STUDY AND ANALYSIS OF REFRIGERATION TECHNOLOGY USED IN ICE PLANT

SARAVANAN.D[1]

[1]*Lecturer, Dept of Mechanical Engineering(R&A/C)*
Valivalam Desikar Polytechnic College Nagapattinam

---***---

Abstract – *The use of ice plays an important role in day-to-day preservation of food, chemical, medicines, fisheries etc., Refrigeration is very essential for the manufacture of block ice. This article presents the refrigeration system used for block ice manufacture. The study includes the various refrigeration equipments used in the ice plants. An ice plant consists of various components such as compressor, condenser, expansion valve and evaporator. The refrigeration cycle and various thermodynamic processes involved in refrigeration system adopted in ice plant are to be analyzed. The primary and secondary refrigerant used for extracting heat or chilling the normal water for its conversion to ice blocks are to be analyzed. Comparative studies of brine solutions, ice can sizes and freezing tank sizes are discussed.*

Key Words: **Block Ice, Chilling tank, Primary Refrigerant, Secondary Refrigerant, Brines, Thermodynamic Processes, Agitator.**

1. INTRODUCTION

Refrigeration is the process of achieving and maintaining a temperature well below that of the surrounding atmosphere. This technology is used to freeze the water to ice. In modern refrigeration, the refrigerant with low boiling point in liquid state absorbs large quantities of heat when it boils and evaporates. In ice plants the refrigeration effect is used to freeze portable water placed in rectangular tanks which is immersed in a tank called evaporator tank or chilling tank filled by brine solution. Normally the type of refrigeration system used in ice plant is vapour compression refrigeration system with ammonia as the refrigerant. In addition to the basic components such as compressor, condenser, expansion valve, evaporator the refrigeration system includes a chilling tank, refrigerant accumulator, oil separator, receiver and filter drier.

2. WORKING OF VCR SYSTEM IN ICEPLANT

   The low-pressure low temperature vapour ammonia refrigerant from the evaporator enters into the reciprocating type compressor and gets compressed. High pressure high temperature vapour ammonia refrigerant from the compressor enters into the condenser which is usually of shell and tube type where the refrigerant exchanges its latent heat to the cooling water circulated in the tubes of the shell

and tube condenser. Now the refrigerant which is condensed from vapour state to liquid state in the condenser enters into the expansion device where its pressure and temperatures are greatly reduced. The low pressure, low temperature liquid refrigerant enters into the evaporator coil which is immersed in the chilling tank. Now the low pressure low temperature ammonia refrigerant begins boil and evaporates. For evaporation the refrigerant extracts latent heat from brine solution which is kept in the chilling tank. Now the brine solution temperature due to the removal of latent heat reduced to -10^{0}C to -11^{0}C. the agitator installed in the chilling tank is frequently operated using electric motor provides constant motions to the brine solution in the chilling tank. The cans filled with normal water which is placed in the chilling water begins to freeze and the water is converted into ice blocks. The refrigerant which is evaporated in the evaporator tubes which is at low pressure and low temperature in the vapour state now enters into the suction side of the compressor gets compressed and the cycle is repeated.
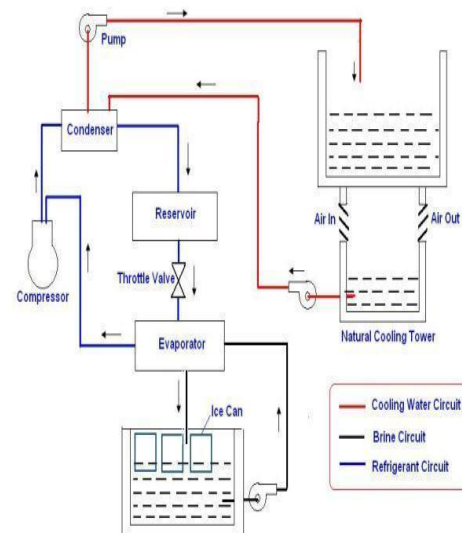

Fig-1: Ice plant refrigeration system

Fig-2: A typical ice plant chilling tank.

3. THERMODYNAMIC PROCESSES IN VCR SYSTEM

In VCR system there are four thermodynamic processes

- ❖ Isentropic compression
- ❖ Constant pressure heat rejection
- ❖ Isenthalpic expansion and
- ❖ Constant pressure heat extraction

3.1 ISENTROPIC COMPRESSION

The low pressure, low temperature vapour refrigerant is compressed isentropically in the compressor. During this process the entropy remains constant. There is an increase in temperature and pressure to condenser pressure. The enthalpy is increased. The work input to the compressor is equal to the difference in enthalpies that is enthalpy after compression minus enthalpy before compression for net mass of refrigerant flow.

3.2 CONSTANT PRESSURE HEAT REJECTION

During this process, the latent heat of the refrigerant is rejected in the condenser at constant pressure. The quantity of heat rejected is equal to the difference in enthalpies before condensation and after condensation that is vapor enthalpy minus liquid enthalpy.

3.3 ISENTHALPIC EXPANSION

During this process the pressure of refrigerant reduced from condenser pressure to evaporator pressure. There is no heat transfer. The enthalpy remains constant. This process is carried over in the expansion device.

3.4 CONSTANT PRESSURE HEAT EXTRACTION

During this process the heat is extracted by the refrigerant flowing through the evaporator tube. The pressure remains constant during this process. The quantity of heat extracted is equal to the difference in enthalpies of the refrigerants after and before evaporations that is vapour enthalpy of refrigerant minus liquid enthalpy of refrigerant for unit mass flow rate if refrigerant

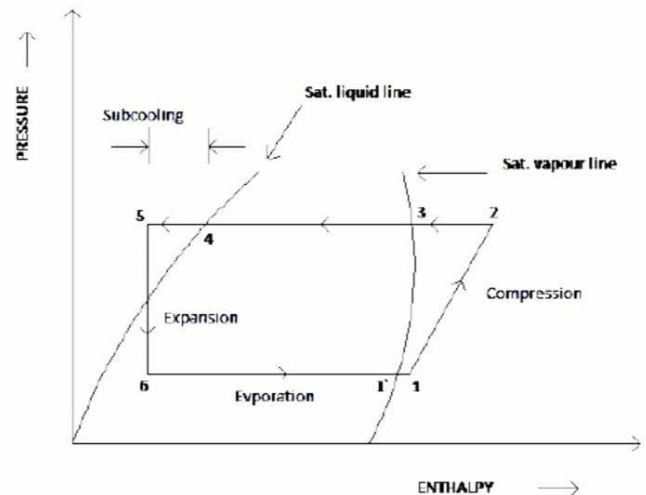All the processes are shown in the p-h diagram in Fig-3

Fig-3: p-h diagram of VCR system

4. PRIMARY AND SECONDARY REFRIGERANT

Basically, refrigerants are classified into primary refrigerant and secondary refrigerant.

Primary refrigerant are used as working medium as in VCR system that rejects heat while flowing through condenser side and extract heat from the space nearer to the evaporator when it flow through the evaporator coil.

Secondary refrigerant are those liquids usually called as brines or antifreezeres are used to transport thermal energy from one location to another. If the operating temperatures are above 0^oC ordinary water can be used as secondary refrigerant. If the operating temperature is below 0^oC antifreezers or brines are used.

The secondary refrigerant does not undergo any phase change when it transfers thermal energy from one location

to another. The freezing point of brine is lower than the freezing point of its constituents. The commonly used secondary refrigerant are water and ethylene glycol, calcium chloride, sodium chloride. The ice plant generally uses primary refrigerant as ammonia and the secondary refrigerant is either sodium chloride or calcium chloride.

Table -1: Comparison of secondary refrigerants (calcium chloride brine and sodium chloride brine)

Calcium chloride	Sodium chloride
Lower enthalpy	Higher enthalpy
Lower obtainable eutectic point -55°C	Higher eutectic point -21°C
Used where there would be no contact with food stuff	Used in food processing
Toxic	Non toxic

Table -2: Standard ice can sizes

Capacity (kg)	L (mm)	B (mm)	H (mm)	Freezing time required (Hrs.)
11	100	260	580	5
22	130	300	815	9
45	190	405	815	20
90	290	570	815	48
135	290	570	1145	48

Table -3: Standard freezing tank sizes

Daily ice making capacity (Ton)	Number of ice cans	Dimensions of freezing tank		
		Length (m)	Width (m)	Depth (m)
10	12 x 14 = 168	10.3	5	1.2
20	16 x 20 = 320	14.2	6.3	1.2
30	20 x 24 = 480	16.5	7.85	1.2
40	26 x 25 = 650	17.5	10	1.2

5. CONCLUSION

In this paper

- ❖ The thermodynamic processes behind the refrigeration system for ice plant refrigeration is discussed.

- ❖ The components included and its working principles of the ice plant refrigeration is described.

- ❖ Use of primary and secondary refrigerants in VCR system for ice plant is outlined.

- ❖ It is observed that Subcooling of primary refrigerant in the ice plant VCR system and perfect insulation of chilling tank can improve the performance of the system.

REFERENCES

[1] C.P. Arora, "Refrigeration and Air Conditioning", Tata McGraw-Hill Company LTD, New Delhi, 1972.

[2] R.J. Dossat, "Principle of Refrigeration", Prentice-Hall, Inc. Simon and Schuster/A Viacom Company, New Jersey, 1997.

[3] J.J. Waterman and J. Graham, "Icing Fisheries", Torry Research Station, Aberdeen U.K., 1968.

[4] Open Internet Sources.

BIOGRAPHIES

D. SARAVANAN M.E.,

Teaching profession in Mechanical Engineering for past 20 years.