Refrigeration Systems

Introduction

The mechanism used for lowering or producing low temperature in a body or a space, whose temperature is already below the temperature of its surrounding, is called the refrigeration system.

Here the heat is being generally pumped from low level to the higher one and is rejected at high temperature.

Refrigeration

The term refrigeration may be defined as the process of removing heat from a substance under controlled conditions.

It also includes the process of reducing heat & maintaining the temperature of a body below the general surroundings temperature.

In other words refrigeration is a means of continued extraction of heat from a body whose temperature is already below the surrounding temperature.

Refrigerator & Refrigerant

A refrigerator is a reversed heat engine or a heat pump which takes out heat from a cold body and delivers it to a hot body.

The refrigerant is a heat carrying medium which during their cycle in a refrigeration system absorbs heat from a low temperature system and delivers it to a higher temperature system.

Refrigerant Product Types

Operating liquids can all be very different to each other, but all must have good phase changing properties, some of the most common types are:-

HFC (hydrofluorocarbon) R404A, R507A, etc;

Ammonia (NH3)

Single-phase liquids, ethylene or propylene glycol, potassium acetates, etc.

CO2 with different levels of maximum operating pressure.

Refrigeration Cycle

In refrigeration system the heat is being generally pumped from low level to higher one and removed at that temperature.

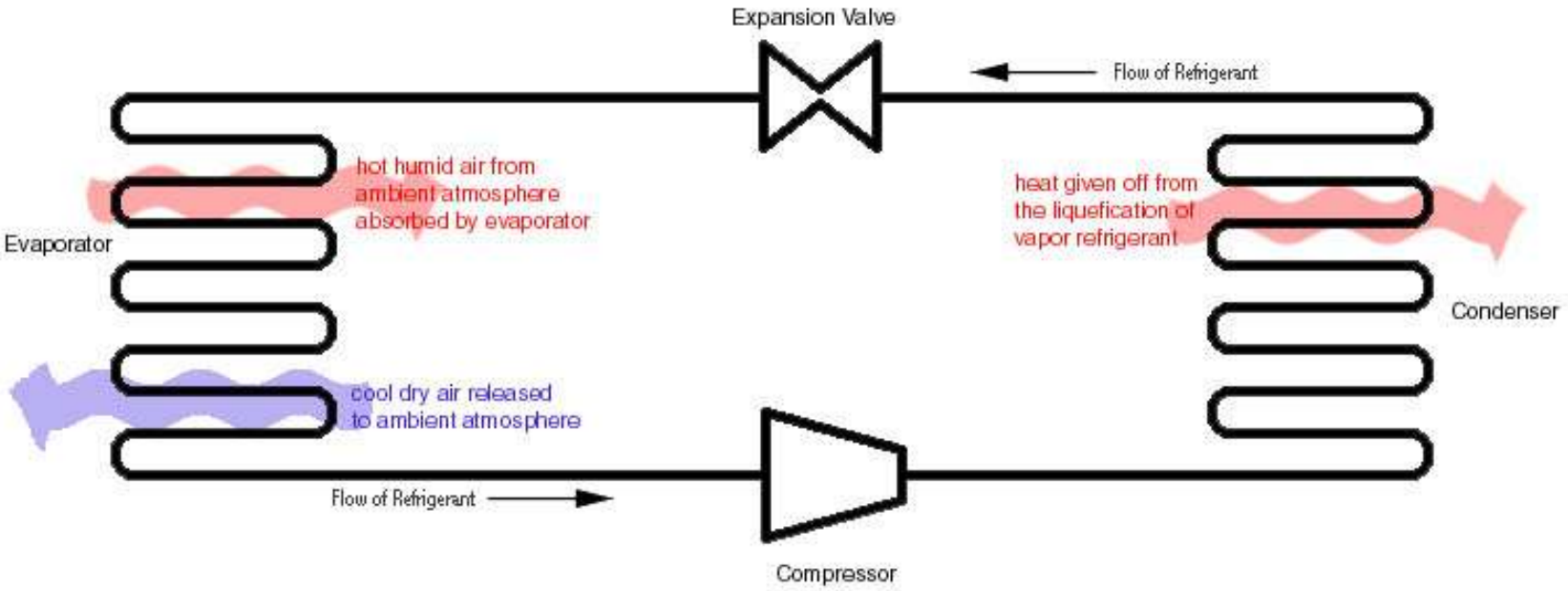
This rejection of heat from low level to higher level of temperature can only be performed with the help of external work according to second law of thermodynamics.

(*the second law can be expressed in several ways, but the simplest being that heat will naturally flow from a hotter to a colder body*.)

The total amount of heat being rejected to the outside body consist of two parts:-

- the heat extracted from the body to be cooled .

- the heat equivalent to the mechanical work required for extracting it.



Simple single stage vapour compression refrigeration system were the condenser may be water or air cooled

As we said earlier a refrigerator is a reverse heat engine (**Stirling engine)** run in the reverse direction by means of external aid.

Every type of refrigeration system used for producing cold must have the following four basic units:-

- Low temperature thermal sink to which the heat is rejected for cooling the space.

- Means of extracting the heat energy from that sink, raising its level of temperature before delivering it to heat receiver.

- A receiver is a storage to which the heat is transferred from the high temperature high pressure refrigerant.

- Means of reducing the pressure and temperature of the refrigerant before it return to the sink.

The processes of this cycle are evaporation, compression, condensation & expansion.

By reversing the heat engine cycle completely and by changing the working agent, a refrigeration cycle is obtained.

Refrigeration Systems

- Vapour compression refrigeration system
- Vapour absorption refrigeration system
- Thermo electric refrigeration system

Vapour Compression Refrigeration

- This is the most important system from the point of commercial and domestic utility and most practical form of refrigeration.

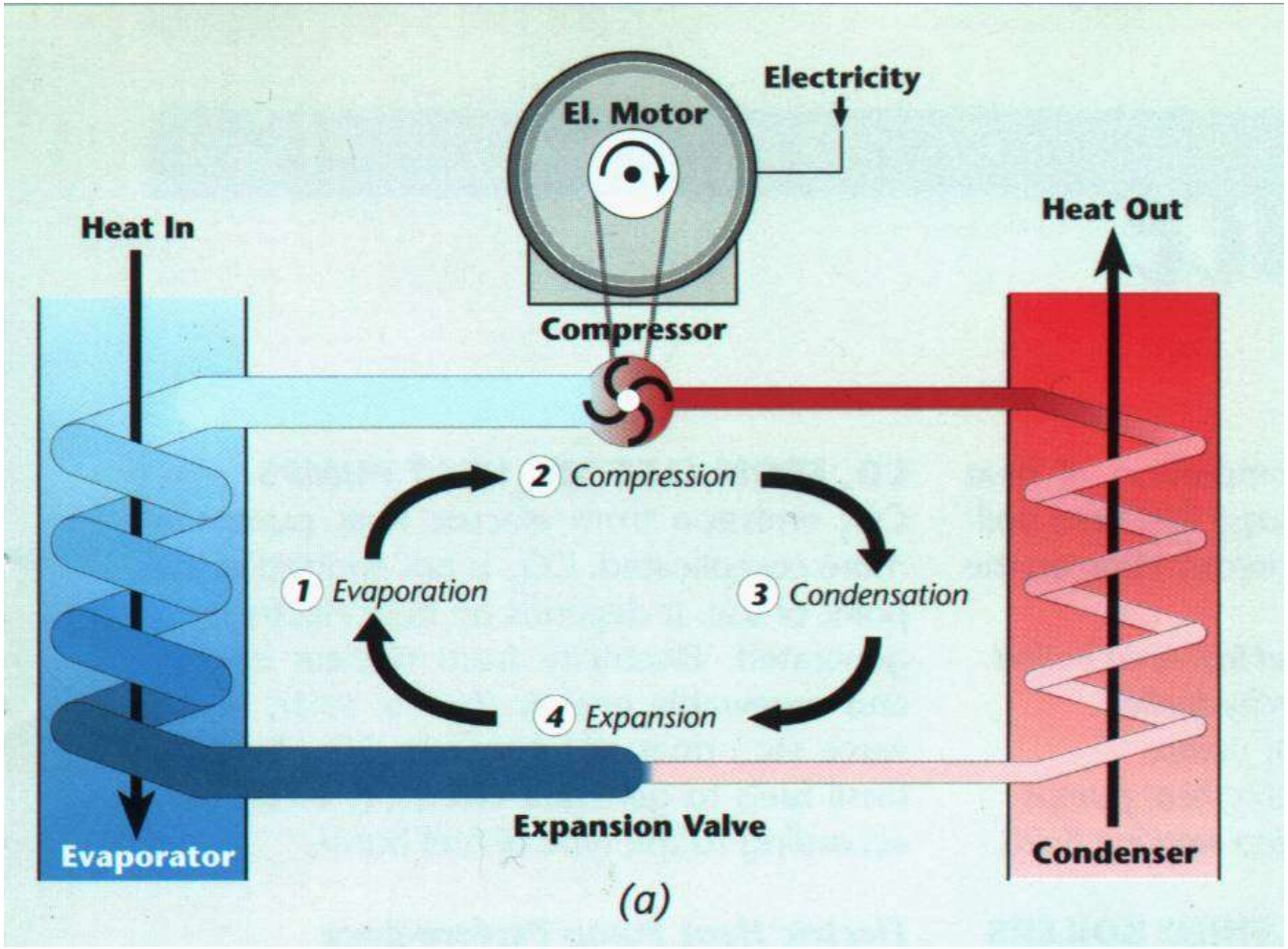
- The working fluid refrigerant used in this refrigeration system readily evaporates and condenses or changes alternatively between the vapour and liquid phases without leaving the refrigerating plant

- During evaporation it absorbs heat from the cold body or in condensing or cooling it rejects heat to the external hot body.

- The heat absorbed from cold body during evaporation is used as its latent heat for converting it from liquid to vapour.

- Thus a cooling effect is created in working fluid.

Vapour Compression Refrigeration



This system of refrigeration thus act as latent heat pump since its pump its latent heat from the cold body such as brine & rejects it or deliver it to the external hot body or the cooling medium.

According to the law of thermodynamics , this can be done only on the expenditure of energy which is supplied to the system in the form of electro/mechanical energy driving the compressor.

The vapour compression cycle is used in most of the modern refrigeration systems in large industrial plants.

The vapour in this cycle is circulated through the various components of the system, where it undergoes a number of changes in its state or condition.

Each cycle of operation consists of the four fundamental changes of state or processes:-

Expansion

Vaporisation

Compression

Condensation

Compressor

The low pressure and temperature refrigerant from evaporator is drawn into the compressor through the inlet or suction valve, where it is compressed to a high pressure and temperature.

The high pressure and temperature vapour refrigerant is discharged into the condenser through the delivery or discharge valve.

Condenser

The condenser or the cooler consists of coils of pipe in which the high pressure and temperature vapour refrigerant is cooled & condensed.

The refrigerant while passing through the condenser, rejects its latent heat to surrounding condensing medium which is normally air or water.

Thus hot refrigerant vapour received from compressor is converted into liquid form in condenser.

Receiver

The condensed liquid refrigerant from the condenser is stored in a vessel, known as receiver, from where it is supplied to the expansion valve or refrigerant control valve. The amount of refrigerant in the system can usually assessed by a sight glass arrangement on this vessel

Expansion Valve

The function of this valve is to allow the liquid refrigerant under high pressure and temperature to pass at a controlled rate after reducing its pressure and temperature some of liquid refrigerant evaporates as it passes through the expansion valve, but the greater portion is vaporized in the evaporator at the low pressure and temperature.

Evaporator

An evaporator consists of coils of pipes in which the liquid vapour refrigerant at low pressure and temperature is evaporated and changed into a vapour refrigerant at low pressure and temperature.

During evaporation process, the liquid vapour refrigerant absorbs its latent heat of vaporization from the medium which is to be cooled.

Advantages

- Smaller size for a given refrigerating capacity
- Higher coeff. of performance
- Lower power requirements for a given capacity
- Less complexity in both design & operation
- It can be used over large of temperature ranges.

Charging the System with Refrigerant

Adding a refrigerant charge is done by an outdoor unit service valves that is connected to a refrigerant supply via a manifold, the charge must be added in the liquid state into the liquid outlet service valve, with the compressor in operation.

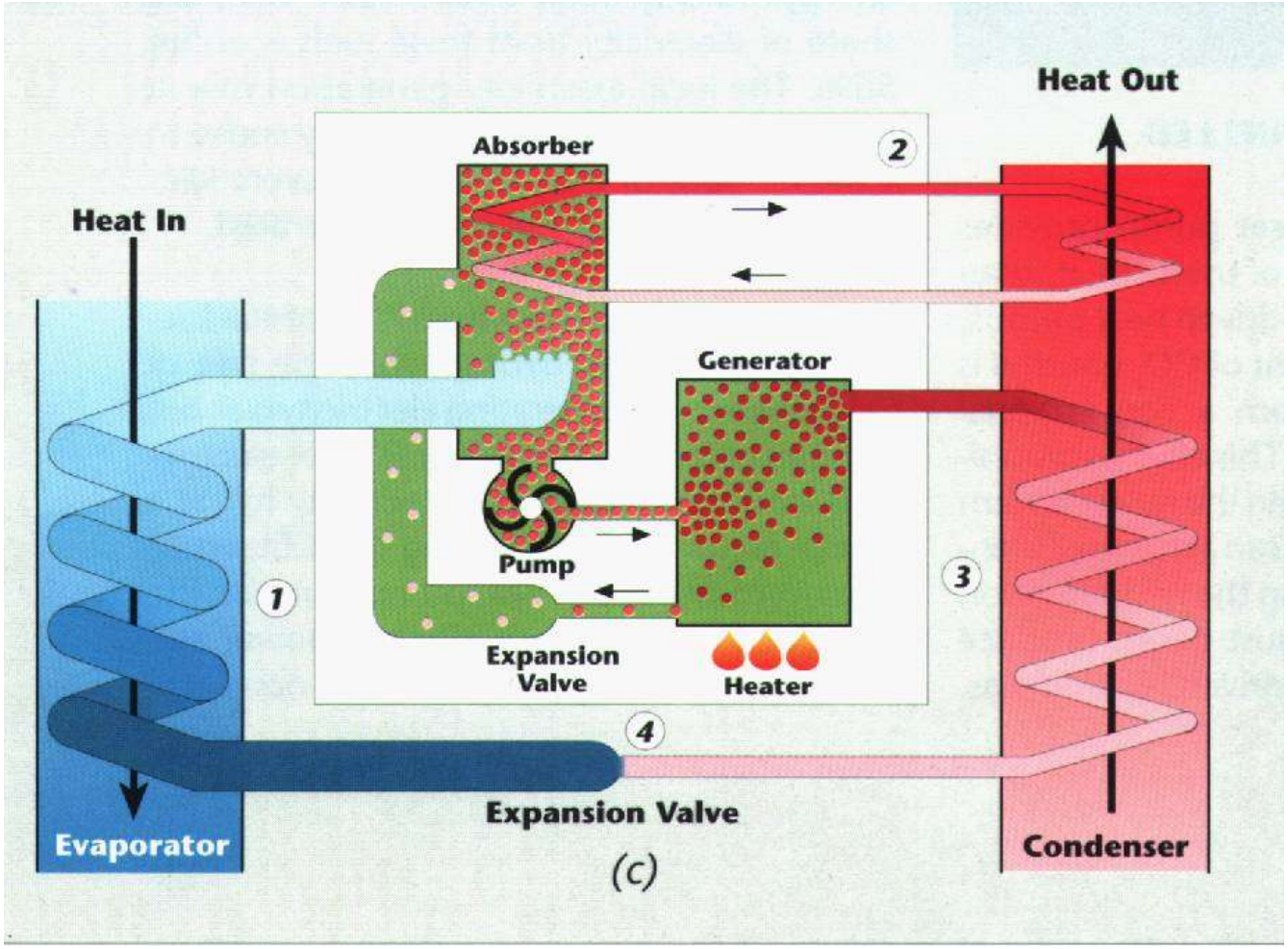
The liquid refrigerant must not added to the compressor suction line.

Vapour absorption refrigeration system

A vapour absorption refrigeration is a machine that produces chilled water using a heat source rather than electro/mechanical input as in previous vapour compression cycle. It seems unreasonable that cooling can be achieved with heat, but that is what occurs within an absorption chillier.

The basic difference is that an electric chillier employs a mechanical compressor to create the pressure differences necessary to circulate the refrigerant whereas the absorption chillers use heat source and do not use a mechanical compressor. The differences causes an absorption system to use little to no work input, but energy must be supplied in the form of heat. This makes the system very attractive when there is a cheap source of heat, such as solar heat or waste heat from electricity or heat generation.

Vapour absorption refrigeration system



Thermo electric refrigeration system

Thermoelectric cooling is a way to remove thermal energy from a medium, device or component by applying a voltage of constant polarity to a junction between dissimilar electrical conductors or semiconductors. It is used in electronic systems and computers to cool sensitive components such as power amplifiers

Domestic Refrigerator

The application of refrigeration for domestic purposes are mainly in the form of domestic refrigerators and home freezers.

The main purpose of this type of refrigeration is to provide low temp. for storage and distribution of foods and drinks.

It represents a significant portion of the refrigeration industry due to the use of these units in large number.

For domestic preservation, the storage is generally short term. The domestic refrigerators used for the purposes are usually small in sizes with rating for relatively small quantise.

The unit is usually self contained and hermetically sealed.

Due to short term storage the domestic refrigerator load is intermittent.

The requirement of domestic refrigerator is that:-

- it should be simple in construction
- automatic in action
- nominal in initial cost

- dependable and without any necessity of expert inspection & repair.
- Non irritant & non toxic refrigerant should be used.
- Generally methylene chloride, freon-12, freon -11 are used as refrigerants.

- The common type of domestic refrigerator have a cabinet shaped with compressor motor-fan assembly, the condensed and receiver fitted in their basement.

- The expansion valve evaporator coils are exposed in the storage cabinet with the piping, carrying liquid refrigerant passing through the body.

- The heat of the bodies to be cooled is carried to the evaporator coils by means of air trapped in the cabinet.

- Refrigeration is not only provided with double walled cabinet packed with materials having high thermal insulation such as fibreglass or expanded rubber but also all around the inside of door flap soft rubber seal is used which makes rubber air tight.

END OF PRESENTATION

ANY QUESTIONS