

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

**NPTEL
NPTEL ONLINE CERTIFICATION COURSE**

Refrigeration and Air-conditioning

**Lecture-35
Air-Conditioning Systems**

**with
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Hello I welcome you all in this course on refrigeration and air conditioning and today we will discuss different kind of AC systems say air conditioning has variety of applications it starting from half tonne of refrigeration or 0.1 of one tonne of refrigeration to 1000 tonnes of refrigeration so for variety and there is a variety in application same type of system cannot be used everywhere we cannot use same type of system for 0.1TR and 1000TR, so they are different systems for different type of applications.

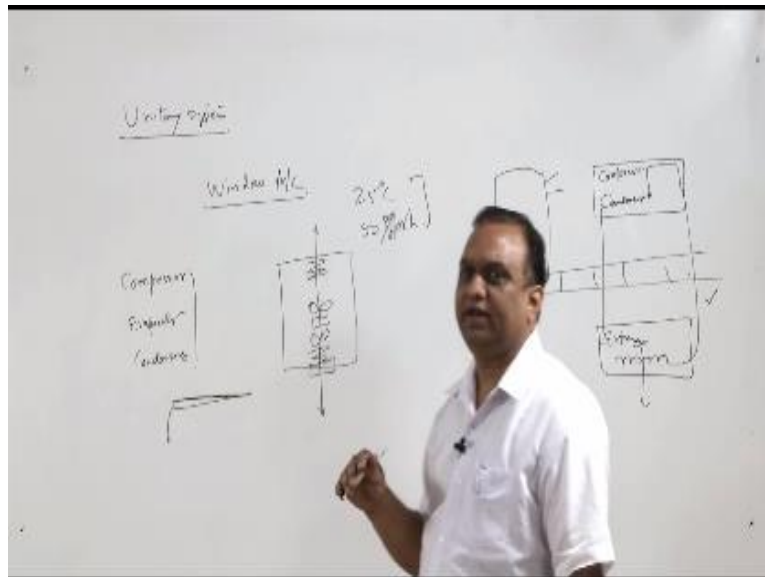
Number 2 technology is also different I mean nowadays there is a lot of stress on energy efficient system so over the years in air conditioning industry also the industry has evolved energy efficient system because the saving in energy is directly related with the saving in the running cost of the system. So we will start with the small units of air conditioning system that is unitary system.

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- Unitary system (self contained, split)
- Central system (All air, All water, Air-water)
- Constant air volume (CAV) system (Single zone system, Terminal reheat system, dual duct system, multizone)
- Variable air volume (VAV) system
- Air-water induction system (Fan-coil with separate primary air)
- VRF system
- Steam Jet Cooling System



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So unitary air conditioning system means it is a self contained unit or a split unit it comes in the form of mass manufacturing from the industries and these units for example, window air condition, window air condition is a self contained unit it is a box and this box is fixed in any of the wall of the room this box has all the arrangement I mean all compressor, compressor is hermetically sealed compressor in hermetically sealed compressor the compressor and the motor are housed in a single unit in hermetically sealed compressor.

The motor and the compressor are housed in the single unit and the wire connected to the motors are there only come out only come out of the body of the compressor and the cooling of the motor coil is done with the help of refrigerant so this hermetically sealed compressor is used in unitary systems and they have evaporator and they have condensers. For the movement of air if N is provided if N is provided and the motor is provided in fact it has two fans one is pushing window in this side one is pushing in them in this side that is condenser side here they are condenser coils here they are you operator coils and both the fans are mounted or the same motor.

This unitary system can be fixed in any of the wall of the room the precaution has to be taken that a proper slope of the unit has to be maintained a slight slope backward slope has to be given which is normally neglected by installation because in this evaporator coil the condensation of refrigerant will take place if backward slope is not given then the water will start draining on the wall of the room this you must have witnessed in many of the applications. So in this type of system a slight backward slope is given and the temperature of air which is at the grill is approximately 13 to 14°C.

I mean at this temperature air is supplied to the occupancy and occupancy temperature as I told you earlier it is approximately it has to be maintained around 25°C temperature and 50%RH 50% relative humidity. Now another type of unit in a unitary system is a split type of system, now split here there is a split between high pressure side and the low pressure side. In a split system in fact there are two units. So one unit is split it in two units in this unit there is only expansion device and coil evaporator coil and there is a fan also which blows air over evaporator coil.

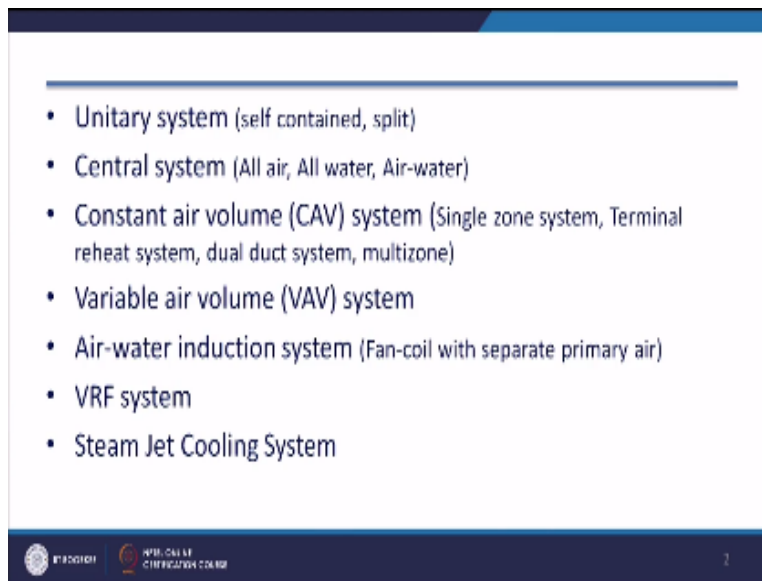
This is inside unit this is a room wall and outside this unit is connected with the outside unit and outside unit has compressor and condenser and it has got a separate fan a separate fan is for outside the unit and separate fan for inside unit. Now the vapor from evaporator the cycle remains same the vapor from evaporator goes to the compressor from compressor to condenser and condenser to expansion device and from expansion device to the evaporator.

Now this unit is a sort of silent type of unit because compressor is outside major source of noise in any air conditioning system is compressor so compressor is housed outside the building and inside the building there is only operator in a fan so noise level is low in this type of system. Second thing is precaution has to be taken that distance between these two must now be very large should not be any case more than 20 meters if this distance is large definitely for the flow of fluid inside the pipe the pressure drop will take place and that will affect the performance of the system.

Now these type of systems are suitable for example, window type of air conditioning system is suitable up to say three terms of refrigeration. Now these type of a still be type of system we can

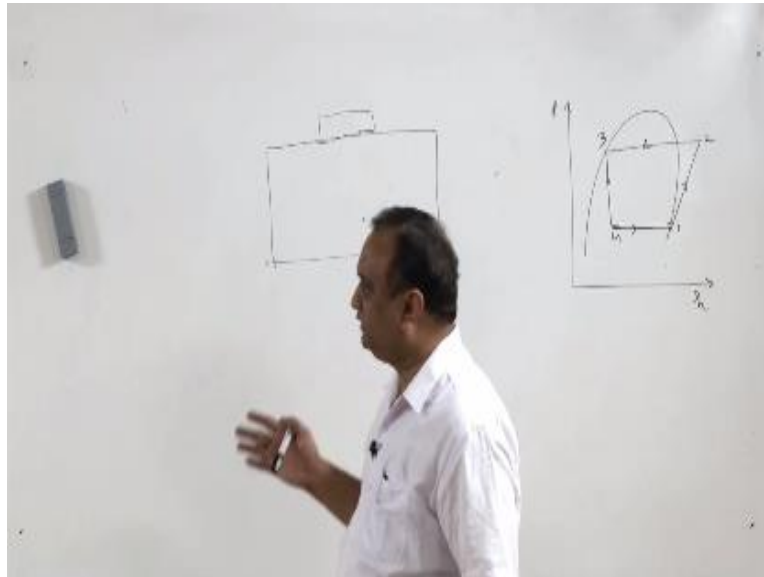
go for higher capacity but suppose I want to have 50 tonnes of refrigeration, 50 tonnes of refrigeration none of these units will work single unit will work if you provide multiple unit that is another case but single unit will not work for 50 tonnes of refrigeration. Now for such type of load 100 tonnes, 50 tonnes or 100 tonnes central system is used.

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Now unitary system a package type of unit is also used package type of unit I mean it is a larger size of window type of window AC.

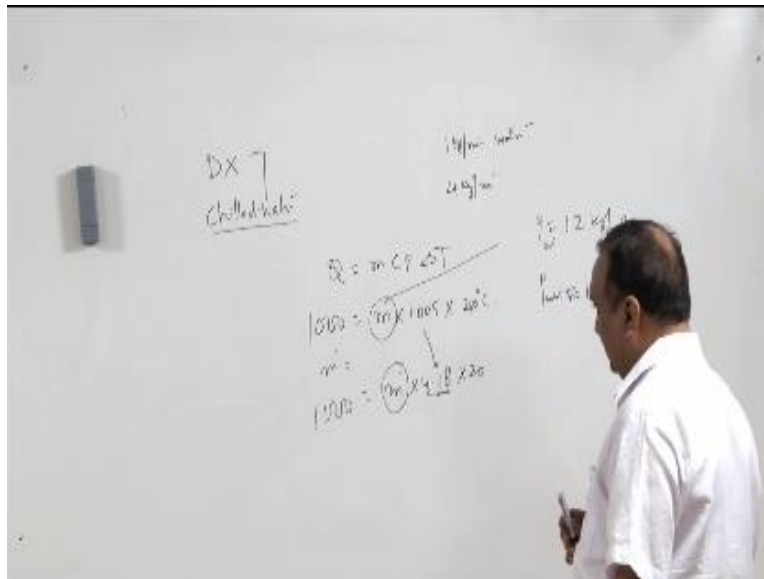
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Where everything is put in one package and it is placed at the rooftop it is a direct expansion type of system direct expansion time is after the expansion in the expansion wall that is 1,2,3 and 4 so in this unit after expansion in the wall the refrigerant goes to the evaporator and the air comes directly in contact with the evaporator this is known as direct expansion type of you means there is no secondary refrigerant like chilled water or brain and this unit is placed at the rooftop and air is supplied to a room or a set of rooms through decks and this type of unit is known as package type of unit.

Now central system centrally AC system there is a compressor house mainly in the basement of the building there are two type of systems.

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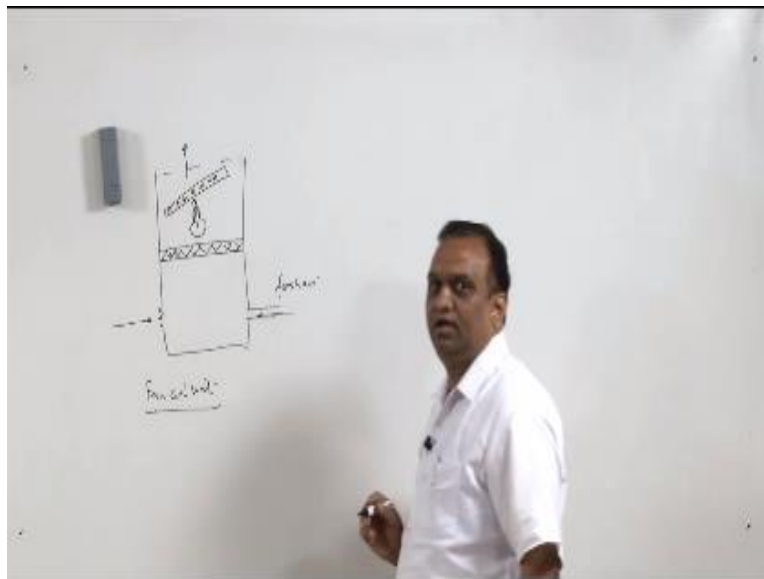
Where is direct expansion type of system and chilled water type of system in direct expansion system it is same the air which takes heat from the room goes to the evaporator coil gives heat to the refrigerant in it comes back and it chilled water type of air conditioning system the chilled water is produced in the evaporator coil in a separate tank the chilled water is produced and this chilled water is circulated throughout the building through a pump the benefit of chilled water system is if you look at the heat carrying capacity of air and water suppose as you know that Q is equal to $MCP\Delta T$ suppose one kilowatt of heat has to be carried away by air for we have to find the mass of the air so mass of the air CP for air is 1.005 and ΔT let us say ΔT is the 25° and 20°C, right.

We can find the mass flow rate of the air and in the similar case suppose 1000 has to be carried away by the water 4.18 into let us say 20 again because specific heat of water is approximately four times the specific heat of air so mass of the water is automatically reduced by 4 times suppose here we need suppose in a case we need 1kg of water 1 kg per minute of water then air will lead only 4 kg per minute that is one thing.

Second thing is if you look at the density, density of air is 1.2 at normal temperature pressure that is 1.2 dot normal temperatures STP, I mean at 25°C it is 1.2 kg/ m³ density of air. Now density of water is approximately 1000kg/m³ so it is 7 or 800 times, so now you can imagine the amount of water is required to carry the heat which is equivalent to the heat carried away by the vapor, so for very large systems instead of using air water is used for as a medium of heat transfer and water is water works as a secondary refrigerant it takes heat from the room and then heat is discharged to the evaporator.

Now in some of the cases in some of the cases mixing of these to be the is done that is also there the mixing I mean part of the system is running with the air whole air and part of the system is working with cold water.

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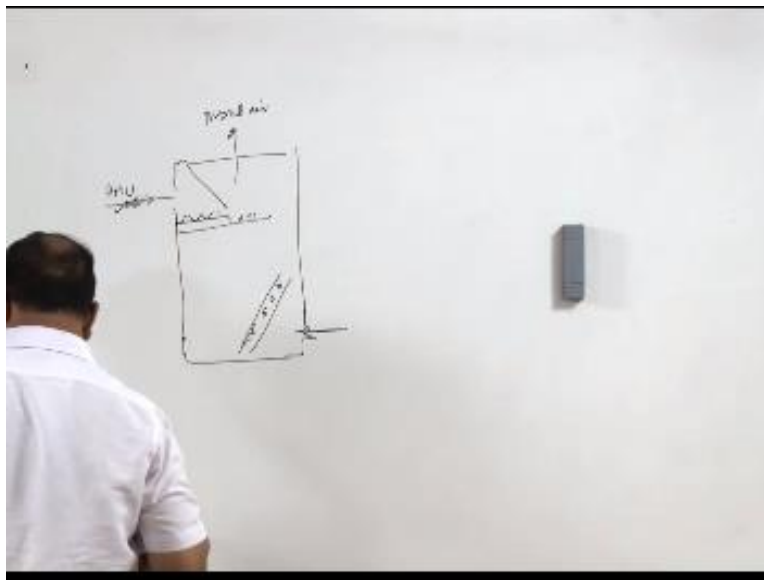


Now if you look at a typical fan coil unit which is used in a system, in a chilled water type of system so this is a unit and it has first of all if filter is provided filter are must in the circuit otherwise the contaminated air will enter the room and this side there is a passage for fresh air and this side there is a damper for room here and this side is for fresh air. Now fresh air enters from this side room air means return air return here which is coming from the roof it will enter

from this side they will get mixed here and there is a coil arrangement here chilled water coils arrangement here air is blown over these coils with the help of a fan or blower and then it is supplied to the room.

So this is a typical arrangement for fan coil unit, which is used in air conditioning systems. Now in addition to the fan coil units this is all air system I have already explained all water system the fan coil unit will be used, now third type of system is air water system so in this system we take benefit of both the systems air systems and water systems and the cooling in the system is done with the help of air and water.

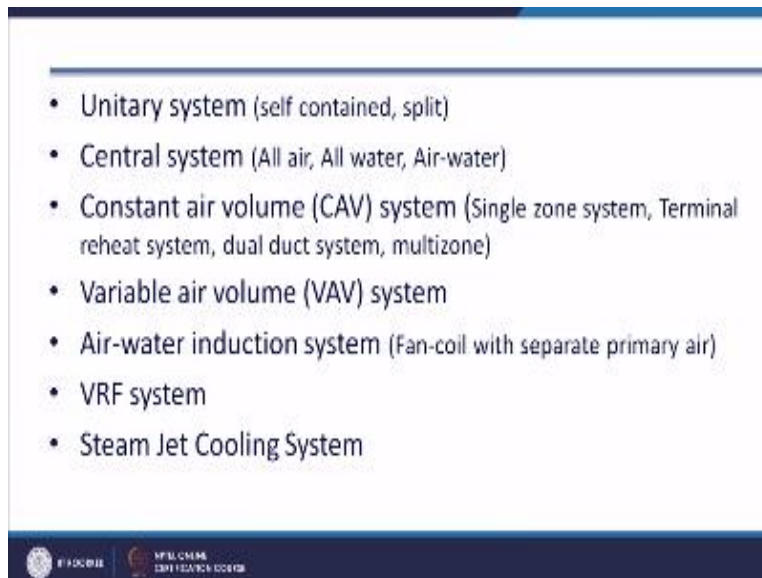
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Now in this type of system we take induced air from the room, so induced air from the room that is a return here from the room it enters from this side and there is a fan coil arrangement so this air when it comes into the contact of chilled water circulated in this coil it gives heat to the chilled water, now fresh air from HU the air from air handling unit here from air handling unit comes from this side and there are dampers here so dampers helps in controlling the mixture how much fresh air shall be mixed with the return air of the room and because these air they pass through a nozzle the nozzle is this extension of this there is there nozzels and after mixing it is

supplied here, right, this mixed here is a mixture of a the flash here coming from the HU and the here coming from the room so likewise there can be many arrangements in a central system now third one is constant here.

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Volume system now this unitary systems like a window AC is split AC most of the system or earlier system they were constant.

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Here volume systems constant year volume system is constant volume of here is discharge in the room right so the flow in the room is coming in constant if you look at a data sheet of an split AC or window type AC the flow rate is fixed flow rate is fixed may be three ended CFM sorry just 300CFM or 500CFM whatever the flow rate is the flow rate is fixed so that is why they are called constant volume system the constant volume system can be a single zone system the single zone can be a signal room or multiple room or even a floor if floor can also be a single zone.

Now in different zones different environmental conditions can be maintained that is why a big building normally in big buildings zoning is done right and for each zone normally for earlier system for each zone there is a separate expansion device now this is the terminary heat systems this is very interesting suppose in a particular zone we do not need very low temperatures for example in one room the temperature requirement is 21°C in another room the temperature requirement is 26°C so in a turbulent reheat system at the point of supply of air mixing heating of air takes place.

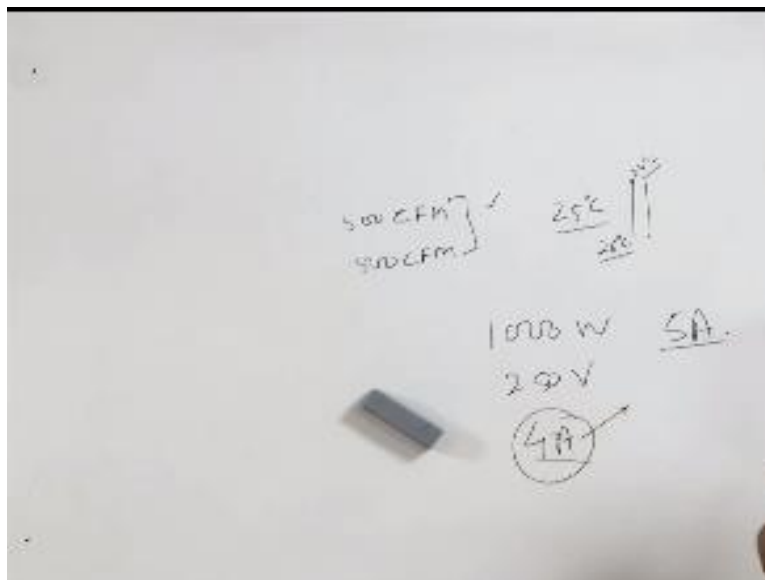
So cold air may be entering from this side at 21°C but zone where 26°C temperature is required the heating of air is done heating loss air is done and there is a heating coil we can do the electrical heating electrical heating can be done or heating with a steam heating with hot water any mode of heating can be used and this temperature is increased to 26°C will be sending it the turbulent heating system is not a very efficient system definitely once on one side we are cooling the outside air which is available at 40°C to 21°C and again we are heating it to 26°C so this system is not very energy efficient system.

But it is very flexible and easy to control because we have to simply use the heating suppose electrical heating system is there so fine control can be done in such type of system so in terminal reheat type of system the heating of air takes place at the supply terminal but dual depth system the dual depth systems are normally very popular in the industries where air supply and return board that are provided one is supply that another is return duct the velocity of air remains completely higher in these type of ducts there is smaller in size and normally if when the velocity is high pressure loss is also high instep of depths and these deaths are also helpful this type of arrangement is also useful in making the system more efficient but this type of system it may not be efficient but it is I mean the terminal heat of system is I mean it is very flexible and workable system so during duct system there are two depths what is supply depths the air supply at a very high velocity and then there is a return ears.

For example suppose a worker in industries is standing before a furnace is at high very high temperature so we cannot pull the entire environment so what is being done air is blown over the body of the worker and from the supply that it takes the u-turn and goes through the return depth and it is taken away so that area that area get in fact the human occupant of that area gets the comfort cooling by the air but entire areas not cool so door duct system has many advantages like this multi is only in a building definitely some part is 26°C required some power 21°C required or different air conditions are required at the condition of air is required indifferent part of the building.

So multi zoning is done and each zone is provided a separate expansion device to attain the state of the air now the fourth is variable air volume system VAV system variable air volume system means so it is a sort of on-off type of system you must have observed in the window AC or split AC it does not run continuously it switches on switches off so if thermostat is faced let us say it 25°C.

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So when the temperature is 26°C it sorry yes 26°C it will switch on I mean it depends upon the sweating and when temperature is 24°C it will switch off flow rate will remain same so when 24°C air is reached temperature of air is reach the system will switch off slowly the temperature will start rising when it goes to 26°C this term will again switch on now in air conditioning water the starting current is very high I starting current is approximately three to four times the normal current that is why 15 ampere fitting is done for window type of AC window type of AC suppose one kilowatt motor one kilowatt means 1000watts 200 for 250 230 volts or let us say 250 volts so it is for MPR right.

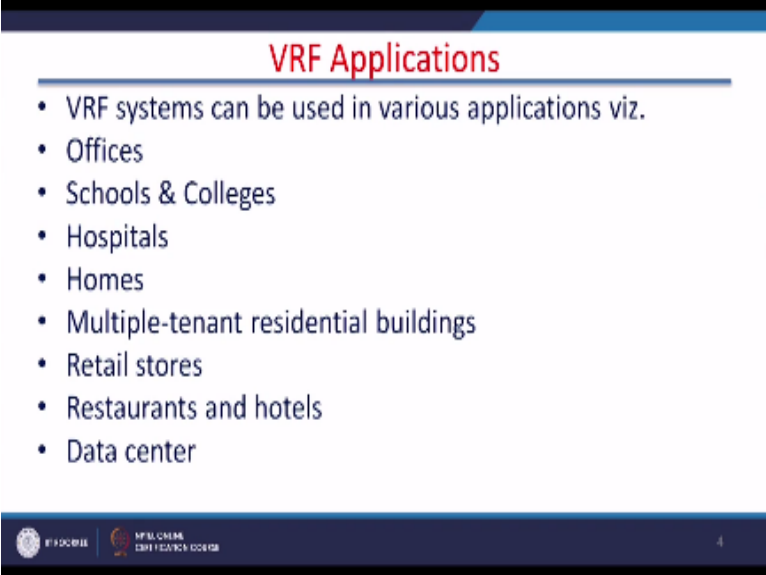
And for mpr because the starting current is high for ampere normal house domestic electrical wiring is five-year ampere wiring right but we do not use normal wiring is dedicated wearing is provided for window type of AC because starting current is 12 or 13 ampere it is three times so starting current is I that is why 15 ampere wiring is provided for window type of EC so we are talking about the variable air volume system where volume of the air changes right and if.

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When the temperature inside the space reaches the required temperature and we do not be no longer required pulled here the dampers starts closing the dampers starts closing and the static pressure in the duct it increases when there is a shoot in the static pressure of in the depth it gives signal to the air handling unit and the supply of air in the room is reduced so variable air volume system is an energy efficient system now air water induction system fan coil unit with sep separate primary I have already explained you this type of now the this one VRF system this is important I will take up this one VRF system now VRF system is variable refrigeration refrigerant flow system.

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The slide features a dark blue header with the title "VRF Applications" in red. Below the title is a list of applications for VRF systems. At the bottom, there are logos for "FACULTY" and "INSTITUTE OF ENGINEERING & TECHNOLOGY" along with a small number "4".

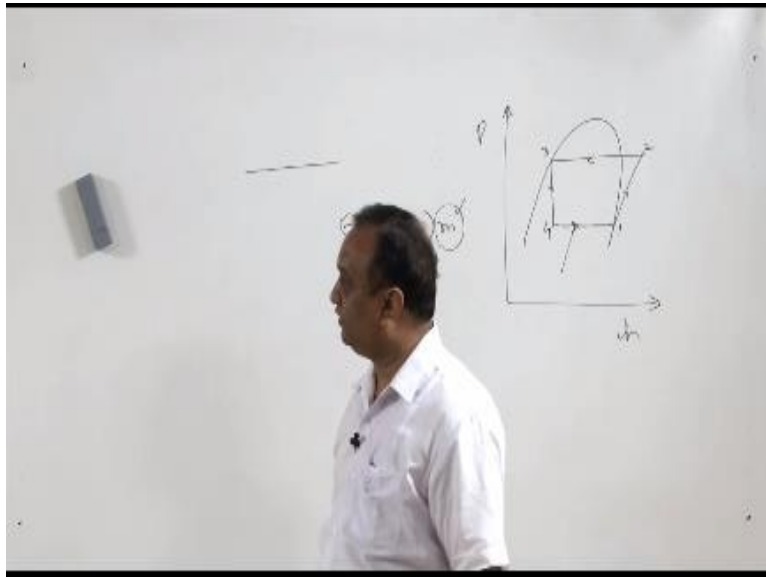
VRF Applications

- VRF systems can be used in various applications viz.
- Offices
- Schools & Colleges
- Hospitals
- Homes
- Multiple-tenant residential buildings
- Retail stores
- Restaurants and hotels
- Data center

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So instead of controlling air flow in the system refrigerant flow assist in the in the system is controlled.

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Instead of suppose in a cycle as you know the $p-h$ diagram so the heat taken away by the refrigerant depends upon $h_1 - h_4 \times$ mass flow rate but if I vary this mass flow rate as per the load on the coil I shall not have to make any other arrangement so this type of arrangement where mass flow rate is varied according to the load on the coil is known as variable refrigerant flow system so it has many applications offices school college hospital home retail store multi-tenant residential building restaurants hotels data center now invariable refrigerant flow system scroll compressors are used.

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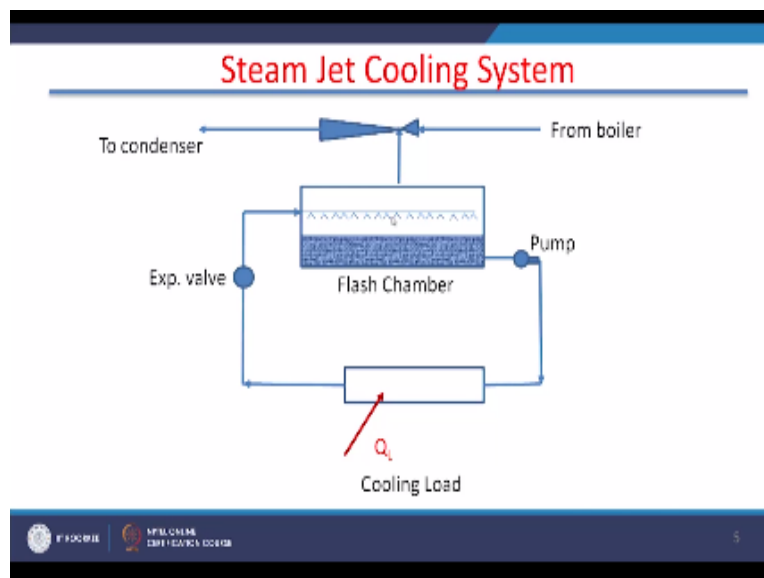
Scroll compressors are but nothing but they are spirals there is one is pattern and in the scroll system there is compressing the reason in the scroll right and one spiral evolves not rotate revolves around another spiral so when they revolves around another spiral a the refrigerant cone refrigerant entering from this side from the evaporator it get compressed and it emerges here for at higher pressure so this compressor is used for VRF system now in this compressor if I change the frequency of this revolution of one is six fix as per a suppose black one is fixed spiral and this is the spiral which does the revolution around the fixed spell so if I control the frequency of this moving spiral.

I can control the mass flow rate also so this is this type of technology is known as inverter technology where with the help of frequency of moving spiral the refrigerant flow is controlled now another the type of technology in this VRF system is the digital scroll type of technology where because it has certain height also this spiral has certain depth also and that is and they are engaged with each other to a certain depth one is fixed another if I change this over lapping okay if I change the distance between these two is perils when one is peril is fixed inside the another is parallel if I teach the suppose this is fixed which panel this is moving it is better like this so if i

change the over lapping of these two spirals that can also be controlled for that can also be used for controlling the mass flow rate.

Through the system so nowadays VRF technology this is the latest technologies it is emerging fast and at the part load off I mean up to ten percent part load I mean that is very high ten percent of the part load it gives high efficiency is maintained so if in those applications like hotels where I mean we do not know the load in the system this type of technology is very helpful.

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There is another type of cooling system which is totally environmentally safe that is Steve jet cooling system in the steam jet cooling system water is used as a refrigerant and chilled water is circulated in the evaporator now the water cooling is done in a flash chamber and in flash chamber the Whopper water is evaporated in order to evaporate water vacuum has to be created inside a flash chamber and for creating vacuum inside the flash chamber a steam ejector is used so from a boiler steam is supplied to the steam ejector inside the ejector there is an ozone which imparts very high velocity to this steam.

And this very high velocity of a steam creates low pressure just in the vicinity of the neck of the nozzle and this neck of the nozzle is connected to the Flash chamber so low pressure very low pressure is created inside the Flash chamber and the water is evaporated for the evaporation of water heat is taken from the pool of water present inside the flash chamber and that causes cooling of water inside the water present inside the flag shimmer this water is circulated in the evaporator coils with the help of a pump and cooling water after taking heat inside a an evaporator it is expanded in the expansion wall and it is sent back to the Flex chamber now there are several advantages of this system first of all it is flexible in operation it has no moving part.

And it is vibrations free it can be easily installed also outdoors weight of the system per ton of refrigeration capacity is less system is reliable and maintenance cost is less and this system has does not have any leakage health hazard which may happen in the case of other refrigerants so this is a special type of system which is absolutely environment safe but the only issue with the system is it cannot be used for the temperature where the temperature requirement is less than 0°C so this is all for today and in the next lecture we will start with the human physiology you.

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