A Study on Fabrication and Analysis of Iceplant using R-404a

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Abstract— Refrigeration is the process of maintaining a temperature of a system lower than the temperature of surrounding by continous removal of heat. Refrigeration is the method used to cool the space around us to a particular temperature and to freeze water into ice. Based on the application we can use refrigeration to create large amount of ice with minimum consumption of energy. 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 and finally leads to degradation of our ozone layer. The environmental impacts like global warming and ozone depletion has become a challenge to the refrigeration industry. Chloro Fluoro Carbons (CFCs) and Hydro Flouro Carbons (HCFCs) are referred to as an Ozone Depleting Substances (ODS) because once these gases are released into the environment and reach the stratosphere, depletes the ozone layer. A detailed experimentation was carried out to analyse the performance of the system using R-404A refrigerant. The refrigerant R404a is an alternate refrigerant to CFCs and HCFCs as they are ozone friendly and have less Global Warming Potential (GWP) than R12 and R134a. In this paper, R404a can be a potential HFC refrigerant replacement for new and existing system presently using R22 with minimum investment and efforts.

Key words: Refrigeration, Fabrication, Vapour Compression system, COP

I. INTRODUCTION

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

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 work on the vapour compression refrigeration cycle. The main component of the system are compressor, condenser, evaporator, expansion valve, receiver.

Due to the phase out of CFC which was responsible for major ozone depletion and global warming are now being replaced by substitutes which are friendly to the environment. R404a is Zeotropic refrigerant blend of R125/143a/134a (44, 52, 4%) which can be a suitable alternate for R134 a, R410a and CFC R502 Zeotropic refrigerants therefore do not boil at constant temperatures unlike azeotropic refrigerants. Any substitute should generally possess some ideal properties like non flammability, non toxic, friendly to the natural environment, stable at all operating conditions and have similar characteristics of the refrigerant for which Hydro Flouro Carbons (HFC's) and its blends of refrigerants such as zeotropes are finding its applications in most of the commercial refrigeration sector as alternate substitutes and are cost effective.

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 reason

1) Due to harmful effect on ozone layer
2) Need of improvement in efficiency of system to conserves 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 blended product of 44% R125+ 52% R143A+4%R134A.

II. COMPONENTS

1) Compressor
2) Condenser
3) Evaporator
4) Chilling tank
   Expansion valve

III. WORKING OF ICE PLANT[1,2,3]

In ice plant the tank are filled with chilled brine. the brine temperature is maintained at -10oC.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 refrigerantR-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.The actual fabricated moel of Iceplant is as shown in Fig.2.

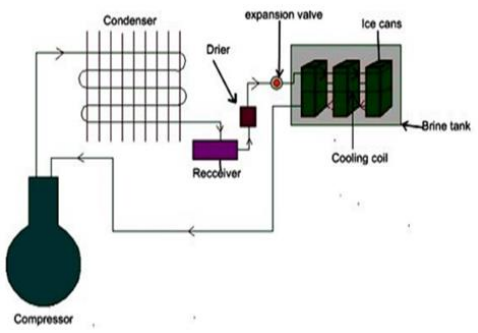

Fig. 1: Working of IcePlant

Fig. 2: Actual Fabricated model

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 has Pentafluroethane(CHF2-CF3), which is 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.
- It's 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 doesn't harm the environment.
- It is economical and easily available in the market.

Chemical Name	Pentafluroethane/1,1,1-Trifluroethane/,1,1,1-Tetrafluroethane
Chemical Formula	CHF_2-CF_3/CH_3-CF_3/CF_3-CH_2F
Boiling Point at atm.	-46.4/-45.7°C
Critical temperature	72.07°C
Critical Pressure	37.32 bar
Critical Density	485kg/m^3
Critical volume	2.06 x 10^{-3} m^3/kg

Table 1: Physical properties of R-404a

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 (-23oC) and (54oC)respectively.

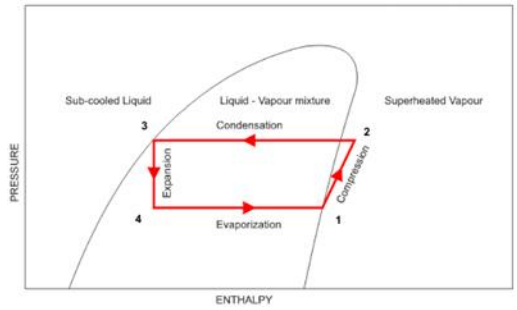

Fig. 3: PH diagram of simple refrigeration system

From the refrigeration chart of R-404A we get the values of enthalpy ,

h_1=355 KJ/Kg, h_2=400 KJ/Kg , h_3=h_4=292 KJ/Kg

COP=(h_1-h_4)/(h_2-h_1)=(355-292)/(400-355)=1.4

Let's assume relative COP of an ice plant =0.65, so we know that $(COP)_{RELATIVE}$=$(COP)_{actual}/COP_{th}$

Hence $(COP)_{TH}$ =2.15

B. *Refrigeration Effect Produced:*

$(COP)_{actual}$ =1.4 and actual work done

$W_{actual} = h_2-h_1$

W_{actual} =400-355

W_{actual} =45KJ/Kg

We know that net refrigeration effect produced per kg of refrigerant

Refrigeration Effect= W_{actual} x $(COP)_{actual}$

Refrigeration Effect =45 x 1.4

Refrigeration Effect =63KJ/Kg

Net refrigeration produced/hr

= mass flow rate (m) x refrigeration effect

Net refrigeration produced/hr =1 x 63

= 63KJ/min = 63/210

Net refrigeration produced/hr = 0.3 TR

(Let m=1Kg/min,1TR=210KJ/min)

VI. CONCLUSION

In this paper, a study on fabrication and analysis of an ice plant using R-404A 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.

This system provide better cooling capacity than R-134a.

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 The energy consumed is 20% less when compared to R134a. Hence it could be justified that zeotropic blends of refrigerant could be the best alternative for any refrigeration system.. This system is fabricated for checking its performance and suitability.

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