Chapter 1
Cycle of Operation

Chapter Objectives

This chapter describes the working cycle of the vapour absorption heat pump and the functions of its various components

What is Refrigeration ?

Refrigeration is defined as the process of extracting heat from a low temperature medium and transfering it to a high temperature heat sink. Refrigeration maintains the temperature of the heat source below that of its surroundings while transfering the extracted heat to a heat sink.

Basic Principles

The boiling point of water is directly proportional to pressure. At atmospheric pressure water boils at 100°C. At lower pressure it boils at lower temperature. At 6mmHg absolute pressure the boiling point of water is 3.7°C.

To change water from liquid to vapour it has to be heated. The heat is absorbed by the water and its temperature starts rising. However it rises until it reaches a point where the temperature stays constant and it starts boiling, ie. the liquid water vapourises. This point is called the boiling point. At this point all the heat being absorbed by the water does not change its temperature but only its phase. This heat, required to change the phase of a liquid to vapour, is called the Latent of Vapoursation. Similarly the heat rejected by a vapour when it condenses is called the Latent Heat of Condensation.

Lithium Bromide (LiBr) is a chemical similar to common salt (NaCl). LiBr is soluble in water. The LiBr water solution has a property to absorb water due to its chemical affinity. As the concentration of LiBr solution increases, its affinity towards water increases. Also as the temperature of LiBr solution decreases, its affinity to water increases.

Further there is a large difference between vapour pressure of LiBr and water. This means that if we heat the LiBr water solution, the water will vapourise but the LiBr will stay in the solution and become concentrated.

Absorption Cycle overview

Absorption systems use heat energy to produce a refrigerating effect. In these systems the refrigerant, ie. water, absorbs heat at a low temperature and pressure during evaporation and releases heat at a high temperature and pressure during condensation.

A solution known as absorbent, ie. Lithium Bromide (LiBr), is used to absorb the vapourised refrigerant (after its evaporation at low pressure). This solution, containing the absorbed vapour is heated at a higher pressure. The refrigerant vapourises and the solution is restored to its original concentration for recirculation.

In a double effect absorption machine, the latent heat of condensation of the refrigerant generated in the first stage generator, is used in a second stage generator to enhance the efficiency of the cycle

When the refrigerant undergoes a series of evaporation, absorption, pressurisation, vapourisation, condensation, throttling, and expansion processes, absorbing heat from a low temperature heat source and releasing it to a high temperature sink, so that its state is restored to its original one, it is said to have completed a refrigerating cycle.

Chapter 2
Water Circuit Considerations

Chapter Objective

This chapter describes the effects of changes in the hot / cooling and chilled water specifications and other issues, on the performance and operation of the machine.

The lower the temperature of hot / cooling water, the better.

The temperature at which the refrigerant vapour in the condenser condenses, goes down in proportion to the reduction in the temperature of hot / cooling water. Hence the temperature differences available in the absorber and condenser increase enabling the machine to deliver a higher than rated capacity. As the capacity increases for the same solution flow rate, the various inefficiencies of the heat exchange reduce, thereby increasing the efficiency of operation.

Extremely low hot / cooling water temperature is not acceptable.

LiBr solution crystallizes when it is cooled. As the LiBr solution concentration decreases, the crystallization temperature decreases. At a concentration of 65% the crystallization temperature is 42°C, at a concentration of 60% the crystallization temperature is 17°C and at a concentration of 55% the crystallization temperature is 5°C. The cooling water cools the diluted LiBr in the absorber, which cools the concentrated LiBr in the low temperature heat exchanger (LTHE). If the concentrated LiBr is cooled so that it crystallizes in the LTHE, the LiBr stops flowing through the LTHE, and the machine cannot operate. Hence the temperature of cooling water is to be controlled to ensure that the LiBr does not crystallize.

Capacity of the machine reduces when hot / cooling water temperature increases

LiBr becomes hot when it absorbs vapourised refrigerant. As the temperature of LiBr solution increases its the absorption power decreases. Hot / cooling water removes heat from the LiBr and ensures maximum absorption of the refrigerant. If the hot / cooling water temperature increases, so does the LiBr temperature. Hence the absorption of refrigerant vapour is reduced and the pressure in the evaporator increases. The rated chilled water temperature cannot be maintained and steam is wasted. To prevent this, the maintenance of the hot / cooling water temperature is essential and hot / cooling water temperature should not be allowed to rise.

Interlock between chilled and hot / cooling water flows

If the chilled water flow to the machine stops for any reason, the hot / cooling water flow to the machine should also stop immediately. If the hot / cooling water flow to the machine continues when the chilled water flow is stopped, the absorbent solution in the absorber continues to get cooled and creates a high vacuum in the lower shell. The refrigerant temperature drops sharply and the evaporator tubes may ice as the chilled water becomes stagnant.

For more details refer page V.3

Water treatment of chilled and hot / cooling water

The water treatment of chilled and hot / cooling water is important for the machine performance and long life.

If the water quality is bad and shows a scaling tendency, scale adheres to the inside of the heat transfer tubes of the evaporator, absorber and condenser. The heat transfer between the chilled water and the refrigerant, and the hot / cooling water and the LiBr solution and the condensing refrigerant reduces. This causes an increase in the LiBr and condensed refrigerant temperatures and increases the steam consumption. The chilled and hot / cooling water should be treated to prevent scaling inside the tubes.