(Unit – 7)

Pharmaceutics – II

(Unit Operations I, including Engineering Drawing)

" Refrigeration and Air Conditioning "

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Refrigeration System

Refrigeration is the process of cooling a space, substance, or system to lower or maintain its temperature. In other words, refrigeration means artificial (human-made) cooling system. Energy in the form of heat is removed from a low-temperature reservoir and transferred to a high-temperature reservoir. Refrigeration has many applications, including household refrigerators, industrial freezers, cryogenics, and air conditioning. Heat pumps may use the heat output of the refrigeration process, and also may be designed to be reversible, but are otherwise similar to air conditioning units.

Refrigeration has had a large impact on industry, lifestyle, agriculture, and settlement patterns. The idea of preserving food dates back to at least the ancient Roman and Chinese empires. However, mechanical refrigeration technology has rapidly evolved in the last century, from ice harvesting to temperature-controlled rail cars. The introduction of refrigerated rail cars contributed to the westward expansion of the United States, allowing settlement in areas that were not on main transport channels such as rivers, harbors, or valley trails. Settlements were also developing in infertile parts of the country, filled with newly discovered natural resources.

How Does A Refrigerator Work?

To put it simply there are 3 steps by which a refrigerator or a fridge works:

1. *Cool refrigerant is passed around food items kept inside the fridge.*
2. *Refrigerant absorbs heat from the food items.*
3. *Refrigerant transfers the absorbed heat to the relatively cooler surroundings outside.*

Although there were techniques that people used in ancient times to get cold water, they were certainly not as easy as opening a door at home and taking out a bottle of ice-cold water. Even if they could get cold water to drink, they certainly didn't have anything that could make their food stay fresh for days or even weeks on end.

Fortunately, we have a little something that does all of these things for us – a refrigerator!

We will take a look at the science of a refrigerator, specifically the different parts of a refrigerator and how they actually work together to preserve our food for extended periods.

Refrigerator working principle

The working principle of a refrigerator (and refrigeration, in general) is very simple: it involves the removal of heat from one region and its deposition to another. When you pass a low-temperature liquid close to objects that you want to cool, heat from those objects is transferred to the liquid, which evaporates and takes away the heat in the process.

You may already know that gases heat up when you compress them and cool down when they are allowed to expand. That's why a bicycle pump feels warm when you use it to pump air inside a tire, while sprayed perfume feels cold.

he tendency of gases to become hot when compressed and cold when expanded, along with the help of a few nifty devices, helps a refrigerator cool the stuff being kept inside it.

Parts of a refrigerator

A refrigerator consists of a few key components that play a vital role in the refrigeration process:

Expansion valve

Also referred to as the flow control device, an expansion valve controls the flow of the liquid refrigerant (also known as 'coolant') into the evaporator. It's actually a very small device that is sensitive to temperature changes of the refrigerant.

Compressor

The compressor consists of a motor that 'sucks in' the refrigerant from the evaporator and compresses it in a cylinder to make a hot, high-pressure gas.

Evaporator

This is the part that actually cools the stuff kept inside a refrigerator. It consists of finned tubes (made of metals with high thermal conductivity to maximize heat transfer) that absorb heat blown through a coil by a fan. The evaporator absorbs heat from the stuff kept inside, and as a result of this heat, the liquid refrigerant turns into vapor.

Condenser

The condenser consists of a coiled set of tubes with external fins and is located at the rear of the refrigerator. It helps in the liquefaction of the gaseous refrigerant by absorbing its heat and subsequently expelling it to the surroundings.

As the heat of the refrigerant is removed, its temperature drops to condensation temperature, and it changes its state from vapor to liquid.

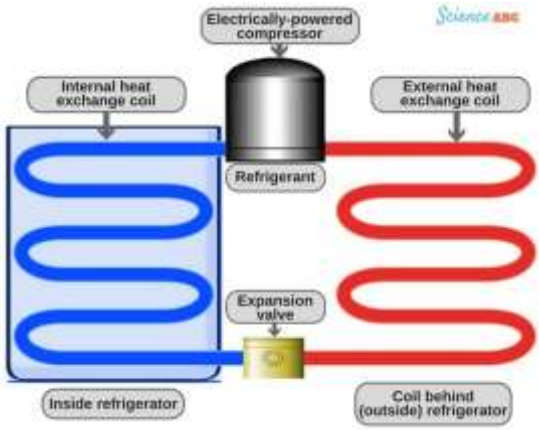
Refrigerant

Also, commonly referred to as the coolant, it's the liquid that keeps the refrigeration cycle going. It's actually a specially designed chemical that is capable of alternating between being a hot gas and a cool liquid.

In the 20th century, fluorocarbons, especially CFCs, were a common choice as a refrigerant. However, they're being replaced by more environment-friendly refrigerants, such as ammonia, R-290, R-600A etc.

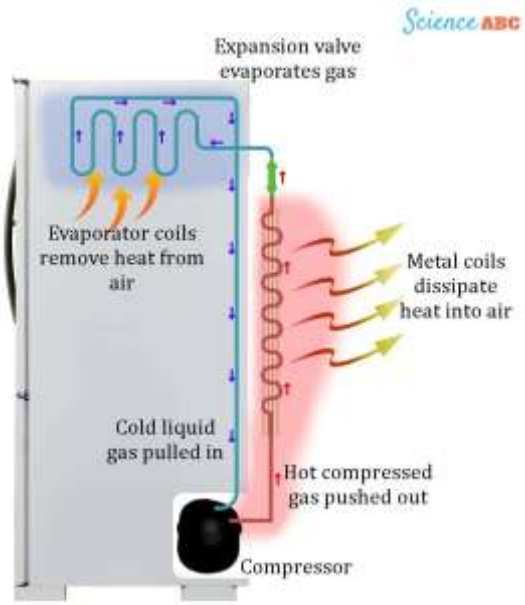
Refrigerator function: How does a refrigerator work?

The refrigerant, which is now in a liquid state, passes through the expansion valve and turns into a cool gas due to the sudden drop in pressure.



As the cool refrigerant gas flows through the chiller cabinet, it absorbs the heat from the food items inside the fridge. The refrigerant, which is now a gas, flows into the compressor, which sucks it inside and compresses the molecules together to make it into a hot, high-pressure gas.

Now, this gas transports to the condenser coils (thin radiator pipes) located at the back of the fridge, where the coils help dissipate its heat so that it becomes cool enough to condense and convert back into its liquid phase. Because the heat collected from the food items is given off to the surroundings via the condenser, it feels hot to the touch.



After the condenser, the liquid refrigerant travels back to the expansion valve, where it experiences a pressure drop and once again becomes a cool gas. It then absorbs heat from the contents of the fridge and the whole cycle repeats itself.

APPLICATIONS OF REFRIGERATION IN 7 DIFFERENT INDUSTRIES

Refrigeration and cooling systems are designed to fulfill determined requirements based on the specific characteristics of each industry. The main industries that require refrigeration or cooling systems are:

1. District Cooling
2. Electricity Production
3. Chemical and Petrochemicals
4. Pharmaceutical
5. Food & Beverages
6. Data Centers
7. Other industries

1. DISTRICT COOLING

One of the top markets for cooling is focused on providing cooled air to urban and touristic areas, thus keeping enclosed ambiances comfortable independently of the outside weather. In big hotels, resorts and district areas, refrigeration production is usually delivered by District Cooling systems.

The concept of District Cooling is based around the generation of cooling streams (mainly chilled water) with different technologies in a central plant. It is then distributed to different populated places like homes, offices, venues, or other residential or commercial projects. By centralizing the cooling production, a higher efficiency is achieved. This, due to optimization of industrial equipment and electricity consumption compared to individual refrigeration systems for each building. In addition, District Cooling has other advantages, like a reduction in capital, operation, and maintenance costs with respect to individual cooling systems. Combined with energy storage systems, a considerable reduction in peak electricity demand can be achieved. District Cooling provides important economic and environmental benefits to residential communities and touristic areas.

2. ELECTRICITY PRODUCTION

Electricity generation is often based on the combustion of different fuels. To achieve a higher efficiency, inlet air must be in determined conditions. If the temperature of the inlet air is too high, its density decreases, suffering a decline in the electric production. To avoid this problem, systems like Turbine Inlet Air Cooling System, a system in ARANER's portfolio, are used to cool down these air streams. Other parts of production and distribution systems, like electric generators or distribution plants, also generate heat when operating. To minimize maintenance operations, refrigeration systems are necessary. This refrigeration equipment is usually based on compression or absorption cycles.

3. CHEMICAL & PETROCHEMICAL

Although chemical and petrochemical reactions are not as strictly controlled as the reactions in the Pharmaceutical field, control of temperature is an important factor in reaching high efficiency in their transformations. Distillations, crystallizations or condensations are operations requiring the removal of heat; hence refrigeration systems are necessary to obtain their products. In chemical and petrochemical industries, large scale cooling plants are used in their processes. Due to the high flow required and the location of the industries, river water or seawater is used as refrigerant. Compression cycles and absorption cycles are used to cool down the hot stream after the heat has been dissipated in the different operations. Moreover, since hot streams are also required in other parts of the process, heat exchangers are usually applied to heat these streams and maximize the efficiency of the operation.

4. PHARMACEUTICAL

The Pharmaceutical industry is based around operations where fulfillment of strict conditions is essential for the success of every process. Going further, many production procedures imply biological or biochemical reactions that only take place in strict conditions in which microbiological species generate chemical compounds at their maximum yield. This is why it is so important that Pharmaceutical firms develop their products in clean disinfected rooms.

One of the most important parameters in this industry is temperature. Moreover, strains used for drug and medicine production are stored in very controlled conditions, usually at low temperatures. For these reasons, the Pharmaceutical industry must rely on highly sophisticated refrigeration systems that permit the temperature adjustment of rooms and storage units to extremely precise temperatures.

For Pharmaceuticals, the size of cooling plants tends to be smaller, since the production capacity of pharmaceutical industry equipment is limited. Normally, this industry utilizes a central cooling plant with transformer stations and refrigerants that are distributed through the different clean rooms of the factory. Other refrigeration systems that can be found in this industry are oxy-chlorination plants, ammonia/chlorine/oxygen liquefaction plants, or compressed air cooling.

5. FOOD & BEVERAGES

Maintaining the cold chain in the F&B industry is vital for preserving products and avoiding possible microbiological contamination. Each product has its own optimal conditions for storage and preservation. In the preparation process, temperature is one of the most important parameters to assure food safety. In products like fish, poultry, meat, dairies or fruits, refrigeration systems are necessary to keep products in low temperatures and extend the recommended consumption period. Other types of F&B industries—like a brewery—require several refrigeration systems to finish the biological and chemical

reactions that take place during the process, and to preserve the optimal conditions of the product once the process is finished.

6. DATA CENTRES

Data centers store groups of servers used to process and distribute data. The servers naturally produce heat during operation, and if the heat is not removed, the temperature rises. Unfortunately, this can adversely affect the functioning of the servers. To prevent this problem, powerful air-cooling systems are usually placed in these data centers, dissipating the heat produced and minimizing maintenance operations. These cooling systems are commonly air-based or liquid-based, depending on exterior conditions. Furthermore, new cooling systems are starting to be more environmentally friendly, using seawater as a refrigerant.

7. OTHER INDUSTRIES

There are other industries such as naval or metallurgical, which rely on refrigeration for their operations or to have a comfortable ambient for their workers to develop their activities. Cooling systems for these industries must be thoroughly designed to avoid short and long terms problems that can result in very high costs of maintenance and operation.

Air conditioning system

INTRODUCTION

- Definition - Air conditioning is the process of altering the properties of air (primarily temperature and humidity) to more favorable conditions.
- The control of these conditions may be desirable to maintain the health and comfort of the occupants, or to meet the requirements of industrial processes irrespective of the external climatic conditions.

PRINCIPLES OF AIR-CONDITIONING

The goal is to keep it more comfortable inside the house than it is outside.

TYPE OF AIR-CONDITIONING

1. Window air-conditioning system
2. Split air-conditioning system
3. Centralized air-conditioning system
4. Package air-conditioning system

1) Window air conditioning system

- Window air conditioners are one of the most commonly used and cheapest type of air conditioners.
- To install one of these units, you need the space to make a slot in the wall, and there should also be some open space behind the wall.
- Window air-conditioner units are reliable and simple-to-install solution to keep a room cool while avoiding the costly construction of a central air system.
- Better yet, when the summer heat dies down, these units can be easily removed for storage, and you can use the window sill for other purpose

2) Split Air-Conditioning System

- The split air conditioner comprises of two parts: the outdoor unit and the indoor unit.
- The outdoor unit, fitted outside the room, houses components like the compressor, condenser and expansion valve.
- The indoor unit comprises the evaporator or cooling coil and the cooling fan. For this unit you don't have to make any slot in the wall of the room.
- Further, the present day split units have aesthetic looks and add to the beauty of the room. The split air conditioner can be used to cool one or two rooms

3) Centralized Air-Conditioning System

- The central air conditioning plants or the systems are used when large buildings, hotels, theaters, airports, shopping malls etc. are to be air conditioned completely.
- The window and split air conditioners are used for single rooms or small office spaces.
- If the whole building is to be cooled it is not economically viable to put window or split air conditioner in each and every room.
- Further, these small units cannot satisfactorily cool the large halls, auditoriums, receptions areas etc.

4) Packaged Air-Conditioning System

- The window and split air conditioners are usually used for the small air conditioning capacities up to 5 tons.
- The central air conditioning systems are used for where the cooling loads extend beyond 20 tons.
- The packaged air conditioners are used for the cooling capacities in between these two extremes.
- The packaged air conditioners are available in the fixed rated capacities of 3,5, 7, 10 and 15 tons.
- These units are used commonly in places like restaurants, telephone exchanges, homes, small halls, etc.

New Invented Technology for Air-Conditioning System

1. DISTRICT COOLING SYSTEM
2. CHILLED BEAM SYSTEM

❖ **District Cooling System**

District Cooling Systems (DCS) is a system which distributes chilled water or other media, usually provided from a dedicated cooling plant, to multiple buildings for air conditioning or other uses.

1. District Cooling System

To centralized production of chilled water by using district cooling plant. The generated chilled water will then be channeled to various building blocks through pre- insulated seamless underground pipes.

Advantages

- ✓ Improve energy efficiency
- ✓ Protect environment
- ✓ Save spaces
- ✓ Improve urban view
- ✓ Reduce manpower for operation and maintenance District Cooling System.

How the System Work?

- ➢ DC means the centralized production and distribution of cooling energy. Chilled water is delivered via an underground insulated pipeline to office, industrial and residential buildings to cool the indoor air of the buildings within a district. Specially designed units in each building then use this water to lower the temperature of air passing through the buildings ACS.
- ➢ The output of one cooling plant is enough to meet the cooling-energy demand of dozens of buildings. DC can be run on electricity or natural gas and can use either regular water or seawater. Along with electricity and water, DC constitute a new form of energy service.

DCS – COMPONENTS

- ➢ Central Chiller Plant – generate chilled water for cooling purposes.
- ➢ Distribution Network – distribute chilled water to building.
- ➢ User Station – interface own building air-conditioning circuit.

2. *Chilled beam system*

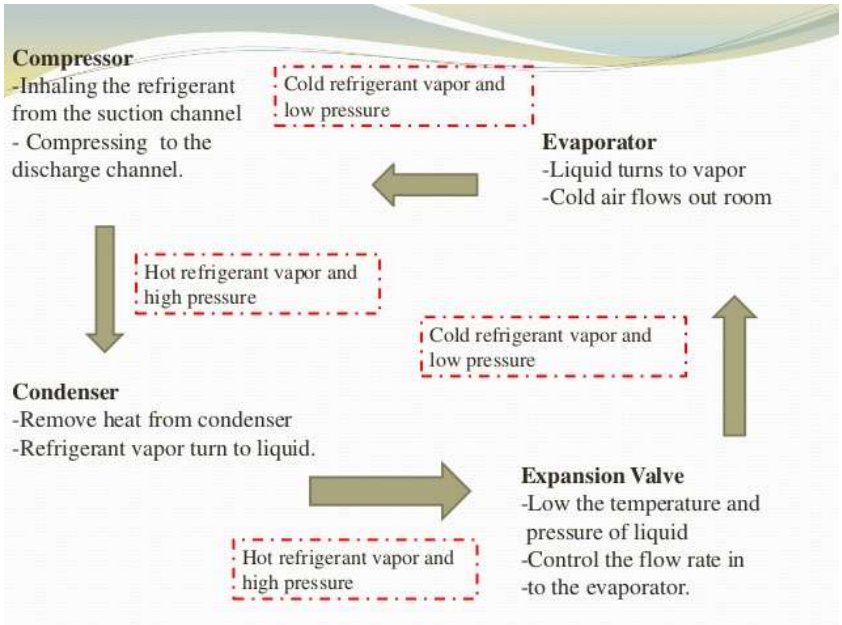
- It is a type of convection HVAC system designed to heat or cooled high rise building such as commercial building.
- It's primarily gives off its cooling effect through convection by using water to remove heat from a room.
- Pipes of water passed through the beam suspended short distance from the ceiling of a room.
- As the beam chills the air around it, the air becomes denser and falls to the floor.
- It is replaced by warmer air moving up from below, causing a constant flow of convection and cooling the room.

ADVANTAGES

- Simple to design and control
- Smaller ductwork
- Less mechanical space
- Less maintenance
- Increase comfort

DISADVANTAGES

- Not well known in our industry
- Higher construction cost
- Many engineers aren't familiar with this technology
- Dew point concerns, building must have a good control of humidity to prevent condensation on chilled beam surface



THE COOLANT

- Heat is removed from the cooling by coolant.
- as a heat absorber from the evaporator
- *Good coolant must have features;*
    1. Non-toxic
    2. Not explosive
    3. Non-corrosive components
- Not explosive
- Soluble in oil to lubricate effectively
- Harmless when responding to oil even in the presence of moisture
- Have a high resistance to electricity.

Application of Air Conditioning.

Air-conditioning is an important part of human society. Day by day it's the environment that we live-in is in verge of pollution overtake. It's important to us that we breath good conditioned air. Air conditioners have following applications.

1. Air conditioning can be defined as conditioning the air for a natural and comfortable atmosphere within the living area particularly in our home or office.
2. Filtering air for dust particles, mold, insects, and much other microorganism living in air.
3. Employed in large super computer halls to small desktops rooms for keeping them their cool and for their prolonged working.
4. Constant temperature is to be maintained in tool room as you know metal are not so trusted with changing temperature for their dimensions.
5. Air conditioning helps the shop owners for a good sale. Or maybe that is why we hang out in malls more often in college days.
6. Air conditioner maintains the humidity level.
7. Air conditioner can keep your food fresh for a little longer. Sometimes even for 2 years in cold rooms.
8. Air conditioner is used in Operation theatre so that patients could get well soon other than getting his wounds septic due to the microorganisms present in air, which as stated, in a condition without AC.
9. Air conditioning keeps your office toilet smell free its 80% fresh air for every intake air.
10. AC's are used in car and other such vehicle for the comfort of the rider. Aeroplan too.
11. Testing rooms are generally air conditioned.
12. Parking lot needs Air conditioning. That doesn't mean to cool the air but just to circulate the air. A fan specifically exhaust fan will do the work.
13. Air conditioning in airports and bus stand for the comfort of passengers.

Advantages

Most people use air conditioners to stay more comfortable in their homes or offices during hot and humid summer weather. Under extreme conditions, air conditioners may keep elderly and other vulnerable people safer from heat-induced health problems. Air conditioners are used in many commercial settings not only for increased comfort but for decreasing heat stress on delicate machinery such as computers and reducing food spoilage in grocery stores and restaurants.

1. **Prevents Dehydration and Heat strokes**

Being exposed to excessive heat for long periods can cause dehydration. This is because high temperature leads to profuse sweating and makes your body lose water. If you fail to replenish this lost water, the result will be dehydration. Since air conditioners reduce sweating, they can minimize the risk of water loss and dehydration.

Heat strokes are another problem that excessive heat can cause. This is because too much heat can make it difficult for the body to regulate its temperature. Failing to treat this problem early enough can cause damage to the brain and other organs of the body. Since air conditioners reduce the temperature of the air, they can be helpful in preventing heat strokes.

2. **Improves the Quality of Air**

Air conditioners can significantly improve indoor air quality and create a much healthier atmosphere. This is because they are capable of flittering out pollen, dust, and other allergens present in the environment. By reducing humidity, air conditioners can check the growth of mildew and mold.

3. **Helps to Reduce Asthma and Allergies**

Air conditions can help to filter as well as disinfect the air that we breathe. This can help to reduce the risk of asthma attacks and allergies by removing pollen and dust, and also preventing the growth of mildew and mold. Being exposed to mold is one of the main factors that increase the risk of asthma attacks, allergic reactions, and other respiratory issues. The fact that we close our windows while using air conditioners helps to prevent the entry of environmental allergens, bacteria, and dust.

Disadvantages

Air conditioners use a lot of electricity. This creates both financial disadvantages for the people who have to pay for the power, and more generalized environmental disadvantages caused by power production. Because a large percentage of electricity is created by coal-burning power plants, air conditioning contributes indirectly to the release of greenhouse gases and other pollutants. In addition, according to The Independent, spending too much time in an air-conditioned environment can contribute to health problems such as asthma, tightness in the chest and other respiratory ailments.

1. Skin Dryness

Spending increased amount of time in an air-conditioned room can make your skin lose its moisture, thereby becoming sensitive and dry. It can also cause irritation and dryness of the mucous membrane.

2. Aggravation of Respiratory Problems

A sudden change in temperature has shown to exacerbate the symptoms of various respiratory diseases. Fortunately, you can significantly reduce the risk of this problem by setting a higher temperature and decreasing it gradually.

3. Respiratory Tract Infections and Allergies

Not cleaning the air conditioner can cause the buildup of dust, bacteria, and pollen in the air filters. This will significantly increase the risk of asthma attacks and respiratory tract infections.