2.3 AIR-CONDITIONING

Nowadays the air conditioning system is widely used in both domestic and commercial environments. Air cooling or air conditioning is the process of removing heat and moisture from inside the occupied space, to improve the comfort of occupants. This process is most commonly used to achieve a more comfortable interior environment, typically for humans. The definition of air-conditioning is, A system for controlling the humidity, ventilation and temperature in a building or vehicle, typically to maintain a cool atmosphere in warm conditions. While air conditioners can differ from model to model, they are available in any range from small units that can cool a small bedroom to massive units installed on the roof of office towers that can cool an entire building.

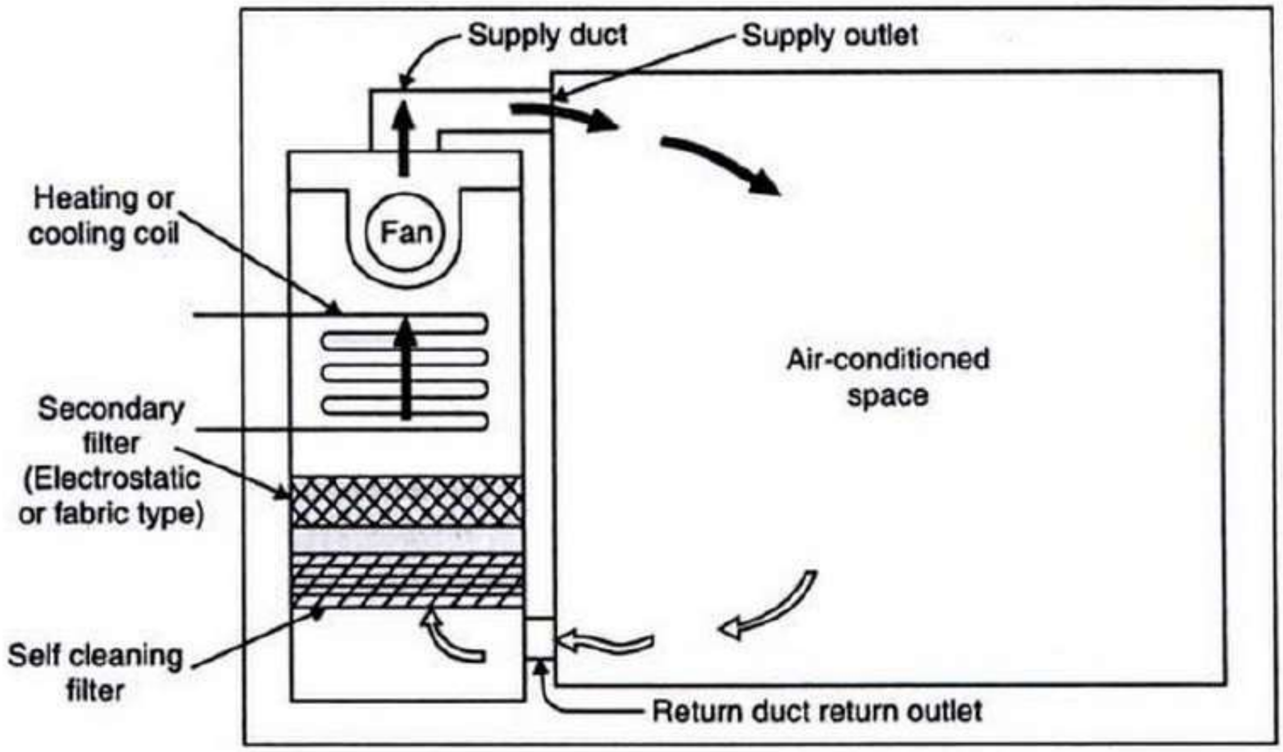

Figure 2.3.1 Air-conditioning cycle

[Source: "Utilisation of Electrical Power" by R. K. Rajput, Page: 174]

Equipment Used in an Air Conditioning System

Following are the main equipment or parts used in an air conditioning system:

1. **Circulation fan:** The main function of this fan is to move air to and from the room.
2. **Air conditioning unit**: It is a unit, which consists of cooling and dehumidifying processes for summer air conditioning or heating and humidification processes for winter air conditioning.

3. **Supply duct**: it directs the conditioned air from the circulating fan to the space to be air-conditioned at the proper point.
4. **Supply outlets**: these are the grills, which distribute the conditioned air evenly in the room.
5. **Return outlets:** these are the openings in a room surface which allow the room air to enter the return duct.
6. **Filters:** The main function of the filters is to remove dust, "dirt and other harmful bacteria's form the air.

Air Conditioner Working Principle

An air conditioner continuously draws the air from an indoor space to be cooled, cools it by the refrigeration principles and discharges back into the same indoor space that needs to be cooled. This continuous cyclic process of drawl, cooling and recalculation of the cooled air keep the indoor space cool at the required lower temperature needed for comfort cooling or industrial cooling purpose. When you switch the air conditioner on, the thermostat control sends 120V of alternating current to the compressor and the fan motor. The compressor act as a pump compressing the refrigerant in gas form into the condenser coils. Located the back of the unit. Where the gas is condensed into a hot liquid. The condenser coils dissipate the heat as the liquid travels through them. Once the liquid refrigerant has passed through the condenser coils and the capillary tube where it undergoes expansion. The liquid refrigerant passes through the evaporator coils. it travels to the evaporator coils located near the front of the unit. As the refrigerant liquid enters these coils it expands into a gas which makes the coils cold. The gas flows through the coils to a suction line, attached to the compressor converts the gas back into a liquid and the cooling cycle continues. At the same time, the fan motor rotates a blower wheel which draws in air to be cooled by the evaporator coils before recirculating it back into the room. It also operates the condenser fan blade which blows outside air through the condenser coils to cool them. The air temperature is regulated by the thermostat control depending on the model. The control may be a thermostat switch and sensing bulb assembly or electronic control board that works with a sensor. The sensing bulb or electronic sensor is clipped to the front of the evaporator coils to monitor the temperature of the air entering the coils. Once the room has sufficiently cooled the thermostat control shuts off the voltage to the compressor. Some models which use event can operate the fan motor only to draw in cool air at night. However, when the appliance is actively cooling the air the vent must be closed for the system to work properly. A slinger ring on the condenser fan blade picks up collected water at the bottom and sprays it on to the condenser coils to help the coils dissipate the heat. To prevent the water from dripping into the room the appliance should be tilted back slightly when they installed.

2.6 ENERGY EFFICIENT MOTORS

An energy efficient motor (EEM) is a motor that gives you the same output strength by consuming lesser amounts of power. EEM is manufactured using the same frame as a standard motor, but they have some differences:

1. Higher quality and thinner steel laminations in the stator
2. more copper in the winding
3. Optimized air gap between the rotor and the stator
4. Reduced fan losses
5. Closer machining tolerances
6. High quality aluminum used in rotor frame

STANDARD MOTOR EFFICIENCY

Standard motor efficiency is the ratio of mechanical power delivered by the motor (output) to the electrical power supplied to the motor (input).

% Efficiency = (Mechanical power output/Electrical power input) x 100%

EEM utilizes improved motor design and high-quality materials to reduce motor losses, therefore improving motor efficiency.

NEED FOR EFFICIENT MOTORS

In the future, the cost of energy will increase due to environmental problems and limited resources. The electric motors consume a major part of the electric energy in industries. Thus, implementing energy efficient motor could save a significant amount of electricity. It would also reduce the production of green-house gases and push down the total environmental cost of electricity generation. Also, these motors can reduce maintenance costs and improve operations in industry. Efficient energy use is achieved primarily by means of a more efficient technology or process rather than by changes in individual behavior.

Average Full Load Nominal Efficiencies Standard and Energy Efficient Motors		
Rated hp	**Standard Motor**	**High-Efficiency Motor**
10.0	85.2	90.1
20.0	87.8	91.9
30.0	89.1	92.7
50.0	90.5	93.8
100.0	91.8	94.7
150.0	92.9	95.5
200.0	94.0	95.4

An EEM produces the same shaft output power, but uses less input power than a standard efficiency motor. A standard motor is a compromise between efficiency, endurance, starting torque, and initial cost. Standard motor generally competes on price, not efficiency. On the contrary, EEM competes on efficiency, not price. Shortly, EEM is needed

a) When there is a new installation or modification to your plant.

b) When old motors are damaged and need rewinding.

c) When existing motors are underloaded or overloaded.

d) While protecting other devices.

WAYS OF IMPROVING EFFICIENCY

The various ways of improving efficiency includes:

a) Reduction of iron losses

b) Reduction of flux density

c) Usage of low loss magnetic material

d) Reduction of stator and rotor copper losses

e) Increasing the copper section i.e., the stator slot area or rotor bar section

f) Increasing stator yoke

g) Reducing rotor diameter

h) Increasing the speed of starting current

i) Reducing the starting torque

j) Increasing core length for maintaining the starting torque

k) Increasing the thickness of the copper wires wound around the core of the motor. This reduces both the electrical resistance losses in the wires and the temperature at which the motor operates.

l) Using more and thinner high-quality steel sheets for the main fixed and rotating parts of the motor. This also minimizes electrical losses.

m) Narrowing the air gap between the spinning and stationary motor components, increasing the strength of its magnetic field. This lets the motor deliver the same output using less power.

Construction of EEM

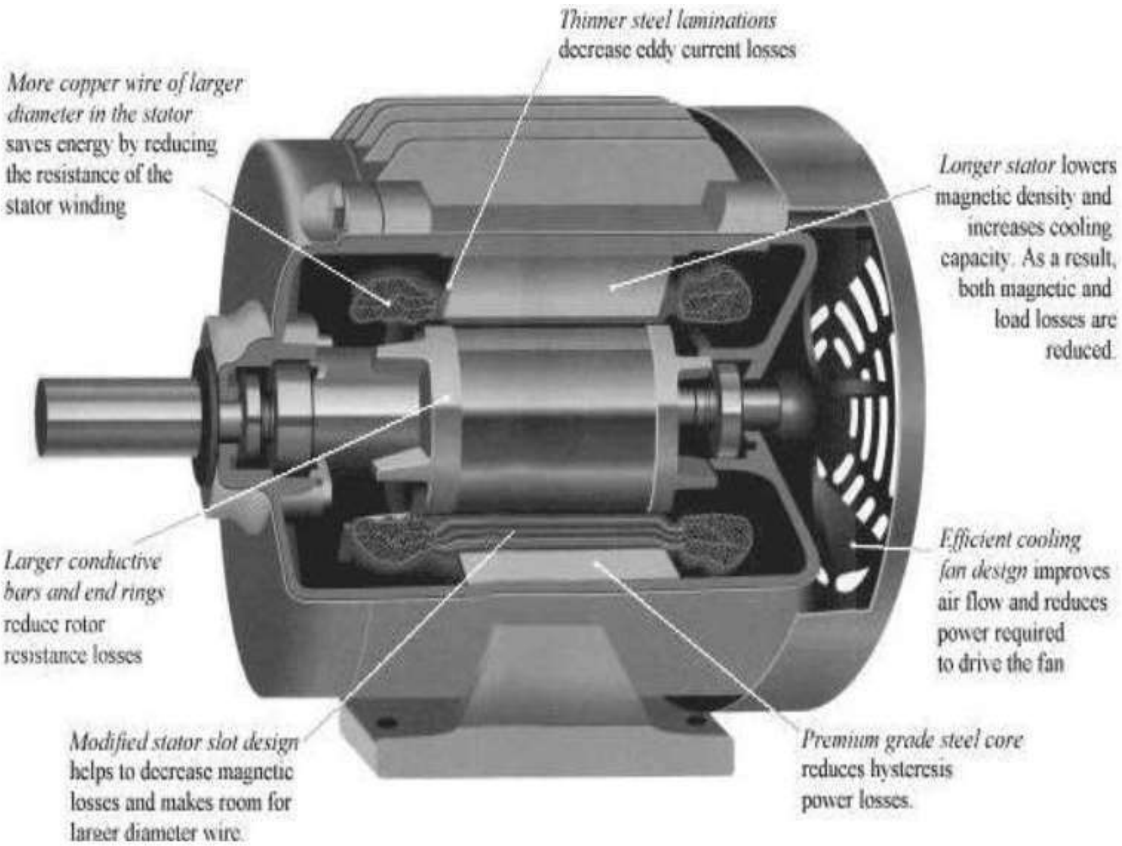

Figure 2.6.1 Energy efficient motor

[Source: "Energy-Efficient Electric Motors" by John C. Andreas, Page: 3]

MOTOR LIFE CYCLE

Motor efficiency details:

Standard → Eff3

Improved → Eff2

Energy efficient → Eff1

Eff1 motors are expensive to buy, be deployed for 24/7 working. Eff2 motors can be installed in all cases.

DIRECT SAVINGS and PAYBACK ANALYSIS

In many new installations, the extra cost of a premium-efficiency motor is justified by the energy and demand savings.

Consider a new application of a 50 hp motor with the following specifications:

- 6,000 hours of annual use at 75% load
- Cost of electricity = $.06/kWh
- Demand charge = $70/kW-yr
- Efficiency of EPAct motor = 93.9% at 75% load
- Efficiency of premium-efficiency motor = 94.8% at 75% load
- Extra list cost of premium-efficiency motor = $470
- Price is 65% of list
- Actual extra cost = $305

The yearly savings afforded by the premium-efficiency motors are as follows:

- Demand savings = 50 hp x (1/0.939 -1/0.948) x 0.75 x 0.746 kW /hp = 0.283kW
- Energy savings = 0.283 kW x 6,000 hr/yr = 1,697 kWh
- Cost savings = $.06/kWh x 1,697 kWh + $70/kW-yr x 0.283 kW = $122/year
- Simple payback period = $305/$122 = 2.5 years

The most common method used by equipment buyers to evaluate conservation investments is the simple payback, or the time that it will take for the savings to pay back the cost of the in-vestment. The simple payback is calculated by dividing the incremental cost of the efficient equipment by the value of the expected annual energy savings. For example, if an efficient motor costs $500 more than a standard motor and is expected to save $400/year, the simple payback will be 1.25 years. The use of the simple payback introduces some errors into the calculation by assuming that inflation is zero and utility rates are constant. It also ignores the life of the measure. A device with a 6-month payback may seem like a good investment, but it's not if it lasts only 8 months. Because of the short payback requirements of most motor users, however, and the relatively low cost of installing efficient motors and drives, the errors in simple payback analysis are generally minor.

EFFICIENCY EVALUATION FACTOR

Efficiency evaluations attempt to relate the results obtained from a specific programme to the resources expended to maintain the programme. Efficiency evaluations are receiving increasingly greater attention as programmes must compete with the limited resources.

Energy efficiency index

- Cooling tower
  - Fan efficiency
  - Cooling efficiency
  - Water loss of cooling tower
- Heat exchanger
  - Surface heat flux intensity
  - End temperature difference
  - Power and heat ratio
- Water pump
  - Pump efficiency
  - Water loss of pump
  - Operating efficiency
- Pipe
  - Surplus coefficient of pipe
  - Coefficient of heat loss
- Valve
  - Surplus coefficient of valve

Advantages:

1) EEM has a lower slip so they have a higher speed than standard motors.

2) EEM can reduce maintenance costs and improve operations in industry due to robustness and reliability. It is of low cost than standard motor.

3) Increasing the productivity.

4) Efficiencies are 3% to 7% higher compared with standard motors.

5) Design improvements focus on reducing intrinsic motor losses.

Benefits of energy efficient motors:

Motor	Efficiency class-III	Efficiency class-II	Efficiency class-I
Rating	30 HP	30 HP	30 HP
Efficiency	88%	91.4%	93.2%
Load (KW)	16.5	16.5	16.5
Motor Input, KW	18.75	18.05	17.7
Annual KWh used	1,64,250	1,58,118	1,55,052
Annual KWh saved	-	6,132	9,198
Annual Rs saved	-	30,660	45,990

Characteristics of energy efficient motors

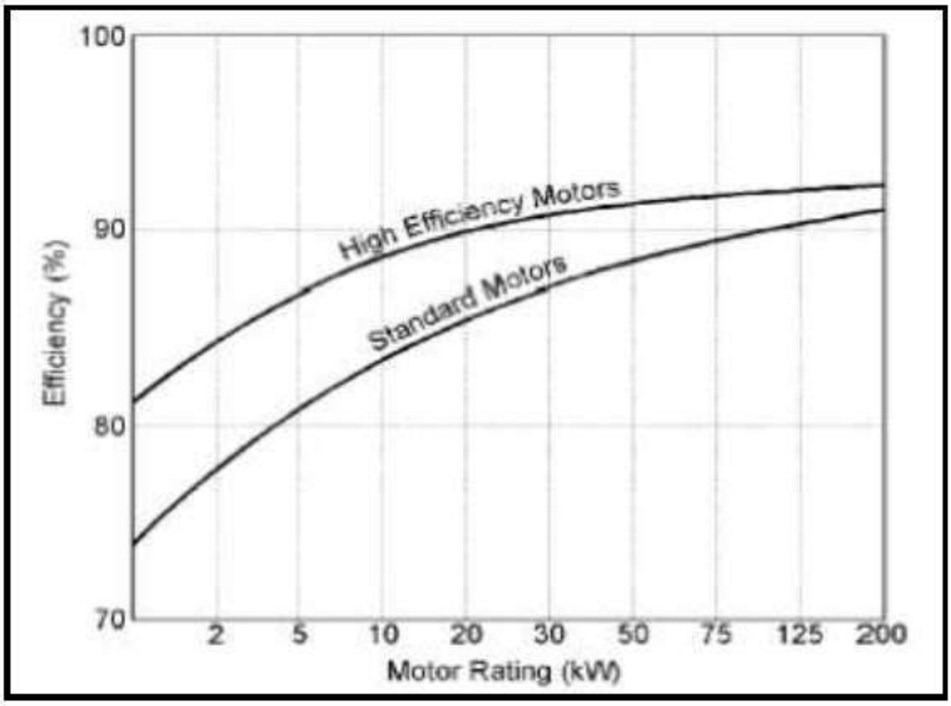

Figure 2.6.2 Characteristics of standard and energy efficient motor

[Source: "www.beeindia.gov.in," Page: 33]

2.1 REFRIGERATION

Refrigeration is the science of producing and maintaining temperatures below that of the surrounding atmosphere. This means the removing of heat from a substance to be cooled. Heat always passes downhill from a warm body to a cooler one, until both bodies are at the same temperature. Not only perishables, today many human work spaces in offices and factory buildings are air-conditioned and a refrigeration unit is the heart of the system. Before the advent of mechanical refrigeration water was kept cool by storing it in semi-porous jugs so that the water could seep through and evaporate. The evaporation carried away heat and cooled the water. This system was used by the Egyptians and by the Indians in the Southwest. Natural ice from lakes and rivers was often cut during winter and stored in caves, straw-lined pits and later in saw-dust insulated buildings to be used as required. The Romans carried pack trains of snow from Alps to Rome for cooling the Emperor's drinks. Though these methods of cooling all make use of natural phenomena, they were used to maintain a lower temperature in a space or product and may properly be called refrigeration. Refrigeration means the cooling or removal of heat from a system. The equipment employed to maintain the system at a low temperature is termed as refrigerating system and the system which is kept at lower temperature is called refrigerated system.

DOMESTIC REFRIGERATOR

The common type of domestic refrigerator has a cabinet shaped with compressor, the condenser and receiver fitted in their basement. The expansion valve and evaporator coils are exposed in the storage cabinet with the piping's carrying liquid refrigerant passing through the body. Generally, methylene chloride, Freon-12, and Freon-11 are used as the refrigerants. Refrigeration is not only provided with double-walled cabinet packed with materials having high thermal insulation such as fiberglass, cork or expanded rubber but also all around the inside of door flap soft rubber seal is used which makes the cabinet airtight. Also the door is provided with automatic closing mechanism – door hinges are provided in such a way that door flap when left in open position automatically comes to closing position due to gravity and as it approaches closing position it is attracted by the magnetic strip fitted behind the sealing rubber ring and thus the door is closed with snap action. All this is done to prevent leakage of atmospheric heat inside the refrigerator. The main precaution to be taken is that very hot things should not be put in the refrigerator if it is done it will quickly evaporate the refrigerant in evaporator coils producing a large vapor pressure increasing the duty of the compressor. It may damage the motor, which is short-time rated.

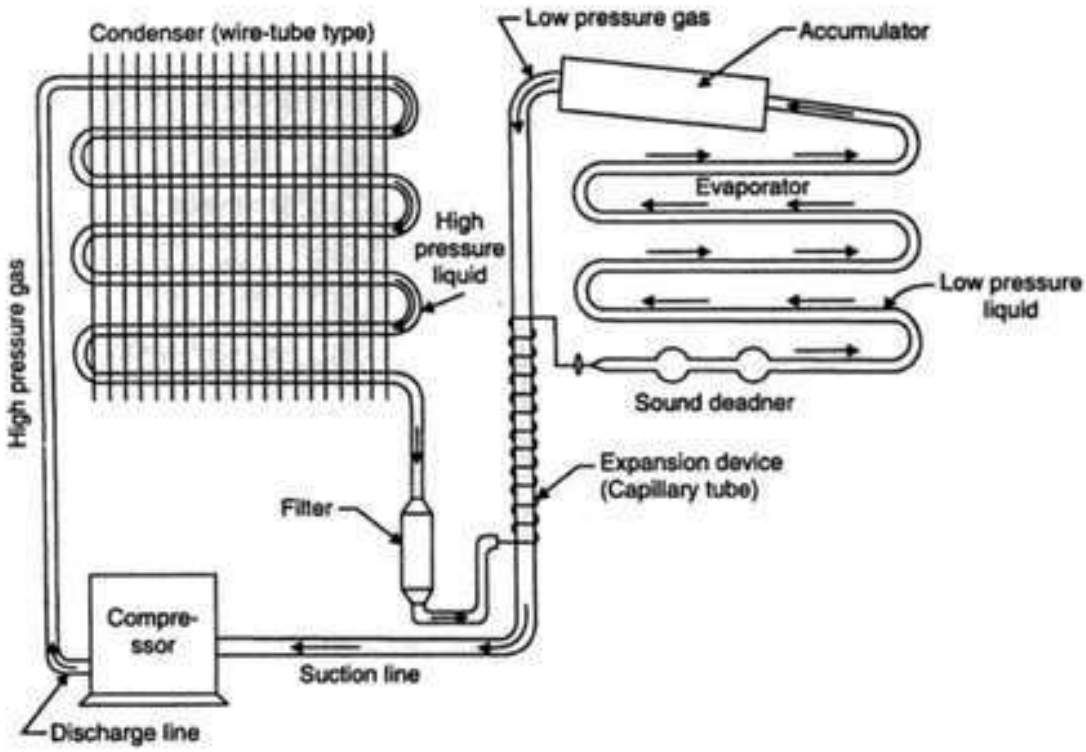

Figure 2.1.1 Domestic refrigerator details

[Source: "Utilisation of Electrical Power" by R. K. Rajput, Page: 163]

Working

The heat of the items, to be cooled is carried to the evaporator coils by means of air trapped in the cabinet. The working fluid, known as a refrigerant, used in refrigerator readily evaporates and condenses or changes alternately between the vapor and liquid phases without leaving the refrigerator. The refrigerant keeps circulating from evaporator coil to condenser till compressor motor is connected to the supply. During evaporation, it absorbs heat from items placed in the refrigerator and in condensing or cooling or liquefying it rejects heat outside the refrigerator. The heat absorbed from items placed in the refrigerator during evaporation is used as its latent heat for converting it from liquid to vapor. Thus, a cooling effect is created in the working fluid. And this decreases the temperature inside the refrigerator. When a predetermined value of the temperature is achieved inside the refrigerator, thermostat switch operates and disconnects the compressor motor from the electric supply. Further circulation of refrigerant and its cooling effect stops. After some time, when the temperature increases and reaches up to a predetermined value, thermostat operates again and connects the compressor motor to the supply. And the cooling process starts again. This cycle is repeated continuously to maintain the temperature in a predetermined temperature range. In this way, the refrigerant is circulated through the coils of the refrigerator to maintain the temperature in the required temperature range.

Electrical Circuit of a Refrigerator

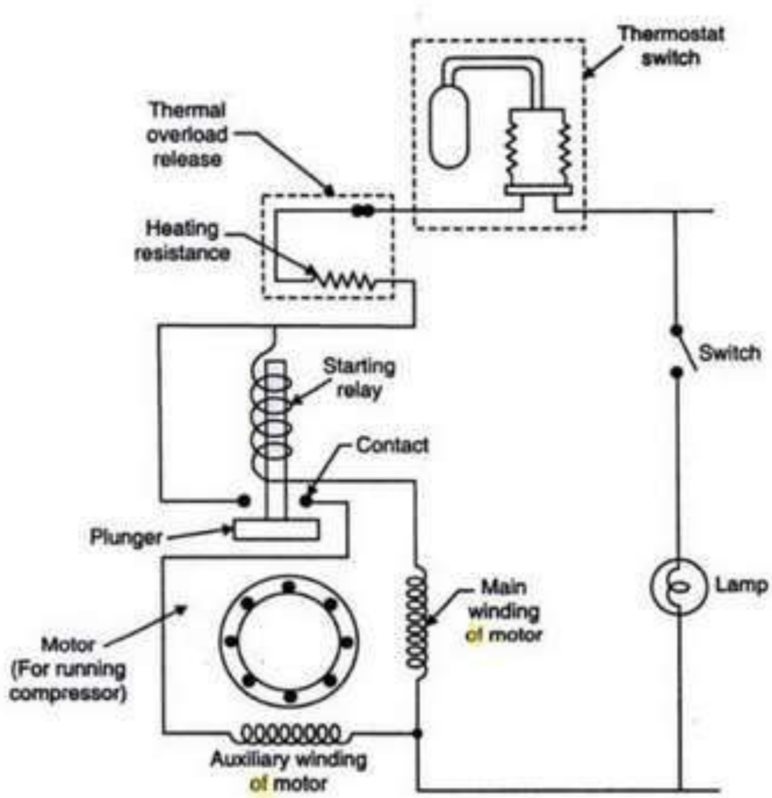

Figure 2.1.2 Electrical circuit of domestic refrigerator

[Source: "Utilisation of Electrical Power" by R. K. Rajput, Page: 164]

The electrical circuit of a refrigerator is shown in Figure. The refrigerator is provided with a door push switch, which closes on the opening of the refrigerator and puts the lamp on. Split-phase single phase induction motor is used in the sealed compressor unit to run the compressor. Thermal overload release is provided to protect the motor from damage against the flow of over-current. Thermostat switch is provided to control the temperature inside the refrigerator. The temperature inside the refrigerator can be adjusted using the temperature control screw. Greater the distance between contacts, the greater will be the temperature inside the refrigerator and vice versa. To protect the motor against the under-voltage use of automatic voltage regulator is essential since, in case of fall in applied voltage, the motor will draw heavy current to develop the required torque and will become hot.

Vapor Compression System Parts

The refrigerant in this unit is circulated through the various components of the system with the help of a motor installed in the compressor unit where it undergoes a number of changes in its state or condition. Each cycle of operation consists of the four fundamental changes in the state of the refrigerant:

(i) expansion

(ii) vaporization

(iii) compression

(iv) condensation.

The vapor compression system of a domestic refrigerator consists of the following five essential parts:

Compressor: The low pressure and temperature vapor refrigerant from the evaporator is drawn into the compressor through the inlet or suction valve, where it is compressed to high pressure and temperature. The high pressure and temperature vapor refrigerant is discharged into the condenser through the delivery or discharge valve.

Condenser: The condenser or cooler consists of coils of pipe in which the high pressure and temperature vapor refrigerant is cooled and condensed. The refrigerant, while passing through the condenser, rejects its latent heat to the external surrounding air. Thus hot refrigerant vapor received from the compressor is converted into liquid form in the condenser.

Receiver: The condensed liquid refrigerant from the condenser is stored in a vessel, known as a receiver, from where it is supplied to the expansion valve or refrigerant control valve.

Expansion Valve or Throttle 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 the 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 pipe in which the liquid-vapor refrigerant at low pressure and temperature is evaporated and changed into vapor refrigerant at low pressure and temperature. During the evaporation process, the liquid-vapor refrigerant absorbs its latent heat of vaporization from the medium which is to be cooled (i.e. items placed in the refrigerator).

2.5 SMART AIR-CONDITIONING UNITS

The need for man and his interest in conditioning is due to ancient times. for example, ancients enjoyed drinking cold water without having any kind of ice in their countries by putting water in pottery vessels and leave them on the roofs of their houses at sunset and long nights, Dry desert air vaporizes the water that passes through the pores of pottery vessels and the water inside it becomes cold. The Romans and the Greeks used their slaves to bring the snow from the mountain tops and then store it in huge conical pits in the ground, lined with leaves and covered to use it when needed. Also, the great Alexander used this natural ice to cool wine barrels that he offered to his soldiers in every battle they won. Emperor Nero was always offering chilled food at his concerts. Hundreds of slaves were used to store the natural ice in the vaults of his palace. People continued to use natural ice only as a way to cool their drinks for a long time. With the increasing need for natural ice over time and the great difficulties to get and keep it for a long time, many scientists and researchers began to produce artificial ice. The first of these scientists was the great scientist Michael Faraday (Varday) and Dr William Cullen in 1775 using the theory of discharge for the production of artificial ice, but this experience did not pass the walls of his laboratory. In 1834, an American engineer named Jakob Perkins made the first machine to produce artificial ice, which was very successful in preserving frozen meat and beer. In the thirty years following the manufacture of this machine, many inventors and scientists were interested in manufacturing machines that produce artificial ice, which led to an increase in the number of ice factories in different places in the nineteenth century and spread its use among all classes after it was limited to the rich and elite By the discovery of electricity at the beginning of the 20th century, the industry of cooling and air conditioning has made great progress felt by any human being in our time. So that there is no house at this time without an electric refrigerator or air conditioning device. Recent studies show that buildings occupy the top place in energy usage, counting for 40% of total energy usage in many countries. A large part of the energy used in the buildings is used for fans, air conditioning (HVAC) and heating systems, which counting for up to 50% of the total energy use in the buildings so improve energy efficiency of buildings, especially the improvement of the HVAC system is very important and will have an impact in reducing overall usage For energy. When talking about reducing the use of energy, which has become an urgent necessity locally, globally and environmentally for the safety of our planet from the harmful effects of carbon dioxide and its impact on the heating of the Earth, we must pay attention to reduce the use of the spent energy on the air conditioning and ventilation systems of buildings and find solutions and systems to reduce the excessive energy usage.

Mobile phones and wearable devices have been integrated with intelligent sensors for temperature and human movement so that we can control the working and living environment in the various climatic conditions of the atmosphere and get appropriate feedback, especially information technology for occupants of public places like factories, companies, institutions and residential buildings through mobile phones and wearable devices, which placed on the human body. this information can be used to adjust air conditioners in advance according to human intentions, which is called intention to cause control. The results showed that the indoor temperature can be controlled accurately with errors below ± 0.1 ° C As the weather conditions for the residents cannot be achieved quickly within 2 minutes, air conditioning compressor must be operated in a timely manner so that it can reach the appropriate weather conditions for the inhabitants of the places before they arrive . This ideal solution is what made us think about the appropriate solutions by using smart devices and wearable devices that can detect the temperature of the person and the type of activity that he exercises, Which helped to set sleep times flexibly and adjust sleep function optimally and maintain human health during sleep. During sleep, it can reduce energy consumption by up to 46.9%. With intelligent air conditioners and smart air conditioners can provide a comfortable environment and achieve the objectives of energy conservation and environmental protection at the same time. In order to become smart air conditioners using communication technology and adjusting air conditioners is not just an idea in the world of IT, smart air conditioners can be combined with an infrared sensor for human position sensors as well as with meteorological networks to obtain weather information abroad. These devices can be worn without affecting human activity from now on. It is expected that the indoor temperature will be controlled efficiently, considering the human comfort and energy used in air conditioners.

Figure 2.5.1 Evolution of air conditioning units

[Source: "International Journal of Scientific & Technology Research" by Nabil Ahmad Moussa, Page: 3]

Figure 2.5.1 shows the evolution of the air conditioning units (windows unit) and the transition to split unit, which allows control of the external unit or internal unit accurately and also control between them as distinctly in figure 2.5.2.

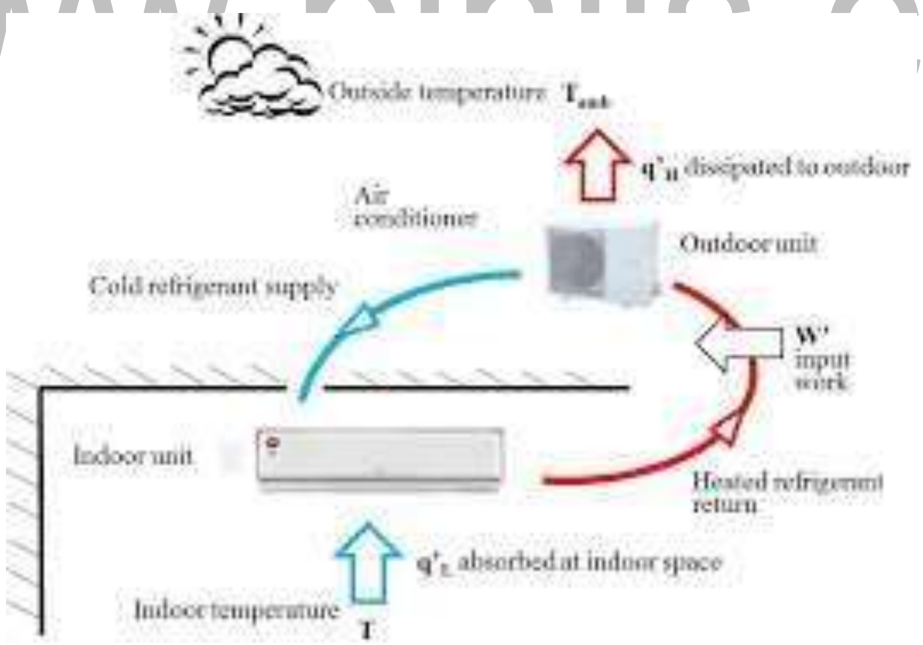

Figure 2.5.2 Refrigerant flow

[Source: "International Journal of Scientific & Technology Research" by Nabil Ahmad Moussa, Page: 3]

Indoor temperature(T) can be controlled and is related to the work of the internal unit where the air flows through it cross-sided through the propeller as shown in figure 2.5.2. The red line in the figure refers to the coolers of heat absorption from a closed place (q_L) through the evaporator and dissipating that heat (q_H) to the outside air through the outdoor unit. And the temperature is the controller in the operation unit, we can install the evaporator temperature sensor in the internal unit of the type of air conditioning (Split Unit).

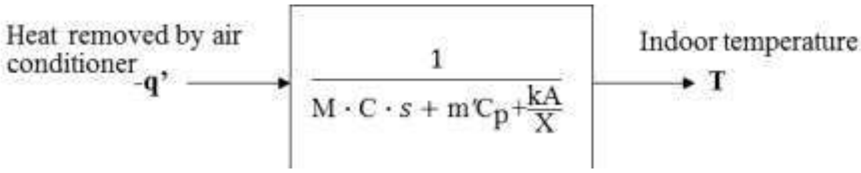

Figure 2.5.3 Open loop transfer function

[Source: "International Journal of Scientific & Technology Research" by Nabil Ahmad Moussa, Page: 4]

This signal is received by a remote control to control the operation of the unit depending on the temperature changes according to the following box diagram:

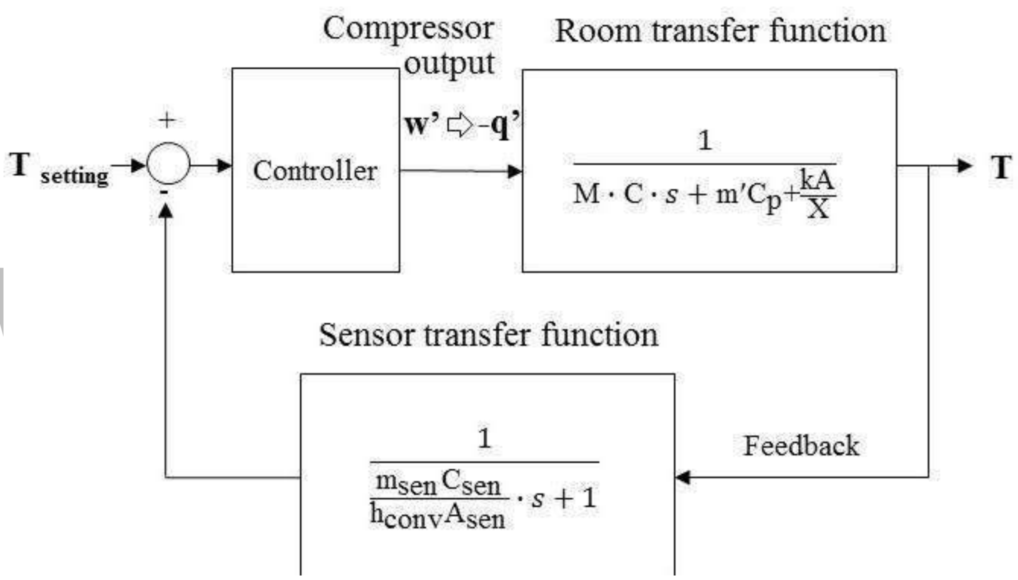

Figure 2.5.4 Closed loop transfer function

[Source: "International Journal of Scientific & Technology Research" by Nabil Ahmad Moussa, Page: 4]

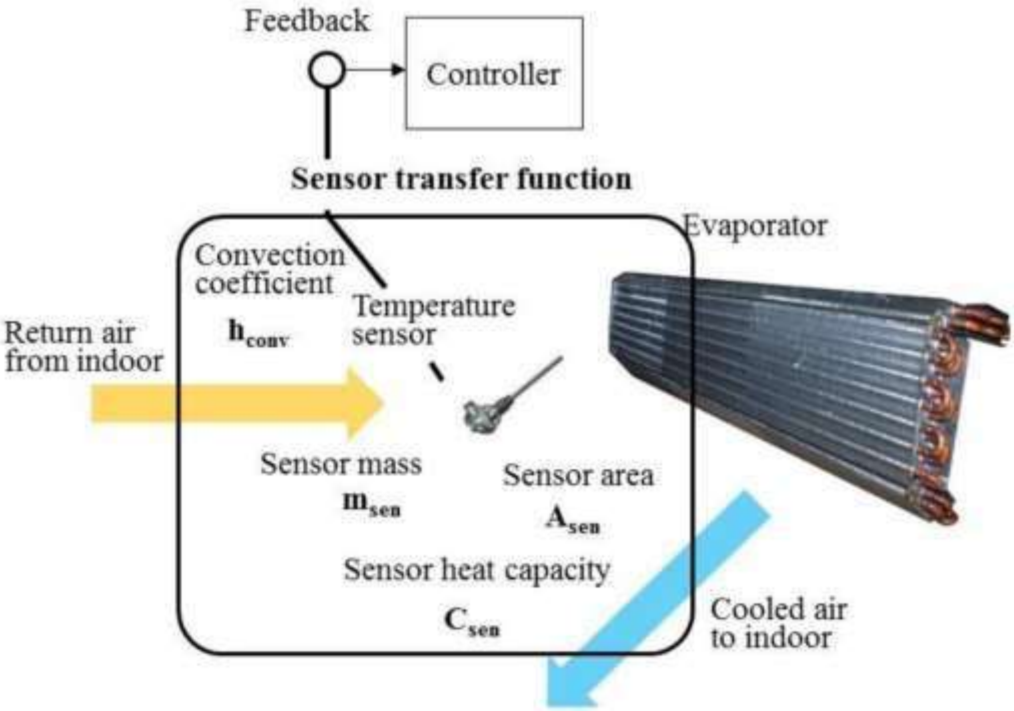

Figure 2.5.5 Sensor based system

[Source: "International Journal of Scientific & Technology Research" by Nabil Ahmad Moussa, Page: 4]

This is a model of the sensor method and control of the operation of the air conditioners by smart devices that can be personal phones or watch worn around the wrist. Either be controlling the turning on and off the compressor as in the following diagram:

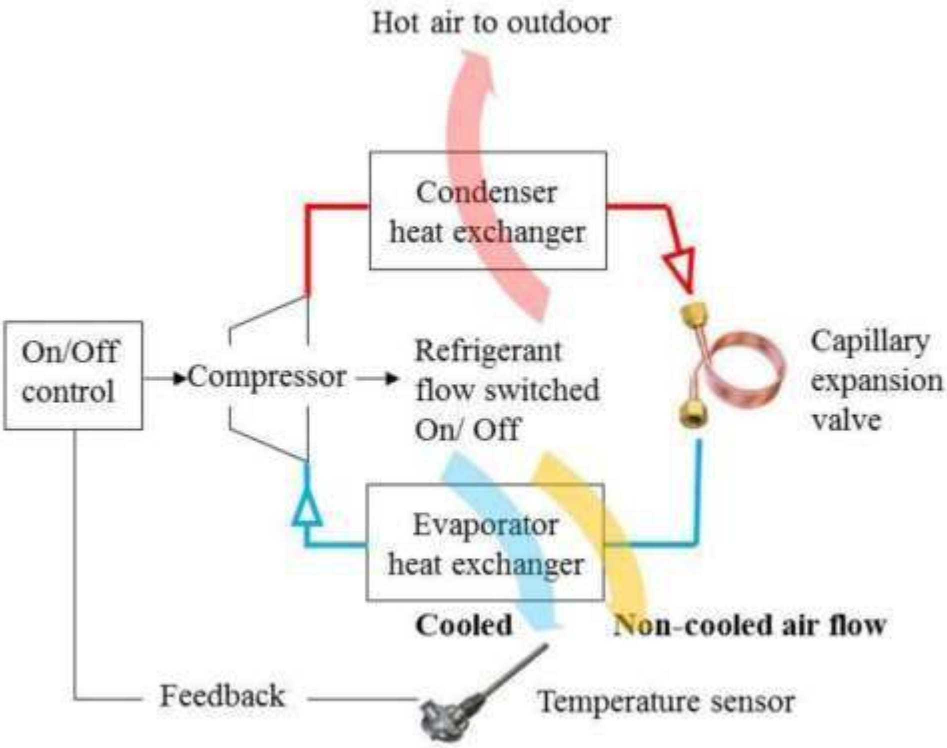

Figure 2.5.6 Capillary expansion valve system

[Source: "International Journal of Scientific & Technology Research" by Nabil Ahmad Moussa, Page: 4]

Or by changing the flow of coolant by changing the speed of the compressor as shown in figure 2.5.7.

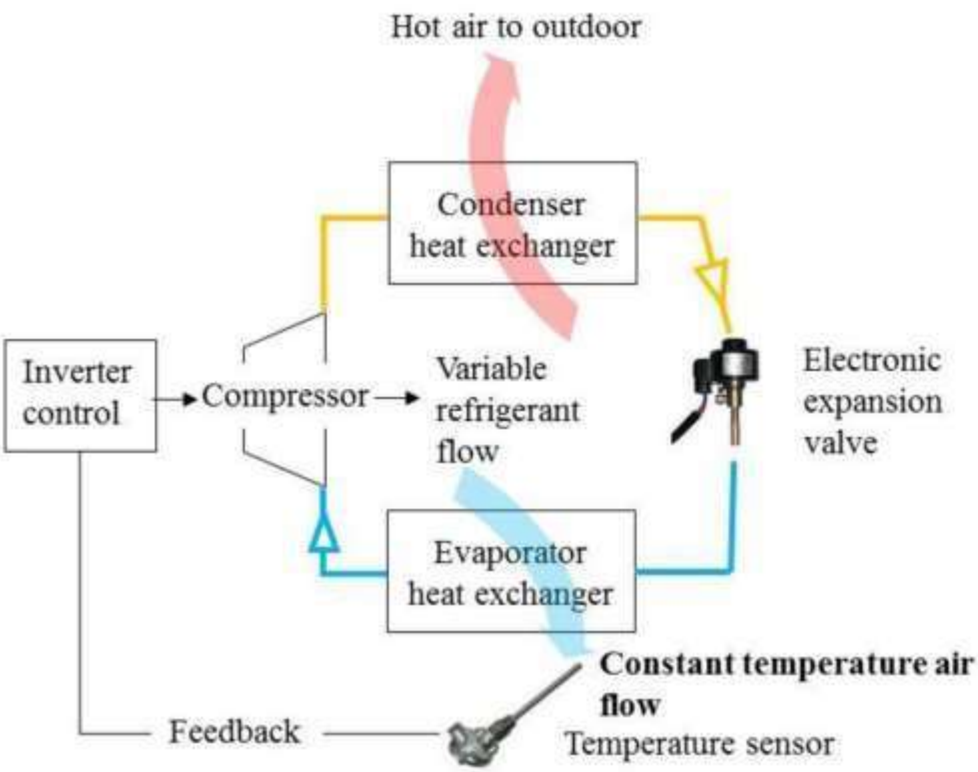

Figure 2.5.7 Electronic expansion valve system

[Source: "International Journal of Scientific & Technology Research" by Nabil Ahmad Moussa, Page: 4]

Intelligent Control Based on Smart Sensors:

Control depends on quantitative analysis between fixed values and variable values that are monitored by smart sensors, which collect information and send it to smartphones or wearable devices that include:

1. Mobile phones with GPS and the expected time to be in the place to be operated
2. Bracelet can read the situation of the residents of the cooled places, which increases the temperature of the place during sleep to provide energy consumption, so it can control the air conditioner in accordance with the activity of residents. The system uses multiple sensors to achieve intelligent control such as an internal infrared sensor that can detect human position and control airflow. Or mobile phones with GPS and expected personal timetables for movement can be used to detect the occupant position of chilled places as in figure 2.5.8.

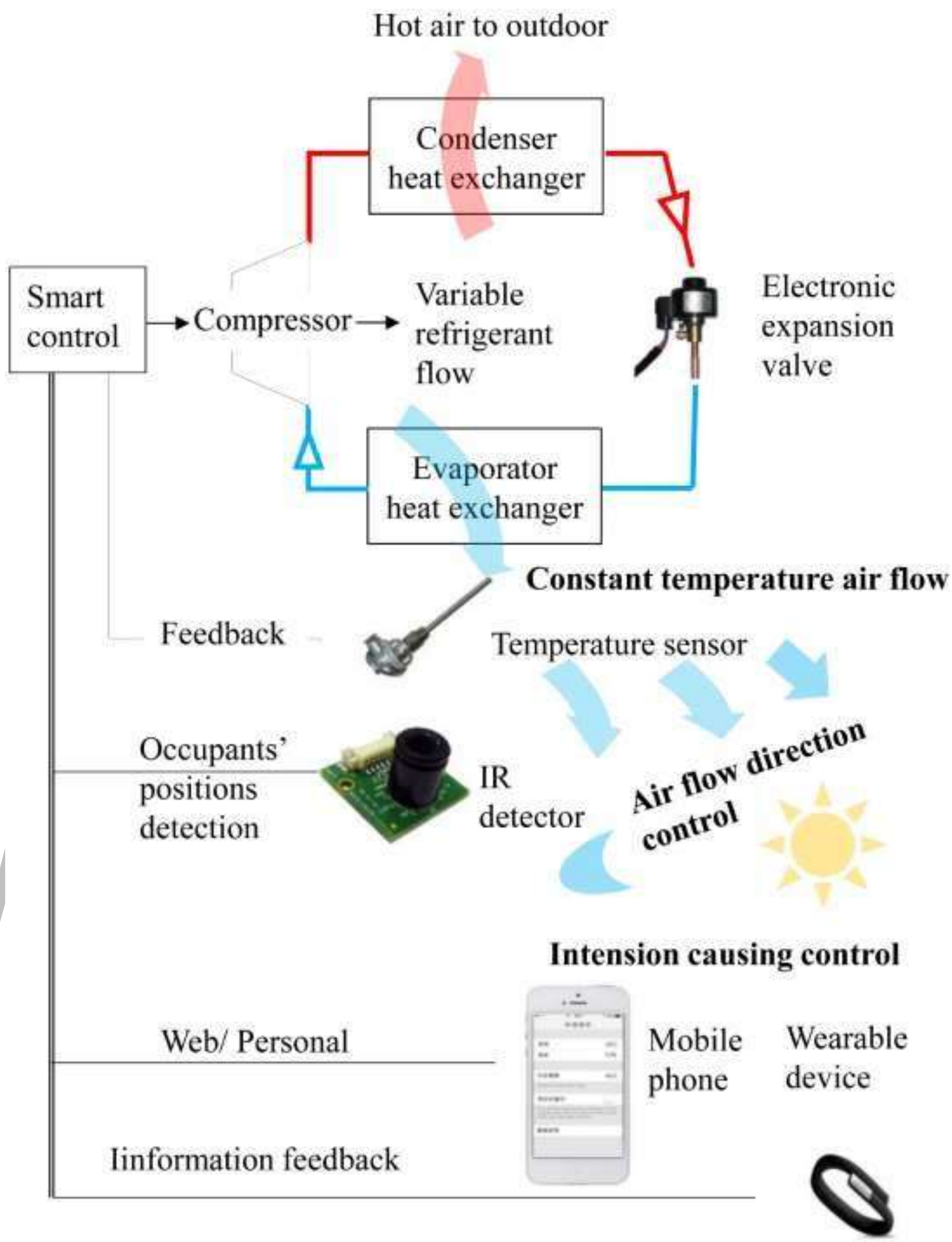

Figure 2.5.8 Smart air-conditioned system

[Source: "International Journal of Scientific & Technology Research" by Nabil Ahmad Moussa, Page: 5]

2.4 VARIOUS TYPES OF AIR-CONDITIONING SYSTEM

The air conditioning system may be broadly classified as follows:

a. According to the purpose

(i) Comfort air conditioning system.

(ii) Industrial air conditioning system.

b. According to a season of the year

(i) Winter air conditioning system.

(ii) Summer air conditioning system.

(iii) Year-round air conditioning system.

c. According to the arrangement of equipment

(i) The unitary air conditioning system

(ii) Central air conditioning system.

a. According to the purpose

(i) Comfort air conditioning system

In comfort air conditioning, the air is brought to the required dry bulb temperature and relative humidity for human health, comfort and efficiency. If sufficient data of the required is not available, then it is assumed to be 21°C dry bulb temperature and 50% relative humidity. Ex. In homes, offices, shops, restaurants, theatres, hospitals, schools etc. are using air-conditioning systems to give comfort to people.

(ii) Industrial air conditioning system

In the industrial air conditioning system, the inside dry bulb temperature and relative humidity of the air is kept constant for working of the machine and for the manufacturing process. Textile mills, Paper mills, Machine part manufacturing plants, Toolroom, Photographic etc. are using this type of air-conditioning systems.

b. According to a season of the year

(i) Winter air conditioning system

Air conditioner working principle In winter air conditioning system, the air is burnt and heated, which is generally followed by humidification. The outside air flows through a damper and mixes with the recirculated air. The mixed air passes through a filter to remove the dirt, dust and impurities. The air now passes through a preheat coil to prevent the possible freezing of water and to control the evaporation of water in the humidity.

After that, the air is made to pass through a reheat coil to bring the air to the designed dry bulb temperature. Now, the conditioned air is supplied to the conditioned space by a fan. From the conditioned space, a part of the air is exhausted to the atmosphere by the exhaust fans. The remaining part of the used air is again conditioned and this will repeat again and again.

(ii) Summer air conditioning system

Air conditioner working principle in summer air conditioning system. In this system, the air is cooled and generally dehumidified. Schematic for a typical summer air conditioning system is arranged. The outside air flows through the damper and mixed with recirculated air (which is obtained from the conditioned space). The mixed air passes through a filter to remove the dirt, dust and impurities. The air now passes through a cooling coil. The coil has a temperature much below the required dry bulb temperature of the air in the conditioned space. The cooled air passes through a perforated membrane and loses its moisture in the condensed from which is collected in the sump. After that, the air is made to pass through a heating coil which heats the air slowly. This is done to bring the air to the designed dry bulb temperature and relative humidity. Now the conditioned air is supplied to the conditioned space by a fan. From conditioned space, a part of the used air is rejected to the atmosphere by the exhaust fan. The remaining air is again conditioned and this repeated for again and again. The outside air is sucked and made to mix with recirculated air to make for the loss of conditioned air through exhaust fan from the conditioned space.

(iii) Year-round air conditioning system

In year-round air conditioning system, it should have equipment for both the summer and winter air conditioning. Schematic for a modern summer year-round air conditioning is arranged. Air conditioner working principle. In year-round air conditioning system. In this, the outside air flows through the damper and mixed with the recirculated air. The mixed air passes through a filter to remove dirt, dust and impurities. In summer air conditioning system, the cooling by operates to cool the air to the desired valve. The dehumidification is obtained by operating the cooling coil at a lower temperature than the dew point temperature. In winter air conditioning system, the cooling coil is made inoperative and the heating coil operates to heat the air. The spray type humidifier is also used in the dry season to humidify the air.

c. According to the arrangement of equipment

(i) Unitary air conditioning System

- In unitary air conditioning system, the assembled air conditioner is installed in or adjacent to the space to be conditioned.
- Unitary systems, the common type of one room conditioners, sit in a window or wall opening, with interior controls.
- Interior air is cooled as a fan blows it over the evaporator.
- The exterior air is heated as a second fan blows it over the conditioner.
- In this process, heat is supplied from the room and discharge to the environment.
- A large house or building may have several such units, permitting each room to be cooled separately.

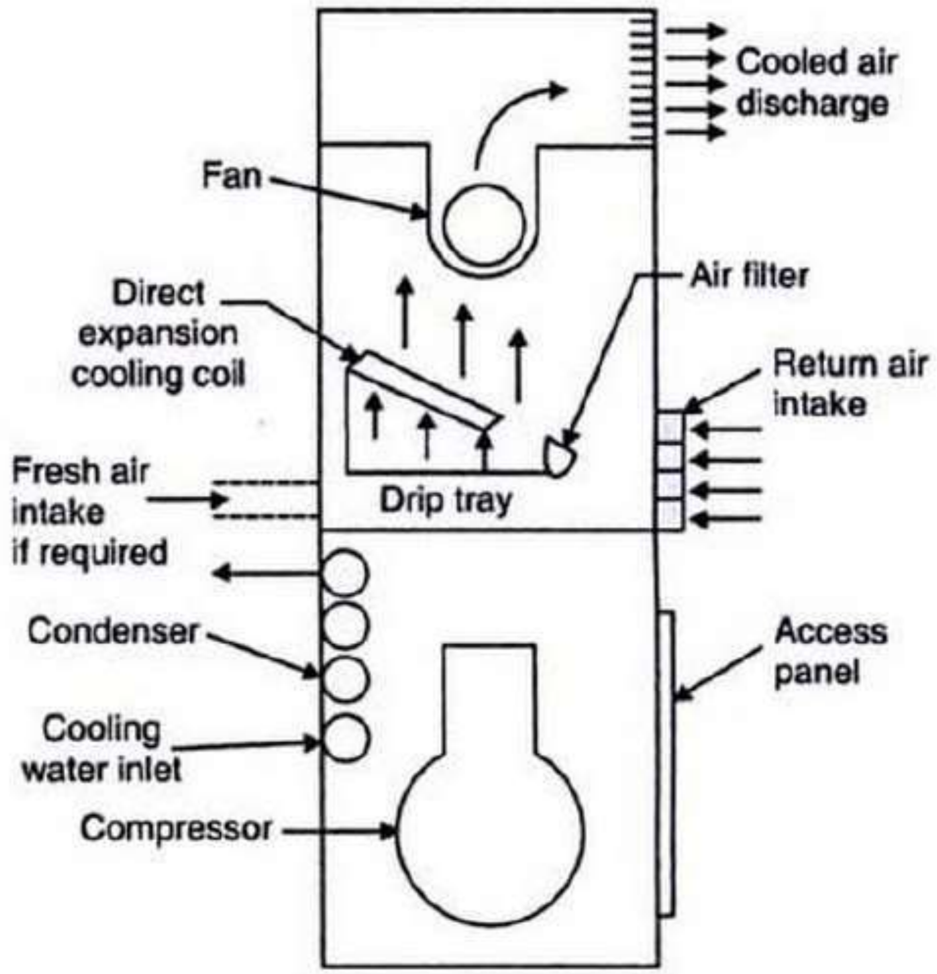

Figure 2.4.1 Unit air-conditioner

[Source: "Utilisation of Electrical Power" by R. K. Rajput, Page: 178]

The unitary air conditioning systems are of the following two types,

1. Window unit
2. Vertical packed units or PTAC systems

Window Unit

These types of conditioners have a small capacity of 1TR to 3TR and are mentioned through a window or wall. They are employed to condition the air of one room only. If the room is bigger in size, then two or more units are used.

Vertical packed units or PTAC systems

These type of air conditioners are bigger in the capacity of 5 to 20TR and are adjacent to the space to be conditioned. This unit is very useful for conditioning the air of a restaurant, bank or small office. PTAC systems are also known as wall split air conditioning systems or ductless systems. These PTAC systems which are widely used in hotels have two separate units, the evaporative unit on the interior and the condensing unit on the exterior, with tubing passes through the wall and connect them together. This minimizes the interior system footprint and allows each room to be adjacent independently. PTAC system may be adapted to provide heating in cold weather, either directly by using an electric strip, gas or other heaters, or by reversing the refrigerant flow to heat the interior and draw heat from the exterior air, converting the air into a heat pump.

While room air conditioning provides maximum flexibility when cooling rooms it is generally more expensive than a central air conditioning system.

(ii) Central Air Conditioning System

It is a most important type of air conditioning system. It uses when the required cooling capacity 25TR or more. It uses when the air flow is more than 300 m^3/min or different zones in a building are to be air-conditioned.

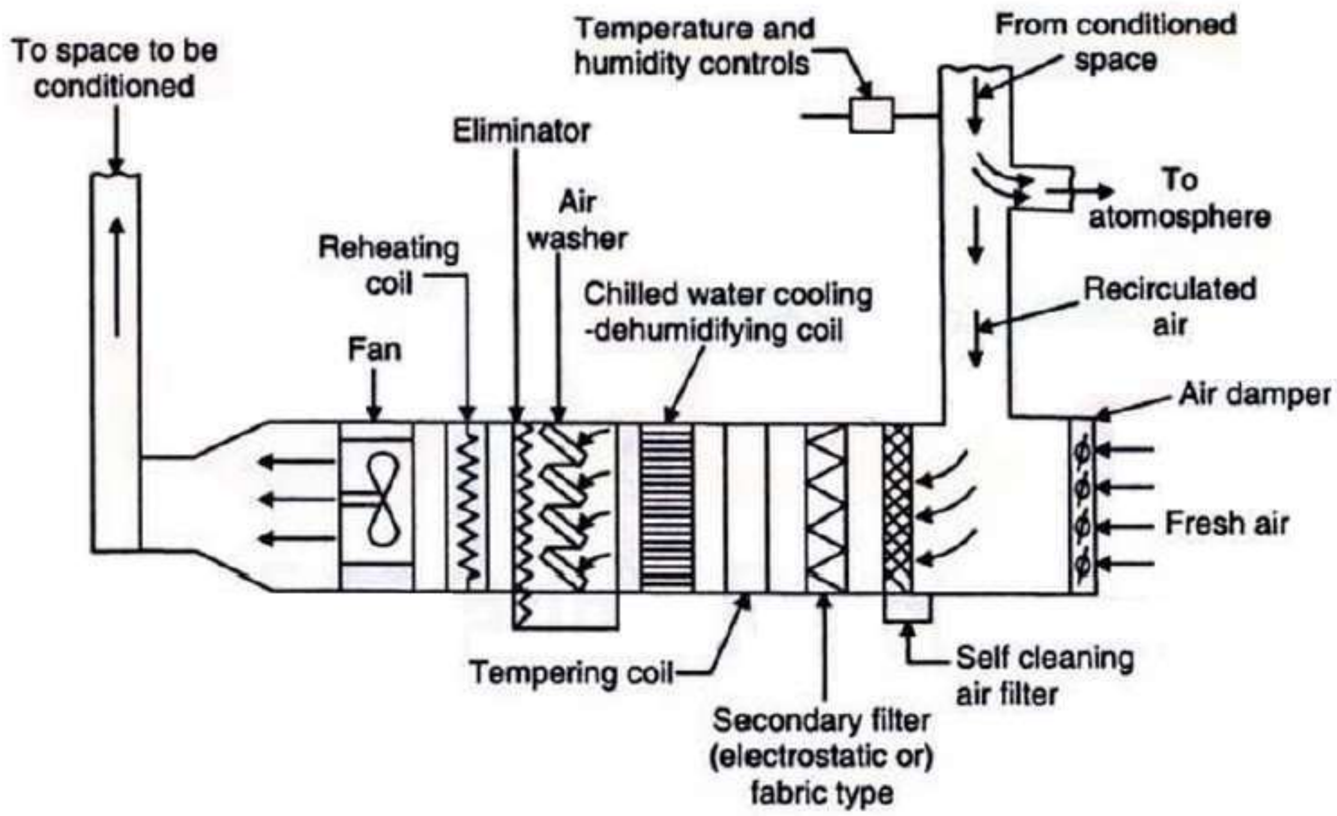

Figure 2.4.2 Central system

[Source: "Utilisation of Electrical Power" by R. K. Rajput, Page: 176]

APPLICATIONS

i. Using air-conditioner is common in food cooking and processing areas. Used in hospital operating theatres to provide comfortable conditions to patients. And many more industries like Textile, Printing, Photographic and much more.

ii. Air-conditioning system used as the commercial purpose for a human being. Example, in Theatres, Departmental store-room etc.

iii. Many of transport vehicles use air-conditioning systems such as cars, trains, aircraft, ships etc. This provides a comfortable condition for the passengers.

iv. The air-conditioning system used in Television-centres, Computer centres and museum for a special purpose.

2.2 WATER COOLERS

Water is one of the most needed things for a man. In summer season, cold water gives life to a thirsty man. At 10°C, water is most refreshing. Thus, cooling of water in summer becomes necessary. Water coolers are used to produce cold water at about 7 to 13°C. The temperature of water is controlled with the help of a thermostatic switch. Water cooler may be classified as:

1. Instantaneous type water coolers
   a. Bottle type cooler
   b. Pressure type cooler
   c. Self-contained or remote type cooler
2. Storage type water coolers

Instantaneous type water coolers

In this type of coolers that cooling coil is wrapped round the pipe line such that by the time water reaches the tank it is cooled to desired temperature. The description of various types of instantaneous type water coolers is given below:

Bottle type cooler

In this type water to be cooled is stored in a bottle or reservoir. For filling glass tumblers or containers faucet or similar means are provided. The dripping water from the faucet is collected in the waste water basin or water drip. Its usual size is 25 litres and is suitable for places where plumbing installations is expensive and drains are available.

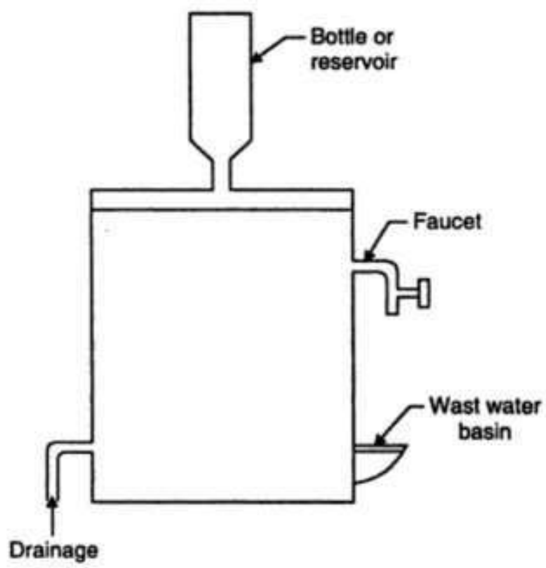

Figure 2.2.1 Bottle type water cooler

[Source: "Utilisation of Electrical Power" by R. K. Rajput, Page: 167]

Pressure type cooler

Here water is supplied under pressure. For filling glass tumblers or containers faucets or similar means are provided. A valve is employed to control an appropriate flow f water or projected stream of water from a bubbler. An arrangement should be made to collect water and allow complete collection of water spreading from the bubbler. The temperature of waste water is low, it is used for cooling the supply water by passing through a pipe coil wrapped round the drainage line. By doing so, the cooling load for cooler is reduced. Since the water is supplied under pressure the cold water can be obtained from the top mounted at any height of the cooler. In case of bottle type, faucet has to be at a height upto which syphoned water can be obtained from the tank of the cooler. The refrigeration system is usually mounted at the bottom structure of the cooler body and a cooling coil is wrapped round the water tank, to ensure good surface contact between the evaporative tube and tank, either the tank surface is corrugated to accommodate pipe or pipes are secured using soft solder to give metal contact. Sometimes, a helical or U-type coil is immersed in the water tank. Although this arrangement gives high heat transfer from water to the coil yet formation of undesirable salt due to chemical reaction between water contaminant and the copper surface proves to be a great disadvantage in this system.

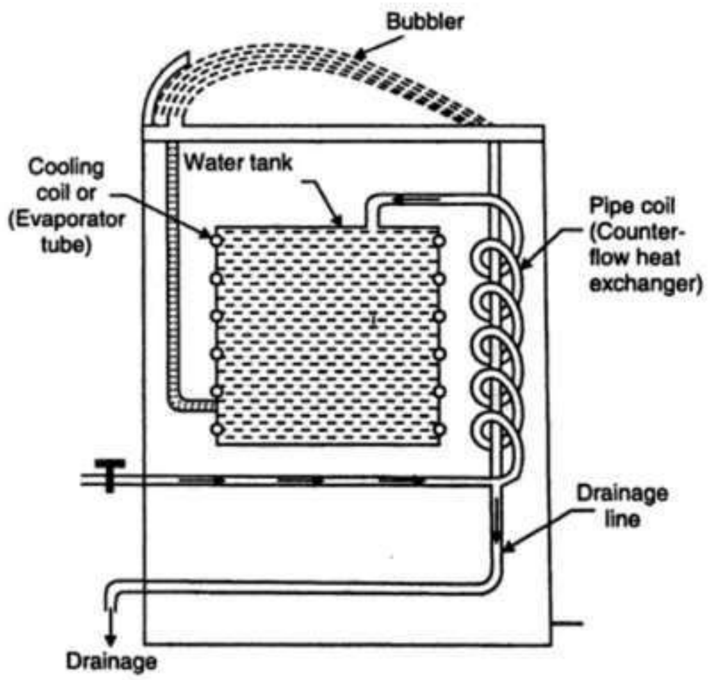

Figure 2.2.2 Pressure type water cooler

[Source: "Utilisation of Electrical Power" by R. K. Rajput, Page: 167]

Self-contained or remote type cooler

This type of water cooler employs mechanical refrigeration system and is a factory assembled unit. A remote cooler cools the water which is supplied to the desired drinking place (away from the system). It is quite a useful unit since it does not require extra space near the place of work.

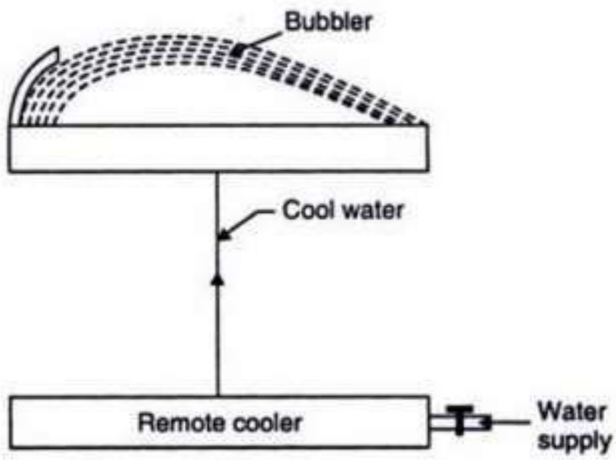

Figure 2.2.3 Remote type water cooler

[Source: "Utilisation of Electrical Power" by R. K. Rajput, Page: 168]

Storage type water coolers

Such type of coolers is used where continuous supply of water is not available. The figure shows a schematic storage type water cooler which is self-explanatory. Here, water is filled in the storage tank and level of the water is kept same by the use of a float-valve. The storage tank is surrounded by an evaporator coil through which flows a low-pressure liquid refrigerant which takes away the heat of water and thus makes it cold. When the water attains desired temperature, the thermostat operates and disconnects the power supply to the motor. The motor used is capacitor-start capacitor-run single phase induction motor.

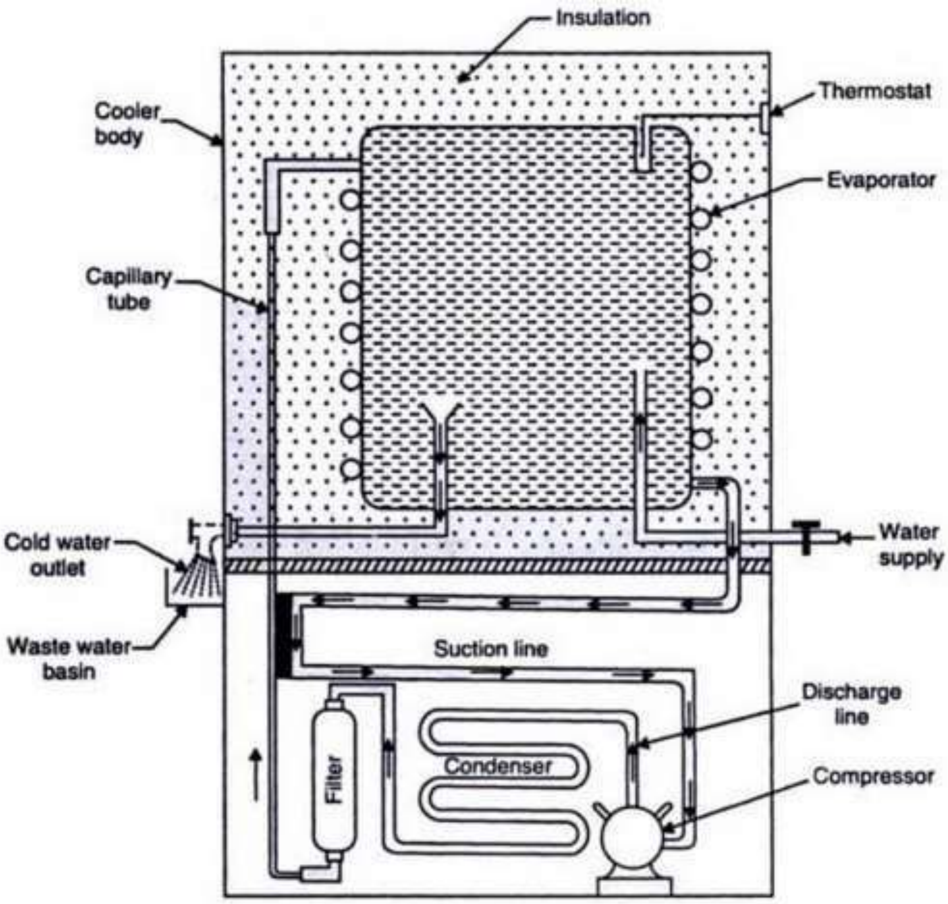

Figure 2.2.4 Storage type water cooler

[Source: "Utilisation of Electrical Power" by R. K. Rajput, Page: 168]