 layer is known as GREEN HOUSE EFFECT. Therefore, attention has been given to save the earth from Green House Effect by replacing the conventional Freon group refrigerants

By new emerging refrigerants. CFCs in stratosphere are destroyed by solar ultra violet radiation, thereby releasing chlorine atoms that do react with O3.

Global Warming

$C0_2$, CFCs, chlorine have impact on global environment because all of them belong to a category of chemicals known as green house gases. These gases allow solar radiation to pass through earth atmosphere and maintain a temperature on earth consistent with the needs of living things. However, the presently increased release of CO_2, CFCs into environment will significantly increase the average earth temperature known as Global Warming.

The commonly used parameters that describe the potential of refrigerant on global warming are ozone depletion potential (ODP) and global warming potential (GWP). These parameters not only reflect the capacity of an individual molecule to be a part of ozone depleting or global warming processes, but also the atmospheric life span of the chemicals and horizon of time considered for future O_3 depletion or global warming process.

IV. APPLICATIONS OF REFRIGERATION SYSTEMS

The will to survive is responsible for the progress of mankind has made so far. He had learnt to adapt to his physical surroundings by his strong will and creative ability. In his path of progress he encountered the problem of finding a way, of preserving food during seasons of abundance, in order to live through the seasons of scarcity.

This induced him to discover and develop such methods of food preservation as drying, pickling and salting, until he found that perishables lasted longer, when stored under colder environments. Now he turned his resources in finding a way to lower the temperature of closed space used for storing food stuffs. His patience and determination resulted in the invention of means and methods and methods of achieving this.

The means of producing a low temperature by mechanical methods are quite recent. The first development took place in 1834 when 'Perkins' proposed a hand operated compressing machine working on ether. In 1851 Came George's air refrigeration machine and in 1856 'Linde' developed a machine working on ammonia. The pace of development was slow when steam engines were the only prime movers known to run the compressor. But the advent of electric motors and consequent higher speeds of compressors, the scope of applications of refrigeration widened.

There are several applications which directly or indirectly act towards the betterment of human civilization. The refrigeration applications are grouped in to six general categories and they are discussed in brief.

1. Domestic refrigeration.
2. Commercial refrigeration.
3. Industrial refrigeration.
4. Marine and Transport refrigeration.
5. Air conditioning

Domestic Refrigeration

The final point of storage for most of the food stuff is the house hold refrigeration or freezer, which come under the domestic refrigeration. These units are usually small in size, having power input ratings of between 35W and 375W and are hermetically sealed type.

Commercial Refrigeration

This is concerned with the designing, installation and maintenance of refrigerated fixtures of the type used by retail stores, restaurants, hotels and other institutions, for storing, displaying and processing of perishable commodities of all types

Industrial Refrigeration

This is different from commercial refrigeration by virtue of its size. It require a qualified attendant on continues duty. Some typical examples are, refrigeration is used to reduce the temperature of air to a very low level so as to liquefy and fractional distillation of it to separate it into its constituents, which are used for medical and other industrial purposes. Refrigeration is one way of removing moisture from air, and hence dehumidifying it. This is used in production of high purity Oxygen and in the preparation of pharmaceuticals. De-waxing of crude petroleum is done by lowering the temperature by the means of refrigeration. Refrigeration is also used as a local anesthesia by the world of medicine. It is also used to remove the heat given off, would cause undue expansion and stress the concrete.

Marine And Transport Refrigeration

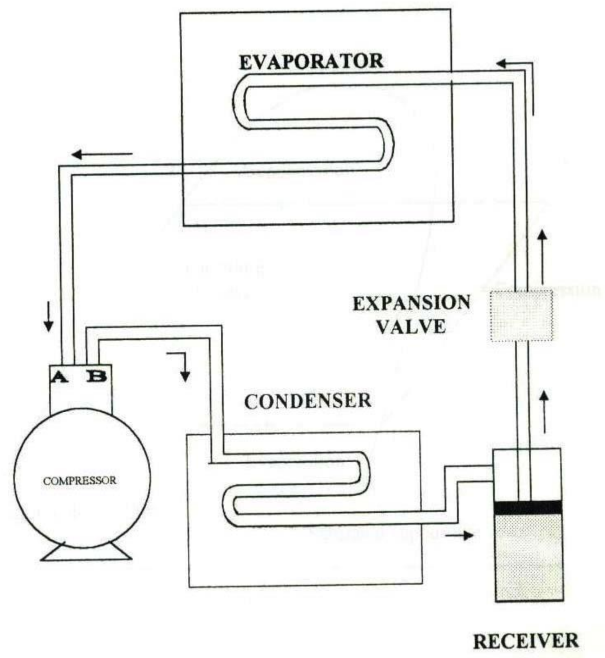
Refrigeration has become a necessity aboard marine vessels for storing fish, for the comfort of passengers and for transporting perishable cargo. Transport refrigeration is concerned with the refrigerating equipment as it is applied to trucks, both long distance and local delivery, and refrigerated railway cars

Air Conditioning

As the name implies, it is concerned with the condition of air in some designated area of space. This involved the control of space temperature, air motion, filtering and cleaning of air. This is divided into comfort and industrial air conditioning. Air conditioning which has as its primary function the conditioning of air for human comfort is called comfort air conditioning e.g. homes, schools, offices, hotels, public buildings automobiles etc. Industrial air conditioning deals with the control of moisture content of hygroscope materials, govern the rate of chemical and biochemical reactions, limit the variations in size of precision manufactured articles as a result of thermal expansion and provides clean and filtered air, which is often essential to trouble free operation and to the production of high quality products.

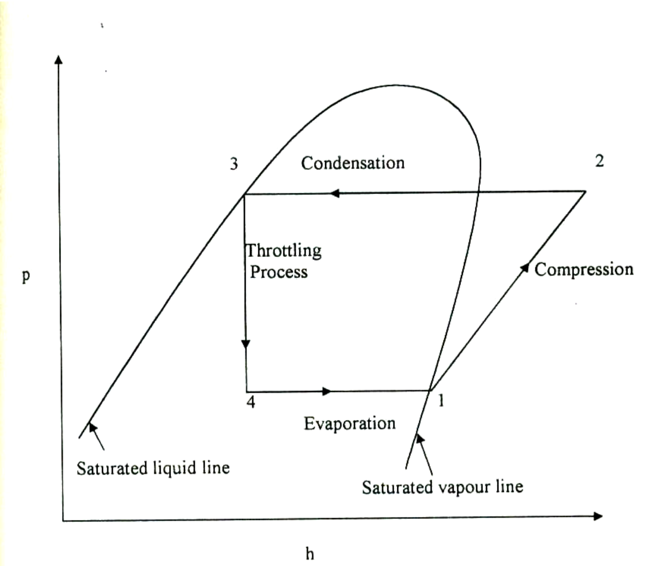
V.VAPOUR COMPRESSION RERIGERATION SYSTEM AND CYCLE

A vapour compression refrigeration system is an improved type of air refrigeration system in which a suitable working substance, termed as refrigerant, is used. Since low pressure vapour refrigerant from the evaporator is changed into high pressure vapour refrigerant in the compressor, it is named as vapour compression refrigeration system. The refrigerant condenses and evaporates at temperatures and pressures close to atmospheric conditions. The refrigerants, usually, used for this purpose are ammonia (NH}), Carbon dioxide (CO_2;) and Sulphur dioxide (SO2). The refrigerant used does not leave the system, but is circulated throughout the system alternately condensing and evaporating. In evaporating, the refrigerant absorbs its latent heat from the brine (brine is used as it has a very low freezing temperature) which is used for circulating it around the cold chamber. While condensing it gives out its latent heat to the circulating water of the cooler. The vapour compression refrigeration system is, therefore a latent heat pump, as it pumps its latent heat from the brine and delivers it to the cooler.



Vapour compression refrigeration system

The vapour compression cycle is shown on p-h diagram



Compression Process:

The vapour refrigerant at low pressure PI and temperature TIis compressed isentropically. For reversible adiabatic or isentropic compression of 1 kg of vapour the shaft work per kg input is given by

$W_c = (h_2\text{-hi})$

Where Wc = shaft work

h_1 = enthalpy of vapour refrigerant at temp T_1, i.e. at the suction of the compressor, and

h_2 = enthalpy of vapour refrigerant at temp T_2, i.e. at the discharge of the compressor.

Condensing Process

The high pressure and high temperature vapour refrigerant from the compressor is passed through the condenser where it is completely condensed at constant pressure $P_2$and temperature T_2. The vapour refrigerant is changed into liquid refrigerant. The refrigerant while passing through the condenser, gives its latent to the surrounding condensing medium.

Expansion Process

The liquid refrigerant at pressure $P_3 = P_2$and temp $T_3 = T_2$ is expanded by throttling process through the expansion valve to a low pressure $P_4 = P_1$and temp $T_4 = T_1$. We have already discussed that some of the liquid refrigerant evaporates as it passes through the expansion valve, but the greater portion is vaporized in the evaporator. We know that during throttling process, no heat is absorbed or rejected by the liquid refrigerant.

Vaporizing Process

The liquid-vapour mixture of the refrigerant at pressure $P_4=P_1$and temperature $T_4=T_1$ is evaporated and changed into vapour refrigerant at constant pressure and temperature. During evaporation the liquid-vapour refrigerant absorbs it latent heat of vapourization from the medium (air, water or brine) which is to be cooled. This heat which is absorbed by the refrigerant is called refrigerating effect and it is briefly written as RE. The process of vapourization continues up to point 1 which is the starting point and thus the cycle is completed.

We know that the refrigerating effect of the heat absorbed or extracted by the vapour refrigerant during evaporation per kg of refrigerant is given by

$R_E= h_1\text{-}h_4$ --- (since $h_3=h_4$)

h_3 = sensible heat temperature Ta i.e. enthalpy of liquid refrigerant leaving the condenser It may be noticed from the cycle that the liquid-vapour refrigerant has extracted heat during the evaporation and the work will be done by the compressor for isentropic compression of the high pressure and temperature vapour refrigerant

Coefficient of Performance

$$\text{C.O.P} = \frac{\text{Refrigerating effect}}{\text{Work done}} = \frac{h_1 - h_4}{h_2 - h_1}$$

Advantages over Air Refrigeration System

- As working cycle is near the Carnot cycle, the C.O.P is high. The C.O.P of vapour cycle lies between 3 and 4 whereas the C.O.P of the air cycle is always less than one.
- Running cost of vapour refrigeration system is only $1/5^{th}$ used on ground level.
- As heat is carried away by the latent heat of vapour, the amount of liquid circulated is less for Ton of Refrigeration, so that the size of evaporator is smaller for same refrigerating effect.
- Just by adjusting the throttle valve of the same unit, the required temperature of the evaporator can be achieved.

Disadvantages

- First investment cost is high.
- The prevention of leakage of the refrigerant is the major problem in Vapour Compression System.

Model Calculations:

Refrigerant: R502

Operating temperature range = -20°C to 40°C

Evaporator Temperature = -20°C

Condenser temperature: 40°C

Enthalpy values:

h_1=345.85kJ/kg;

h_2=368kJ/kg

$h_3=h_4$=254.48kJ/kg

Assuming the capacity= 1TR (3.5KW)

Mass flow rate =

(Capacity in KW)/ (Refrigeration Effect)

= (3.5 KW)/ (345.85-254.48)

=0.0383 kg/s

COP= $(h_1\text{-}h_4)/(h_2\text{-}h_1)$

=4.125

Power consumption=$m_f*(h_2\text{-}h_1)$

=0.848KW

Heat rejection in condenser=$m_f*(h_2\text{-}h_3)$

=4.347KW.

Refrigerant: R404A

Operating temperature range = -20°C to 40°C

Evaporator Temperature = -20°C

Condenser temperature: 40°C

Enthalpy values:

h_1=355kJ/kg;

h_2=398kJ/kg

$h_3=h_4$=260kJ/kg

Assuming the capacity= 1TR (3.5KW)
Mass flow rate =
(Capacity in KW)/ (Refrigeration Effect)
== (3.5 KW)/ (355-260)
=0.0368 kg/s
COP= $(h_1-h_4)/(h_2-h_1)$
=2.209
Power consumption=$m_f*(h_2-h_1)$
=1.582KW
Heat rejection in condenser=$m_f*(h_2-h_3)$
=5.078KW

Refrigerant: R507A

Operating temperature range = -20°C to 40°C
Evaporator Temperature = -20°C
Condenser temperature: 40°C

Enthalpy values:

h_1=351.54kJ/kg;
h_2=376.22kJ/kg
$h_3=h_4$=259.96kJ/kg
Assuming the capacity= 1TR (3.5KW)
Mass flow rate =
(Capacity in KW)/ (Refrigeration Effect)
= (3.5 KW)/ (351.54-259.96)
=0.0382 kg/s
COP= $(h_1-h_4)/(h_2-h_1)$
=3.71
Power consumption=$m_f*(h_2-h_1)$
=0.942KW
Heat rejection in condenser=$m_f*(h_2-h_3)$
=4.441KW

VI.RESULTS

Condenser Temperature is Constant (**T_c =40^{o}C**) and varying evaporator temp. Of 3 refrigerants.

Evaporator temp. (^{o}C)	Ref. mass flow rate kg/sec	Ref. mass flow rate kg/sec	Ref. mass flow rate kg/sec
	R404A	R502	R507A
-30	0.0388	0.0404	0.0407
-25	0.0380	0.0393	0.0394
-20	0.0368	0.0383	0.0382
-15	0.0357	0.0373	0.0371
-10	0.035	0.0364	0.036
-5	0.0343	0.0356	0.0351
0	0.0324	0.0349	0.0342

Ref. mass flow rate V/S evaporator temperature

Evaporator temperature(^{o}C)	COP	COP	COP
	R404A	R502	R507A
-30	1.875	3.22	2.831
-25	1.916	3.631	3.229
-20	2.209	4.125	3.7106
-15	2.33	4.72	4.301
-10	2.5	5.453	5.039
-5	2.833	6.376	5.982
0	3.6	7.56	7.216

COP V/SEvaporator temperature

Evaporator temp.(^{o}C)	POWER CONSUMPTION (KW)	POWER CONSUMPTION (KW)	POWER CONSUMPTION(KW
	R404A	R502	R507A
-30	1.862	1.08	1.5604
-25	1.825	0.963	1.083
-20	1.582	0.848	0.942
-15	1.47	0.74	0.813
-10	1.4	0.6402	0.693
-5	1.234	0.547	0.584
0	0.972	0.462	0.483

Compressor work V/Sevaporator temperature

Evaporator temp.(^{o}C)	Heat rej. KW	Heat rej. KW	Heat rej. KW
	R404A	R502	R507A
-30	5.354	4.586	4.731
-25	5.325	4.41	4.5806
-20	5.078	4.347	4.441
-15	4.998	4.234	4.313
-10	4.9	4.132	4.185
-5	4.733	4.0413	4.08
0	4.471	3.961	3.976

Heat rejection in condenser V/Sevaporator temparature

Evaporator temperature is constant (Te=-20^{o}C) and varying condenser temperature of 3 refrigerants

Condenser temp(^{o}C)	Ref. mass flow rate kg/sec	Ref. mass flow rate kg/sec	Ref. mass flow rate kg/sec
	R404A	R502	R507A
40	0.0368	0.0383	0.0382
45	0.0411	0.0372	0.0421
50	0.045	0.0447	0.0472
55	0.0522	0.0492	0.0541

Ref. mass flow rate V/Scondenser temperature

Condenser temp(^{o}C)	Power consumption (KW	Power consumption (KW	Power consumption (KW
	R404A	R502	R507A
40	1.582	0.848	0.942
45	1.84	0.522	1.056
50	2,25	1.041	1.179
55	2.871	1.175	1.298

Power consumption V/Scondensing temperature

Condenser temp(^{o}C)	Heat rej. KW	Heat rej. KW	Heat rej. KW
	R404A	R502	R507A
40	5.078	4.347	4.441
45	5.343	4.013	4.55
50	5.715	4.479	4.677
55	6.368	4.675	4.794

Heat rejection V/Scondensing temperature

Performance analysis of 3 refrigerants (R404A, R502&R507A) for the same working conditions of the evaporator temperature and condensing temperature. Condenser temperature ($Tc=40^0C$) and evaporator temperature ($Te= -20^0C$)

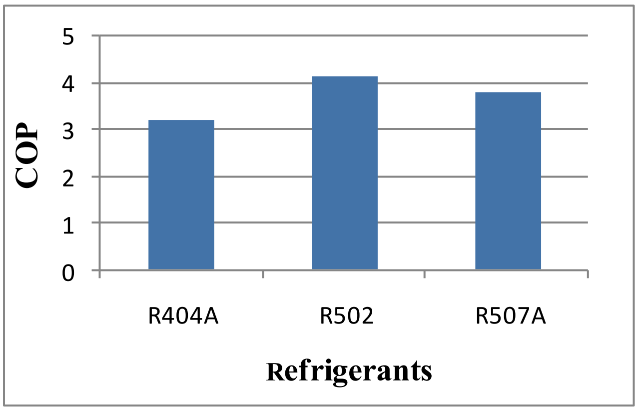
Different performance parameters of 3 refrigerants

Performance parameter	R404A	R502	R507A
Ref. mass flow rate kg/sec	0.0350	0.0368	0.0374
Compressor power KW	1.242	0.560	0.593
C.O.P	2.850	6.389	5.991
Heat rejection in condenser KW	4.744	4.043	4.17

SUMMARY

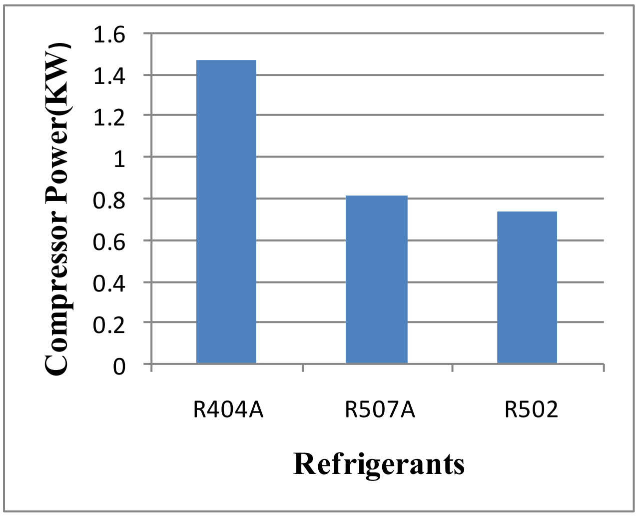
Analysis of C.O.P

From the results obtained by the theoretical work, as shown in the bar chart -1 the COP of R-502 is greater than R-507A and R-404A.



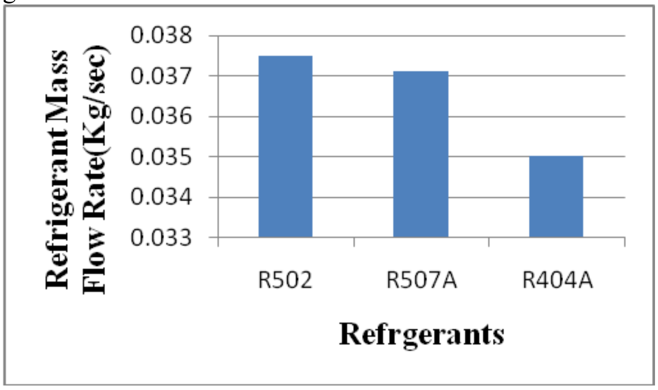
Analysis of Compressor Power

From the results obtained by the theoretical work, as shown in the bar chart -2 the Compressor power of R-404A is greater than R-507A and R-502



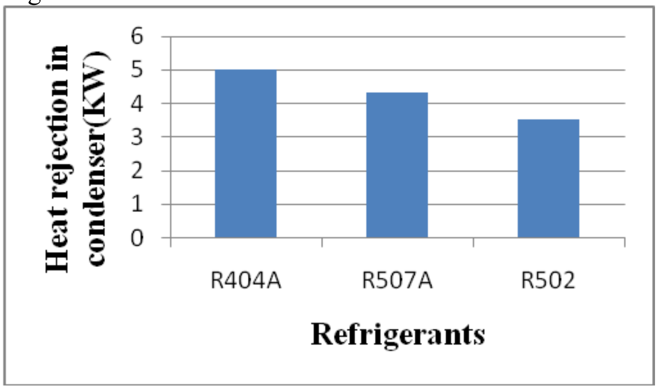
Analysis of Refrigerant mass flow rate

From the results obtained by the theoretical work, as shown in the bar chart -3 the Refrigerant mass flow rate of R-502 is greater than R-507A and R-404A

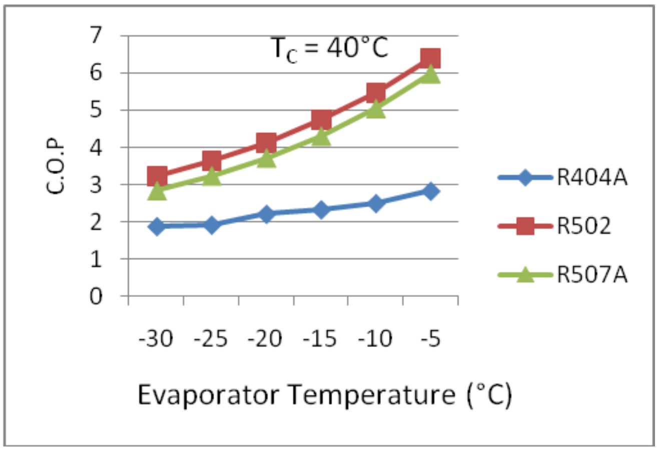


Analysis of Heat rejection in condenser

From the results obtained by the theoretical work, as shown in the bar chart -3 the Heat rejection in condenser of R-404A is greater than R-507A and R-502

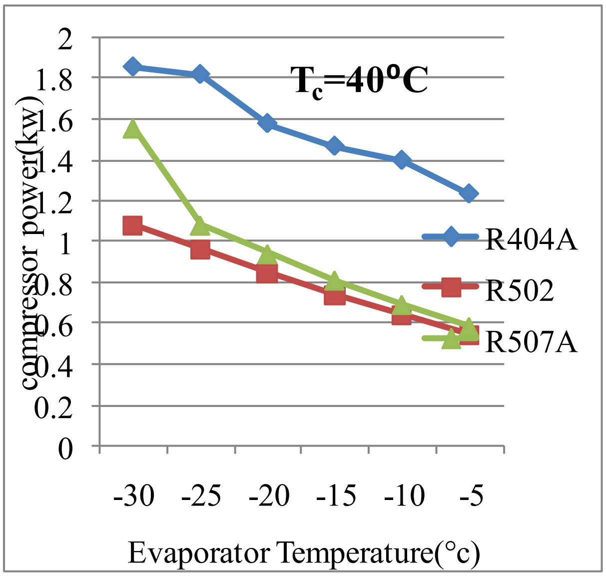


Heat rejection in condenser V/S Refrigerant



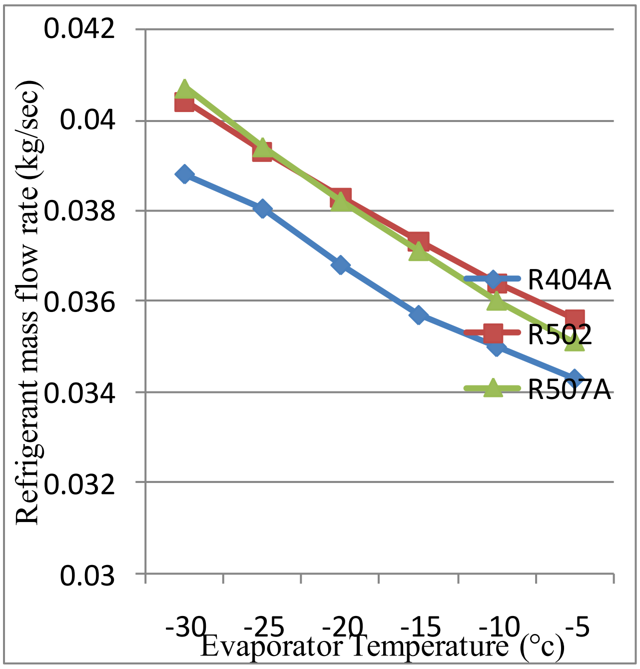
COP V/S evaporator temperature

The graph shows the plot of C.O.P. with respect evaporator temperature varies (-30°c to 0°c) at condenser temperature is constant (40°c) for refrigerant R-404A, R-502 and R-507A. These curves shows that for a particular condenser temperature, C.O.P. increases as evaporator temperature goes on increasing.



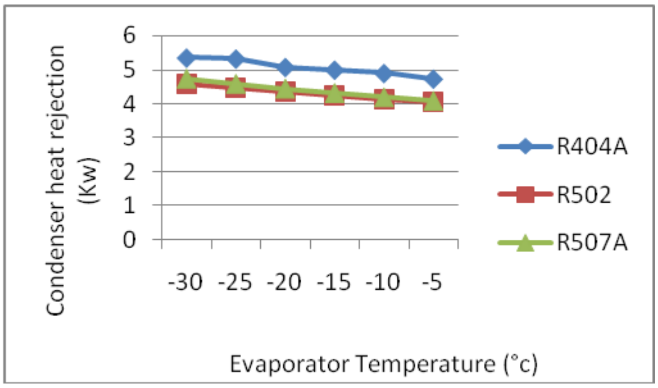
Evaporator temperature V/S compressor work

The graph shows the plot of Compressor power with respect evaporator temperature varies (-30°c to 0°c) at condenser temperature is constant (40°c) for refrigerant R-404A, R-502 and R-507A. These curves shows that for a particular condenser temperature,. Compressor power decreases as evaporator temperature goes on increasing.



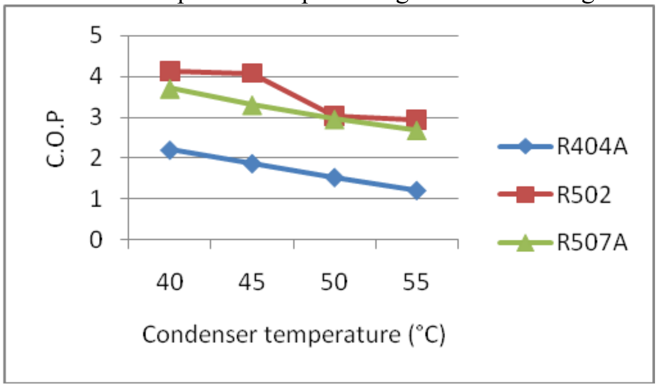
Evaporator temperatureV/S refrigerator mass flow rate

The graphshows the plot of mass flow rate of refrigerant with respect evaporator temperature varies (-30°c to 0°c) at condenser temperature is constant (40°c) for refrigerant R-404A, R-502 and R-507A. These curves shows that for a particular condenser temperature, mass flow rate decreases as evaporator temperature goes on increasing.



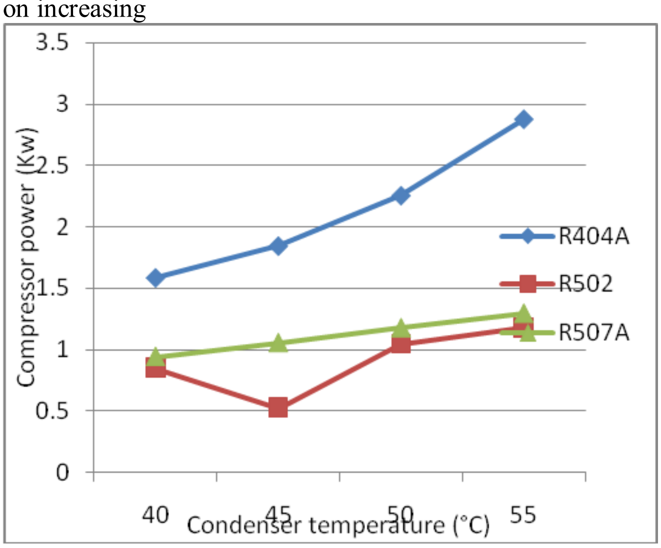
Condenser heat rejectionV/Sevaporator temperature

The graph **4** shows the plot of Heat rejection condenser with respect evaporator temperature varies (-30°c to 0°c) at condenser temperature is constant (40°c) for refrigerant R-404A, R-502 and R-507A. These curves shows that for a particular condenser temperature, Heat rejection condenser decreases as evaporator temperature goes on increasing.



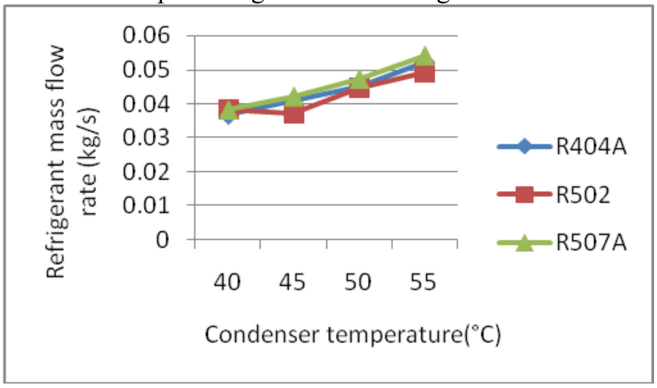
COP V/SCondenser temperature

The graph shows the plot of C.O.P. with respect condenser temperature varies (40°c to 55°c) at evaporator temperature is constant (-20°c) for refrigerant R-404A, R-502 and R-507A. These curves shows that for a particular evaporator temperature, C.O.P. decreases as condenser temperature goes on increasing



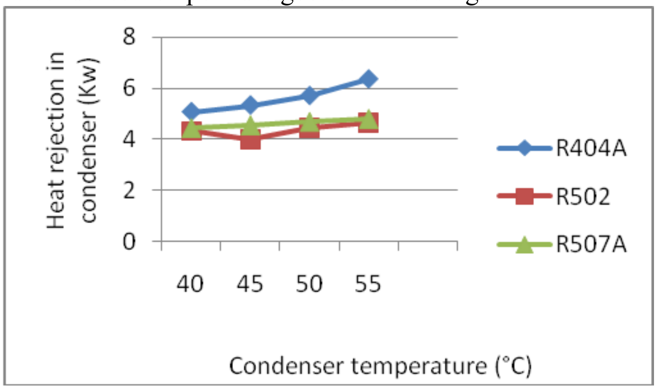
Condenser power V/Scondenser temperature

The graph shows the plot of Compressor power with respect condenser temperature varies (40°c to550°c) at evaporator temperature is constant (-20°c) for refrigerant R-404A, R-502 and R-507A. These curves shows that for a particular evaporator temperature,. Compressor power increases as condenser temperature goes on increasing



Refrigerant mass flow V/S condenser temperature

The graph shows the plot of mass flow rate of refrigerant with respect condenser temperature varies (40°c to 55°c) at evaporator temperature is constant (-20°c) for refrigerant R-404A, R-502 and R-507A. These curves shows that for a particular evaporator temperature, mass flow rate increases as condenser temperature goes on increasing.



Heat rejectionin condenser V/Scondenser temp.

The graph shows the plot of Heat rejection condenser with respect condenser temperature varies (40°c to 55°c) at evaporator temperature is constant (-20°c) for refrigerant R-404A, R-502 and R-507A. These curves shows that for a particular evaporator temperature, Heat rejection condenser increases as condenser temperature goes on increasing.

VII.CONCLUSIONS

In the present work R-507A and R-404A are investigated on thermodynamic performance.The properties of R-507A and R-404A are compared with those of R-502 Hence the evaporator ranges of -30 to 0^0C and the condenser ranges of 40^0C to 55^0C temperatures are chosen for the investigation. The thermodynamic analysis shows that over the entire ranger evaporator temperature R-502, and R-507A behave similar to R404A.With regard to COP, condenser heat rejection and power requirement for 1TR. While for the same cycle of operation the mass flow rate required by R-407C and R-410A. Condenser heat rejection varies more for R-502 than R-507A and R-404A.The power requirement, over the range of the investigation for R-404A higher than R-507A .The same are higher for R-404A compare to R-502.It may be concluded that R-404A compare to R-502 gives lower COP, lower massflow rate, and requires higher power and heat rejection.R-404A also gives lower COP, lower mass flow rate and requires higher power and heat rejection. But the variations are quite small, hence their use is recommended as alternatives for R-502 refrigerant. The small limitations are outweighed by their zero ODP and GWP.

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