Class: Fourth Stage
Subject: Refrigeration Systems
Ammar Abdulkadhim
E-mail: AmmarAbdulkadhim@uomus.edu.iq

Chapter Six

Thermal Analysis of Absorption Refrigeration Systems

1. Relation of the absorption to the vapor-compression cycle

- Ferdinand Carré, a Frenchman, invented the absorption system and took out a United States patent in 1860.
- The first use of the system in the United States was probably made by the ' Confederate States during the Civil War after the supply of natural ice had been cut off from the North.
- The absorption cycle is similar in certain respects to the vapor-compression cycle. A refrigeration cycle will operate with the condenser, expansion valve, and evaporator shown in Fig. 1 if the low-pressure vapor from the evaporator can be transformed into high-pressure vapor and delivered to the condenser. The vapor-compression system uses a compressor for this task.
- The absorption system first absorbs the low-pressure vapor in an appropriate absorbing liquid. Embodied in the absorption process is the conversion of vapor into liquid; since this process is akin to condensation, heat must be rejected during the process. The next step is to elevate the pressure of the liquid with a pump, and the final step releases the vapor from the-absorbing liquid by adding heat.
- The vapor-compression cycle is described as a **work-operated cycle** because the elevation of pressure of the refrigerant is accomplished by a compressor that requires work.
- The absorption cycle, on the other hand, is referred to as a **heat-operated cycle** because most of the operating cost is associated with providing the heat that drives off the vapor from the high-pressure liquid. Indeed there is a requirement for some work in the absorption cycle to drive the pump, but the amount of work for a given quantity of refrigeration is minor compared with that needed in the vapor-compression cycle.

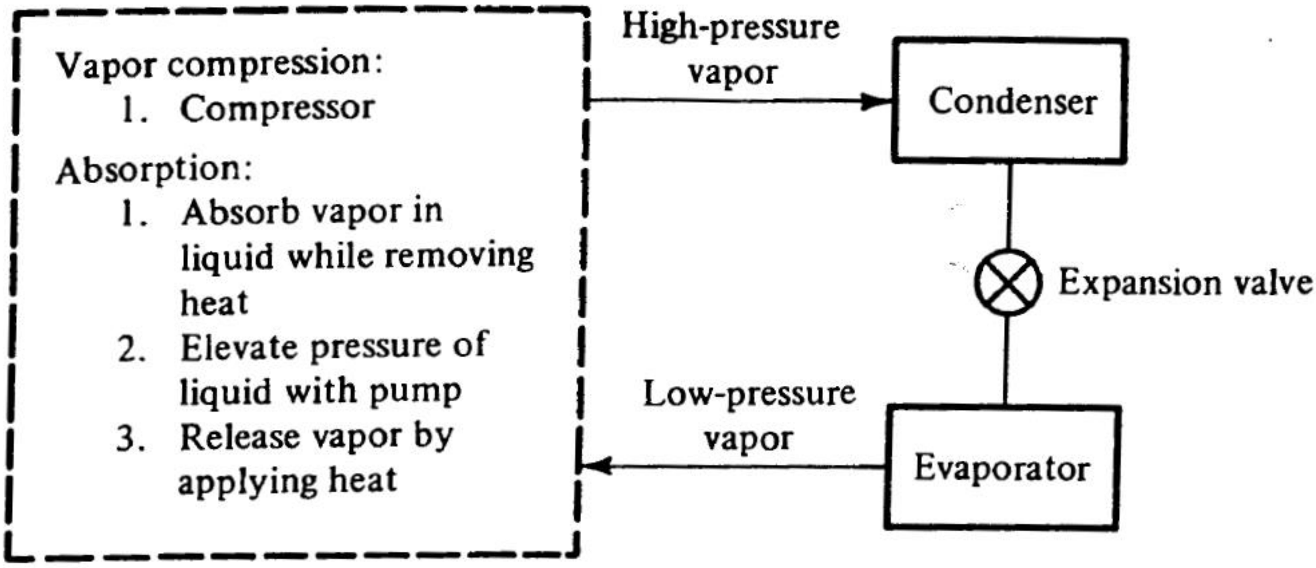

Figure 1 Methods of transforming low-pressure vapor into high-pressure vapor in a refrigeration system.

2. The absorption cycle

- The refrigerant in the absorption cycles are either **water or ammonia** NOT **halocarbon refrigerants**
- The basic absorption cycle is shown in Figure 2. The condenser and evaporator are as shown in Figure 1, and the compression operation is provided by the assembly in the left half of the diagram.
- Low-pressure vapor from the evaporator is absorbed by the liquid solution in the absorber.
- If this absorption process were executed adiabatically, the temperature of the solution would rise and eventually the absorption of vapor would cease. To perpetuate the absorption process the absorber is cooled by water or air that ultimately rejects this heat to the atmosphere.
- The pump receives low-pressure liquid from the absorber, elevates the pressure of the liquid, and delivers the liquid to the generator.
- In the generator, heat from a high-temperature source (such as combustion, steam, heating coil, solar energy, etc.) drives off the vapor that had been absorbed by the

solution. The vapour will be driven into the condenser that will be at high refrigerant vapor pressure.

- The liquid solution returns to the absorber through a throttling valve whose purpose is to provide a pressure drop to maintain the pressure difference between the generator and absorber.
- The pattern for the flow of heat to and from the four heat-exchange components in the absorption cycle is that high-temperature heat enters the generator while low temperature heat from the substance being refrigerated enters the evaporator. The heat rejection from the cycle occurs at the absorber and condenser at temperatures such that the heat can be rejected to atmosphere.

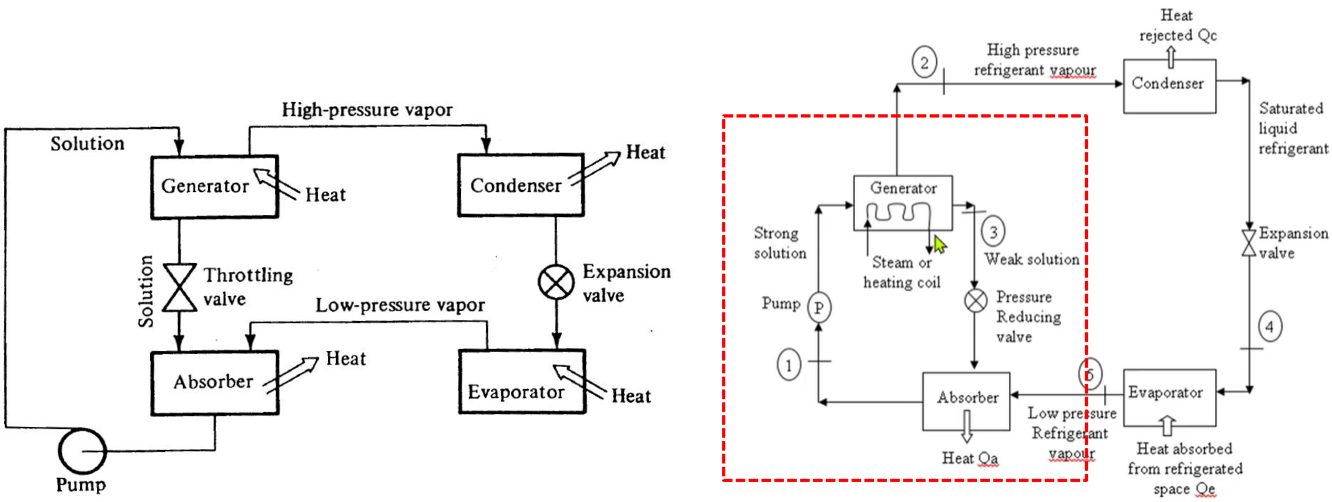

Figure 2 The basic absorption unit.

3. Comparison between Absorption and Vapor Compression Refrigeration Systems

Absorption Refrigeration Systems	Vapor Refrigeration Systems
1. Described as heat- operated cycle	**1.** Described as work – operated cycle
2. Consists four parts : - Evaporator - Absorber - Generator - Condenser	**2.** Consists four parts : - Evaporator - Compressor - Condenser - Expansion device
3. Requires small quantities of power for its operation	**3.** Requires large quantities of power for its operation
4. The refrigerant must be either LiBr-water, or Nh3- water	**4.** The refrigerant may be any Freon
5. The working pressures of the absorption refrigeration cycle are very low	**5.** The working pressures is higher
6. $COP = \frac{Refrigeration\ Effect}{Rate\ of\ Heat\ Addition\ into\ the\ Generator}$	**6.** $COP = \frac{Refrigeration\ Effect}{Comppressor\ Work}$
7. Lower COP	**7.** Higher COP
8. The running cost is cheaper, but initial capital cost is much higher.	**8.** The running cost is very high, but the initial capital cost is lower
9. There are no major moving parts hence they don't vibrate, don't make noise and also don't require heavy foundations. So it operate silently.	**9.** It operated at very high speeds and it makes lots of vibrations and noise due to the action of the compressor
10. No greenhouse effect	**10.** Most of the halocarbon refrigerants used produces greenhouse effect.
11. The working life is smaller because of the corrosion	**11.** It has higher working life

4. Advantages of Absorption over the Vapor Compression Refrigeration Systems

- In absorption system the only moving parts of the entire system is a pump which has a small motor. Thus the operation of this system is essentially quit & need less power.
- The absorption system uses heat energy to change the condition of the refrigerant from evaporator while the compression system uses mechanical energy.
- The absorption system designed to use steam, solar energy & other heat sources. Thus it can be used where the electric power is difficult to obtain or is very expensive.
- The load variation does not effect the performance of absorption system. While the performance of compression system at partial loads is poor.
- The absorption systems can be built in capacities well above 1000 tons of refrigeration each which is largest size for single compressor units.

5. Lithium bromide absorption refrigeration system:

- This system uses a solution of lithium bromide in water.
- In this system, the water is being used as a refrigerant whereas lithium bromide, which is a highly hydroscopic salt, as an absorbent.
- The lithium bromide solution has a strong affinity for water vapour because of its very low vapour pressure.
- This system is very popular for air conditioning in which low refrigeration temperature (not below 0 ^{o}Celsius) are required.
- Lithium bromide- water system designed in two forms:

- The first where all the components of cycle are placed in same shell, its upper half contain the generator & condenser while its lower half contain the evaporator & absorber this type called (one shell system) as in simple absorption system.
- The second form consists of two shells, the first shell (high pressure side) contain the generator & condenser, while the second shell (low pressure side) contain the evaporator & absorber. This system called (two shell system) as show in figure below.