

# TO DESIGN A PLATE FREEZER FOR LOW TEMPERATURE APPLICATION AND INCREASING ITS EFFICIENCY BY USING SOLENOID VALVE”

SHAHNAWAZ KHAN<sup>1</sup>, BILAL YAR KHAN<sup>2</sup>, MUHAMMED ASIM<sup>3</sup>, ABDUL KHAN<sup>4</sup>

<sup>1</sup>, Dept. of Mechanical, Anjuman College of Engg and Technology, Nagpur, India

<sup>2</sup>Dept. of Mechanical, Anjuman College of Engg and Technology, Nagpur, India.

## ABSTRACT:

Refrigeration is a process in which work is done to move heat from one location to another. There are many applications of refrigeration in our daily life. Refrigeration has had a large impact on industry, lifestyle, agriculture and settlement patterns, since refrigeration is one of the most important aspects of thermal environment engineering therefore with the advancement of science and technology, the luxuries of yesterday are necessity of today. In addition, refrigeration embraces industrial refrigeration, including the processing and preservation of food. Refrigeration may be produced by several methods. One of these methods is vapors compression system. It is used in majority of refrigeration applications. Vapour compression system is further modified for better performance and control. Such systems are compound systems, multi evaporator systems etc. Multi evaporator systems yield the higher value of coefficient of performance compared to single evaporator system. Techniques of freezing vary for each application. The type of refrigeration used for preserving fruits cannot suit the need of the fish industries. Later it has been discovered that the number of viable vegetative microorganisms in food are usually greatly reduced by freezing if quick freezing is employed. The conventional freezers could not cope with this higher rate of freezing. Plate type evaporators may be used in single or in banks. The plates may be manifolds for parallel flow of the refrigerant or they may be connected for series flow. Plate evaporators are especially useful used for liquid cooling installation where unusual peak load conditions are encountered periodically. By the development of the plate freezer, the challenge of quick freezing has been met to enhance effective preservation.

**Keywords:** Refrigeration, Compressor, Condenser, Evaporator, Expansion Valve.

## 1. INTRODUCTION

According to the second law of thermodynamics heat cannot spontaneously flow from a colder location to a hotter area; work is required to achieve this. An air conditioner requires work to cool a living space, moving heat from the cooler interior to the warmer outdoors. Similarly, a refrigerator moves heat from inside the cold icebox to the warmer room-temperature air of the kitchen. Conventional food preservation is done by keeping the food inside chambers having evaporator coils around it. This chamber is insulated from the surroundings by a casing. The heat transfer takes place from the food to the freezer surface through the air gap. As air is a bad conductor of heat, the freezing rate is low and time consuming. The freezing rate was increased by the development of the freezer. Only compactable foods can utilize this method. The operating principle of the refrigeration cycle was described mathematically by Sadi Carnot in 1824 as a heat engine. Heat pump and refrigeration cycles can be classified as *vapor compression*, *vapor absorption*, *gas cycle*, or *Stirling cycle* types. In VCR system the refrigerant used, readily evaporates and condenses alternately between the vapor and liquid phases. In evaporator, it absorbs heat from the body, & in condenser, it rejects heat to atmosphere. The heat absorbed from cold body during evaporation is used as its latent heat to change phase from liquid to vapour. Thus a cooling effect is created in the working fluid.

## II. PLATE FREEZER

In the plate freezer the evaporator plates are arranged in parallel. The Plate freezer under consideration is a multi plate freezer. In the plate freezer there are two plates through which the refrigerant expands. The food is placed between the plates and are brought closer so that the food gets pressed to a pre-determined pressure. As the plates are in direct contact with the food, there is better heat transfer and hence the freezing rate is increased. The plate used is copper plate, which is having a high heat transfer coefficient. The two plates are brought closer manually. Compared to the conventional method of freezing this method takes only a Quarter of the time required to bring 1 kg of meat from 30 °C to -20 °C, the freezing rate is increased about four times. This is the most important reason why plate freezers are replacing conventional freezing equipments in the recent past.

Plate freezers are commonly used for freezing brick-shaped packaged products. The packaged products are firmly pressed between the plates. High rates of heat transfer can be obtained between the packaged product and the refrigerant plates. Plate freezers are used to freeze flat products, such as pastries, fish fillets, and beef patties, as

well as irregular-shaped vegetables that are packaged in brick-shaped containers, such as asparagus, cauliflower, spinach, and broccoli.

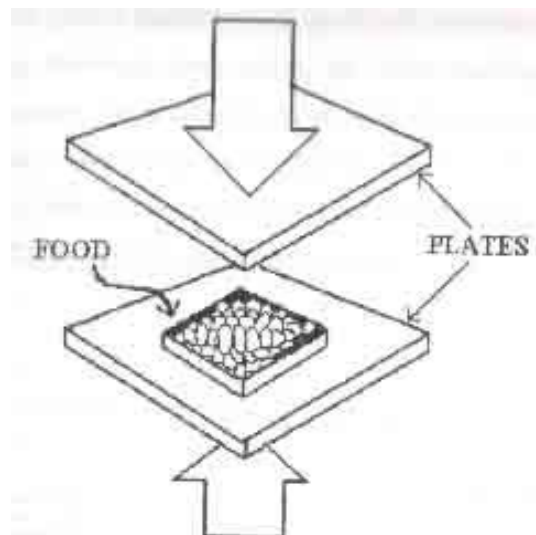
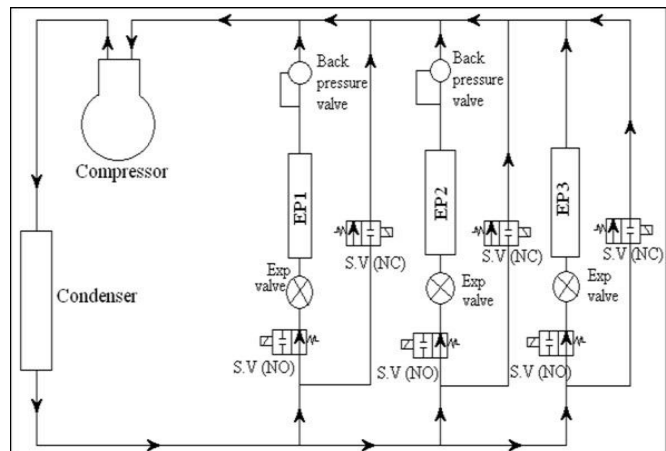


Figure 4. Flat Plate Evaporator

### 2.1 FLOW DIAGRAM OF PLATE FREEZER

In the plate freezer the evaporator plates are arranged in parallel as show in Fig. 5. The low pressure vapor refrigerant enters the compressor which compresses it to high pressure and high temperature vapor refrigerant , it is then passed to the condenser where it changes its phase to high temperature high pressure liquid refrigerant. It is now passed to the solenoid valve, the function of the solenoid valve is to simply turn refrigerant flow on and off, after solenoid valve it is then passed to the expansion valve where the high pressure liquid refrigerant is converted to low pressure liquid refrigerant and then it is passed to the evaporator where it absorbs heat from the surrounding and get converted to low pressure vapor refrigerant. The back pressure valve is provided in the circuit to maintain equal pressure in the suction line. The evaporators can be arranged in series or parallel. There can be just a single expansion valve catering to all the evaporators or there can be an individual expansion valve for each evaporator. In the similar way, a single compressor (staged or non-staged) can cater to all the evaporators or their can be multiple compressors in the system too. In certain cases, the system can have different outdoor units also, depending on the condensing requirements. The choice of the system arrangement depends on application, initial and operational costs. The most common of these arrangements is one with multiple evaporators connected in parallel, each with an individual expansion device, a variable speed compressor or a staged set of compressors and a single outdoor or condensing unit.

Figure 5 {line diagram of multi plate freezer}

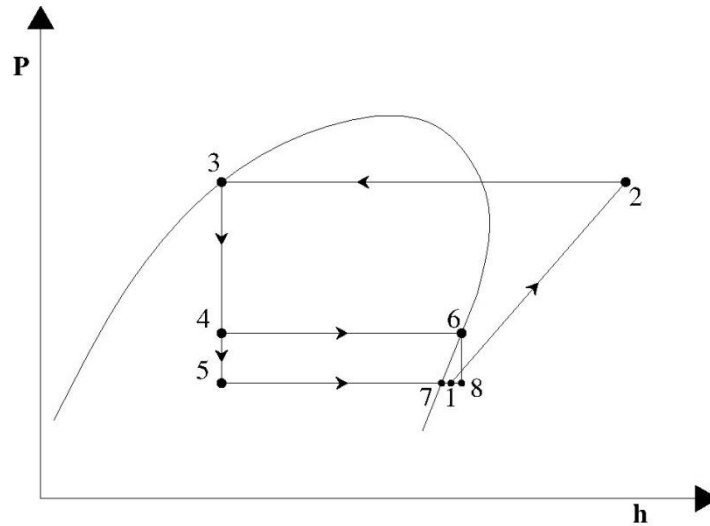


Figure shows the p-h diagram of multi plate freezer with single compressor multi evaporator and individual expansion valve.

### III. SYSTEM COMPONENTS AND THEIR ANALYSIS

#### 3.1. COMPRESSOR

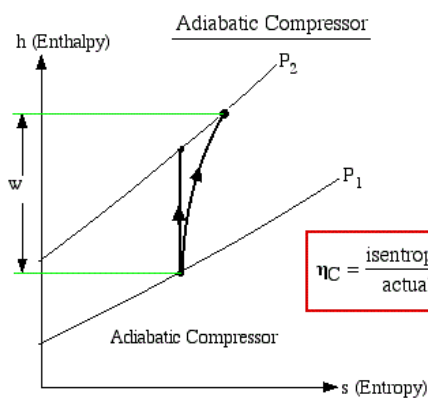


Figure a

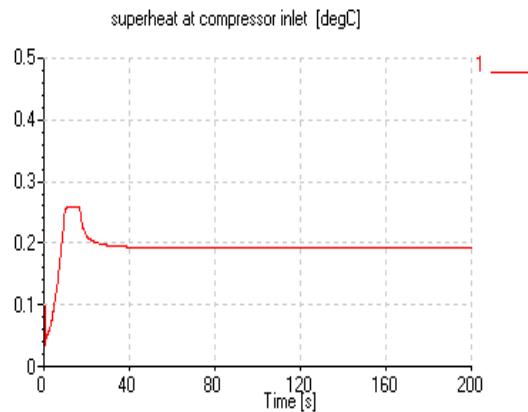


Figure b

Fig no.6 Analysis of compressor with superheating

Fig a. shows the actual work of compressor which is greater than isentropic work and fig b shows the behavior of compressor when superheated refrigerant is passed during suction.

#### 3.2 EVAPORATOR.

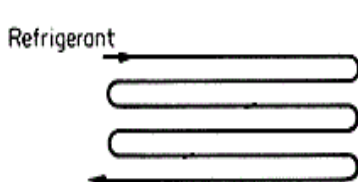


Figure a

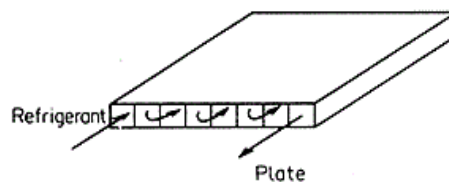


Figure b.

Figure no. 7. Schematic diagram of Evaporator plate

Each evaporator consists of copper tube installed between two plates and the plates are brazed together along the edges so as to form a rectangular box plate. The space between the plates is filled with ethylene glycol which acts as an anti freezing agent. Since the bottom plate is fixed and the top plate is moving, two flexible hoses are used to connect the top and bottom plate.

### 3.3 EXPANSION VALVE.

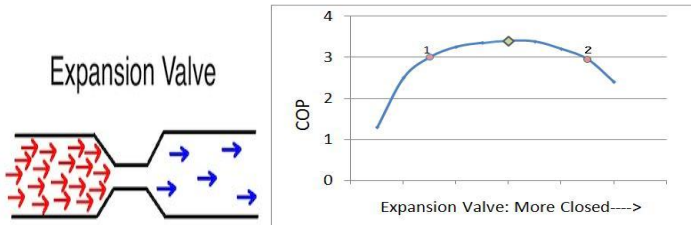


Figure a.

Figure b.

Figure no. 8. Function & Performance of Expansion valve

Expansion valve reduces the pressure of liquid from high to low so that the liquid refrigerant vaporizes at designed pressure in the evaporator, and also controls the flow of refrigerant according to load on the evaporator.

### 3.4 CONDENSOR.

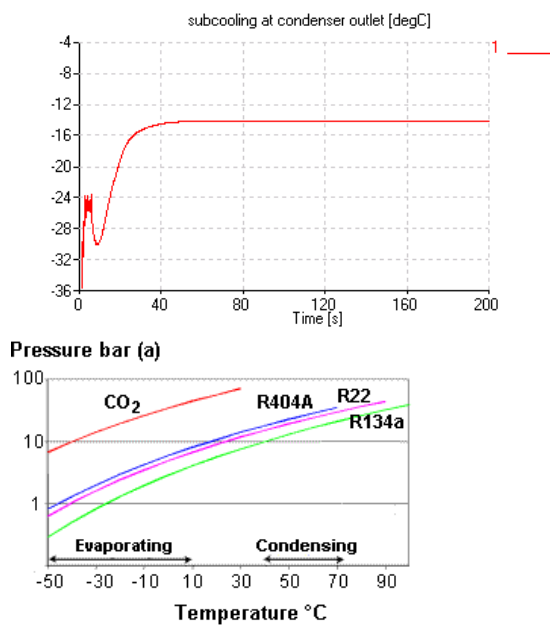


Figure no. a.

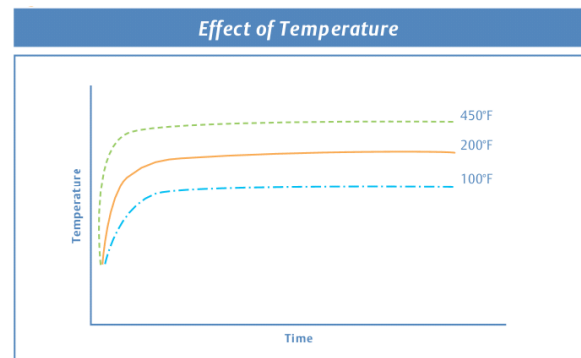


Figure no. b.

Figure no. 9. Analysis of condenser with sub cooling.

Condenser function is to remove heat of the hot vapor discharged from the condenser such that the vapor in the condenser changes its phase to high pressure liquid. Efficiency may be given as, the difference of the outlet and inlet temperature of cooling water to the vacuum present in it and inlet temp of cooling water.

### 3.5 SOLENOID VALVE

A solenoid valve is an electromechanical valve frequently used to control the flow of liquid or gas. Their function is simply to turn refrigerant flow on and off. Solenoid valves offer fast and safe switching, reliability, long life and compact design. When the solenoid coil is electrically energized,

it produces a magnetic field that attracts iron and many of its alloys, then the iron armature or plunger is drawn up into the core of the solenoid. A stem and pin or poppet attached to this plunger opens the valve port. When the solenoid valve is de-energized, the plunger falls, and the poppet closes the valve port. The figure here shows behavior of solenoid valve under different temperatures.

#### REFRIGERANT R-134a

- The refrigerant used is R-134a. (1,1,1,2-tetrafluoroethane)
- R-134a does not contain any chlorine or bromine atoms and therefore is widely accepted by scientists as it does not cause any destruction of stratospheric ozone.
- R-134a has the boiling point of  $-26.6^{\circ}\text{C}$ . ( $-15.9^{\circ}\text{F}$ )
- It is non-flammable and non-toxic.
- It is chemically stable and inert.
- Melting point is  $-103.3^{\circ}\text{C}$ . (169.89 k)

#### IV. CONCLUSION.

We can conclude that quick freezing can be obtained as compared to the conventional refrigeration system and we can get the temperature inside the plate freezer to exactly the same required temperature. Also we can use this system at different temperatures depending on our need, cost saving is another benefit by utilizing multi-evaporator system. Enlargement of the refrigerant hoses is necessary to maintain reasonable circuit pressure drops. In the case of smaller installations, the units may employ multiple, light industrial semi-hermetic compressors. One of the drawback of this system is that it is not versatile i.e irregular shaped packages cannot be cooled.

#### V. REFERENCES

- [1] Kumbhar A. D., "Design, fabrication and performance evaluation of a single compressor multi evaporator system", M.E. Dissertation, WCE, Sangli 1989.
- [2] Arora C. P., "Refrigeration and Air conditioning", Tata McGraw Hill Private Limited, 3rd Edition, 2008.
- [3] Dossat R. J., "Principles of Refrigeration", Pearson, 4th Edition, 2007.
- [4] Václavek, L., Lohan, J. M., Ryan, A. M., "Optimization of Temperature Control during Cooling in a Multizone Refrigeration System", ASHRAE Trans. v 108 (PART 2), pp. 119-128, 2002.