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PERFORMANCE ANALYSIS OF ICE PLANT USING ECOFRIENDLY REFRIGERANTS

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Abstract

Refrigeration may be defined as the process of achieving and maintaining a temperature below that of the surroundings, the aim being to freeze ice, cool some product, or space to the required temperature. The basis of modern refrigeration is the ability of liquids to absorb enormous quantities of heat as they boil and evaporate. One of the important applications of refrigeration is in ice plant. Ice plant is used for producing refrigeration effect which uses the vapour compression cycle and by using this cycle we are doing Performance Analysis of Ice Plant Using Ecofriendly Refrigerants. Several refrigerants have emerged as substitutes to replace R22, the most widely used fluorocarbon refrigerants in the world. These include the environmentally –friendly hydrocarbon (HFC) refrigerants R134a, R410A and R407C. 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 and R407C] 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 this paper, R407C can be a potential HFC refrigerant replacement for new and existing systems presently using R22 with minimum investment and efforts.

Key Words: Compression system, Ice Plant, Performance study, Refrigeration, R22, R134a, R410A and R407C

1. INTRODUCTION

Refrigeration, cooling, and heating processes are important in a variety of everyday situations, including the air conditioning and heating of buildings, hospitals, operation theatres, hotels, restaurants, Automobiles and transportation. Refrigeration also finds large-scale industrial applications, especially in the manufacture of ice, dehydration of gases, domestic and commercial refrigerators, large scale warehouses for storage and preservation of foods and beverages and a host of other commercial and industrial services. Applications of refrigerants in the petroleum industry include lubricating-oil purification, low temperature reactions, and the separation of volatile hydrocarbons. Evaporation and condensing processes in refrigeration systems are as a result of the heat transfer occurring by means of phase change in refrigerants. Therefore, the design of a cooling system largely depends on the properties of the refrigerants.

For many years, CFCs and HCFCs have been used successfully as refrigerants, blowing agents, cleaning solvents, and aerosol propellants. CFCs seem to be an ideal choice due to their unique combination of properties. However, after the discovery of the harmful effects of CFC based refrigerants on the ozone layer, search to find new alternative refrigerants to these working fluids gained momentum in the recent years. By international agreement (Montreal Protocol), signed in 1987 and later amended several times, this group of refrigerants, were scheduled to be phased out by 1st January 1996, in the developed countries and by the year 2000 in the developing countries.

According to this study, the history of refrigerants can be classified into four generations based on defining selection criteria. It discusses displacement of earlier working fluids, with successive criteria, and remerges interest in some early refrigerants, for example renewed interest in those now identified as natural refrigerants. This study further examines the outlook for current options in the contexts of existing international agreements, including the Montreal and Kyoto Protocols to avert stratospheric ozone depletion and global climate change, respectively.

Finding drop-in replacements for CFC based working fluids is important due to two main reasons:

Firstly, their harmful effects on the ozone layer and worldwide concern over global warming and, secondly, there is a stringent need for improvement in system efficiency to conserve resources. Due to the reasons listed above, the researchers prompted with the alternatives, which can be used instead of CFCs. In finding the alternatives to the CFC based cooling refrigerants often, mixtures of binary, ternary, or even quartet are suggested. Mixing two or more refrigerants gives us a chance to obtain the desired thermodynamic properties (i.e. often closing to CFC based ones for current systems) of the refrigerants by changing the mixture ratios.

A theoretical development of the thermodynamic properties of two mixtures of hydrofluoric-carbon (HFC) refrigerants, i.e. R407C and R410A (in the superheated vapour state), was carried out by Monte [2, 3]. Arora et al. [4] did the theoretical analysis of a vapour compression refrigeration system with

R502, R404A and R507A. Their work presents a detailed exergy analysis of an actual vapour compression refrigeration (VCR) cycle. The efficiency effect in condenser was highest, and lowest in liquid vapour heat exchanger for the refrigerants considered.

Wang et al. investigated the potential benefits and performance improving options of compressor cooling. Selbas et al. Performed the exergy based thermo economic optimization of sub cooled and superheated vapour compression refrigeration cycle for three refrigerants: R22, R134a, and R407C.

Thermodynamic properties of refrigerants were formulated using the Artificial Neural Network methodology. Kiatsiiroat and Thalang proposed a blend of R22/R124/R152 as an alternative and easy retrofit for R12. Arcaklioglu et al. developed an algorithm to find refrigerant mixtures of equal volumetric cooling capacity when compared to CFC based refrigerants in vapour compression refrigeration systems. Han et al. presented the new ternary non-isotropic mixture of R32/R125/R161 as an alternative refrigerant to R407C.

The development of refrigeration system model which simulates the actual working of reciprocating chillers has been the goal of many researchers. Winkler et al. did the comprehensive investigation of numerical methods in simulating a steady-state vapour compression system. The purpose of his work was to describe and investigate the robustness and efficiency of three unique algorithms used to simulate a modular/component-based vapour compression system. Cabello et al. made a simplified steady-state modelling of a single stage vapour compression plant. In this work a simplified steady-state model to predict the energy performance of a single stage vapour compression plant was proposed. This model has been validated using experimental data obtained from a test bench using three working fluids (R134a, R407C and R22).

Khan and Zubair evaluated the performance of vapour compression system by developing a finite- time thermodynamic model. The model can be used to study the performance of a variable-speed refrigeration system in which the evaporator capacity is varied by changing the mass-flow rate of the refrigerant, while keeping the inlet chilled-water temperature as constant. The model can also be used for predicting an optimum distribution of heat-exchanger areas between the evaporator and condenser for a given total heat exchanger arena.

1.1 Physical and environmental characteristics of selected refrigerants

From literature review, several refrigerants have emerged as substitutes to replace R22, the most widely used fluorocarbon refrigerants in the world. These include the environmentally – friendly hydrocarbon (HFC) refrigerants R134a, R410A and R407C and M20. Table 1 shows the physical and environmental characteristics of these refrigerants

S.N.	Properties	R22	R134A	R410A	R407C
1	Molecular Weight (kg / Kmol)	86.47	102	72.58	86.20
2	B.P. at 1.013 bar [°C]	-40.8	-26.1	-51.4	-43.6
3	Critical temperature [°C]	96.1	101.1	70.5	85.8
4	Critical pressure [kPa]	4990	4060	4810	4600
5	ODP	0.05	0	0	0
6	GWP100	1810	1300	2100	1800

1.2 Ice Manufacturing

It is used for producing refrigeration effect to freeze potable water in standard can spliced in rectangular tank which is filled by brine. A good definition of refrigeration is the removal of heat energy so that a space or material is colder than its surroundings. An ice plant based on same principle as a simple refrigeration system. An ice plant contains various parts such as compressor, condenser, receiver, expansion valve, and evaporator and refrigeration accumulator. A refrigeration is always been a great deal for human being and play a vital role in preserving food , chemical, medicine, fisheries and providing appropriate temperature in working Entity of any industry. Refrigeration in the coming years becomes very essential deal for drastic development of the industrial sector.

1.3 Application of an Ice Plant

1. Meat Industries
2. Poultry Industry
3. **Fish** Industry
4. Milk and Milk Products Industry
5. Chemical Industries

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2. LITRATURE REVIEW

The history of an ice plant is very wide and considerable for the development of the large scale plant; initially the plant was tested for in house production of ice for homely use. Many investigations have been conducted in the research into comparison of production of ice with variation in refrigerant. Many researches were conducted in the field of ice plant for increasing their efficiency, various papers were presented and many thesis were written in the field of development of ice plant. Some of the literatures are listed in support of development of Ice plant.

Norbert Muller, (1) presented “Turbo chillers” This paper describes the use of water as a refrigerant in industrial chillers is an environmental friendly new technology, successfully installed over the recent years. This technology has its challenges in all stages of its realization from the development, through design and manufacturing and it is rewarding to an out of the box thinking in the phase of planning the chillers implementation. Due to use of the water as the refrigerant the COP of the plant is increased.

Brijesh H Patel ve Lalit S Patel (2) presented “Experimental investigation of sub cooling effect on simple vapour compression cycle by domestic refrigerant”, this paper gives an understanding of basic vapour compression refrigeration cycle & performance of refrigeration system can be determined using refrigerator test.

In domestic refrigerator have been conducted sub cooling parameter take in order to analyze performance of the refrigerator. Using of thermoelectric, module in domestic refrigerator for cooling the effect on COP and refrigerating effect is investigated. The performance of the refrigerator test rig analyze by using the actual pressure-enthalpy diagram of actual refrigeration cycle and using the equation. The result obtained showed that COP of vapour compression refrigeration cycle with thermoelectric module is higher than vapour compression system without module. As increase in the cooling reduces the compressor work done and increases the system refrigeration capacity

J. Kiihnl Kine (3), presented “New age water chillers” This paper summarizes vacuum process technology producing chilled water and ice needs no refrigerant of the conventional kind, but water from the process itself is used to generate cooling.

This eye catching novelty incorporates many of the considerations about the future of refrigerants ‘ozone friendly’ no extra demand for safety measures or for skilful operators, no special requirements concerning the installation components, lower maintenance cost since leakage can be accommodated room the system. Vacuum- process technology may be used not only for production for chilled water but also for Binary Ice –Pump able suspension of minute crystals in an aqueous solution. This means that all the advantages related to a latent heat system may become available.

Bilal Amed Querashi, Syed M. Zubair (4), Presented “ The effect of refrigerant combinations on performance of a vapour compression refrigeration system with dedicated mechanical cooling” , This paper describes performance characteristics due to use of different refrigerant combinations in vapour compression cycles with dedicated mechanical cooling are investigated. For scratch designs R134a used in a both cycles produced the best results in terms of COP, COP gain and relative compressor sizing. In retrofit cases, considering the high sensitivity of COP to the relative size of heat exchangers in the sub cooler and low gain in COP obtained due to installation of dedicated cooling cycle with other refrigerant, it seems that dedicated mechanical cooling may be more suited by use of R134a rather than to use other.

Brandon F LACHNER, Gregory F NELIS (5), Presented, “An investigation into the feasibility of the use of R134a as a refrigerant”. This paper summarizes the result of a 21 century research project funded by the air conditioning and refrigeration technology institute (ARTI) that investigated the economic feasibility of an R134a based vapour compression chillers with a nominal capacity of 1000 tons. Presented are various potential cycle configured and results of simulations for those cycle configuration. The simulation were performed using component level modules developed to accurately size equipment and predict system performance for the most attractive cycles configuration. These components models address issues that are partially crucial in water refrigerant cycles such as compressor discharged superheat and refrigerant side pressure drop, where possible, these components models were verified through compression against the current state of the art technology for

large chillers. The capital cost and expected to traditional halocarbon refrigerants currently in use. It was found that the first cost associated with its higher COP.

P.G.H. Usages (6), Presented “Ice production with water as refrigerant”, this paper describes that the static cooling is a development regarding an indirect operating cooling system based on the evaporation of R134a and suitable for moderate and warm climate.

This system Consumes very little energy. Temperatures below the wet bulb temperature can be achieved. It characterizes itself also by no pollution and almost no maintenance costs. The only moving part is one fan, static cooling implies that no condensation will occur during the cooling process. The heat is taken indirectly from the air by means of a heat exchanger, made of only synthetic materials. The absolute humidity of the air to be cooled remains unchanged during the cooling process. The air is cooled below the wet bulb temperature by means of hygroscopic layer on the external cooler surface. The disengaged humidity does not enter the room to be conditioned, but disappear into the open air from a micro biological point of view, it is important to know that there is no water collector filled with water that no aerosols are formed and so on legoonella bacterium can be transported, Static cooling is an alternative to use of F gasses and an answer to the CO_2 policy. It makes cooling possible where this would hardly be feasible because of insufficient supply of energy.

Calm (7) reviewed the progression of refrigerants, from early uses to the present, and also addressed future directions and International Journal of Energy and Environment (IJEE), Volume 2, Issue 2, 2011, pp.297-310 ISSN 2076-2895 (Print), ISSN 2076-2909 (Online) ©2011 International Energy & Environment Foundation. All rights reserved.298 substitutes

Lal et al. (8) give experimental investigation on the performance of a window air-conditioner operated with R22 and M20 refrigerant mixture tested at different refrigerant charge levels. It was concluded that among the mixtures considered M20 (R407C 80% & HC blend 20%) had the optimal composition in respect of better COP and per day energy consumption.

Ecir et al. (9) used ten different modelling techniques within data mining process for the prediction of thermo physical properties of refrigerants (R134a, R404a, R407c and R410a). Relations depending on temperature and pressure were carried out for the determination of thermo physical properties of the refrigerants.

3. COMPONENT OF ICE PLANT

Our ice plant contains various parts such as- Compressor, condenser, filter drier, Expansion valve, Evaporator coil, chilling tank and various measuring equipments like digital temperature indicator, pressure gauges, energy meter etc.

Figure 1: Ice Plant Consisting Of Various Components

3.1 Compressor

A refrigerating compressor, as the name indicates, is a machine used to compress the vapour refrigerant from the evaporator and to raise its pressure so that the corresponding saturation is higher than that of the cooling medium. It also continually circulates the refrigerant through the refrigerating system. Since the compression of refrigerant requires some work to be done on it, therefore a compressor must be driven by some prime mover.

3.2condenser

The condenser is an important device used in the high pressure side of a refrigeration system. Its function is to remove heat of hot vapour refrigerant discharge from the compressor. The hot vapour consists of the heat absorbed by the evaporator and the heat of compression added by the mechanical energy of compressor motor. The heat from the hot vapour refrigerant in a condenser is removed first by transferring it to the walls of the condensers tubes and then from the tubes to the condensing or cooling medium. The high temperature, high pressure ammonia vapour is condensed in a condenser which may be of shell and tube type or evaporative type. The selection of the condenser depends of the capacity of the refrigerating system, the type of refrigerant used and the type of cooling medium available. Generally the condensers used are water cooled condensers (the water cooled condensers are further divided into waste water and re-circulated water system type) and evaporating condensers.

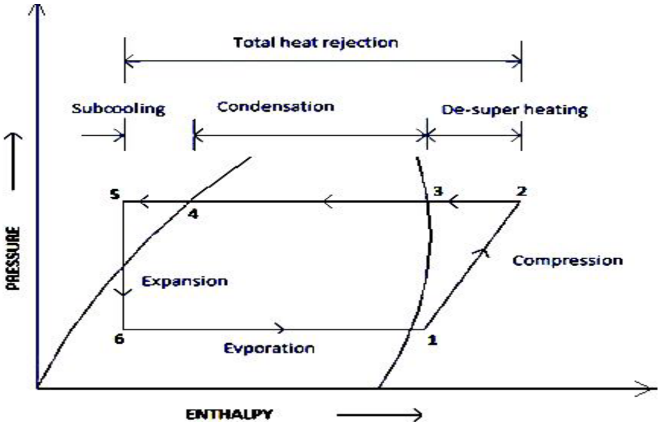


Figure 2: - P-H Diagram of Condenser

In these Experiments a Semi- Hermetic refrigerating compressor and forced air cooled condenser is used as shown in figure below:

Figure 3. Ice Plant Compressor & Condenser

3.3 Receiver

A liquid receiver will be required if it is necessary to temporarily store refrigerant charge within the system, or to accommodate the excess refrigerant arising from changing operating conditions. The total refrigerant charge required in a circuit will vary with different operating loads and ambient, and must be sufficient at all times so that only liquid enters the expansion valve. A receiver requires a minimum operating charge which adds to overall charge and cost, and also increases system complexity. Hence receivers are avoided on many smaller systems. The total refrigerant charge required in a circuit will vary with different operating loads and ambient, and must be sufficient at all times so that only liquid enters the expansion valve. This implies that, at times, the circuit would have too much charge, which would back up in the condenser and reduce its efficiency. A drain tank is required directly after the condenser which can hold this reserve of liquid, and is termed the receiver.

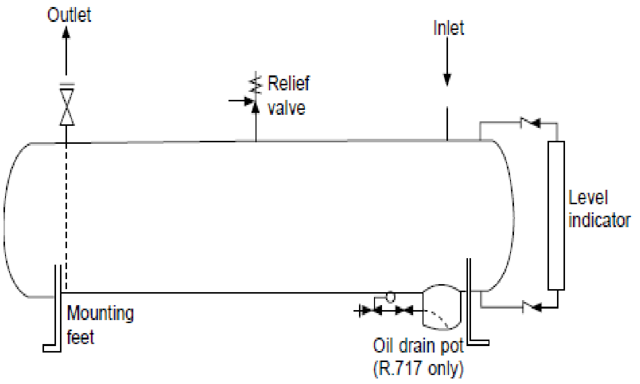


Figure 4: - Receiver

3.4 Expansion valve

The expansion device (also known as metric device or throttling device) is an important device that divides the high pressure side and the low pressure side of a refrigerating system. It is connected the receiver (containing liquid vapour at high pressure) and the evaporator (containing liquid refrigerant at low pressure). The expansion device performs the following functions like to reduce the high pressure liquid refrigerant to low pressure liquid refrigerant before being fed to the evaporator and to maintain the desire pressure difference between the high and low pressure side of the system, so that the liquid refrigerant vaporizes at the designed pressure in the evaporator**.** There are many types of expansion devices used viz. capillary tubes, automatic or constant-pressure expansion valve, low side float valve, high side float valve and thermostatic expansion valve in an ice plant industry depending upon its capacity

The capillary tube is used as an expansion device used in small capacity hermetic sealed refrigeration units such as domestic refrigeration, water cooler, room air conditioner and freezers. It is a cooper tube of small diameter and of varying length depending upon the application.

Figure 5. Capillary Tube

3.5 Evaporator

The evaporator is an important device used in the low pressure side of the refrigeration system. The liquid refrigerant from the expansion valve enters into the evaporator where its boil and change into vapour. The function of the evaporator is to absorb heat from the surrounding location or medium which is to be cooled, by mean of a refrigerant. The temperature of the boiling refrigerant in the evaporator must always be less than that of the surrounding medium so that heat flows to the refrigerant

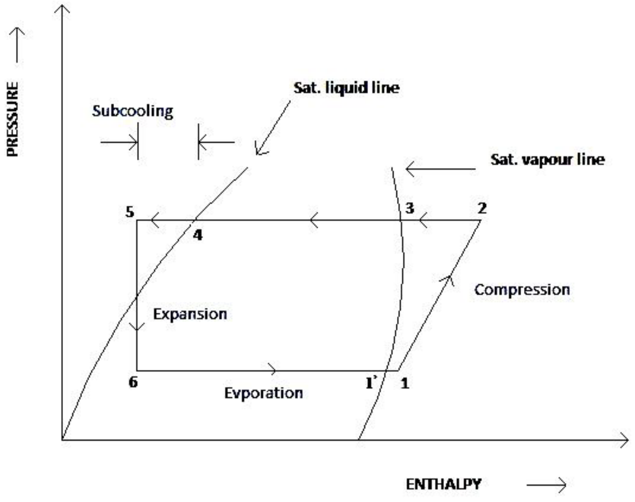


Figure 6. P-h diagram of simple refrigerating system

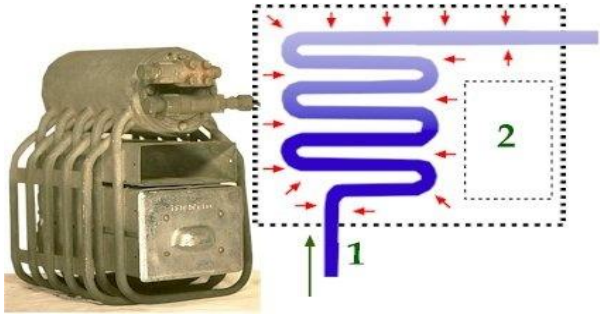


Figure 7:- Evaporator

4. THERMODYNAMIC ANALYSIS

Considering the steady-state cyclic operation of the system shown in Figures 1 and 2, refrigerant vapour enters the compressor at state 4 and saturated liquid exits the condenser at state 1.The refrigerant then flows through the expansion valve to the evaporator. Referring to Figure 1, using the first law of thermodynamics and the fact that change in internal energy is zero for a cyclic process, we get

$$Q_{cond} + Q_{loss,\ cond} – (Q_{evap} + Q_{loss,\ evap}) – (W – Q_{loss,\ W}) = 0 \quad (1)$$

where Q_{cond} is the rate of heat rejection in condenser (kW), Q_{loss}, cond is the rate of heat leak from the hot refrigerant (kW), Q_{evap} is the rate of heat absorbed by the evaporator (kW), Q_{loss}, evap is the rate of heat leak from the ambient to the cold refrigerant (kW), W is the rate of electrical power input to compressor (kW) and Q_{loss}, W is the rate of heat leak from the compressor shell to ambient (kW). Heat transfer to and from the cycle occurs by convection to flowing fluid streams with finite mass flow rates and specific heats. Therefore, the heat-transfer rate to the cycle in the evaporator becomes

$$Q_{evap} = (\varepsilon_C)_{evap} (T_{in,\ evap} – T_{evap}) = m_{ref} (h2 - h3) \quad (2)$$

where ε is the effectiveness of heat exchanger, C is capacitance rate for the external fluids (kW/K), Tin, evap is the evaporator coolant inlet temperature (K), T_{evap} is refrigerant temperature in the evaporator (K), m_{ref} is the mass flow rate of refrigerant (kg/s) and h is specific enthalpy of refrigerant at state point (kJ/kg).Similarly, the heat-transfer rate between the refrigeration cycle and the sink in the condenser is

$$Q_{cond} = (\varepsilon_C) \text{ cond } (T_{cond} – T_{in,\ cond}) = m_{ref} (h6 - h1) \quad (3)$$

where, T_{cond} is the refrigerant temperature in the condenser (K) and $T_{in,cond}$ is the condenser coolant inlet temperature (K).The power required by the compressor, described in terms of an isentropic efficiency, is given by

$$W = m_{ref} (h5 - h4) \quad (4)$$

We assume that the heat leaking into the suction line is

$$Q_{loss}, \text{ evap} = m_{ref} (h4 - h3) \quad (5)$$

Similarly, the heat leakage from the discharge can be expressed as

$$Q \text{ loss, cond} + Q \text{ loss} = m_{ref} (h6 - h5) \quad (6)$$

$$T_{hCOP}=Q_{evap} / W \quad (7)$$

$$\text{Refrigeration efficiency} = \text{COP}/ (\text{COP}) \text{ cannot} \quad (8)$$

The above equations have been solved numerically by using the thermodynamic property data (using REFPR OF) for the five refrigerants (R22, R134a, R410A, R407C and M20). The program gives the COP and all other system parameters for the following set of input data: Evaporator coolant inlet temperature($T_{in,evap}$), Condenser coolant inlet temperature ($T_{in,cond}$), Rate of heat absorbed by evaporator (Q_{evap}),product of condenser effectiveness and capacitance rate of external fluid [$(\varepsilon_{C})_{cond}$], product of evaporator effectiveness and capacitance rate of external fluid [$(\varepsilon C)_{evap}$] and efficiency of compressor (η_{comp}) i.e. COP is defined as the refrigerating effect over the net work input

4.1. Refrigeration Cycle

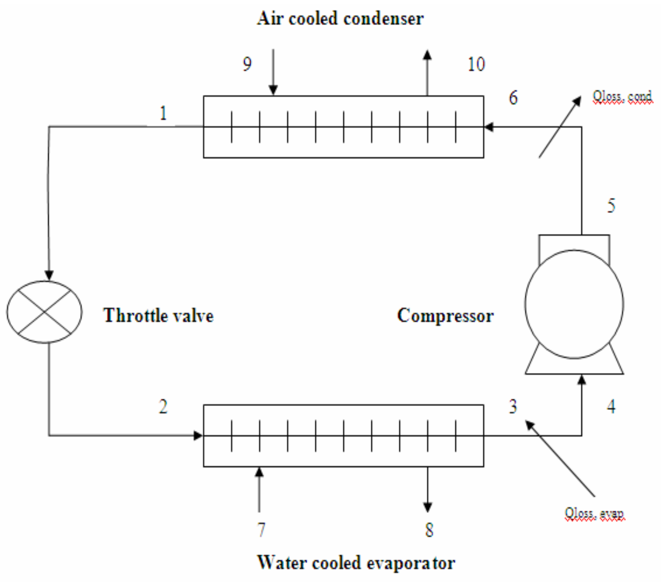
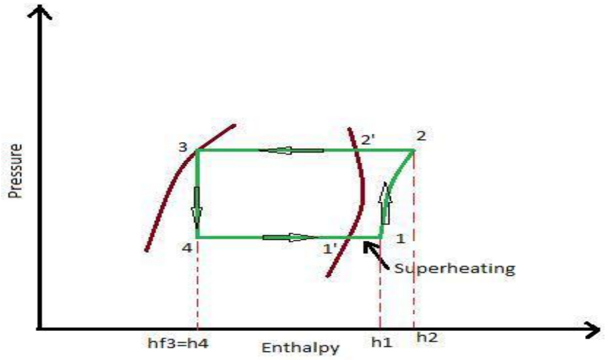


Figure8. Schematic diagram of a simple refrigeration cycle



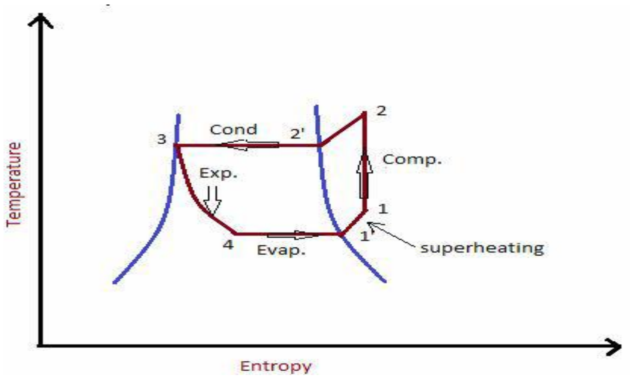


Figure 9. P-h & T-S diagram for vapour compression cycle

4.3 NIST CYCLE D SOFTWARE

The CYCLE D package simulate vapour compression refrigeration cycle that use pure refrigerants or mixture of refrigerants the model can simulate a basic sub critical or trans critical refrigeration cycle both with or without a liquid line/suction line heat exchanger. In addition the model can simulate a sub critical two state economizer cycle the sub critical three stages economizer cycle and a sub critical two stage compressor cycle with inter cooling. CYCLE D operates in a user friendly Microsoft windows environment that facilitates evaluating the performance of selected working fluid at different operating conditions.

CYCLE D includes 48 pure refrigerants which can be selected as the working fluid these pure refrigerants can also be combined to form blends of up to five components. In addition CYCLE D includes 54 pre defend mixtures.

The condenser and evaporator are represented by specifying the refrigerant temperature in each of this heat exchanger. The refrigerant temperature in the condensers can be specified to be a bubble point, a dew point temperature, or an average temperature. The average temperature is calculated as an arithmetic mean of the dew point and the bubble point temperature. Additionally refrigerant sub cooling at the condenser outlet can be specifying. The refrigerant temperature in the evaporator can be specified as either a dew point temperature or average temperature in the evaporator. The average temperature in the evaporator is calculated as an arithmetic mean of the dew point temperature and the temperature of the refrigerant entering the evaporator.

The use of an average temperature in the condenser and the evaporator as a mean of refrigerant temperature at the end of two phase processes is a simplification for zoetrope's whose temperature profile versus enthalpy i.e. a two phase region is not linear. However this method is used to make CYCLE D mimic the method used by industry for compressor calorimeter testing.

For a basic subcritical cycle, CYCLE D provides two options for representation for the compressor the "compressor efficiency" option and the "compressor map" option. For other subcritical cycle and for the Trans critical cycle, only the "compressor efficiency" option is available. The "compressor efficiency" option requires input values are isentropic efficiency, compressor volumetric efficiency, electric motor efficiency and target system cooling capacity, which is evaporator capacity adjusted for the heat added by the indoor coil fan.

5. Comparison of performance parameters for different refrigerants:-

Several refrigerants have emerged as candidates to replace R22, the most widely used fluorocarbon refrigerant in the world. These include the environmentally-friendly hydro fluorocarbon (HFC) refrigerants R134a, R410A and R407C; R134a is a pure refrigerant, whereas R407C and 410A are blends of refrigerants. R410A is a mixture of R32 and R125, while R407C is a blend of R32, R125 and R134a.

The advantages of blending refrigerants are that properties such as flammability, capacity, discharge temperature and efficiency can be tailored for specific applications. There are many considerations in selecting a refrigerant, and each has an impact on the overall performance, reliability, cost and market acceptance of a manufacturer's system. On the basis of above results, R134a, R410A and R407C are compared
with R22 at the designed conditions.

Input data:

1. System cooling capacity (Tons) = 10.00
2. Compressor isentropic efficiency = .700
3. Compressor volumetric efficiency = .820
4. Electric motor efficiency = .850
5. Pressure drop (sat. temp.) (^{0}c):
   in the suction line = 1.5,
   in the discharge line = 1.5
6. Evaporator: dew-point temp. (^{0}c) = 7.0
7. Condenser: bubble-point temp. (^{0}c) = 45.0
   Sub cooling (^{0}c) = 5.0
8. Effectiveness of the llsl heat exchange = .30
9. Parasitic powers (kW): indoor fan = .300 outdoor fans = .400, controls = .100

R22

Compressor power = 2.998 kW
Compressor COP: COP_c = 3.435,
Refrigerant mass flow rate = 6.1242E-02 kg/s,
Total power = 3.798 kW
Cooling capacity: evaporator= 10.300 kW ,
system = 10.000 kW
System COP: $COP_{c, sys}$ = 2.633 ,

R134

Compressor power = 3.108 kW

Compressor COP: COP_c = 3.314
Refrigerant mass flow rate = 6.4917E-02 kg/s,
Total power = 3.908 kW
Cooling capacity: evaporator= 10.300 kW ,
system = 10.000 kW
System COP: $COP_{c,\, sys\, =}$ 2.559 ,

R407C

Compressor power = 3.764 kW
Compressor COP: COP_c = 2.736
Refrigerant mass flow rate = 6.2378E-02 kg/s
Total power = 4.564 kW
Cooling capacity: evaporator= 10.300 kW
System = 10.000 kW
System COP: $COP_{c,\, sys\, =}$ 2.191

R410A

Compressor power = 3.446 kW
Compressor COP: COP_c = 2.989
Refrigerant mass flow rate = 5.9819E-02 kg
Total power = 4.246 kW
Cooling capacity: evaporator= 10.300 kW
System = 10.000 kW
System COP: $COP_{c,sys}$ = 2.355

The calculations have been carried out for two different situations:

a) Evaporation temperature - 10 ^{0}C and condensation temperature + 35 ^{0}C
b) Evaporation temperature + 5 ^{0}C and condensation temperature + 45 ^{0}C

The evaporation temperature refers to the temperature the liquid is cooled to, and the condensing temperature refers to the ambient temperature. A small temperature difference will always occur between the heat exchangers.

For the compression cycle, the isentropic efficiency is set to 0.60 and heat loss from the compressor is set to zero.

S NO.	**Refrigerants**	**COP** **(T_e=-10^{0}c)** **(T_c=+35^{0}c)**	**COP** **(T_e=+5^{0}c)** **(T_c=+45^{0}c)**
01	R-134	2.78	3.30
02	R-407C	2.71	3.15
03	R-410A	2.65	3.05

Where $T_{e=}$Evaporator Temparture
T_c=Condenser Temparture

Note: The refrigerants with mixtures (R407C and R410A) have temperature glides by evaporation. R407C has significant glide, making an explicit comparison with refrigerants without glide difficult. No pressure drop in condenser and evaporator and no internal heat exchange.

The comparison shows that R410A is inferior in terms of theoretical efficiency. Nevertheless, a great share of the marked is turning towards R410A in smaller AC applications. The main advantage ofR410A is the volumetric efficiency that results in smaller components and better price competitiveness.

6. CONCLUSION

In this communication, an extensive thermodynamic analysis of R134a, R410A, and R407C in comparison to R22 has been presented. From the comparison of performance parameters it can be concluded that R407C is a potential HFC refrigerant replacement for new and existing systems presently using R22 with minimum investment and efforts. R134a is a lower capacity and lower pressure refrigerant than R22. Because of these characteristics, system with R134a of the same capacity requires a larger displacement compressor and larger evaporator, condenser, and tubing. The end result is a system which costs more to build and to opera than an equivalent R22 system.

R407C is a potential HFC refrigerant replacement for R22 system such as new or existing residential and commercial air conditioners and heat pumps. A system with R407 C having similar capacity and pressures as R22 can be designed. Because of these features, it can be used as an alternative in R22systems with a minimum of redesign. System efficiency is slightly lower as compared R22 system due to temperature glide.

R407C exhibits a relatively high temperature glide (7 K) compared to the other refrigerants, which have almost no glide. It also offer '0' ODP, low global warming potential. European market embraced R407C and currently offers a wide R407C air conditioner product range. Further, as witch over to polyolester lubricant is also required.R410A has been in the market place for more than 10 years and is the leading HFC refrigerant for replacing R22 in residential and light commercial air-condition and heat pump systems. R410A is having a 50-60% higher pressure refrigerant than R22.

As a result of higher pressures and higher gas density, smaller displacement compressors can be used along with smaller diameter tubing and valves and therefore, R410A should only be used in new systems designed for this refrigerant and should not be substituted into existing R22 systems. Greater skill and attention to cleanliness is required during the Installation of an R410A system to prevent moisture entering into the system. R410 A requires POE oil which is highly hydroscopic. Further, R410A has reduced environmental footprint as compare to an R22 unit for a comparable size range.

6.2 FUTURE SCOPE

There are many future options for the modifications in ice plants regarding their coefficient of performance and rate of cooling. Some are listed below:-

Earlier the ice plants uses the R22 as refrigerant but now a days the use of R22 is vanishes and R134a took the place of R22 which is more eco friendly refrigerant but in future we can replace this R143a from R718 water based refrigerant or R407.

The modern ice plants are already going well but if we concentrate on their pressure ratio then it can more advantageous to us and its Co efficient of Performance will increase. In future if we work on multi stage compressor then the efficiency will surely increased and causes more rate of cooling. In future an ice plant can be installed in place of small refrigeration system for better cooling such an in railways wagons for long route transportation. In future the ice plant can be the more preferable cooling device for the food beverages industry and fisheries industry for long term protection of good for the supply and sales.

In future if I get a chance to work on Vapour Compression Refrigeration Cycle then I would like to work on the theses of the ice plant.

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