A Study on Anasysis and Fabrication of an Ice Plant Model

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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 to freeze potable water in standard cans placed in rectangular tank which is filled by brine. Our project based on simple refrigeration system which uses the vapour compression cycle. The vapour compression cycle comprises four process compression, condensing, and expansion and evaporation process. Our ice plant model 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. The conventional ice plant has been studied and a prototype model of an ice plant has been fabricated with above said accessories. The model is analyzed for its cooling capacity assumed per unit mass flow rate of refrigerant. Its COP is also calculated. The model is compared for its coefficient of performance (COP) and cooling capacity by using R-134 a refrigerant with a theoretical COP and cooling capacity obtained using refrigerant R-22. The variations found in COP and cooling capacity are 0.12 and 0.042 TR respectively for unit mass flow rate of the refrigerant.

Keywords: *Fabrication, Refrigeration , Compression, Cycle, Evaporation,* Coefficient of performance

1. INTRODUCTION

ICE manufacture is used for producing refrigeration effect to freeze potable water in standard cans placed 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, 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.

2. COMPONENTS OF AN ICE PLANT:

In the study of an ice plant the components generally used are viz. compressor, oil separator,

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condenser, receiver, drier, expansion valve, evaporator, chilling Tank, refrigerant accumulator and pressure gauge.

2.1 COMPRESSOR [16]

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. In other words the purpose of the compressor in the vapour compression cycle is to compress the low-pressure dry gas from the evaporator and raise its pressure to that of the condenser. Compressors may be divided into two types, positive displacement and dynamic, as shown below. Positive displacement types compress discrete volumes of low-pressure gas by physically reducing the volumes causing a pressure increase, whereas dynamic types raise the velocity of the low-pressure gas and subsequently reduce it in a way which causes a pressure increase.

Ammonia compressor is the heart of refrigeration plants like Ice plants. Three types of Ammonia based refrigeration compressors available in India are, a) Reciprocal, b) Screw and c) Rotary type. Reciprocal and screw type ammonia compressors are widely used in India in all types and size of Refrigeration plants and cold storages. There are many types of compressors used in an ice plant industries depending upon its capacity. The compressor used in this model is hermitically sealed reciprocating compressor capacity of 240 BTU (1/5 TN). The hermitically sealed compressor is discussed in details ahead.

Fig.1: Small hermetically sealed compressor unit

2.1.1 HERMETICALLY SEALED, OPEN, OR SEMI-HERMETIC COMPRESSOR:

In hermetic and most semi-hermetic compressors, the compressor and motor driving the compressor are integrated, and operate within the pressurized gas envelope of the system. The motor is designed to operate and be cooled by the gas or vapor being compressed. The difference between the hermetic and semi-hermetic, is that the hermetic uses a one-piece welded steel casing that cannot be opened for repair; if the hermetic fails it is simply replaced with an entire new unit. A semi-hermetic uses a large cast metal shell with gasket covers that can be opened to replace motor and pump components. The primary advantage of a hermetic and semi-hermetic is that there is no route for the gas to leak out of the system. Open compressors rely on either natural leather or synthetic rubber seals to retain the internal pressure, and these seals require a lubricant such as oil to retain their sealing properties. An open pressurized system such as an automobile air conditioner can leak its operating gases, if it is not operated frequently enough. Open systems rely on lubricant in the system to splash on pump components and seals. If it is not operated frequently enough, the lubricant on the seals slowly evaporates, and then the seals begin to leak until the system is no longer functional and must be recharged. By comparison, a hermetic system can sit unused for years, and can usually be started up again at any time without requiring maintenance or experiencing any loss of system pressure. The disadvantage of hermetic compressors is that the motor drive cannot be repaired or maintained, and the entire compressor must be removed if a motor fails. A further disadvantage is that burnt out windings can contaminate whole systems requiring the system to be entirely pumped down and the gas replaced. Typically hermetic compressors are used in low-cost factory-assembled consumer goods where the cost of repair is high compared to the value of the device, and it would be more economical to just purchase a new device. An advantage of open compressors is that they can be driven by non-electric power sources, such as an internal combustion engine or turbine. However, open compressors that drive refrigeration systems are generally not totally maintenance free throughout the life of the system, since some gas leakage will occur over time.

Condenser[14]

The condenser is an important device used in the high pressure side of a refrigeration system. Its function is to remove heat of hot vapor 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. In this model forced air cooled condenser is used as shown in figure below:

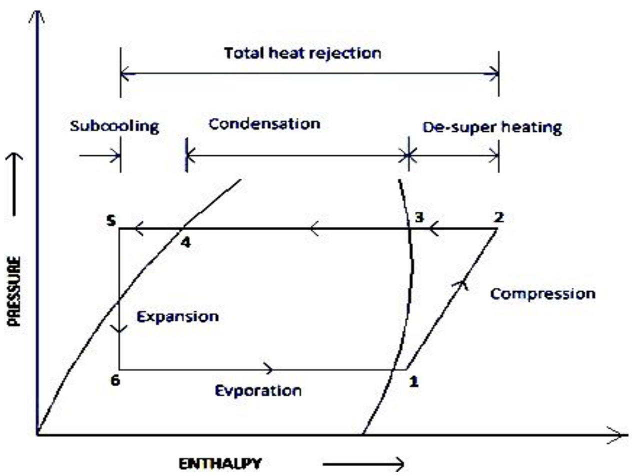

Fig. 2: p-h diagram for condenser

Fig. 3: Forced air cool condenser

2.2.1 Air cooled condenser:

An air cooled condenser is one in which the removal of heat is done by air. It consists of steel or copper tubing through which the refrigerant flows. The size of tube usually ranges from 6-mm to 18-mm outside diameter, depending upon the size of condenser. Generally copper tubes are used because of its excellent heat transfer ability. The condensers with steel tubes are used in ammonia refrigerating systems. The tubes are usually provided with plate type fins to increase the surface area for heat transfer. The fins are usually made from aluminum because of its light weight. The fin spacing is quite wide to reduce dust clogging. The condensers with single row of tubing provide the most efficient heat transfer. This is because the air temperature rises at it passes through each row of tubing. The temperature difference between the air and the vapour refrigerant decrease in each row of tubing and therefore each row becomes less effective. However, single row condensers require more space then multi row condensers. The single row condensers are usually used in small capacity refrigeration systems such as domestic refrigerators, freezers, water coolers and room air conditioners. The air cooled condensers may have two or more rows of tubing, but the condensers with up to six rows of tubing are common. Some condensers have seven or eight rows. However, more than eight rows of tubing are usually not efficient. This is because the air temperature will be too close to the condenser temperature to absorb any more heat after passing through eight row of tubing.

2.3 Receivers [16]

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.

2.4 Filter drier[12]

The function of filter dryer is to remove any physical material from compressor's wear and tear, and remove any moisture presence within an air conditioning system. The Drier is made up of a metal outer container and inside there is a desiccant (moisture removal material) and strainer. Refrigerant passes through the drier and give up any moisture as well as any unwanted matter. The main job of the drier is to protect the metering device from clogging either by Ice (moisture) or blockage by particles. It is not uncommon for driers and filters to block due to their nature of picking up unwanted agents - evidence of this can be seen by frost build up. Filtering process is achieved by mechanical action of partitioning the flow. Particles will be trapped, whilst the refrigerant flow will be maintained. These desiccants can be of two types, viz. absorbent and adsorbent type. In this model adsorbent type filter drier is used which is defined ahead.

2.5 Expansion Devices [14]

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. In this model the capillary tube type expansion devise is used which is discussed in details ahead.

2.5.1 Capillary Tube:

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. The inside diameter of the tube used in refrigeration work is generally about 0.5 mm to 2.25 mm and the length varies from 0.5 m to 5 m. It is installed in the liquid line between the condenser and evaporator. A small filter drier is used on some system to provide additional freeze-up application. In its operation, the liquid refrigerant from the condenser enter the capillarity tube due to friction resistance offered by small diameter tube, the pressure drops since the frictional resistance is directly proportional to the length and inversely proportional to the diameter, therefore longer the capillary tube and smaller its inside diameter, greater is the pressure drop created in the refrigerant flow. In other words, greater pressure difference between the condenser and the evaporators needed forgiven flow rate of refrigerant. The refrigerant system using capillary has the following advantages:

- The cost of the capillary is less than all other form of expansion devices.
- In the compressor stops, the refrigerant continues to flow into the evaporator and equalizes the pressure between the high side and the low side of the system. This considerably decreases the starting load on the compressor. Thus a low starting torque motor can be used to drive compressor, which is a greater advantage.
- Since the refrigerant charge in a capillary tube system is critical, therefore no receiver is necessary.

2.6 Evaporator [14]

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. The evaporator becomes cold and remains cold due to the following two reasons:

- The temperature of the evaporation coil is low due to the low temperature of the refrigerant inside the coil.
- The low temperature of the refrigerant remains unchanged because any heat it absorbs is converted to latent heat as boiling proceeds.

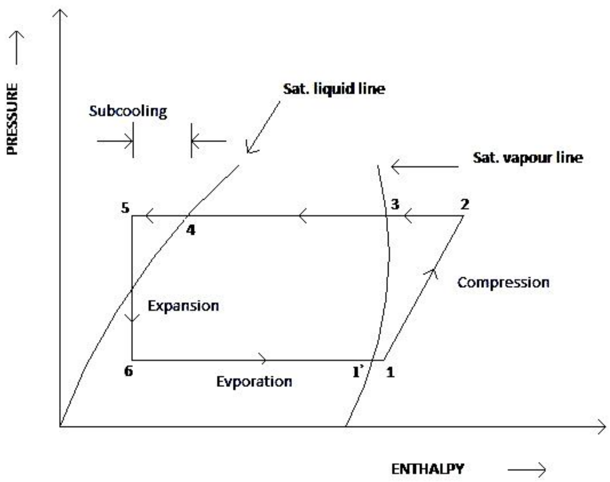

Fig 4: P-h diagram of simple refrigerating system

The liquid refrigerant at low pressure enters the evaporator at point 6, as shown in figure, as the liquid refrigerant passes through the evaporator coil, it continuously absorb heat through the coil walls, medium to be cooled. During this, the refrigerant continues to boil and evaporate. Finally at point 1', the entire liquid refrigerant has evaporated and only vapours refrigerant remains in the evaporator coil. The liquid refrigerant's ability to convert absorbed heat to latent heat is now used up.

Since the vapour refrigerant at point 1' is still colder than the medium being cooled, therefore the vapour refrigerant continues to absorb heat. This heat absorption cause an increase in the sensible heat (or temperature) of the vapour refrigerant. The vapour temperature continues to rise until the vapour leaves the evaporator to the suction line at point 1. At this point the temperature of the vapour is above the saturation temperature and the vapour refrigerant is superheat. There are many types of evaporators used in an ice plant industry depending upon their capacities. In this project the bare tube coil evaporator is used which is discussed in details ahead.

2.6.1 Bare tube coil evaporator:

The bare tube coil evaporators are also known as prime surface evaporators. Because of its simple construction, the bare tube coil is easy to clean and defrost. A little consideration will show that this type of evaporators offers relatively little surface contact area as compared other types of coils. The amount of surface area may be increased by simply extending the length of tube, but there are disadvantage of excessive tube length. The effective of tube is limited by the capacity of expansion valve. If the tube is too long for the valve's capacity, the liquid refrigerant will tend to completely vaporizes early in its progress through the tube, thus tending leading excessive superheating at the outlet. The long tube will also cause considerably greater pressure drop between the inlet and outlet of the evaporator. This results in reduced suction line pressure.

The diameter of the tube in relation to tube length may also be critical. If the tube diameter is to large ,the refrigerant velocity will be too low and the volume of the refrigerant will be too great in relation to the surface area of the tube to allow compete vaporization .this, in turn may allow liquid refrigerant to enter the suction line with possible damage the (i.e. slugging) . On the other hand, if the diameter is too small, the presser drop due to friction may be to high will be reducing the system efficiency.

2.7 Chilling Tank

The main components of chilling tank are viz.ice tank, insulation of ice tank and ice block. Ice tanks are made of such material as wood, steel or concrete. As wooden tanks do not last long enough and are liable to leak, they should preferably be made of steel well coated with waterproof paint. Tanks made of reinforced concrete are also recommended as superior to those of wood. The ice tank contains the direct expansion coils, equally distributed throughout the tank and these coils are submerged in brine. The tank is provided with a suitable frame of hard wood for support the ice cans and a propeller or agitator for keeping the brine in motion: the brine in the tank acts as a medium of contact only, the ammonia evaporating in the ice coils extracts the heat from the brine, which again absorbs the heat for the water in the cans. The tank itself should not be much larger than is necessary to hold the cans, the coils, and the agitator. Insulation of the ice tank is accomplished by using twelve to eighteen inches of good insulating material on each of the sides and not less than twelve inches under the bottom. Commercial sizes of Ice cans vary with the weight of ice cakes required. The cans are made to contain about 5% more than their rated capacity to compensate for thawing.

2.8 Suction Accumulators [16]

Suction line accumulators are sometimes inserted in halocarbon circuits, to serve the purpose of separating return liquid and prevent it passing over to the compressor. Since this liquid will be carrying oil, and this oil must be returned to the compressor, the outlet pipe within the separator dips to the bottom of this vessel and has a small bleed hole, to suck the oil out.

2.9 Oil Separators [16]

During the compression stroke of a reciprocating machine, the gas becomes hotter and some of the oil on the cylinder wall will pass out with the discharge gas. Some oil carry-over will occur with all lubricated compressor types, and in small self-contained systems it quickly finds its way back to the compressor. Start up after a long idle period can result in a large amount of oil carryover for a short period due to foaming. With larger more complex systems with remote evaporator oil, it is desirable to fit an oil separator in the discharge line to reduce carry-over to the system.

3. Working of an Ice Plant [14]

In ice plant the tanks are filled with chilled brine. The brine solution is kept in constant motion by agitators for increasing the heat transfer from the water in the can to the chilled brine. The agitators may be either horizontal or vertical and are operated by means of electric motors .The brine temperature is maintained by the refrigeration plant at -10º C to -11ºc.

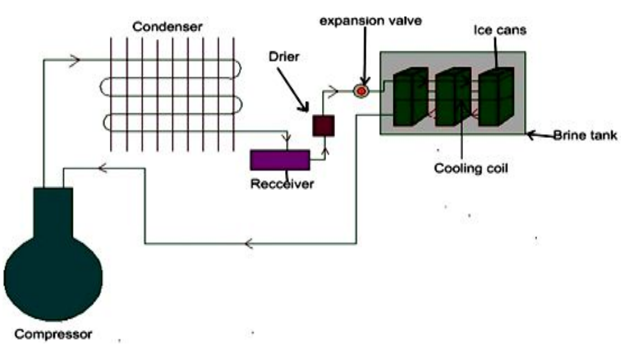

Fig 5: Layout of Ice Plant

The high temperature, high pressure ammonia vapours are condensed in a condenser which may be of shell and tube type or evaporative type. The condensed liquid ammonia is collected in the receiver and then expanded through the expansion valve. Due to the expansion, the pressure of the liquid ammonia is considerably reduced It then passes through the evaporator coils surrounding a brine tank in which brine solution is filled. The low pressure liquid ammonia absorbs heat from the brine the brine solution, equivalent to its latent heat of vaporization, gets converted to vapour state and is once again fed to compressor to complete the cycle. The depth of brine tank is such that the brine level is around 25 mm higher than the water level in the cans. The Tank is insulated on all the four sides and from the bottom. The insulated wooden lids are provided to cover the top in segments, to facilitate the removal of ice cans. The ice cans are fabricated from galvanized steel sheets and are given chromium treatment to prevent corrosion.

In order to get transparent ice, water in the can is agitated by the use of low pressure air through the tubes suspended from the top. Due to agitation, the dissolved impurities such as salt, even colors get collected in the unfrozen water core. It is desirable that it should be taken out and replaced with fresh water.

3.1 Applications: The applications of an ice plant are in Fisheries, Hospital, Chemical Pharmaceutical and Commercially used in different industrial applications etc.

3. FABRICATION AND ANALYSIS OF MODEL

The prototype model of an ice plant has been fabricated consist of compressor, condenser, filter drier, capillary tube, evaporator, chilling tank, energy meter, pressure gauge and digital temperature indicator whose detailed information are given in the Table 1, below for the thermal analysis of model.

Table 1: Specifications and Energy Equations for Different Components

Components	Specifications	Energy equation
Compressor	Specifications of the compressor used in project are given below: • Application with R-134a • Type -Hermetically sealed compressor • Electrical circuit-CSIR • Operating voltage- 1ph, 180-260VAC • Relay- KARP3141 OR MTRP3141 • Start capacitor- 40-60 microF,@275VA Capacity- 240BTU	The S.F.E.E equation- $Q + m_1 (h_1 + \frac{V_1^2}{2} + gz_1) = W + m_2 (h_2 + \frac{V_2^2}{2} + gz_2)$ Applying steady flow energy equation in modified form- Q = 0 ?KE = 0 ? PE = 0 W_c = (-ive) work for compression $mh_1 = -W_c + mh_2$ or $W_c = m (h_{2-} h_1)$ Adiabatic compression work = $m(h_{2-} h_1) = mc_p (T_2 - T_1)$ Here T_1. T_2 are temperatures at inlet and outlet and m is mass flow rate
Condenser	• Single role forced air cool condenser with fan.	The S.F.E.E equation- $Q + m_1 (h_1 + \frac{V_1^2}{2} + gz_1) = W + m_2 (h_2 + \frac{V_2^2}{2} + gz_2)$ Steady flow energy equation can be applied with the following assumptions: • No work interaction, W = 0 • No change in kinetic energy, KE = 0 • No change in potential energy, ?PE = 0 Heat lost by steam = $m (h_{2-} h_1)$, kJ
Filter drier	• Working pressure = 500psig (34.01bar) • For use with CFC, HCFC, HFC, R-134a, R12, R22, R40, R401a, R402a, R404a, R407a, R502a, R502a Refrigerants.	
Expansion device	• Type- capillary tube • Diameter of capillary tube is 1.5mm. • Length of capillary tube is 5m.	Throttling refers to passage of a fluid through some restricted opening under isenthalpic conditions. During flow through these passages enthalpy remains constant, such that $h_1 = h_2$ Based on above throttling process the devise called “throttle valve” has been developed in which pressure drop is realized without involving any work and heat interaction, change in kinetic energy and potential energy. Temperature may drop or increase during the throttling process and shall depend upon the Joule Thomson coefficient, a property based on characteristic of substance. Joule-Thomson coefficient $\mu = (?T/?p)_h$ = constt And if $\mu = 0$, Temperature remains constant $\mu>0$, Temperature decrease. $\mu<0$, Temperature increase.

Components	Specifications	Energy equation
Evaporator coil	Specifications of the evaporator used in project are given below: • Diameter of copper coil is 0.6mm. • Length of copper coil is 7500mm.	Heat transfer rate at evaporator or refrigeration capacity, Q_e is given by: $Q_e = m_r (h_1 - h_4)$ Where m_r is the mass flow rate in Kg/sec, h_1 and h_2 are the specific enthalpies (kJ/kg) at the exit and inlet to the evaporator, respectively. (h_1-h_4) is known as specific refrigeration effect or simply refrigeration effect, which is equal to the heat transferred at the evaporator per kilogram of refrigerant.
Chilling tank	• dimensions of tank – length=600mm, width=450mm, height=300mm • Insulation is done with the help of wood and thermocol. • The thickness of wood and thermocol are 10 mm and 25.4mm	
Energy meter	• Static watt hour meter • AC single phase two wire CI-1 • Rating- 5-20 Amp, 240V, 50H$_z$, 3200 imp/kwh	
Digital Temperature indicator	• Temperature range =- -50°C to+70°C • Using environment temperature = -5°C to +50°C • Accuracy = +1 to -1°C • Humidity = 5% to 80% • Power = two battery (LR 44, 1.5V)	

Fig. 6: Ice plant model

3. Refrigerant

Refrigerant used in this prototype model is R-134a and it is also known as Tetrafluoroethane (CF3CH2F) from the family of HFC refrigerant. The properties of refrigerant R-134a are as under:

- R134a is also known as Tetrafluoroethane (CF3CH2F) from the family of HFC refrigerant. With the discovery of the damaging effect of CFCs and HCFCs refrigerants to the ozone layer, the HFC family of refrigerant has been widely used as their replacement.
- It is now being used as a replacement for R-12 CFC refrigerant in the area of centrifugal, rotary screw, scroll and reciprocating compressors. It is

safe for normal handling as it is non-toxic, non-flammable and non-corrosive.

- It exists in gas form when expose to the environment as the boiling temperature is -14.9°F or -26.1°C.

5.1 Brine solution used

In this prototype model the mixture of NaCl and water in the proportion of 1:3 is used. The mixture of $CaCl_2$ and water can be used as brine but it is not used because of its toxicity. The comparisons between these two brines are established in the Table 2, below:

Table 2: Comparisons between Two Brines (Calcium and Sodium Chlorides)

Calcium Chloride	Sodium Chloride
• Used in other applications where there would be no contact with food stuff. • Lower enthalpy (capacity) then sodium • Lower obtainable eutectic point -67F • Corrosive • Additives include to reduce formation of scaling and corrosions • Toxic	• Used for food processing. • Higher enthalpy (Capacity). • High eutectic point - 6F. • Corrosive. • Non toxic.

3. RESULT AND DISCUSSION

The analysis of an Ice plant model is based on certain assumptions as given below:

- The chilling tank is perfectly insulated.
- There is no heat loss from or to the chilling tank.
- The power input to the ice plant model is uninterrupted.
- The ice plant model is working in ideal conditions.
- The efficiency of an ice plant is expressed in term of the coefficient of performance (C.O.P).

6.1 COP of an Ice plant model using refrigerant R134a

The coefficient of performance of refrigeration plant is given by the ratio of heat absorbed, by the refrigerant when passing through the evaporator or the system, to the working input to the compressor to compress the refrigeration. The input and outlet temperature and pressure for the compressor of the model is measured and the corresponding properties of R-143a are depicted below in the Table 3 and Table 4. Based on the output results the T-s and p-h diagrams of model are shown in figure 7 & 8.

$T_1 = -5.2\,^{O}C$,
$T_2 = 62.3\,^{O}C$,
$P_1 = 0.124$ MPa (18 psi),
$P_2 = 1.517$ Mpa (220 psi),
$T_{1'} = T_4 = -20.42\,^{O}C$,
$T_{2'} = T_3 = 55.67\,^{O}C$

Table 3: Properties of Saturated R-143a

Pressure	Saturation Temperature, ^{O}C	Enthalpy, kJ/kg	
		Vapour	Liquid
0.124 MPa (18 psi)	-20.42	385.82	173.21
1.517 MPa (220 psi)	55.67	425.85	280.80

Table 4: Properties of Superheated R-143a

Pressure, Mpa	Saturation Temperature, ^{O}C	Enthalpy, kJ/kg
		Vapour
0.124 MPa (18 psi)	-5.2	398.535
1.517 MPa (220 psi)	62.3	434.10

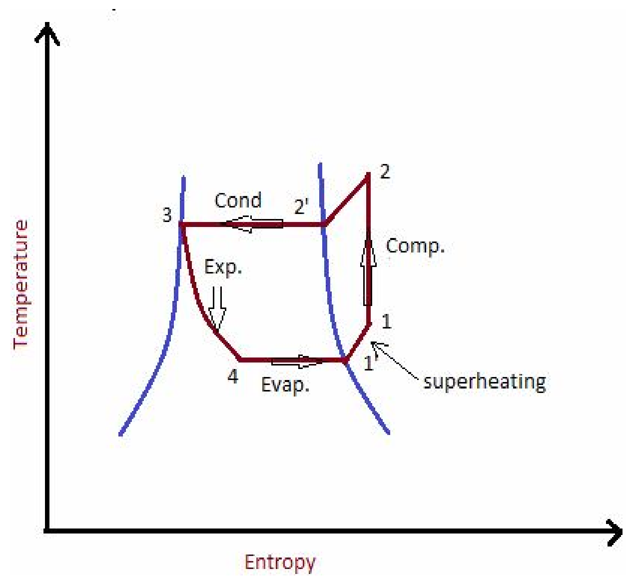

Fig 7: T-s diagram of Ice Plant model using Refrigerant R-134a

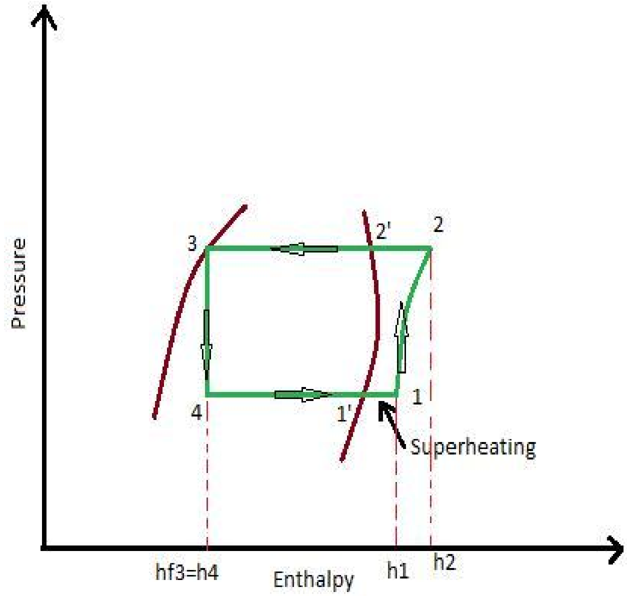

Fig. 8: p-h diagram of Ice Plant model using Refrigerant R-134a

From figure 9, $h_3 = h_4 = h_{f2'} = h_{f3} = 280.80$

$(COP)_{actual} = (h_1 - h_{f3}) / (h_2 - h_1) = (398.535 - 280.80) / (434.10 - 398.535) = 3.31$

Let's assume relative COP of an Ice plant is 0.65, so

We know that, $(COP)_{relative} = (COP)_{actual} / (COP)_{th}$

Hence, $(COP)_{th} = 5.092$

6.2 Cooling produced per hour

$(COP)_{actual} = 3.31$ and actual work done, $w_{actual} = h_2 - h_1 = 434.10 - 398.535 = 35.565$ kJ/kg

We know that net cooling (or refrigeration effect) produced per kg of refrigerant= $w_{actual} * (C.O.P)_{actual}$

= 35.565 * 3.31= 117.72 kJ/kg

Net cooling produced per hour = mass flow rate (m) * refrigeration effect

=1*117.72 = 117.72 kJ/min = 117.72 /210 = 0.56 TR (Let mass flow rate, m = 1kg/min, 1 TR=210 kJ/min)

7. CONCLUSION

In this paper study, analysis and fabrication of an Ice Plant Model is carried out. Based on the results and discussion, conclusions are drawn as under:

- During performance analysis it is observed that when chilling tank is perfectly insulated with the help of plywood, the value of COP and cooling capacity increases. During the study of high capacity ice plants it is observed that concrete and wood instead of thermocol and plywood for insulation of chilling tank are better options.
- The actual COP & cooling capacity obtained are 3.31 and 0.56 TR respectively for per unit mass flow rate of refrigerant R-134a.
- The theoretical COP of an Ice plant model comes to be 5.092 while the relative COP of the model is assumed to be 0.65.

The difference between theoretical COP and actual COP obtained while using refrigerant R-143a is 1.782.

NOMENCLATURE

h	specific enthalpy
m	mass flow rate in Kg/sec
Q	heat supplied
T_1	inlet temperature of refrigerant
T_2	temperature of refrigerant after compression
T_3	temperature of refrigerant after condensation
T_4	temperature of refrigerant after expansion
v	velocity
W	work done
Z	elevation
µ	Joule-Thomson coefficient
COP	Coefficient of performance

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