

A STUDY ON ANALYSIS & FABRICATION OF AN ICE PLANT MODEL

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ABSTRACT

An ice plant is machine used in ice factory to produce ice at large scale. In this paper, analysis and fabrication of ice plant is discussed. We have found Coefficient of Performance equals to 3.2 and net cooling produced per hour to be 0.56 TR.

Keywords: COP, Refrigerating effect, Ton of refrigeration.

I 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. In other words 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. It plays a vital role in preserving food, chemical, medicine, fisheries and providing appropriate temperature in working.

II COMPONENTS OF AN ICE PLANT

Following components are used in fabrication of Ice Plant:

1. Compressor
2. Condenser
3. Receiver
4. Expansion device
5. Evaporator
6. Chilling tank
7. Refrigerant
8. Pressure gauge.

Hermetically sealed compressor:

In hermetic and most semi-hermetic compressor, 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 vapour being compressed. The difference between the hermetic and semi-hermetic, is that hermetic uses a one piece welded steel casing that cannot be opened for repair.



Fig. 01 Hermetically Sealed Compressor

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 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 aluminium 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.

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 copper tube of small diameter and of varying length depending upon the application. It is a capillary tube system is critical, therefore no receiver is necessary. 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 capillary 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 in-side diameter, greater is the pressure drop created in the refrigerant flow. In other words, greater pressure difference between the condenser and the evaporators needed for given flow rate of refrigerant.

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 it boils and changes into vapour. The function of the evaporator is to absorb heat from the surrounding location or medium which is to be cooled, by means 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:

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

Chilling Tank:

The main components of a chilling tank are an ice tank, insulation of the ice tank, and an 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 coil equally distributed throughout the tank and these coils are submerged in brine.

Refrigerant:

Refrigerant used in this prototype model is R-134a and it is also known as Tetrafluoroethane (CF_3CH_2F) from the family of HFC refrigerant. It exists in gas form when exposed to the environment as the boiling temperature is $-26.1^\circ C$.

Pressure Gauge:

This device is used to measure the pressure on the low and high pressure side of the compressor. Bourdon type pressure gauge is used.

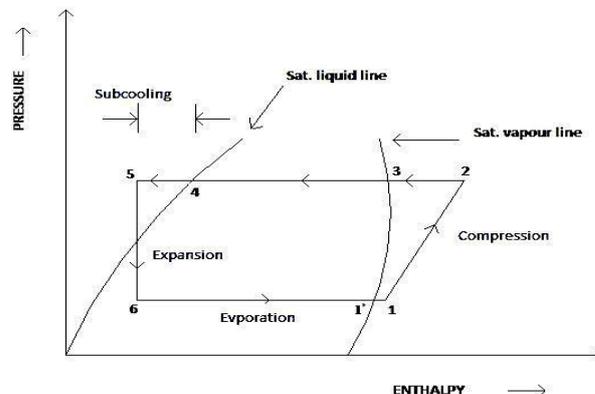


Fig.2 p-h diagram for simple refrigerating system

III FABRICATION AND ANALYSIS OF MODEL

The model is fabricated by the students involved in the project at HEAT ENGINE LABORATORY, B.I.T SINDRI.

The prototype model of an ice plant has been fabricated consisting of

- a) Compressor
- b) Condenser
- c) Capillary tube
- d) Evaporator
- e) Chilling tank
- f) Pressure gauge
- g) Fan
- h) Refrigerant (R-134a)



Fig. 03 Image of fabricated ice plant

Specification and energy equation for different components:

Components	Specifications	Energy Equation
Compressor	<ul style="list-style-type: none"> • Application with R-134a • Type- Hermetically sealed compressor • Operating voltage - 180-260 volts • Capacity – 240 BTU 	<p>The S.F.E.E. equation</p> $Q + m_1 \left(h_1 + \frac{V_1^2}{2} + gz_1 \right) = W + m_2 \left(h_2 + \frac{V_2^2}{2} + gz_2 \right)$

Condenser	<ul style="list-style-type: none"> • Single role air cooled condenser 	$Q + m_1 \left(h_1 + \frac{V_1^2}{2} + gz_1 \right) = W + m_2 \left(h_2 + \frac{V_2^2}{2} + gz_2 \right)$
Filter Drier	<ul style="list-style-type: none"> • Working pressure-(34.01 bar) • For use with CFC, HCFC,HFC, 	
Expansion device	<ul style="list-style-type: none"> • Type-capillary tube • Diameter of capillary tube is 0.5 mm • Length of capillary tube is 11 feet 	

Components	Specifications	Energy Equation
Evaporator coil	<ul style="list-style-type: none"> • Diameter of copper coil – 1cm • Length of copper coil— 1 m 	Heat transfer rate at evaporator or refrigeration capacity Q_e is given by $Q_e = m_r(h_1 - h_4)$
Chilling Tank	<ul style="list-style-type: none"> • Dimensions Length-13cm Breadth-7cm Height-9cm • Insulation is done with the help of wood. • The Thickness of insulation is=1cm 	
Pressure guage	<ul style="list-style-type: none"> • Pressure of 200 to 230 kg/cm² must be maintain at high pressure side. • and 20kg/cm² must be maintained at low side. 	
Fan/ Blower	Operating Voltage/Current – 220V/15amp. RPM- 1500	

IV OBSERVATION & CALCULATION

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.

During the run following data has been recorded:

Inlet temperature of compressor = -5.2°C

Outlet temperature of compressor = 62.3°C

Inlet pressure of compressor = 0.12 MPa

Outlet pressure of compressor = 1.5 MPa

Temperature of the evaporator = -20.42°C

Temperature of the condenser = 55°C

Coefficient of performance:

$$\begin{aligned} \text{COP} &= \frac{\text{Heat absorbed by the evaporator}}{\text{Heat absorbed by the compressor}} \\ &= \frac{M C_p dT}{\Delta h} \end{aligned}$$

$$h_1 = 395 \text{ KJ/Kg}$$

$$h_2 = 435 \text{ KJ/Kg}$$

$$h_3 = h_4 = 280 \text{ KJ/Kg}$$

$$\text{COP} = \frac{h_1 - h_3}{h_2 - h_1} = \frac{395 - 280}{435 - 395} = 3.2$$

Cooling produced per hour:

$$\text{COP} = 3.2$$

$$W_{\text{actual}} = 435 - 395$$

$$= 40 \text{ KJ/Kg}$$

$$\text{Net cooling produced} = W_{\text{actual}} \times \text{COP}$$

$$= 40 \times 3.31$$

$$= 132.4 \text{ KJ/Kg}$$

$$\text{Net cooling produced per hour} = \dot{M} \times \text{Refrigerating Effect}$$

$$= 1 \times 132.4 = 132.4 \text{ KJ/min}$$

$$= \frac{132.4}{210} = 0.56 \text{ TR}$$

V RESULT AND DISCUSSION

In this prototype model the mixture of NaCl and water in the proportion of 1:3 is used. On analysis of an Ice plant model we take some assumption liketank is perfectly insulated and no heat loss from or to the chilling tank. We have found Coefficient of Performance equals to 3.2 and Net cooling produced per hour to be 0.56 TR.

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