1

Introduction

1.1. Refrigeration

Refrigeration has many definitions. In general, it is defined as any **process** of **heat removal.** It is also defined as **that branch** of **science which** deals with the process of **reducing** and **maintaining**, the temperature of a space or material **below** the temperature of the surroundings.

To do this, heat must be removed from the body. This heat must be transferred to another body whose temperature is below that of the refrigerated body.

In **short**, refrigerating and heating are actually opposite ends of the same process.

1.2. Heat Load

Definition. The rate at which heat must be removed from the refrigerated space or material in order to produce and maintain the desired temperature conditions.

The heat load is the sum of

(*a*) Heat leaks through walls, doors, and windows.

(*b*) Heat that must be removed from the refrigerated product.

(*c*) Heat that must be removed from the people working in space, by electric lights etc.

1.3. Need for Thermal Insulation

Heat is always flowing from a higher temperature to a lower temperature, the heat is continuously flowing into the refrigerated room from outside. To reduce the flow of heat into the refrigerated room, to a practical minimum value, it is necessary to isolate the region from its surroundings with a good heat insulating material known as **Insulation.**

1.4. Refrigerating Agent

In any refrigerating process, the body used as the **heat absorber** or **cooling agent** is known as **Refrigerant.**

According to the effect of heat absorbed by the refrigerant, all cooling processes may be classified as either **sensible** or **latent.**

The process is said to be **sensible** when the absorbed heat causes an **increase** in the **temperature** of **refrigerant**.

The process is said to be **latent** when the absorbed heat causes a change in the physical state of the refrigerant.

1.5. Development of Refrigeration

1.5.1. Ice Refrigeration. When artificial cooling was first used, on a commercial scale, refrigeration by ice was the most common form of artificial cooling. Now this method of cooling is used only to a limited scale.

The main disadvantage of the method of cooling by ice is the lower temperature is being limited to the melting point of ice that is 0°C. This results in a mean temperature in the storage space of about 10°C in smaller household applications and not less than 4°C in larger applications.

1.5.2. Low Temperature by Freezing Mixture. Lower temperature than those attainable with ice alone may be possible by using "freezing mixture". This mixture composed of ice and some other substance notably a salt, sodium chloride or calcium chloride are generally used in practice. Depending upon the amount of salt added, the temperature is reduced.

This method is also used on a small extent and not radily applicable to commerical plants of any size.

1.5.3. Cooling by Throttling. In actual gas, when throttle, a drop in temperature will takes place. On this principle, the system may be constructed. In this system, high pressure gas is throttled into the refrigerated space and escapes after acquiring heat to the outside air the temperature of gas leaving the throttle valve or device will be lower than that before throttling. The amount of temperature drop depends upon Joule-Thomson-Co-efficient (Refer 16), the pressure drop and the original state of the gas.

1.5.4. Cooling by Reversible Expansion. This method is the improvement the method of 1.5.3. In this, the process is continuous, the gas is supplied by a compressor directly. A cooler is used to provide cooling of surrounding air. The process should be reversible adiabatic.

1.5.5. Cooling by Evaporation. In this method, the latent heat of vaporization of some liquid is used to produce cooling. The vaporizing the liquid needs heat and that is being taken from the substance to be cooled. (Example : Earthen jar, cooling of finger dipped in a volatile liquid etc). Any refrigerant, throttle and allowed to evaporate produce cooling. The temperature that will reach in the space depends upon the pressure after throttling as well as type of the refrigerant used.

1.6. Unit of Refrigeration

In MKS the unit of refrigeration used is **ton**. In SI, system, kW is used as the unit of refrigeration.

Definition of the Capacity of the System. It is the rate at which it will remove heat from the refrigerated space. It is usually stated in kJ/hr or in terms of its ice melting equivalent.

Before the era of mechanical refrigeration, ice was widely used as a cooling medium. With the development of mechanical refrigeration it was only natural that the cooling capacity of the mechanical refrigeration should be compared with an ice-melting equivalent.

When one-ton of ice melts, in one day, it will absorb,

$$900 \times 335 = 30{,}1500 \text{ kJ/Day}$$

where 900 kg = 1 short ton

335 kJ/kg = Latent heat of ice.

$$\therefore \text{ Heat absorbed/hr} = \frac{30{,}1500}{24} \text{ kJ/hr}$$

$$\therefore \text{ Heat absorbed/sec} = \frac{30{,}1500}{24 \times 3600} \text{ kJ/sec}$$

$$= 3.48958 \text{ kJ/sec}$$

$$\simeq 3.5 \text{ kJ/sec.}$$

$$= 3.5 \text{ kW} \qquad (\because \ 1 \text{ kJ/sec} = 1 \text{ kW})$$

So, a mechanical refrigerating system having the capacity of absorbing heat from the refrigerated space at the rate of **3.5. kW** is cooling at a rate equivalent to the melting of **1 ton** of ice in **24 Hr** and is said to have a capacity of **1 ton**.

$$\therefore \quad \boxed{\begin{aligned} 1 \text{ Ton} &= 3.5 \text{ kJ/sec} = 3.5 \text{ kW} \\ &= 210 \text{ kJ/min} \\ &= 12{,}600 \text{ kJ/hr} \end{aligned}} \qquad ...(1.1)$$