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Study on Refrigeration System Designed for Low Temperature

Madhuri Maheshwari[1], Gaurav Shrivastava[2], Bhanu Choubey[3]

M.E.-Tribology & Maintenance Engineering, SGSITS INDORE (M.P.) India
[1]gaurimadhu.maheshari@gmail.com, [2]gauravshrivastava91@yahoo.com, [3]14bhaskar@gmail.com

Abstract- In this paper study on refrigeration system designed for low temperature which has Zero-Ozone depleting point better heat transfer characteristic gives greater refrigerant effect. In this paper we study the main function part like compressor, evaporator, refrigerant, fan and motor, Technical Details of the components. Energy is the primary and most universal measure of all kind of work by human Being and nature. Everything what happen in the world in the expression of flow of energy is one of its form. Most people use the world energy for input to their bodies or to the machines and thus about fuels and power. Energy is an important input in all sectors of counters economy.

I. Introduction of Mechanism

As every product require deferent storage temp for maintaining the quality of eatable or potable material. Keeping that aspect in view a low temp generating refrigeration system has been designed to maintain -22 °C. It is the process of removing heat from an enclosed space, or from a substance, and rejecting it elsewhere for the primary purpose of lowering the temperature of the enclosed space or substance and then maintaining that lower temperature. The term cooling refers generally to any natural or artificial process by which heat is dissipated. The process of artificially producing extreme cold temperatures is referred to as cryogenics. Cold is the absence of heat, hence in order to decrease a temperature, one "removes heat", rather than "adding cold." In order to satisfy the Second Law of Thermodynamics, some form of work must be performed to accomplish this. This work is traditionally done by mechanical work but can also be done by magnetism, laser or other means. However, all refrigeration uses the three basic methods of heat transfer: convection, conduction, or radiation.[1]

A. Unit of Refrigeration

The practical unit of refrigeration is expressed in the terms of 'Tonne of refrigeration'. A tonne of refrigeration is defined as the amount of refrigeration effect produced by the uniform melting of one tone (1000kg) of ice from and at 0°C in 24 hours. The latent heat of ice is 335kj/kg, therefore one tonne of refrigeration,

1TR = 1000* 335 KJ 24 hours
= 1000 *335/24*60
= 232.6kj/min

In actual practice, one tonne of refrigeration is taken as a equivalent to 210kj/min or 3.5 Kw.[2]

B. Coefficient of performance

The coefficient of performance is the ratio of heat extracted in the refrigerator to the work done on the refrigerant. It is also known as the theoretical coefficient of performance. Mathematically,

Theoretical C.O.P = Q/W

Q = Amount of heat extracted in the refrigerator or The capacity of refrigerator

W= Amount of work done.

C. Refrigeration System

Deep Freezer is the Device which maintain the temperature always below than the atmospheric temperature. In other word we can say that it is the closed unit which converts the water in to ice. It is generally used for all industrial purpose from a small refrigerator to a big air conditioning plant.

The main components of Freezer are-

Compressor
Condenser
Chilling chamber (Evaporator)
Expansion device[3]

II. Main Function of Parts

A. Compressor

A refrigerant compressor as the name indicates is a machine used to compress the vapour refrigerant from the evaporator and to raise the pressure so that the corresponding saturation temperature is higher than that of the cooling medium. It also continually circulates the refrigerant through the refrigerating system. Since the compression of refrigerant requires some work to be done on it, there fore a compressor are must be driven by some prime mover.

B. Condenser

The condenser is an important device used in high pressure side of a refrigeration system. Its function is to remove heat of the hot vapor refrigerant discharge from the compressor. The heat from the hot vapour refrigerant in a condenser is removed first by transferring it to the walls of the condenser tubes and then from the tubes to the condensing or cooling medium. The selection of a condenser depends upon the capacity of refrigeration system, and the type of refrigerant used and the type of cooling medium available.

C. Evaporator

The evaporator is used in the low vapour side of refrigeration system. The liquid refrigerant from the expansion valve enters in to the evaporator where it boils and changes in to vapour. The function of evaporator is absorbing heat from the surrounding location of medium which is cooled, by means of refrigerant. The evaporator becomes cold and remains cold due to following reason-

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

D. Expansion device

The expansion device also known as the metering device or throttling device it is an important device that divides the high pressure side and the low pressure side of refrigerating system. It is connecting between the receivers (containing liquid refrigerant at high pressure) and the evaporator (containing liquid refrigerant at low pressure). The expansion device performs following functions-

- It reduce high pressure liquid refrigerant to low pressure liquid refrigerant before being fed in to evaporator.
- It maintains the desired pressure difference between the high and low pressure sides of the system, so that liquid refrigerant vaporize at the designed pressure in the evaporator.
- It controls the flow of refrigerant according to the load on the evaporator.

E. Refrigerant

Refrigerant is a heat transporting medium which during their cycle (compression, condensation, expansion and evaporation) in the refrigeration system absorbs heat from a low temperature system and discard the heat so absorbed to a to a higher temperature system.

III. ANALYSIS OF THE SYSTEM

The thermodynamics of the vapor compression cycle can be analyzed on a temperature versus entropy diagram as depicted in Figure 2. At point 1 in the diagram, the circulating refrigerant enters the compressor as a saturated vapor. From point 1 to point 2, the vapor is isentropically compressed (i.e., compressed at constant entropy) and exits the compressor as a superheated vapor. From point 2 to point 3, the superheated vapor travels through part of the condenser which removes the superheat by cooling the vapor. Between point 3 and point 4, the vapor travels through the remainder of the condenser and is condensed into a saturated liquid. The condensation process occurs at essentially constant pressure. Between points 4 and 5, the saturated liquid refrigerant passes through the expansion valve and undergoes an abrupt decrease of pressure. That process results in the adiabatic flash evaporation and auto-refrigeration of a portion of the liquid (typically, less than half of the liquid flashes). The adiabatic flash evaporation process is isenthalpic (i.e., occurs at constant enthalpy).[4]

IV. PARTS AND ACCESSORIES ARE ESSENTIAL TO DESIGN THE SYSTEM

As we know that we want to design the refrigeration system for low production system and to check the performance of our system therefore the following equipment and accessories are required and for checking the performance , some indicators and meter are needed .There are the following equipments **:**

Compressor, Condenser, Evaporator (chilling chamber), Expansion device as a capillary tube Fan and Motor, Filter, Pressure gauge, Temperature indicator with Sensor, Ammeter Volt meter, Ply wood, Frames, Pipe line Thermocouple sheets, Hooks and Nuts[5]

V. FACTOR AFFECTING THE HEAT TRANSFER CAPACITY OF AN EVAPORATOR

Though there are many factor upon which the heat transfer capacity of an evaporator depends are:

A. Material

In order to have rapid heat transfer in an evaporator, the material used for the construction of an evaporator coil should be a good heat conductor. The material which is not affected by the refrigerant must also be selected. Iron and steel can be used with all common refrigerants. Brass and copper are used with all refrigerants except ammonia.

B. Temperature Difference

The temperature difference between the refrigerant with in the evaporator and the product to be cooled plays an important role in the heat transfer capacity of an evaporator

C. Velocity of refrigerant

The velocity of refrigerant also affects the heat transfer capacity of an evaporator. If the velocity refrigerant flowing through the evaporator increases, the overall heat transfer coefficient also increases. But this increased velocity will cause greater pressure loss in the evaporator.

D. Contact surface area

An important factor affecting the evaporator capacity is the contact surface available between the wall of evaporator coil and the medium being cooled. The amount of contact surface, in turn, depends basically on the physical size and shape of the evaporator coil.

E. Heat Transfer during Boiling

The mechanism of boiling is so complex that it is difficult to predict the heat transfer coefficient. It is due the factor such as latent heat effects, surface tension, saturation temperature and the nature of the solid surface. The boiling occurs in the following two ways. Pool boiling as it occurs I flooded evaporators Flow boiling or forced convection boiling as it occurs in direct expansion evaporators. When heat is add to a liquid from a submerged solid surface, the boiling process is called pool boiling. A necessary condition for the occurrence of pool boiling is that the temperature of the heating surface exceeds the saturation temperature of the liquid. In this process, the vapour produce may form bubbles, which grow and subsequently detach themselves from the surface, rising to the free surface due to buoyancy effects. On the other hand, the flow boiling or forced convection boiling occurs in a flowing stream and the boiling surface may it self are a portion of the flow passage. This phenomenon is generally associated with two phase flows through confined passage. The process of pool boiling is shown in fig. In this fig the heat flux is plotted against the excess temperature .the pool boiling experiment have shown that the boiling process of liquid at its saturation temperature has the following three distinct regimes:[6]

F. Interface evaporation

This occurs at the free surface with out the formation of bubbles when the solid wall temperature tw is only few degree (about 5' c) above the saturation temperature of evaporating substance (ts)

G. Nucleate boiling

When the excess temperature (delta t) increases, vapour bubble are formed .these bubble rise above the metal surface but condense before reaching the liquid surface. When the excess temperature is further increased, the bubbles rise and collapse through the free surface by limit surface tension. This process is called nucleated boiling.

H. Film Boiling

When the maximum heat flux limit is reached at point A as shown in fig all the heating surface gets covered with vapour bubbles causing the film boiling process. Heat transfer coefficient for Nucleate boiling:

$$\frac{C_f(T_w-T_s)}{h_{fg}} = C_{sf}\left[\frac{Q/A}{\mu_f h_{fg}}\sqrt{\frac{\sigma}{g(\rho_f-\rho_g)}}\right]^{1/3}\left[\frac{C\mu}{K}\right]_f^s$$

Cf = Specific heat of saturated liquid, in J/Kg K.
Tw-Ts = Excess temperature in K
hfg = enthalpy of vaporization in J/Kg.
Csf = an empirical constant. Its value is 0.013 for combination of tube with R-12 R-22 etc
Q/A = heat flux in W/m^2 ,
Mf = Viscosity of saturated liquid in Kg/m-s.
σ = Surface tension of liquid vapor interface in N/m.
g = Acceleration due to gravity in m/s^2,
ρf = Density of saturated liquid in Kg/m^3,
ρs = Density of saturated vapor in Kg/m^3.

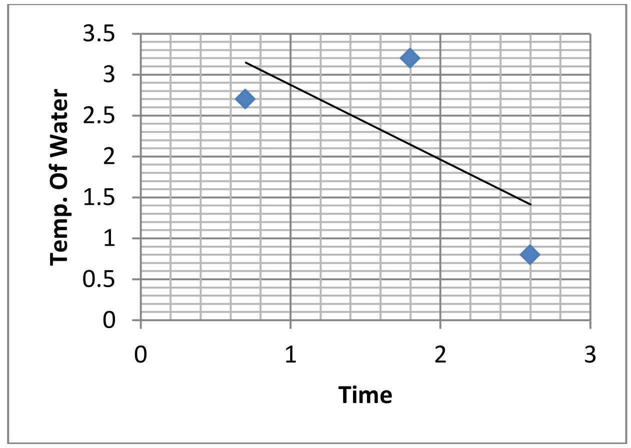
VI. FUNCTION OF EXPANSION DEVICE

The expansion device also known as the metering device or throttling device it is an important device that divides the high pressure side and the low pressure side of refrigerating system. It is connecting between the receivers (containing liquid refrigerant at high pressure) and the evaporator (containing liquid refrigerant at low pressure).

The expansion device performs following functions-

1. It reduce high pressure liquid refrigerant to low pressure liquid refrigerant before being fed in to evaporator.
2. It maintains the desired pressure difference between the high and low pressure sides of the system, so that liquid refrigerant vaporize at the designed pressure in the evaporator.
3. It controls the flow of refrigerant according to the load on the evaporator.[7]

VII. RESULT



Quantity of Water	0.5	Kg			
Initial Temp.	38.7	C			
Time	Supply Voltage	Current drawn	Temp. Of Water	Time	Temp. Of water
14:40	220	1.7	38.7	14:40	38.7
14:40	220	1.7	27.3	14:45	27.3
14:50	220	1.7	21.4	14:50	21.4
14:55	220	1.7	17.5	14:55	17.5

Time of Testing	30 min.
Temp. Diff	28.5
Total heat Extracted	0.03325
Power Consumed	0.374
COP	0.0889037

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