

# Experimentation and Fabrication of Iceplant Using Ecofriendly Refrigerant

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**ABSTRACT:** Refrigeration is the process of maintaining a temperature of a system lower than the temperature of surrounding by continuous removal of heat. Its aim being to freeze ice, cool product and space to desired temperature. The basic of modern refrigeration is the ability of liquid to absorb enormous quantities of heat as they boil and evaporate. One of the most important application of refrigeration is to produce ice for commercial application with minimum utilization of energy. Ice plant is used to produce ice from the potable water placed in standard cans in tank. It is used to produce the refrigeration effect. Ice plant is based on the simple refrigeration system which uses vapour compression refrigeration cycle and by using this we are analysing and fabricating the ice plant. The conventional ice plant uses the R-22 refrigerant which is ozone depleting refrigerant it is harmful to our environment. In order to replace this ozone depleting refrigerant, in this paper, R404a can be a potential HFC refrigerant replacement for new and existing system presently using R22 with minimum investment and efforts.

**KEYWORDS:** Refrigeration, Fabrication, Vapour Compression system, COP.

## I. INTRODUCTION

Refrigeration and cooling is important in our day today life situation. It also has various industrial applications too. Refrigeration is used in manufacturing of ice, domestic and commercial refrigerator, large scale warehouse for storage and preservation of foods, beverages and medicines.

Refrigeration is the process of removing heat from a body. The removed heat is moved to a place where it does not affect the working system. The main objective of refrigeration is to reduce heat to a lower temperature and maintain it at that temperature. The term cooling refers generally to any natural or artificial process by which heat is dissipated.

Ice manufacture is used for producing refrigeration effect to freeze potable water in can. Refrigeration is the process of maintaining a temperature of a system lower than the temperature of surrounding by continuous removal of heat. It works on the vapour compression refrigeration cycle. The main components of the system are compressor, condenser, evaporator, expansion valve, receiver.

In conventional refrigeration system CFCs and HFC refrigerant such as R-22 was widely used. The HFCs are accepted because they contain basically zero ozone depletion potential (ODP). They also have an assigned global warming potential (GWP) factor which is drastically lower than that of HCFCs. CFCs refrigerant should be replaced due to main reasons:

1. Due to harmful effect on ozone layer
2. Need of improvement in efficiency of system to conserve resources.

Thus the requirement for environmentally friendly, working refrigerants necessitated the invention of refrigerant R-404A. Refrigerant R-404A was developed to replace CFC R-502 and HCFC R-22. Refrigerant R-404A is already known as a suitable replacement for R-22 in low temperature applications. Refrigerant R-404a is a blended product of 44% R125+ 52% R143A+4%R134A.

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## II. COMPONENT

- i. Compressor
- ii. Condenser
- iii. Evaporator
- iv. Chilling tank
- v. Expansion valve

## III. WORKING OF ICE PLANT<sup>[3,4,5]</sup>

In ice plant the tank are filled with chilled brine. the brine temperature is maintained at  $-10^{\circ}\text{C}$ . The brine is the secondary refrigerant. The primary refrigerant used do not leave the plant but it is circulated around the system alternatively after condensing and evaporating. The actual working of ice plant is shown in figure-1. In ice plant the function of expansion valve is to expand the refrigerant R-404a coming out from a receiver to low pressure as shown in fig. Then it enter the evaporator where evaporator vaporize the liquid refrigerant from expansion valve by extracting heat from brine and hence brine gets cooled and it is recirculated to water tank containing 'ice can' to absorb heat of water to freeze it and make ice. Then the vaporized refrigerant is compress by the compressor to high pressure and temperature above the atmospheric which will ready to dissipates its heat in the condenser. In condenser refrigerant is condensed by water and the refrigerant give up the heat which is absorbed in the evaporator. This heat is transferred to water which is used as cooling medium in condenser.

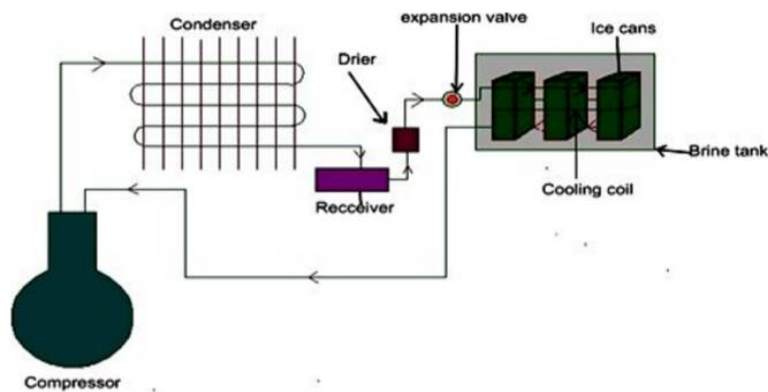


Fig-1- Working of Ice plant

Fig. 1. shows the working of ice plant using vapour compression system



(a)



(b)

Fig. 2. Component of Ice plant (a) Chilling tank used to produced ice containing 'ice cans' and brine solution inside (b) air cooled condenser used in plant

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Fig-3 Actual Fabricated model

Fig. 3. shows the actual fabricated model of ice plant which is used to produced the ice using Refrigerant R-404a.

## IV. REFRIGERANT

Refrigerant is a heat carrying medium, which absorbs heat at a low temperature and discards it at a higher level. The refrigerant alternatively vaporizes from liquid state to absorb heat in the evaporator and condenses in the condenser by rejecting heat to the cooling medium without any chemical change.

We are using refrigerant R-404a, it is also known as Pentafluoroethane ( $\text{CHF}_2\text{-CF}_3$ ), which is an eco-friendly refrigerant. The reason for selection of this refrigerant is given below.

- R404a is a blend of HFC refrigerants commonly used for medium and low temperature refrigeration applications.
- Its composition comprises: HFC-125 (44%), HFC-143a (52%), HFC-134a (4%).
- It is a zeotropic mixture made up of two or more refrigerants with different boiling points.
- It has Zero Ozone Depletion Potential (ODP), as it does not contain chlorine.
- It has Low Global warming potential (GWP), as it does not contain ammonia.
- It is non-toxic and non-flammable.
- It is chemically stable and eco-friendly, hence it doesn't harm the environment.
- It is economical and easily available in the market.

Above stated are the reasons for selection of refrigerant while the below table shows the physical properties of refrigerant.

Table 1-Physical properties of R-404a

Chemical Name	Pentafluoroethane/1,1,1-Trifluoroethane/1,1,1-Tetrafluoroethane
Chemical Formula	$\text{CHF}_2\text{-CF}_3/\text{CH}_3\text{-CF}_3/\text{CF}_3\text{-CH}_2\text{F}$
Boiling Point at atm.	-46.4/-45.7°C
Critical temperature	72.07°C
Critical Pressure	37.32 bar
Critical Density	485 kg/m <sup>3</sup>
Critical volume	2.06 x 10 <sup>-3</sup> m <sup>3</sup> /kg

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## V. CALCULATION

### A. COP OF THE ICE PLANT

COP is given by the ratio of refrigeration effect produced in evaporator to work input to compressor. The inlet and outlet temperature of compressor are (-23°C) and (54°C) respectively.

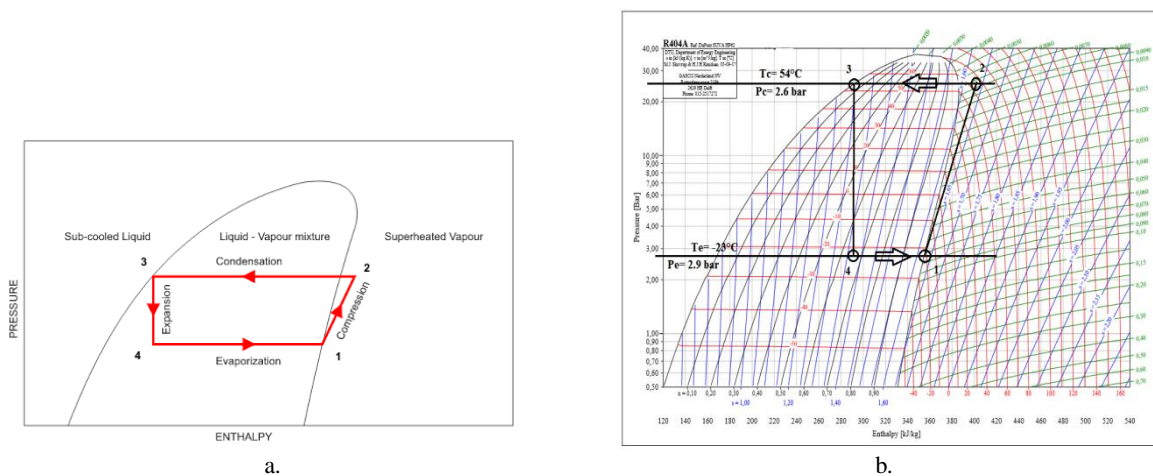


Fig-2- p-h diagram of Simple Refrigeration System(a) p-h diagram(b) p-h diagram on R-404a chart is drawn and from the we get values of enthalpy at different as shown.

$T_1 = -23^\circ\text{C}$ ,  $T_2 = 54^\circ\text{C}$   
 Enthalpy from R-404a chart  
 $h_1 = 355 \text{ kJ/kg}$ ,  $h_2 = 400 \text{ kJ/kg}$ ,  $h_3 = h_4 = 292 \text{ kJ/kg}$   
 $\text{COP} = (h_1 - h_4) / (h_2 - h_1)$   
 $\text{COP} = (355 - 292) / (400 - 355)$

**COP = 1.4**

Let's assume relative COP of an ice plant = 0.65, so we know that  $(\text{COP})_{\text{RELATIVE}} = (\text{COP})_{\text{ACTUAL}} / \text{COP}_{\text{TH}}$   
 Hence  $(\text{COP})_{\text{TH}} = 2.15$

### B. Cooling /Refrigeration Produced per Hour

$(\text{COP})_{\text{ACTUAL}} = 1.4$  and  
 Actual work done,  $W_{\text{ACTUAL}} = h_2 - h_1$   
 $W_{\text{ACTUAL}} = 400 - 355 = 45 \text{ kJ/kg}$   
 We know that net refrigeration effect produced per kg of refrigerant,  
 Refrigeration Effect =  $W_{\text{ACTUAL}} \times (\text{COP})_{\text{ACTUAL}}$   
 Refrigeration Effect =  $45 \times 1.4 = 63 \text{ kJ/kg}$   
 Net refrigeration produced per hour = mass flow rate (m) x refrigeration effect  
 Refrigeration produced per hour =  $1 \times 63 = 63 \text{ kJ/min} = 63/210$

**Refrigeration Produced Per Hour = 0.3TR**

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(Let  $m=1\text{Kg/min}$ ,  $1\text{TR}=210\text{KJ/min}$ )

## VI. RESULT

The result of an Iceplant model is based on certain assumption 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 actual COP of the system is found to be 1.4, which is directly depends upon Refrigeration effect and inversely depend upon the work done by the system.
- If the refrigeration effect is increases by a certain value, the actual COP of the system increases or vice a versa. And if the value of work done increase then the actual COP of the system decreases or vice a versa.
- The actual COP is found out with the help of p-h diagram (R-404a chart) on the basis of the Condenser pressure and Evaporator pressure.
- The efficiency of ice plant is expressed in terms of the coefficient of performance(COP).

## VII. CONCLUSION

- In this paper study ,experimentation and fabrication of an ice plant using ecofriendly refrigerant is carried out.
- In this paper ,we replaced the conventional refrigerant by ecofriendly refrigerant having the similar capacity and the system can be easily design with minimum of redesign .
- The efficiency of system is low as compared to conventional refrigerant system due to temperature difference between saturated vapor temp and saturated liquid temp at constant pressure. As R-404a has zero ODP and low global warming potential it can be used over conventional refrigeration system.
- The actual COP & cooling capacity obtained are 1.4 and 0.3 TR respectively for refrigerant R-404a and the theoretical COP comes to be 2.15 while the relative assume to be 0.65.
- From commercial point of view, the energy consumption is low as compared to conventional system. This system is fabricated for checking its performance and suitability.

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