1.9 AIR CONDITIONING

It is defined as the process of simultaneously controlling and maintaining the properties of air like temperature, humidity, purity, direction of flow in a closed space.

Principle

An air-conditioner continuously draws an air from an indoor space to be cooled and cools it by the refrigeration principles and discharges it back into the same indoor space that needs to be cooled and recirculation of the cooled air keeps the indoor space at the required temperature.

Classification of air-conditioning system

Comfort air- conditioning

Summer air – conditioning

Winter air – conditioning

Year-round air -conditioning

Industrial air-conditioning

Unitary (Window) air-conditioning

Central air-conditioning

Comfort air- conditioning

It is to provide the environment with required temperature and humidity for comfort. It is used in houses, shops hospitals, hotels etc.

Summer air – conditioning

The temperature is high and hence the air conditioning system involves cooling & dehumidification.

Winter air – conditioning

Temperature is lower in the atmospheric hence air conditioning involves heating and dehumidification to provide comfort.

Year-round air –conditioning

System has both winter & summer air-conditioning. One part of the system works in summer and other in winter.

Industrial air-conditioning

It is to provide the environment with the required temperature and humidity according to applications.

Unitary (window) air-conditioning

The unitary or window type air-conditioner is of small capacity. (0.5 tonnes to 2 tonnes). It is used for air conditioning of rooms, small offices.

Central air-conditioning

The central air-conditioning is of large capacity.(around 50 to 100 tonnes). It is used for large commercial buildings.

WINDOW AIR-CONDITIONER (ROOM AIR-CONDITIONER)

It is designed to condition the air in a single room and usually installed in a window.

Construction

Main components are

- Compressor
- Condenser
- Air filter
- Evaporator
- Motor
- Fans
- Thermostat
- Capillary tube

The while unit is divided into two units as

- Indoor unit (an evaporator, air filter, motor driven fan, control panel, trays)
- Outdoor unit (compressor,condenser,trays,motar driven fan)
- Basic refrigeration components are enclosed in a single unit.

Working

The evaporator fan sucks the air from the room to be conditioned through air filter and it passes the air over the cooling coil. It delivers cool and dehumidified air back to the room.

In the evaporator, the liquid refrigerant picks up heat from the room air. This cool air brings down the temperature and humidity levels in the room.

Compressor compresses the low-pressure vapour refrigerant coming from the evaporator or cooling coil and converts into high pressure vapour refrigerant. It is passed into the condenser where it is cooled.

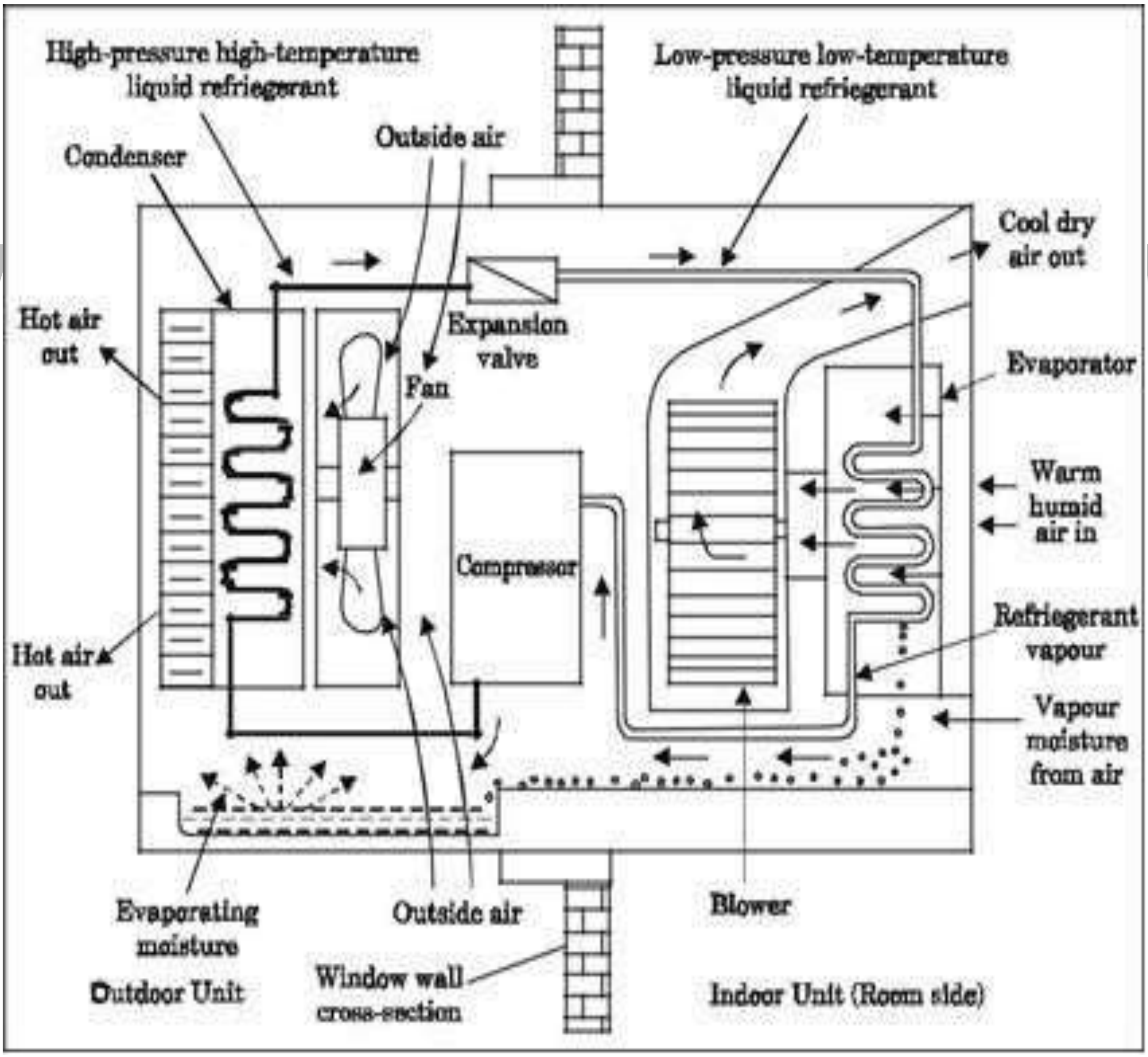


Fig 1.9.1- Window A.C.

Outside air is drawn in by the another fan (which also driven by same motor) and it cools the refrigerant then becomes liquid. The high-pressure low-temperature liquid refrigerant from the condenser enters the capillary tube. It is passes to the evaporator coil.

In the evaporator, the liquid refrigerant picks up heat and gets vapourised. This cycle repeats again & again until required temperature is reached.

Advantages

- Individual temperature control device is provided
- For air distribution, ducts are not required.

Disadvantages

- Unit is installed outside the wall.
- Unit has a fixed air quantity

1.7 Central heating process

A central heating system provides warmth to the whole interior of a building or portion of a buildingfrom one point to multiple rooms.In cold countries the temperature in winter falls to 0^0C and even goes to below that value. The rooms of the building are kept warm by a central heating system based on the principle of convection. It differs from local heating in that the heat generation occurs in one place, such as a furnace room or basement in a house or a mechanical room in a large building.

The heat is distributed throughout the building, typically by forced-air through ductwork, by water circulating through pipes, or by steam fed through pipes. The most common method of heat generation involves the combustion of fossil fuel in a furnace or boiler.The circulating hot water can be used for central heating.

Common components of a central heating system using water-circulation include:

- A gas supply lines, oil tanks and supply linear distinct heating supply lines.
- A Boiler which heats water in the system.
- Pump to circulate the water in the closed system.
- Radiators which are wall-mounted panels through which the heated water passes in order to release heat into rooms
- Hot water from the boiler rises up passes through the radiation of different rooms. Radiation get heated and radiate heat to the room.
- Hot water also reaches the cold water tank at the top of the building. Convection currents are set up and the building is kept warm continuously at a constant temperature.
- The circulating water systems use a closed loop; the same water is heated and then reheated. A sealed system provides a form of central heating in which the water used for heating circulates independently of the building’s normal water supply.

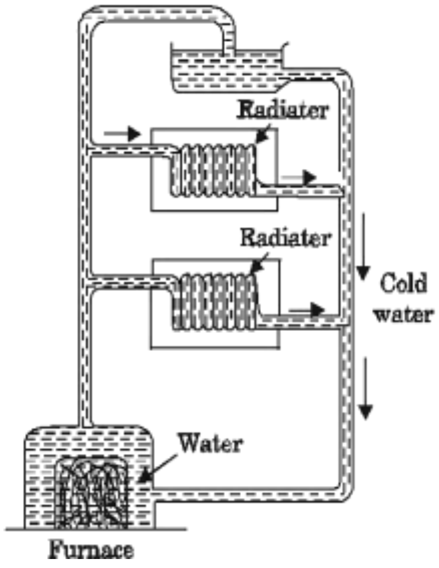


Fig 1.7- Central heating system

1.6.a) CHILLED WATER PLANT

Chilled water is extensively used as a secondary refrigerant in larger commercial, institutional and industrial premises to make cooling available over a large area.

The refrigeration machine that produces chilled water is generally referred to as *chiller*.

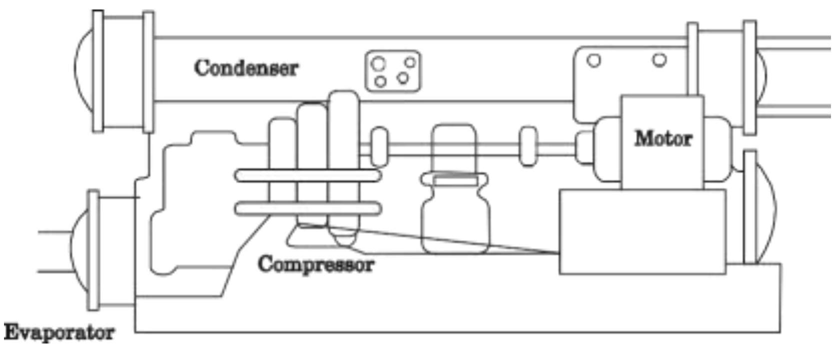


Fig. 1.6.1 Sectional details of a packaged chiller

It consists of the compressor(s), evaporator and condenser packaged as a single unit.

The condensing medium may be water or outdoor air. Air-cooled chillers are typically designed for outdoor installation and have large fans to force outdoor air over the condenser coil for heat rejection.

Water-cooled chillers are designed for indoor installation and are supplied with a source of water for condenser heat rejection. The evaporator consists of a shell-and-tube heat exchanger with refrigerant in the shell and water in the tubes.

b)FAN COIL UNITS

A fan coil unit consists of a heat exchanger in which water is circulated and a fan assembly, incorporating a filter and simple controls, designed for wall perimeter units. The ceiling units mounted within ceiling voids. The ceiling units can be configured as a cassette, drawing air into the centre and discharging at the periphery. Heating elements, electric, hot water or steam can be included.

The chilled water is fed to a number of air-handling units, each sized for a suitable zone, where the conditions

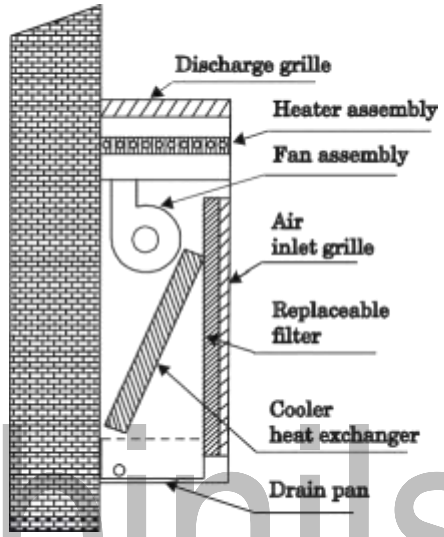
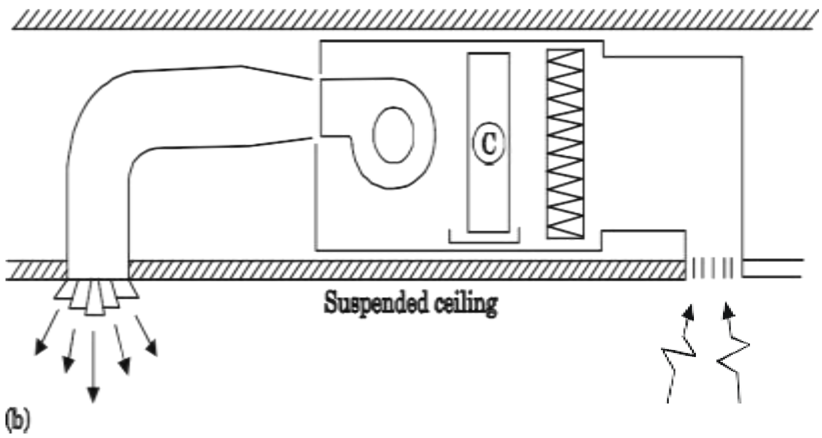


Fig1.6.b.1- *Fan coil units- Wall mounted*

throughout the zone can be satisfied by the outlet air



from the unit.

Fig1.6.b.2- *Fan coil units- Ceiling mounted*

This offers a wise range of comfort conditions within the space, with units serving a single rooms, or part of a room.

The coil is normally operated with a fin temperature below room dew point, so that some latent heat is removed by the coil, which requires a condensate drain. Multi-speed fans are usual, so that the noise level can be reduced at times of light load.

Advantages of this type of system

- Individual control for zone or office, including heating in some zones and cooling in others
- Relatively low cost of standard units
- Simple control system
- Built in standby capacity where several units are located in one zone.

Disadvantages

- Limited flexibility with standard units - all operating parameters fixed by the manufacturer.
- Normally only simple dry bulb control is provied, although some specialist units incorporate electronic control systems and humidifiers.
- Limited control of fresh air input, if any, so that advantage of free cooling cannot be taken.
- Limited ability to control air distribution.
- Visibility of the units and connecting chilled water services may be an issue.

1.13 COOLING LOAD

It is defined as the total heat required to be removed from the space in order to bring it to the desired temperature by air conditioning and refrigeratin equipment.

The purpose of a load estimation is to determine the size of the air conditioning and refrigeration equipment that is required to maintain inside conditions during periods of maximum outside temperatures.

The design load is based on inside and outside design conditions and it is air conditioning and refrigeration equipments to produce satisfactory inside conditions.

It is the rate at which sensible and latent heat must be removed from the space to maintain a constant space dry-bulb air temperature and humidity.

Sensible heat into the space causes its air temperature to rise while latent heat is associated with the rise of the moisture content in the space.

The building design, internal equipment, occupants, and outdoor weather conditions may affect the cooling load in a building using different heat transfer mechanisms.

The Si unit is watts.

Components of a cooling load

The two main components of a cooling load imposed on air conditioning plan operating during hot weather are as follows:

1. Sensible heat gain

When there is a direct addition of heat to the enclosed space, a gain in the sensible heat is to be removed during the process of summer air conditioning. The sensible heat gain may occur due to any one or all of the following sources of heat transfer

- The heat flowing into the building by conduction through exterior walls, floor, ceilings, door and windows due to the temperature difference on their two sides.
- The heat received from solar radiation. It consists of (i) heat transmitted through glass of windows, ventilators or doors and
- The heat absorbed by walls and not exposed on solar radiation and later on transferred to the room by condition.
- The heat gain from the fan work.
- The heat liberated by the occupants.

2. **Latent heat gain**

When there is an addition of water vapour to the air enclosed space, U gain in latent heat is said to occur. This latent heat is to be removed during the process of summer air conditioning. The latent heat gain may occur due to any one or all of the following sources.

- The heat gain due to the moisture in the outside air entering by infiltration.
- The heat gain due to condensation of moisture from occupants.
- The heat gain due to condensation of moisture from any process such as cooking foods which takes place within the conditioned space.

1.0 FENESTRATION

Any opening in a building's envelope including windows, doors, curtain walls and skylights designed to permit the passage of air, light, vehicles, or people. Fenestrations **transmit solar radiation** into the building (normally filled with glazing).

Fenestration Systems

There are various fenestration systems like,

- **i) Glazing**
- **ii) Windows**
- **iii) Curtain walls**
- **iv) Sloped glazing**
- **v) Exterior doors**

i) **Glazing:** Glass which serves the purpose of allowing natural light into a building has been in use.This has led to glazing of majority of the new windows and curtain walls for commercial building construction.

ii) **Windows:** We use wood frame, with some metal windows in institutional construction. Later, steel windows and aluminum windows were introduced.

iii) **Curtain Walls:** A curtain wall is any exterior wall that is attached to the building structure.

iv) **Sloped Glazing:** Skylights have been used to provide interior delighting.

v) **Exterior Doors:** These include entrance and exit doors, as well as industrial loading dock doors.

Main Components of Fenestration system

The Main components of fenestration system are **Glazing, Framing and Shading devices.**

1. **Glazing** :It is the main part of fenestration that lets the light through and it is usually glass. Occasionally plastic. A layer is called a glaze or a pane.
2. **Framing**: It is the material that holds the glazing in place and attaches it to the rest of the enclosure and it is usually wood, metal, and plastic or fiberglass.
3. **Shading devices and/or screens** :A unit may or may not have shading. From other building components that either may or may not be an integral part of the overall assembly.

FUNDAMENTAL MODES OF HEAT TRANSFER

- **Conduction is the process of transmission of heat from one point to another through substance without the actual motion of the particles. Conduction always requires some material medium. The material medium may be solid, liquid, gas.**
- The **transfer of heat** energy between an object and its environment, **due to fluid motion** is called as **convection**
- **The transfer of heat energy by the means of electromagnetic radiation without any original contact between the bodies is called as radiation.**

HEAT TRANSFER THROUGH FENESTRATIONS

Energy flows through fenestration via

- Conductive and convective heat transfer caused by the temperature difference between outdoor and indoor air,
- Net long-wave (above 2500 nm) radiative exchange between the fenestration and its surrounding and between glazing layers, and
- Short-wave (below 2500 nm) solar radiation incident on the fenestration product, either directly from the sun or reflected from the ground or adjacent objects
- Part of the incident solar energy is transmitted and eventually absorbed by the room surfaces.
- Part of the incident solar energy is absorbed by the fenestration and reradiated as thermal energy towards inside.

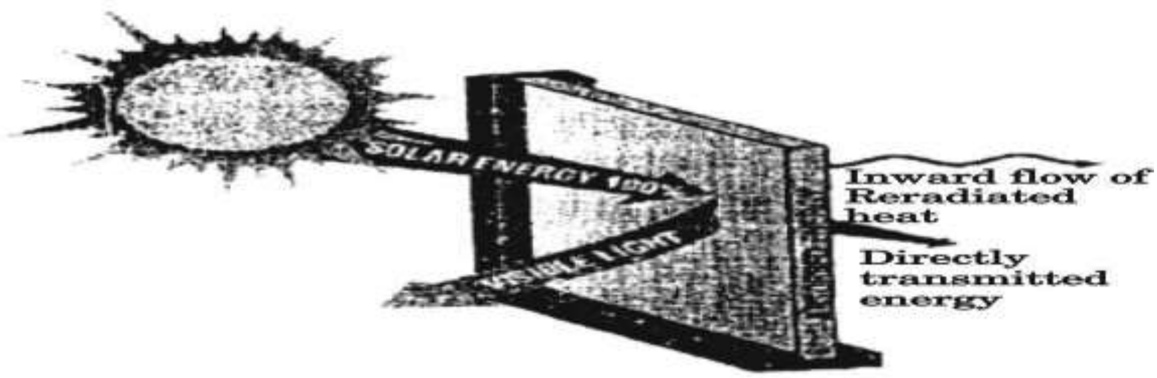


Fig 1.1- Heat transfer through fenestration

Total heat transfer

The heat gain through fenestration consists of two main components:

- ***Q* thermal**= Heat transfer between indoor and outdoor air. This is positive or negative depending on temperature.
- ***Q* solar**= Heat transfer from solar radiation. This is always a positive number.
- $Q_{\mathbf{total}} = Q_{\mathbf{thermal}} + Q_{\mathbf{solar}}$

1.10 PACKAGED AIR CONDITIONER

Packaged air conditioner is a self-contained unit primarily for floor mounting, designed to provide conditioned air to the space to be conditioned.

It includes prime sources of refrigeration for cooling and dehumidification and means for circulation and cleaning of air, with or without external air distribution ducting. It may also include means for heating, humidifying and ventilating air.

The unit comprises a compressor, condenser and evaporator, which are interconnected with copper refrigerant piping and refrigerant controls. It also includes fan for circulation of air and filter. The unit is provided with compressor and fan motor starter and factory-wired safety controls.

Compressor is a device which compresses low-pressure low temperature refrigerant gas to high-pressure high temperature super heated refrigerant gas.

Condenser condenses high pressure high temperature refrigerant gas to liquid refrigerant at approximately the same temperature and pressure by removal of sensible heat of refrigerant by external means of water cooling or air cooling.

The packaged units are also available with microprocessor-based controller installed in the unit for digital display of faults as also several other functions.

The packaged unit can also be provided with winter heating package or humidification package. The packaged unit may be provided with either water-cooled condenser or a remote air cooled condenser with interconnected copper refrigerant piping.

The units are available with reciprocating compressor as also scroll the false ceiling to attend to the indoor unit including periodic cleaning of air filter.

Outdoor unit is mounted at the nearest open area where unobstructed flow of outside air is available for air cooled condenser.

1.3 SHADING DEVICES

The primary objective of shading devices is creating a comfortable internal environment.

Sun shading devices inhibit the solar radiation incident on a building. Sun shading devices are any mechanical equipment or textiles that are used either internally or externally or in between the internal and the external building space. Shading devices can be fixed, manual and automatic movable.

IMPORTANCE OF SUN SHADING DEVICES

- To provide greater comfort for occupants.
- It can improve building energy performance.
- To prevent glare
- To increase useful daylight availability.
- To create a sense of security

SOLAR SHADING

When sunlight hits a pane of glass, it splits into three components, if it is reflected, then there is no effect on heating. If it is absorbed then glass heats up which would transfer heat by conduction and also emits. If it is transmitted, heat up surface behind it.

The proportion between the three components is determined by the angle of incidence and by the type of glazing. Form the types of glazing, the transmitted light is very small if the angle of incidence is larger than 45 from the normal to the glazing. If the angle is 60^{o}, most of the radiation is reflected.

TYPES OF SUN SHADING DEVICES

Shading devices is classified into two types

- Internal shading devices
- External shading devices

Internal shading devices

Internal shading devices such as curtains form of vertical or horizontal blinds attached above the window, can reduce heat energy passing through a window. It limits the glare resulting
from solar radiation. Usually it is adjustable and occupants to allow & regulate the amount of direct light entering their space. Mostly they are attached above windows either horizontally or vertically. It should be made or designed to be durable.

Curtains

It is the most commonly used shading device, mostly used on residential buildings. It is cheaper and can be found in various varieties colors and texture.

Venetian blind

Venetian blinds are basic slatted blinds made of metal or plastic or wood. Suspended by a strip of cloth called tapes, all slats in unions can be rotated through nearly 180 degrees.

Curtains

Venetian blinds

Fig 1.3.1- Curtains & Venetian blind

Vertical Louvre blinds

It is used in commercial and public buildings, it controls the heat, light and glare. It can be used in larger windows and doors.

Roller blinds

Roller blinds are usually stiffened polyester, mounted on a metal pole and operated with a side chain or spring mechanism It is used for block outs, sun screens. Translucent with a metal or plastic chain available hat operates the blind through an aluminum tube to roll up and down.

Pleated blinds

Pleated blinds are shades made from a pleated fabric (which helps to add texture to a room) that pull up to sit flat at the top of a window to hide from sight when open.

Blackout blinds

It is made up of tight woven fabric to help the control the light levels in a room. It is designed to block the external lights to enter the room.

<u>External shading devices</u>

External sun shading devices is considered better than internal shading devices. It is in horizontal, vertical or inclined projections, vegetation in buildings.

Horizontal devices

To shade a window during hot summer months, but to allow sunlight to shine through a window in the winter, to help warm a building.

Vertical devices

Primarily useful for east and west exposures to improve the insulation value of glass in winter months by acting as a windbreak.

The egg-crate

A combination of vertical and horizontal shading elements used in hot climate regions because of their high shading efficiencies. The horizontal elements control ground glare from
reflected solar rays.

Designing Shading Systems

It is difficult to make sweeping generalizations about the design of shading devices.

However, the following design recommendations generally hold true:

- Use fixed overhangs on south-facing glass to control direct beam solar radiation
- Limit the amount of east and west glass since it is harder to shade than south glass.
- A light shelf bounces natural light deeply into a room through high windows while shading lower windows.
- Solar gain has already been admitted into the work space
- These interior devices do offer glare control and can contribute
to visual activity and visual comfort in the work place.
- Carefully consider the durability of shading device
- Shading devices can require a considerable amount of maintenance and repair.
- Be careful when applying shading ideas from one project to another.

1.5 THERMAL COMFORT

It is the condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation or it is the condition of mind when some one is not feeling either too hot or too cold.

Thermal comfort is a method of maintaining a constant air movement and removal of saturated air from inside

The factors that influence thermal comfort are

- Metabolic rate
- Clothing insulation
- Air temperature
- Mean radiant temperature
- Air speed
- Relative humidity

Metabolic rate

It is level of transformation of **chemical energy into heat** by metabolic activities. It is equal to the **energy produced per unit surface area** of an average person at rest.

Clothing insulation

Clothing insulation **prevents heat loss** and consequently the **thermal balance**. It can either help to keep a person as warm or lead to overheating.

Air temperature

It is the **average temperature** of the air surrounding to the occupant with respect to location and time.

Mean radiant temperature

It is the **amount of radiant heat transferred from a surface**. It depends upon ability to absorb or emit heat by the materials.

Air speed

It is defined as the **rate of the air movement at a point, without regard to direction.**

Relative humidity

It is the ratio of the **amount of water vapour in the air to the saturation pressure (or)**

Density of water vapor at the same temperature and pressure.

(or)

The amount of moisture in the air divided by the maximum amount of moisture that could exit in the air at the specific temperature.

INDICES OF THERMAL COMFORT Thermal Index (or) Comfort Scale

A single scale which combines the effects of various thermal comforts such as air temperature, humidity, air movement and radiation is called a Thermal Index or Comfort Scale.

The effective temperature is adjusted by considering the loss or gain of heat by radiation to arrive at a **C**orrected **E**ffective **T**emperature (CET). It is determined by

- Air temperature
- Humidity
- Heat radiation

CET is measured using

- Globe thermometer : to measure air temperature adjusted for heat radiated
- Wet bulb thermometer: to measure humidity.

CLIMATE AND DESIGN OF SOLAR RADIATION

Solar radiation, often called the solar resource, is a general term for the electromagnetic radiation emitted by the sun. It is the intensity of sun rays falling per unit time per unit area and is usually expressed in watts per square metre

W/m^2. Solar radiation can be captured and turned into useful forms of energy, such as heat and electricity, using a variety of technologies.

Basic Principles

Every location on earth receives sunlight at least part of the year. The amount of solar radiation that reaches any one spot on the Earth's surface varies according to:

- Geographic location
- Time of day
- Season
- Local landscape
- Local weather

Because the earth is round, the sun strikes the surface at different angles, ranging from 0 to 90^0.When the sun's rays are vertical, the earth's surface gets all the energy possible. The more slanted the sun's rays are, the longer they travel through the atmosphere, becoming more scattered and diffuse.The earth is nearer the sun when it is summer in the southern hemisphere and winter in the northern hemisphere.

Diffuse and Direct solar Radiation

As sunlight passes through the atmosphere, some of it is absorbed, scattered, and reflected by:

- Air molecules
- Water vapor
- Clouds
- Dust
- Pollutants
- Forest fires
- Volcanoes.

This is called diffuse solar radiation. The solar radiation that reaches the earth's surface without being diffused is called direct beam solar radiation. The sum of the diffuse and direct solar radiation is called global solar radiation.

Solar Radiation: Solar radiation is the radiant energy received from the sun. It is the intensity of sun rays falling per unit time per unit area and is usually expressed in watts per square (w/m^2).

The instruments used for measuring of solar radiation are the pyranometer and the pyrheliometer. The duration of sunshine is measured using a sunshine recorder.

Distribution

The amount of power generated by any solar technology at a particular site depends on how much of the sun's energy reaches it.

Solar passive design

Solar passive buildings are designed to achieve thermal and visual comfort by using natural energy sources and sinks e.g. solar radiation, wet surfaces, outside air, vegetation, etc.Architects and designers can achieve energy efficiency in the buildings they design by studying the macro and micro climate of the site, applying solar passive and bio climatic design features ad taking advantage of the natural resources on site. Designer can achieve a solar passive building design by following the steps mentioned below:

- ❖ Modulating the micro climate of the site through landscaping
- ❖ Optimizing the orientation and building form.
- ❖ Optimizing the building envelope and windows
- ❖ Applying day light integration to reduce the artificial lighting demand.
- ❖ Adopting low energy passive cooling strategies.

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1.4 THERMAL PERFORMANCE OF BUILDINGS

The thermal performance of a building refers to the process of modeling the energy transfer between a building and surroundings.Various heat exchange processes are possible between a building and the external environment.

Heat flows by conduction through various building elements such as walls, roof, ceiling, floor, etc. Heat transfer also takes place from different surfaces by convection and radiation.Besides, solar radiation is transmitted through transparent windows and is absorbed by the internal surfaces of the building.These are shown in Fig.1.5

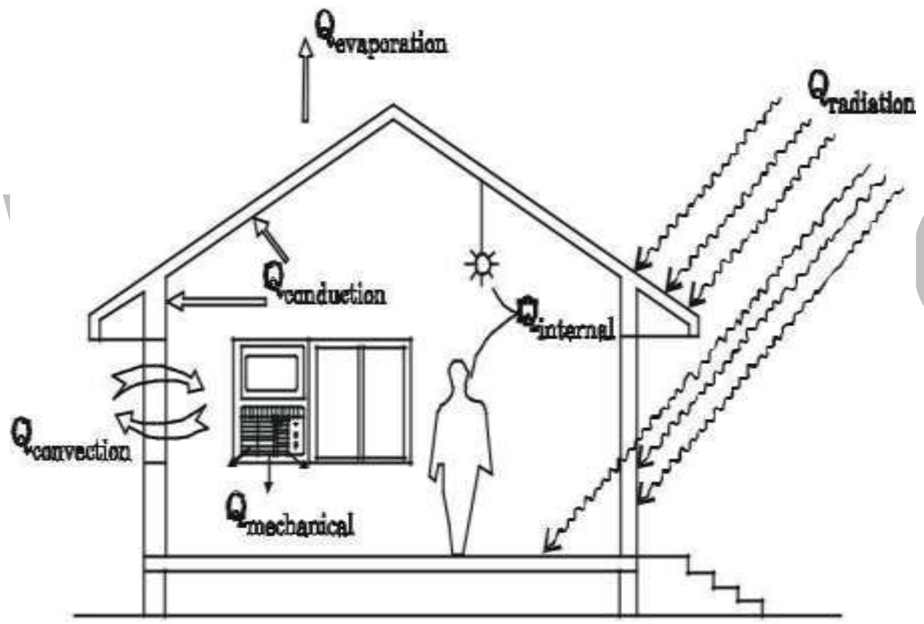

Fig 1.4.1- Thermal performance of a building

There may be evaporation of water resulting in a cooling effect. Heat is also added to the space due to the presence of human occupants and the use of lights and equipments.Due to metabolic activities, the body continuously produces heat, part of which is used as work, while the rest is dissipated into the environment for maintaining body temperature. The body exchanges heat with its surroundings by convection, radiation, evaporation and conduction.If heat is lost, one feels cool. In case of heat gain from surroundings, one feels hot and begins to perspire. Movement of air affects the rate of perspiration, which in turn affects body comfort.

The interaction between a human body and the indoor environment is shown in

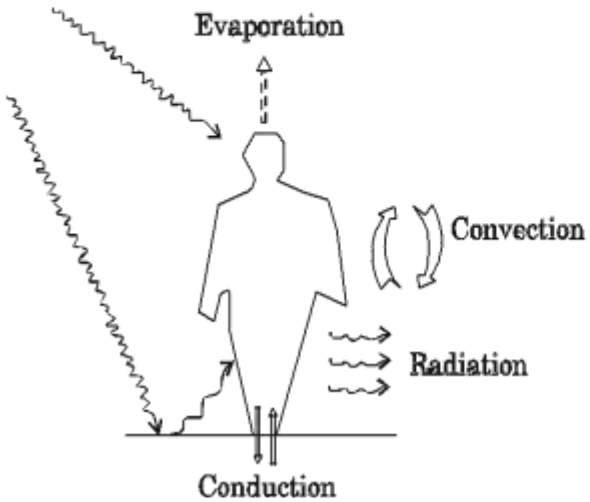

Fig 1.4.2- interaction between a human body and the indoor environment

FACTORS AFFECTING THERMAL PERFORMANCE OF BUILDINGS

The thermal performance of a building depends on a large number of factors. They can be summarised as

- ❖ design variables (geometrical dimensions of building elements such as walls, roof and windows, orient a tion, shading devices, etc.;
- ❖ material properties (density, specific heat, thermal conductivity,transmissivity
- ❖ weather data (solar radiation, ambient temperature, wind speed,humidity, etc.)
- ❖ a building's usage data (internal gains due to occupants, lighting andequipment, air exchanges, etc..

A block diagram showing various factors affecting the heat balance of a building is presented in Fig 1.4.3

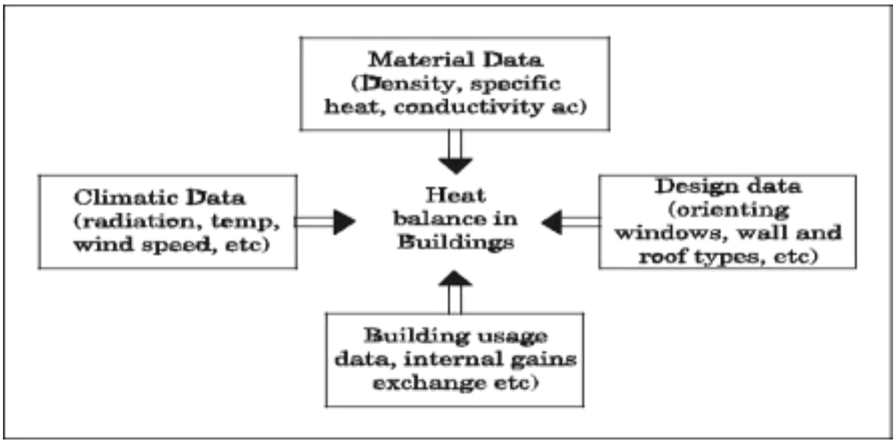

Fig 1.4.3- Heat balance of a building

THERMAL MEASUREMENTS

Every material used in an envelope assembly has fundamental physical properties that determine their energy performance like conductivity, resistance, and thermal mass.Understanding these properties will help are chose the right materials to manage heat flows

- **Thermal conductivity (K)**
- **Thermal conductance (C)**
- **U-Factor (U)**
- **Thermalresistance (R-VALUE)**
- **Thermal mass**
- **Density(ρ)**
- **Specificheat (C)**
- **Thermalcapacity or Thermal mass**

1.Thermal Conductivity *(k)*

A material's ability to conduct heat is known as thermal conductivity.

$$Q = \frac{KA\Delta T}{L}$$

Where Q=Resultant heat flow (watts)

k=thermal conductivity (W/mK)

A=surface area (m^2)

ΔT=temp diff between warm and cold sides (K)

L= thickness or length of material (m)

2.Thermal Conductance (*C*)

Conductivity per unit area for a specified thickness is known as thermal conductance.

For such common materials, it is useful to know the rate of heat flow for that standard

thickness instead of the rate per inch. Unit W/m^2K

3.*U* – Factor (U)

U factor is the overall coefficient of thermal transmittance. Unit W/m^2K.Lower *U*-factors mean less conduction, which means better insulation. (U=1/R)

Q= U TA

$U = \frac{Q}{TA} = W/Km^2$

4.Thermal Resistance (*R*- value=1/U)

A material's ability to resist heat flow is known as R value. Thermal resistance indicates how effective any material is as an insulator.The reciprocal of thermal conductance.unit- m^2K/W

5.Thermal Mass

Thermal mass **is the ability of a material to absorb and store heat energy**. It is a material's resistance to change in temperature as heat added or removed, and is a key factor in dynamic heat transfer interactions within a building.

$$Q = C\Delta T$$

$$C = Q/\Delta T \quad J/^{o}C$$

The four factors to understand are density, specific heat and thermal capacity.

Density (ρ)

Dense materials usually store more heat.Density is the mass of a material per unit volume.

$$\rho = \frac{m}{v} = \text{Kg/m}^3$$

Specific Heat (C)

High specific heat requires a lot of energy to change the temperature. Specific heat is a measure of the amount of heat required to raise the temperature of given mass of material by 1° K. Unit J/Kg K.

$$C = \frac{Q}{m\Delta T} \quad \text{(J /Kg k)}$$

Q=heat energy, ΔT= change in temperature , m= mass

Thermal Capacity

Thermal capacity is the energy required to raise the temperature by 1° K. It is an indicator of the ability of a material to store heat per unit volume.

Density X **Specific heat = heat is stored per unit volume.**

$$C = \frac{Q}{\Delta T} \quad \text{(J/k)}$$

Other important devices for measuring temperature include:

Thermocouples

Thermistors

Resistance temperature detector (RTD)

Pyrometer

Other thermometers

1.8 VENTILATION

Ventilation is the movement of air within a building and between the building and the outdoor. The removal of all vitiated air from a building and its replacement with fresh air is known as ventilation.

Factors Affecting Ventilation

Following factors affect the ventilation from the view point of comfort to the persons and therefore should be considered carefully:

1. Air changes
2. Humidity
3. Quality of air
4. Temperature
5. Use of building.

Types of ventilation

i) Natural ventilation

ii) Mechanical or artificial ventilation

PRINCIPLES OF NATURAL VENTILATION

1. Natural ventilation

Natural ventilation is the process of supplying air to and removing air from an indoor space using mechanical systems.

- The location, size and type of windows play a great role in imparting natural ventilation to the room
- The efficiency of roof ventilators depends on their location, wind direction and height of building.
- The window ventilation with a combination of radiator, deflector and exhaust can give better results.
- The radiators are situated below the still level of the windows and they extend for the full length of the window.
- The exhaust duct is provided near the ceiling of the opposite wall.
- The windows open from bottom and the deflectors may be of curved vanes.

- The velocity of wind creates pressure differences between inside & outside surfaces of a room.
- The rate of air change in a room mainly depends on the designing of the opening, location of inlet and outlet and the difference in temperature between the inside and outside air.
- The natural ventilation when inlets are at the bottom and roof ventilator is at the top.
- Cross ventilation is used to indicate the position of outlets just opposite to inlets

Natural ventilation depends on the direction of wind and it is very difficult to control the entry of air containing smoke, dust. To keep control over the quantity, velocity and temperature of the incoming air is also not very easy.

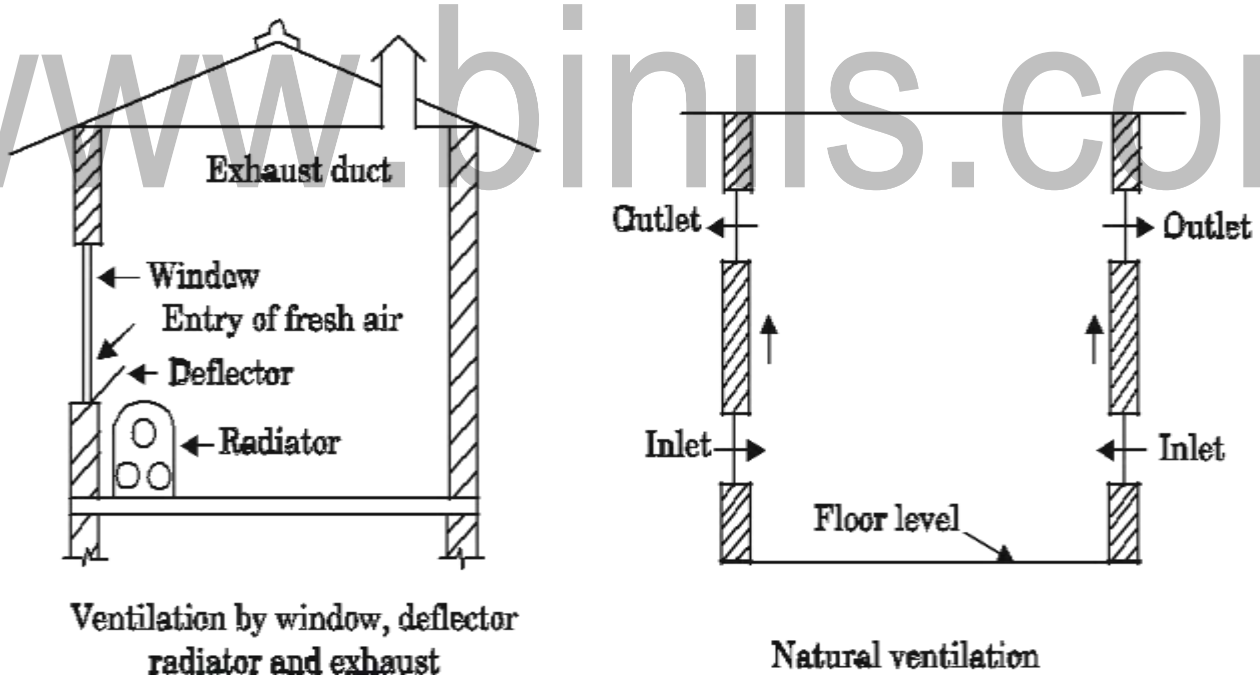

Figure: 1.8.1 a) Ventilation by window, deflector radiator and exhaust

b) Natural ventilation

2. Mechanical or Artificial ventilation

Mechanical arrangement is adopted to provide enough ventilation to the room. There are five methods of the mechanical ventilation

- Exhaust system
- Supply system
- Combination of exhaust and supply system
- Plenum process
- Air-conditioning

VENTILATION MEASUREMENTS

Natural or passive ventilation occurs because of wind and thermal forces which produce a flow of outdoor air through the various openings in a building. The flow of outdoor air through operable windows, doors, and other controllable openings can be effectively used for both temperature and contaminant control. Temperature control by natural ventilation conserves energy and is particularly effective in mild climates. The arrangement, location, and control of ventilating openings can be designed to take into consideration the driving forces of wind and temperature.

The types of openings include:

Windows, doors, and skylights,roof ventilators.Specially designed inlet or outlet openings

Determining and Designing of Ventilation

Natural Ventilation

This is difficult to measure as it varies from time to time. The amount of outside air through windows and other openings depends on the direction and velocity of wind outside (wind action) and/or convection effects arising from temperature or vapour pressure differences (or both) between inside and outside of the building (stack effect)

Stack Effect

Ventilation due to convection effects arising from temperature difference between inside and outside. Natural ventilation by stack effect occurs when air inside a building is at a different temperature than air outside. Thus in heated buildings or in buildings where in hot processes are carried on and in ordinary buildings during summer nights and during pre-monsoon period, the inside temperatures higher than that of outside, cool outside air will tend to enter through openings at low level and warm air will tend to leave through openings at high level.

1.11 WATER PIPING

- Water pipes are pipes or tubes frequently made of poly vinyl chloride, steel, cast iron or copper that carry pressurized and treated fresh water to buildings as well as inside the buildings.
- Hydronics is the use of a liquid heat-transfer medium in heating and cooling systems. The working fluid is typically water, glycol, or mineral oil.
- Some of the oldest and most common examples are steam and hot-water radiators. Historically, in large-scale commercial buildings such as high-rise and campus facilities, a hydronic system may include both a chilled and a heated water loop, to provide for both heating and air conditioning.
- When the hot sweaty air hits the cold coil of the air conditioner, it not only cools the air it squeezes the moisture out of the air too.
- If the building is full of hot humid air, the air conditioner will condense the excess water vapor into liquid water that can be drained outside.
- The water drips from the cooling coil into channels that should be angled toward the back of the unit. Some of the water is used to cool heating coils in the machine, but most will drip out of the unit.
- If an air conditioner is not dripping, it may not properly be doing its job of dehumidifying the room.

Types of Pipes

Pipes come in several types and sizes. They can be divided into three main categories: metallic pipes, cement pipes and plastic pipes.

Metallic pipes include steel pipes, galvanised iron pipes and cast iron pipes. Cement pipes include concrete cement pipes and asbestos cement pipes. Plastic pipes include plasticised polyvinyl chloride (PVC) pipes.