Chemical Process Utilities
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Module No # 09
Lecture No # 45

Types and Components of the Cooling Tower

Welcome to the next lecture of cooling tower now previously we had discussed about the various design parameters pertaining to the cooling tower. Now in this particular chapter we are going to discuss that different type of cooling tower where is component associated with the cooling tower. Now before we will go into the discussion of this particular type of cooling tower let us have a brief outlook of what we discussed in the previous lecture.

In previous lecture we discussed various concepts of hear transfer in cooling tower pertaining to the cooling tower, elements of the cooling tower we had a discussion in which the different type of lower air flow etc., Then different type of heat transfer aspect in cooling tower was discussed like mode of heat transfer. We discussed about the couple of aspects about the heat transfer theory that is overall heat transfer coefficient and Merkel's heat transfer theory.

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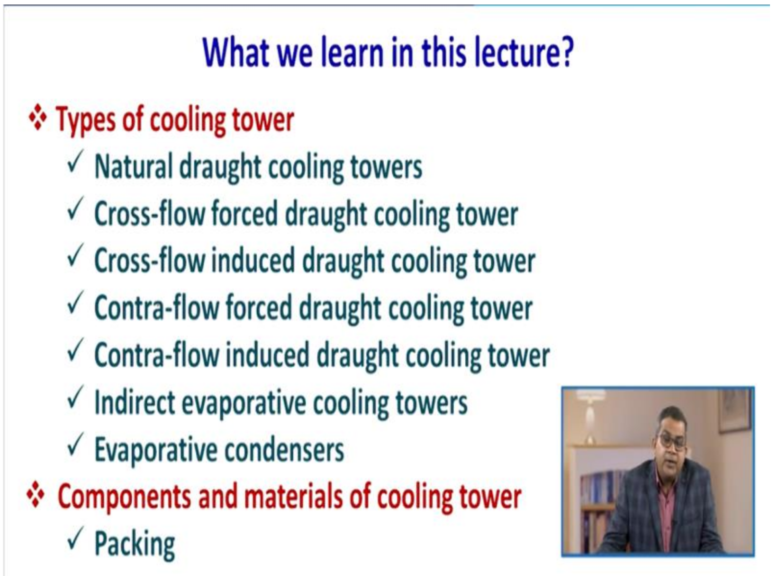

Now since we discussed about the important, we discussed about the various theoretical aspects of cooling tower. Now time has come that we need to discuss the different types of cooling tower. Now there are various types of cooling tower natural draught cooling tower, cross-flow force draught cooling tower. Then cross-flow induced draught cooling tower then contra-flow forced draught cooling tower.

Then contra-flow induced draught cooling tower then indirect evaporative cooling tower then evaporative condensers. Then we will discuss about the various components and materials for cooling towers this including the packing.

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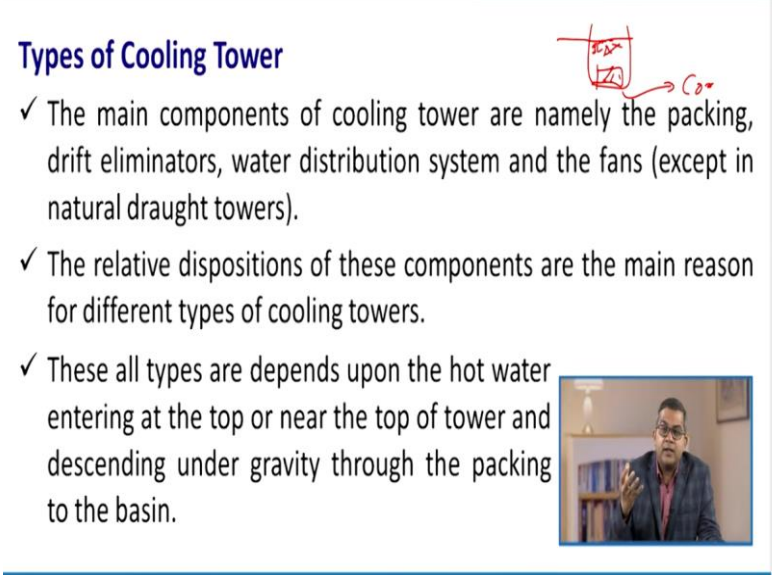

Now let us start discussion with the different type of cooling tower the main component of cooling tower they are mainly packing drift eliminators water distribution system and the fans except in the natural draught towers where we do not have these fans. The relative depositions of these components are the main reason of the different type of cooling towers. Not these all types are depended on the hot water entering at the top or near to the top of the tower and descending into the gravity through the packing to the basin.

Now if you recall the figure here, we are having this water supply line and here we are having the packing and this is the cold-water basin. So, this depends that you are circulating the heat hot water and then how it is descending through the packing and as collected at the bottom.

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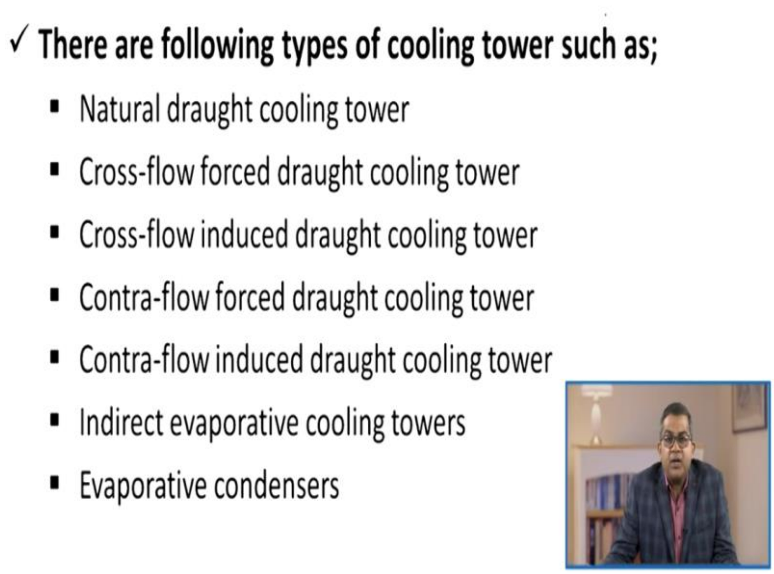

Now as I discussed that there are different type of cooling towers like natural draught cooling tower cross-flow forced draught cooling tower, cross-flow induced draught cooling tower, contra-flow forced draught cooling tower, contra-flow induced draught cooling tower, indirect evaporative cooling tower and evaporative condensers.

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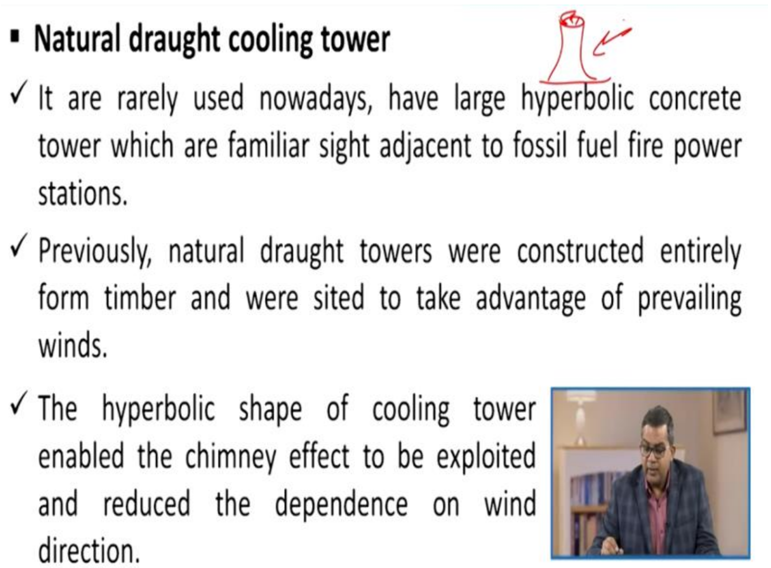

Let us talk about the natural draught cooling tower now they are rarely used now a day. Because you need to look into the various aspects; including environmental and energy issues. Now they have large hyperbolic concrete tower which are familiar site adjustment to the fossil fuel fire plants. So, if you go across through the railway line another thing you see that there are so many cooling towers or so many structures near the power generation plant where you may have this type of structure.

Now this previously natural draught towers they were constructed entirely from timber and was cited to take advantage of prevailing winds the hyperbolic shape of cooling tower enabled the chimney effect to be exploited and reduce the dependence on wind direction. So, this resolves the problem that why they are having.

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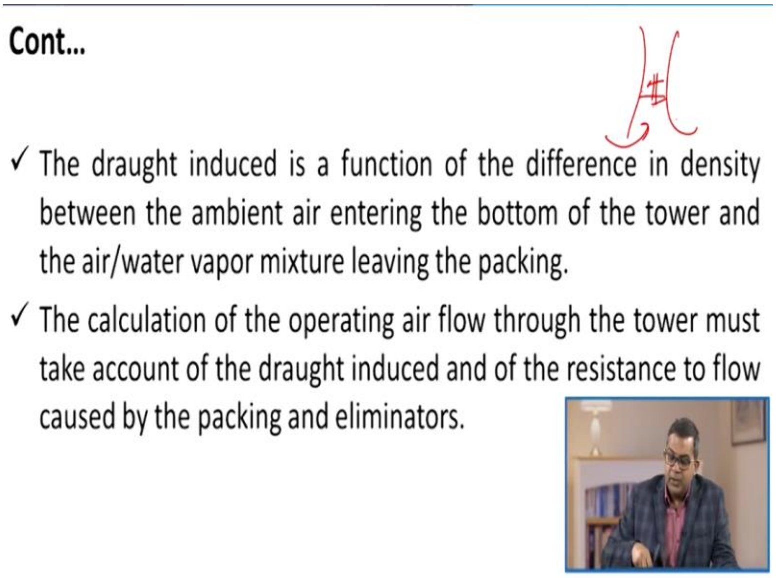

So special type of structure the drought induced is a function of the difference in the density between the ambient air entering to the bottom of the tower. And the air water vapor mixture leaving packing the calculation of operating air flow through the tower this must take account of the drought induced. And the resistance of flow caused by the packing and elimination because there may be a certain packing.

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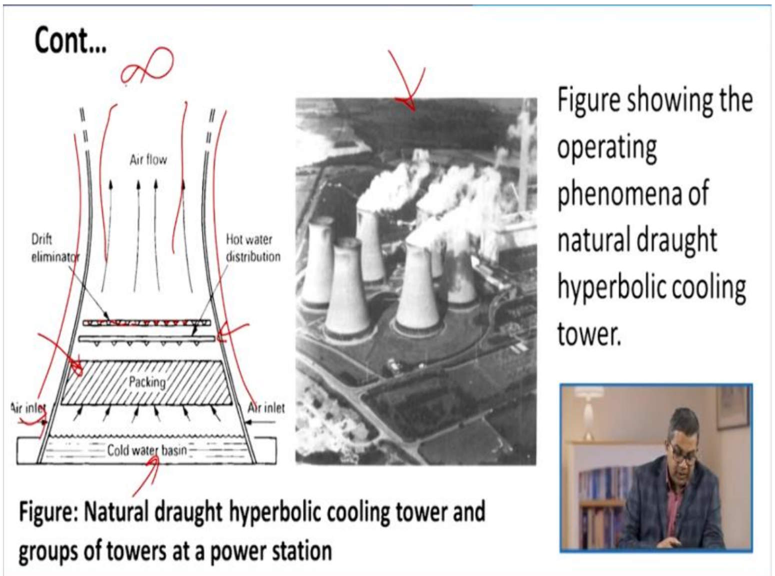

So, they offer the resistance towards the flow now here you see that this is the basic anatomy of the natural draft hyperbolic cooling tower. Here we were disc we are talking about this hyperbolic structure now here you see that this is packing. And we are having the air inlet and this is the cold-water basin and this is the air flow and this you see that this is the air drift eliminator.

And you see find that these are the hot water distribution now this is the actual figure and it's a very common figure. If you pass through nearby this any power generation plant steam operated power generation plant this shows the operating phenomena of natural draught hyperbolic cooling tower. Here you will see that there is no fan etc. So that is why this name implies the natural trot hyperbolic cooling tower.

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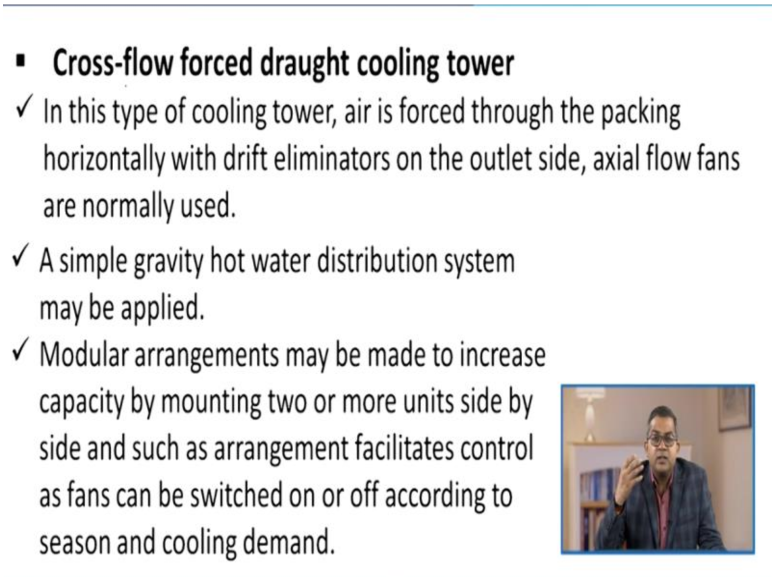

Now let us talk about the cross flow forced drought cooling tower now in this type of cooling tower air is forced through the packing horizontally with drift eliminators on the outlet side and axial flow fans. They are normally used now a simple gravity hot water distribution system may be applied to this particular approach the modular arrangement maybe to increase the capacity by mounting 2 or more units side by side.

And such a arrangement facilitates the control as a fan can be switched on or off according to the season and cooling demand.

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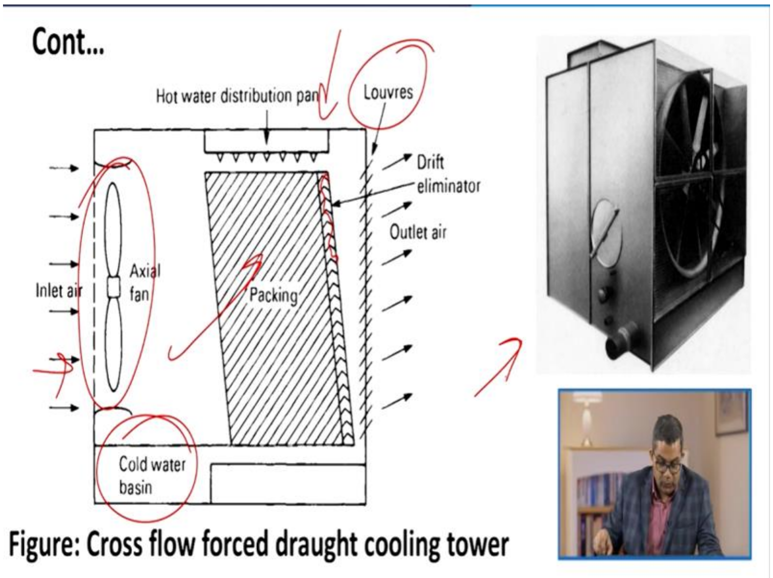

Now here you see the basic anatomy of this cross-flow force dot the things are same the basic phenomena is same here. You are having one axial fan with an inlet fan and this is the packing and you are having this hot water distribution pan and supported by these Louvers and these are the drift eliminators apart from this as usual. We are having the cold-water basin now this is the actual figure of this cross-flow force dark cooling tower.

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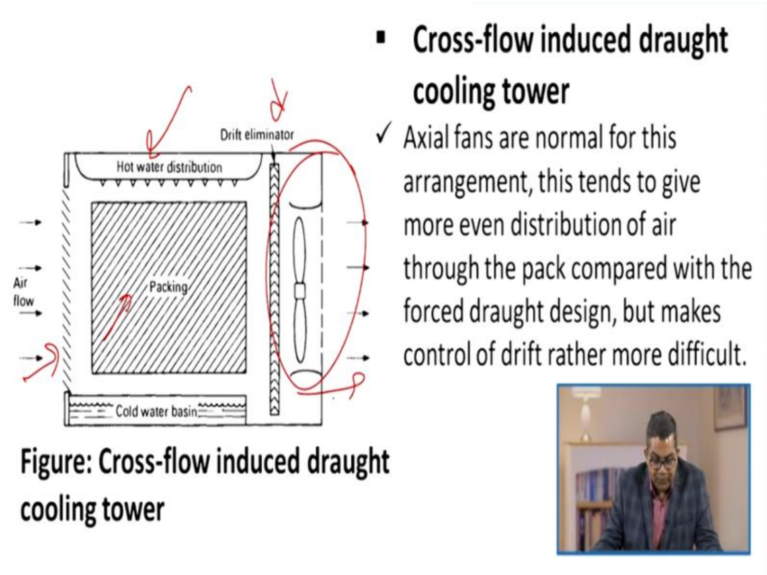

Now let us talk about the cross flow induced drought cooling tower now here the axial fan is normal for this arrangement and this tends to give more even distribution of air through the pack compared with the force dot design. But makes the control of drift; rather more difficult now here you see that this is the air flow. And this is the packing and as usual we are having the hot water distribution with the drift eliminator.

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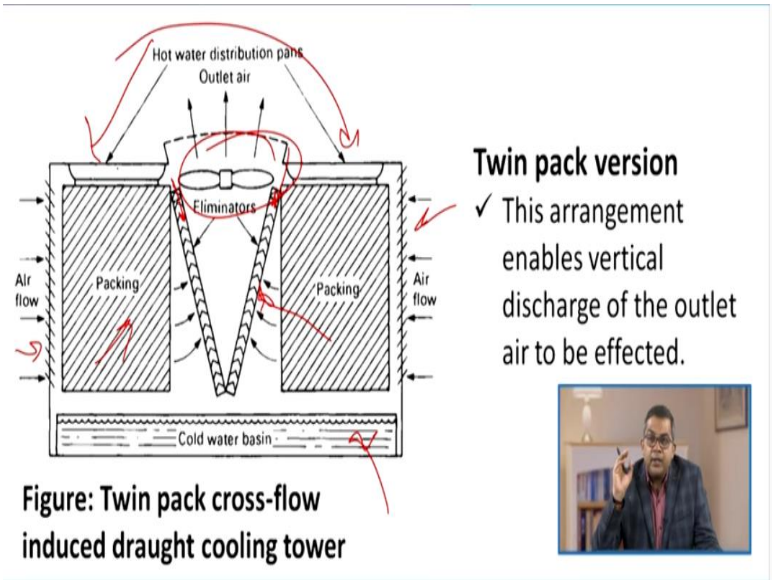

Now here this is the axial fan at the end of this airflow (refer time: 08:36) now apart from this we are having the twin pack version that is a twin pack cross flow induced dot cooling tower. Now here you see that this is the special design here you are having the air and this is the eliminator all these packings are supported by these eliminators. And you are having this axial fan over here.

As usual we are having the cross water this cold-water basin and hot water distribution network is attach over here. Now this arrangement enables vertical discharge of the outlet and this is to be effective.

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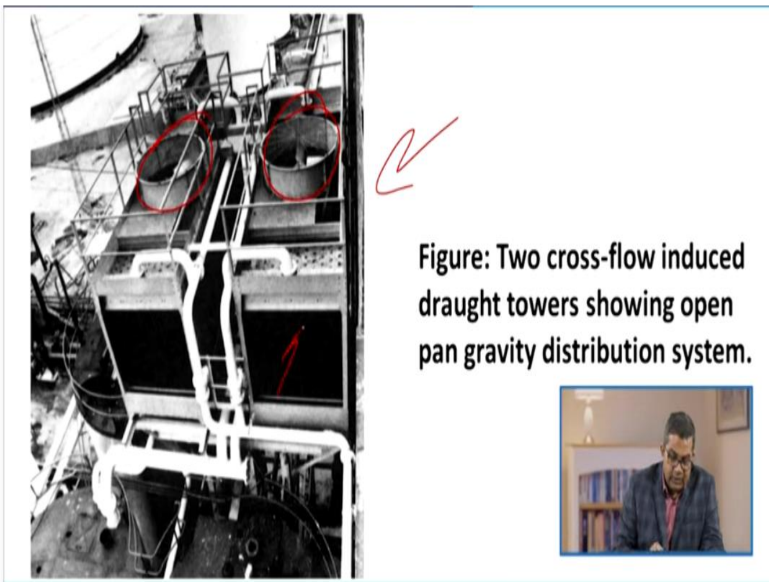

Now here you see that this particular photograph that 2 cross flow induced drop tower showing upon the pan gravity distribution system. So here you see that and these are the packings.

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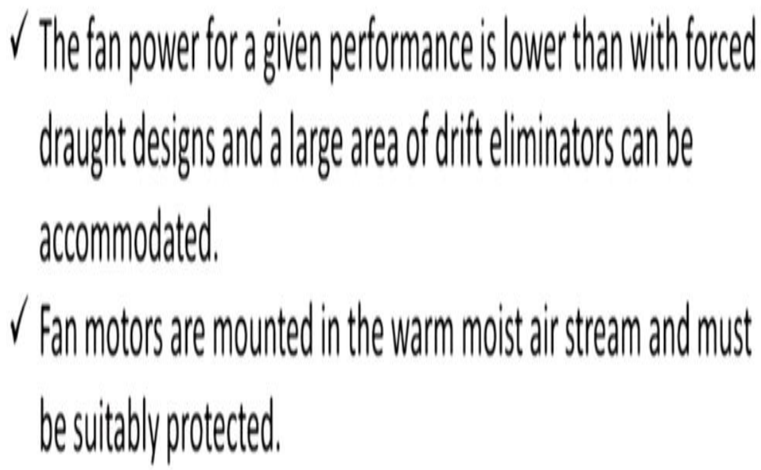

Now that the fan power for a given performance is lower than with the forced draught design and a large area of drift elimination this can be accommodated. Now the fan motors usually here you see these are the fan motors. The fan motors are mounted in the warm moist air stream and must be suitably protected.

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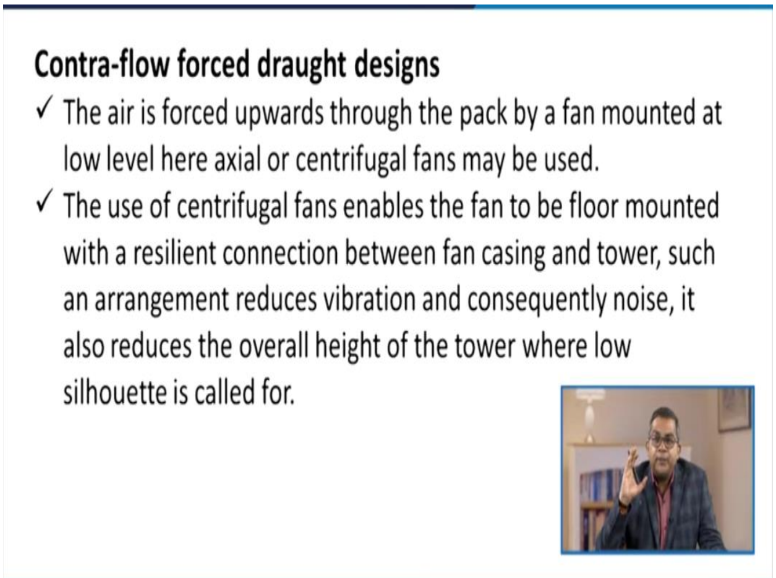

Now let us talk about the contra forced draught design the air is forced upward through the pack by a fan mounted at low level here axial or centrifugal fans sometimes centrifugal fans may also be used. Now the use of centrifugal fans enables the fan to be floor mounted with a resilient connection between a fan casing and tower. Such an arrangement reduces the vibration because see when all these axial fans are operated at a very high speed.

There may a chance of creating excessive vibration now this particular type of arrangement reduces the vibration and consequently noise. It also reduces the overall height of the tower where (()) (11:03) is called for. Now with the either fan type recirculation may be avoided where necessary by a canopy or directional Louvers to concentrate the leaving air stream and increase its velocity.

The modular design with multiple fans sometime may be used with fan switch in or out as the requirement as per the load as per the requirement.

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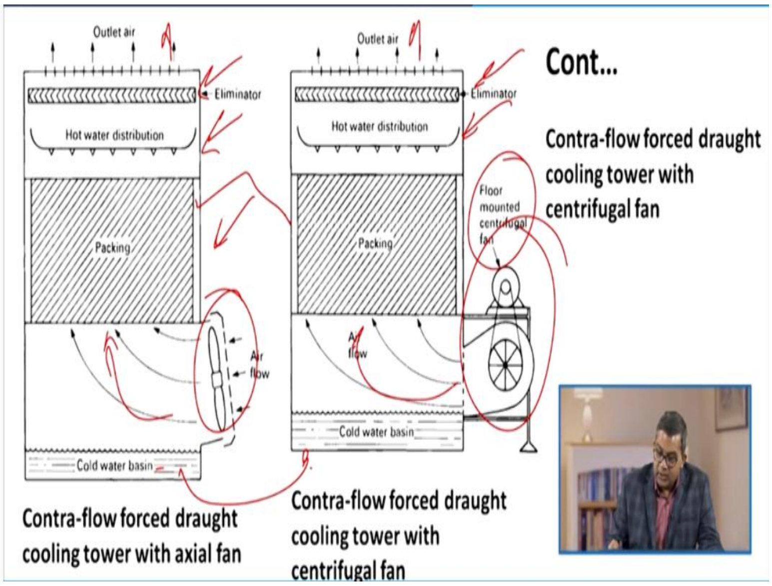

Now you see that this contra flow force start cooling tower with axial fan. Now here you see the contra force draught cooling tower with centrifugal. Now the rest of the things are common like you are having the eliminator in the both configuration hot water distribution outlet airport packing. So cold water basin etc., but if you see the direction of the flow here and this is the floor mounted centrifugal this with the centrifugal fan.

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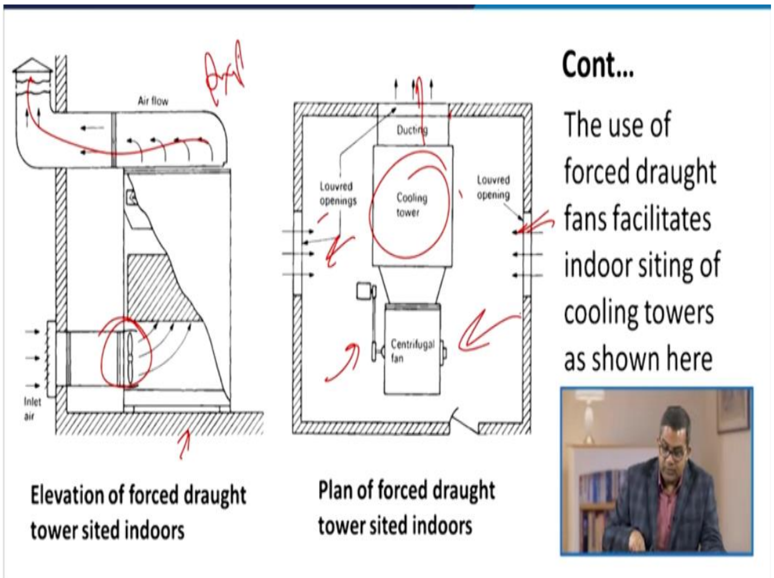

Now the use of a forced draught fan facilitates the indoor sitting of cooling tower. Now here we are showing this that elevation of forced draught tower sighted in door like here you see and this is the air flow inlet. Now here this is the plan of forced draught tower within the indoors now you can see this the Louvers opening cooling tower this is the Louvers opening ducting and this centrifugal pump.

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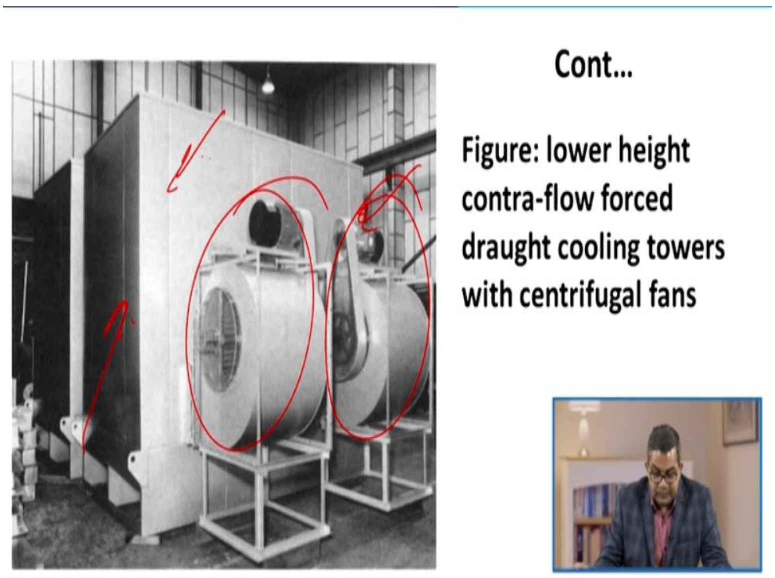

So, both the axial one and this is the centrifugal one now this is the axial figure where the lower height contra force draught cooling towers with the centrifugal fans. Now here you see these are the centrifugal fans and this is the packing or casing what of these cooling towers.

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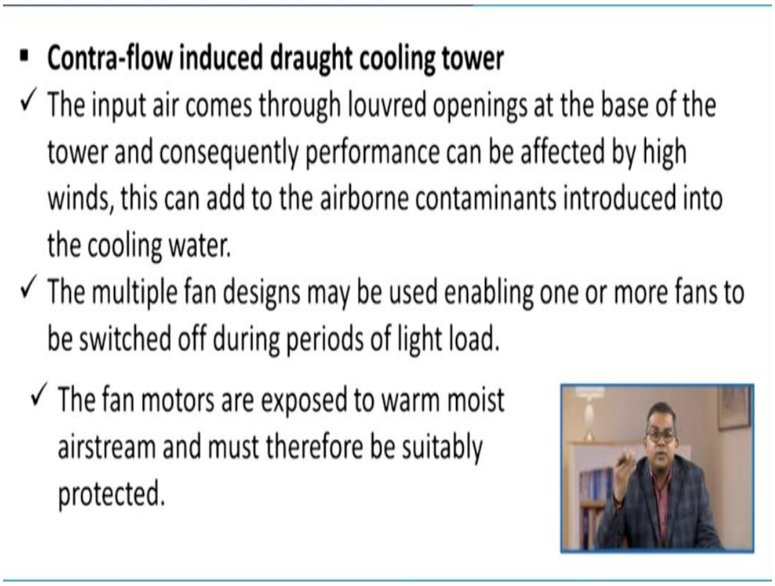

Now let us talk about the contra flow induced draught cooling tower the input air usually comes through Louvered openings at the base of the tower and consequently the performance can be affected by high winds. Now this can add to the airborne contaminations or contaminant's introduction of contaminants into the cooling water. And that sometimes is highly undesirable.

The multiple fan designs maybe used to enable one or more fans to be switched off during the period of light load. So, by this way you can enhance the energy efficiency usually the fan motors they are exposed to warm moist airstream and must therefore be suitably protected and that is one of the important factors. Otherwise, the moist airstream can attract some of the debris or dust and dirt's etc., and that may create a problem pertaining to the higher energy consumption sometimes wear and tear etc.

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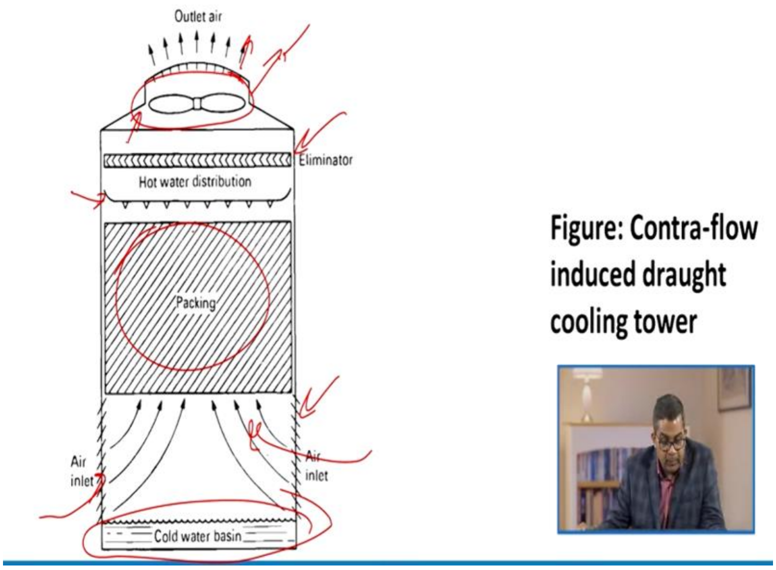

Now this is here you see that this is the contra flow induced draught cooling tower. Now the arrangement is just like that here you are having the fan with the outlet here. So here air inlet supported by Louvers and the packing as supported and here you see that this is the hot water distribution line and dually supported by eliminator and as usually our cold basin. So here you see the contra flow induced draught cooling tower here all this air sucked through this way by giving the fluid in question.

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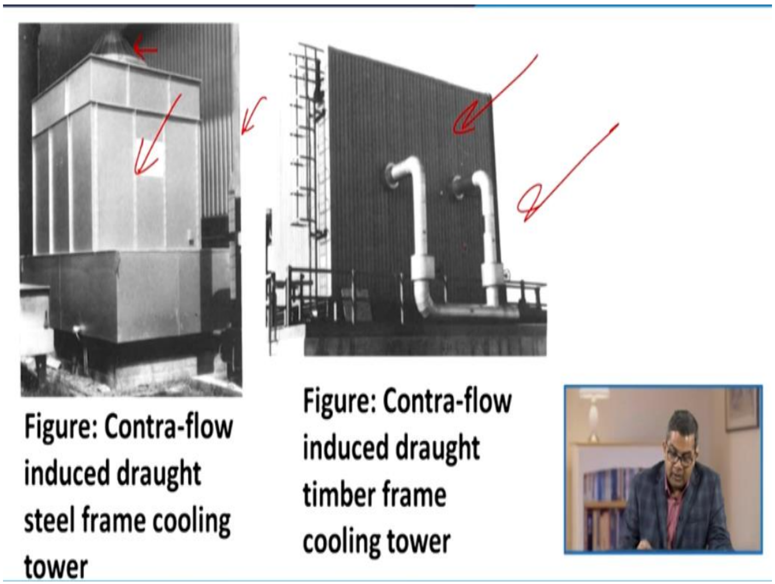

Now here you see that this is the actual figure of contra flow induced dot steel frame cooling tower all these things are in housed or cased in this particular housing. Here you see there are small observations about the fan now here this is the contra flow induced dot timber frame cooling tower previously it was used and these are the supply lines.

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- Advantages and disadvantages of the cooling towers
  - ✓ There are following advantages and disadvantages of different types of cooling towers used such as; counterflow and crossflow cooling tower.
  - ✓ The advantages and disadvantages are based on the kinds of flow in the water cooling towers such as waterside and airside flow.

Now there are various advantages and these advantages associated with such of the cooling tower like they are having a counter flow and cross flow cooling tower. The advantage and disadvantages are based on the kind of flow of water-cooling tower such as water side or air side flow.

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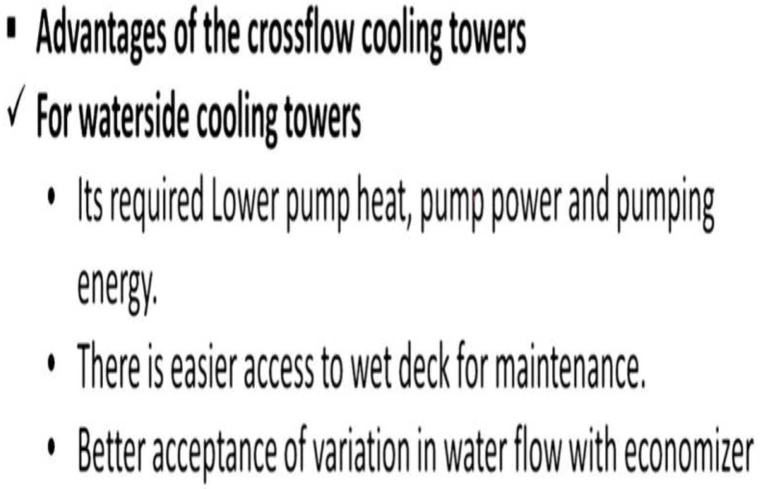

Now if we take the advantages of cross flow cooling towers especially for water side cooling tower. Now it requires a lower pump power and pumping energy now it is easier or there is an easy access to wet duct for maintenance because it is quite essential that the wet duct must be approachable because of the maintenance and other aspects. And sometimes wear and tear may take place so you need replace certain packing another thing.

So, it provides an ease on that particular aspect now better acceptance for variation in water flow for economizer. Now economizer is used for the better energy efficiency so this time in another, words you can say these cooling towers are better energy efficient.

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- **Advantages of the crossflow cooling towers**
  - **For airside cooling towers**
    - Here is lower static pressure loss with lower fan power requirement and energy consumption.
    - Reduce drift
    - Reduce recirculation
    - Required fewer cells for larger capacities

Now for if we talk about the air side cooling towers if we discuss about the advantages associated pertaining to the cross-flow cooling tower. Now here the main advantage is that the lower static pressure loss with lower fan power requirement and thereby the energy consumption is on the lower side. So, you may say that these are somehow they are energy efficient they also reduce the drift they also reduce chances of recirculation and they require fewer cell for larger capacity.

So that is why they offer some sort of economics pertaining to this side cooling tower. Now let us talk about the disadvantages of the cross-flow cooling tower now when we see the water side cooling tower. One disadvantage is that the potential orifice clogging and a poor water distribution over the fill. Now the fed basin may house the biological failing or sometimes invite the microorganism growth because it is the wet in nature.

They have the large tower foot print this is again one of the serious disadvantages. So, if you take the air side cooling towers then the large inlet lower surface area this makes icing and which is more difficult to control. Now if we talk about the advantage of the counter flow cooling towers.

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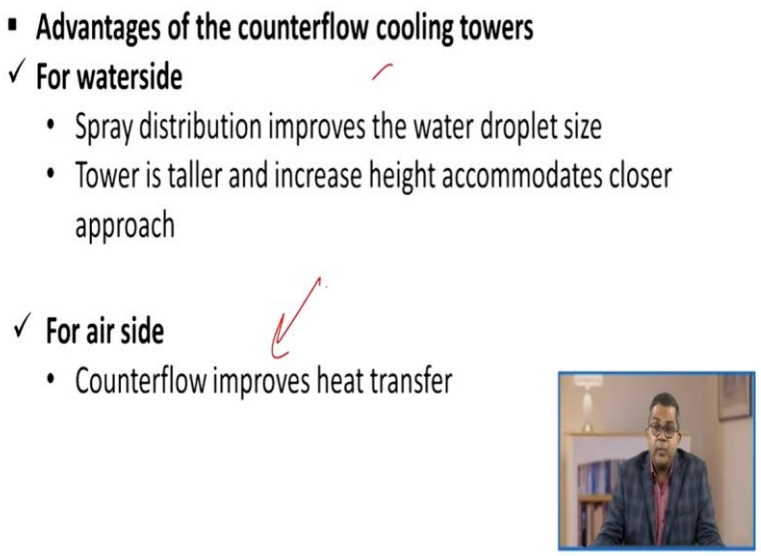

So, if we take the water side in question then the spray distribution this improves the water droplet size. So, if the water droplet size is at the optimum level so the energy efficiency maybe within the control. And the tower is taller and increase height accommodates closer approach now if we take the air side into account then this counter flow improves the heat transfer it is well known phenomena by this counter flow you can improvise the heat transfer.

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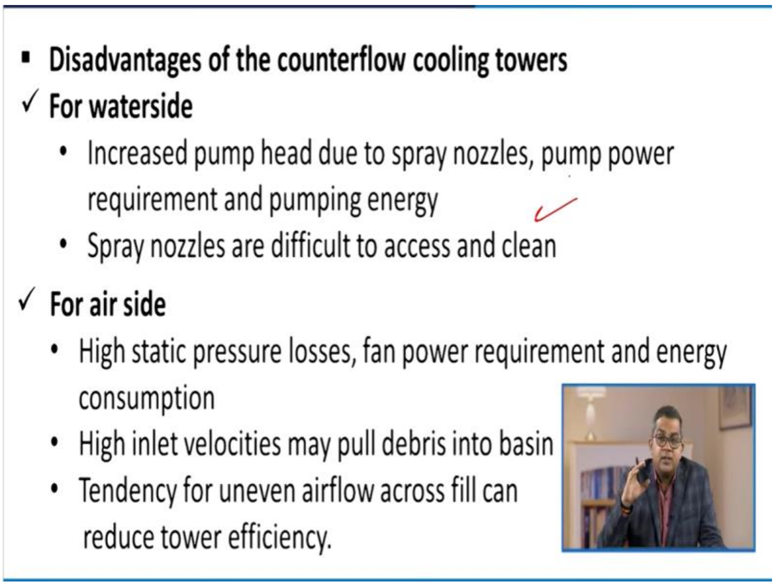

But simultaneously when we talk about the advantages there are so many disadvantages associated with the counter flow cooling tower. Now if take water side first, then increased pump head due to spray nozzle pump power requirement and pumping energy. Now this spray nozzles they are difficult access and clean and sometimes they may clog over the period of time and thereby the efficiency of the cooling tower maybe reduced.

Now if we take the air side then high static pressure losses fan power requirement and energy consumption. The high inlet velocity this may pull debris into the basin and thereby enhancing the microbial or biological activities. Then they may be having a tendency for uneven air flow across fill this can reduce the tower efficiency. Now let us talk about the indirect evaporative cooling tower now when applied to air conditioning system this design incorporates a serpentine coil in the tower instead of packing.

The hot water from the refrigeration plant cool condenser is circulated through coil and cooled in the tower by evaporating process. Although described as the closed-circuit system water is still being evaporated in the tower and cooling efficiency is lower than with the packed tower. A larger sometimes as larger tower is needed with the high capital and running cost.

Sometimes the contamination of the closed cooling water circuit is avoided but purging and the treatment of the tower water is still required. And is likely to be more critical full evaporation cooling can be achieved by interposing heat exchanger between the condenser cooling circuit and the tower with standard packing.

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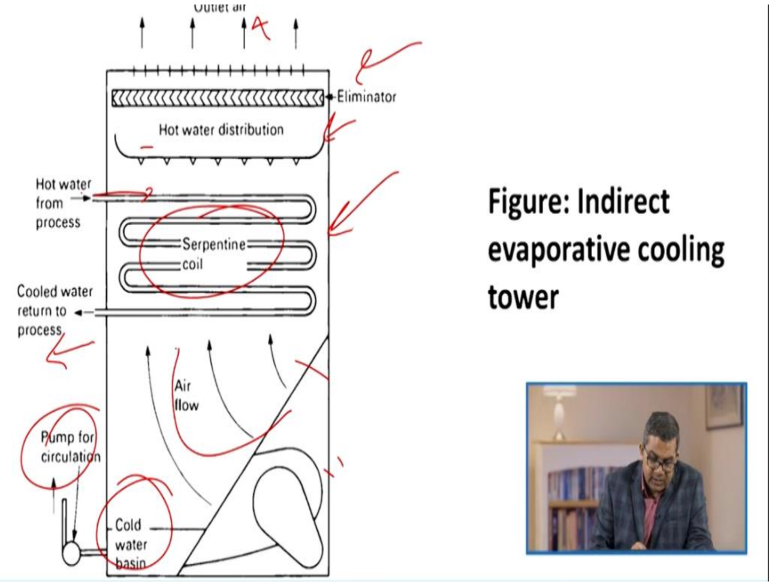

Now this is the basic anatomy of evaporating cooling tower here you see that all these things are as usual. Here you are circulating the hot water from the process and you are getting the cold water return to the process. And as we are discussing about the serpentine coil here these are the serpentine coil here you see that all these things like outlet air eliminators how water distribution all these things as per the basic theory. Now here you see that this is a cool water basin and pump for circulation and this is the air flow.

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- **Evaporative condensers**
  - ✓ The principle is similar to that of the indirect evaporative cooling towers, but in this case refrigerant is piped from the condenser to the cooling tower and cooled by the indirect evaporative method before return to the evaporator/compressor of the air conditioning system.

Now let us talk about the evaporative condensers the principle's similar to that of the indirect evaporative cooling towers. But in this case the refrigerant is piped from the condenser to the cooling tower and cooled by the indirect evaporative method before return to the evaporator compressor of the air conditioning system.

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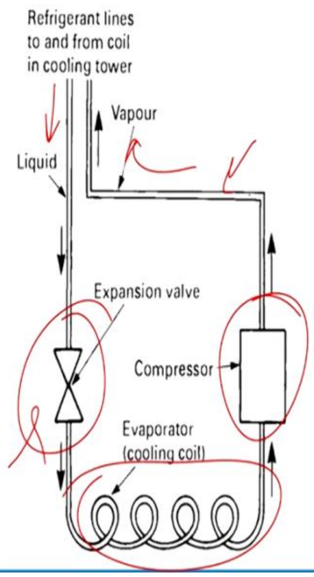

Figure: Use of cooling tower as evaporative condensers

Now here you see that we have represented this use of cooling tower as evaporative condenser. Now here usual your thermodynamic cycle prevails here we are having this compression unit and these are the evaporative cooling cycles with the expansion valve. So, this the refrigerant line and liquid is circulated through the expansion wall and then adiabatic process prevails and then we are having the evaporative coil and it goes to again to the system so these are the vapors.

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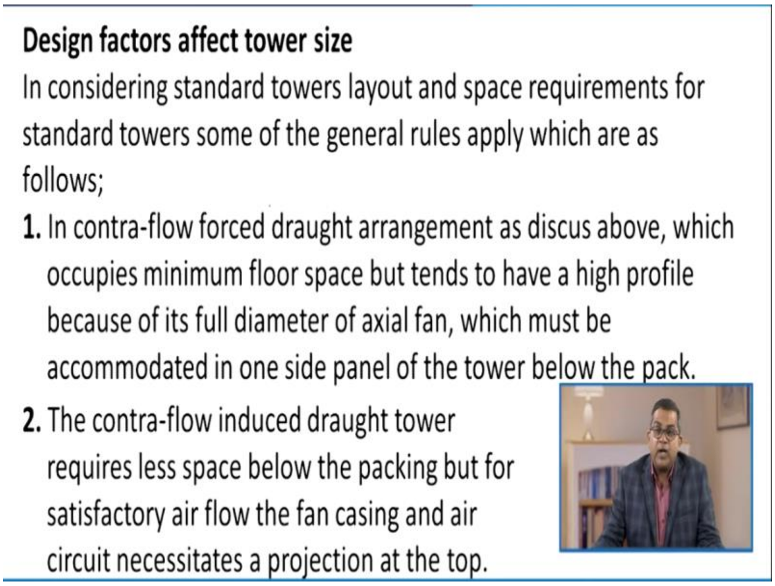

Now let us talk about the design factors or design factor affect the tower size. Now while considering the standard tower layout and space requirement for standard towers some of the general rules they do prevail for the designing of these cooling tower. One is the contra flow force draught arrangement which we have already discussed which occupies the minimum floor space but tends to have a high profile.

Because of its full diameter of axial fan which must be accommodated in one side panel of the tower below the pack if you recall the figure. The second is the contra flow induced tower this requires the less space below the packing but for satisfactory air flow the fan casing and air circuit necessitates a projection at the top. So, it has to be housed at the top of the cooling tower.

The minimum shell height is achieved by a forced draught floor mounted centrifugal fan. But this will increase the floor space requirement and a floor space can be reduced somewhat by encroaching on the area needed for the cold-water basin.

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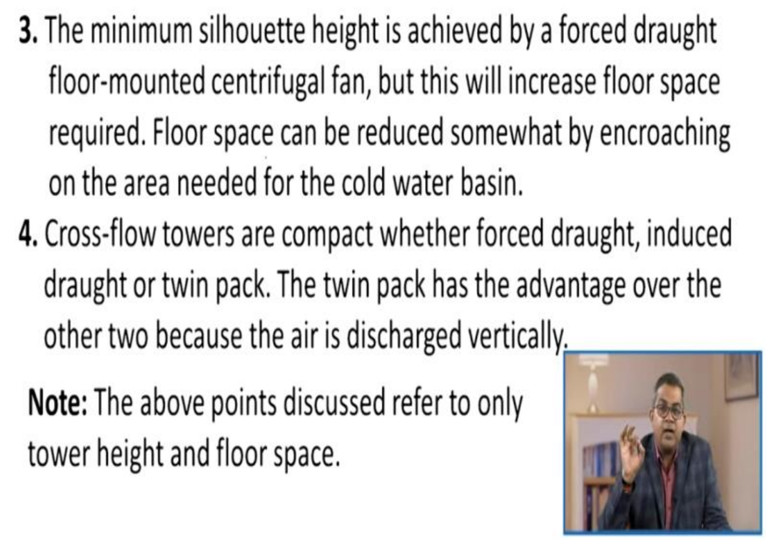

The cross-flow towers they are compact whether forced or induced or twin pack. The twin pack has the advantage over the other 2 because the air is discharged vertically now these point discussed they refer only to the tower height and the floor space.

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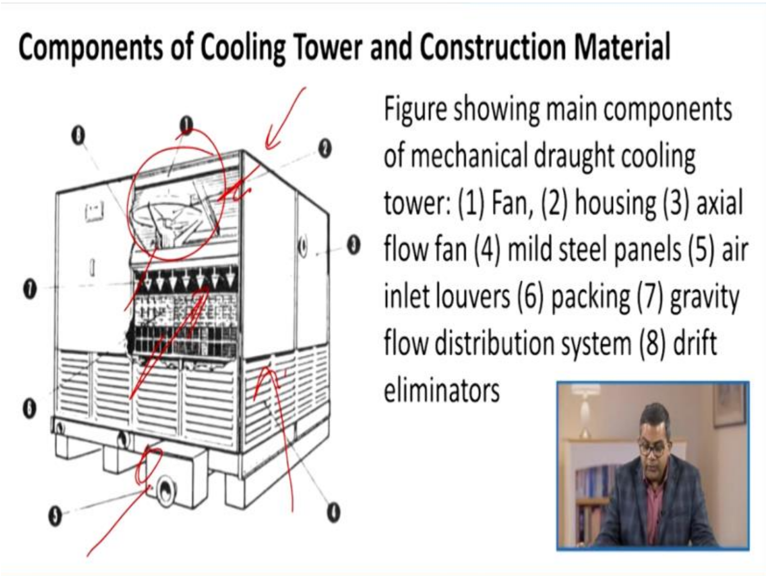

Now let us talk about the component of the cooling tower and the construction material because always like the people may ask that what are the construction material for the packing and other housing etc. Now this particular figure depicted the main components of mechanical draught cooling tower. Now here you see this is the fan and this is the housing and this axial flow fan and mild steel panels. Now here you see that air inlet Louvers packing and the gravity flow distribution system or drift eliminators.

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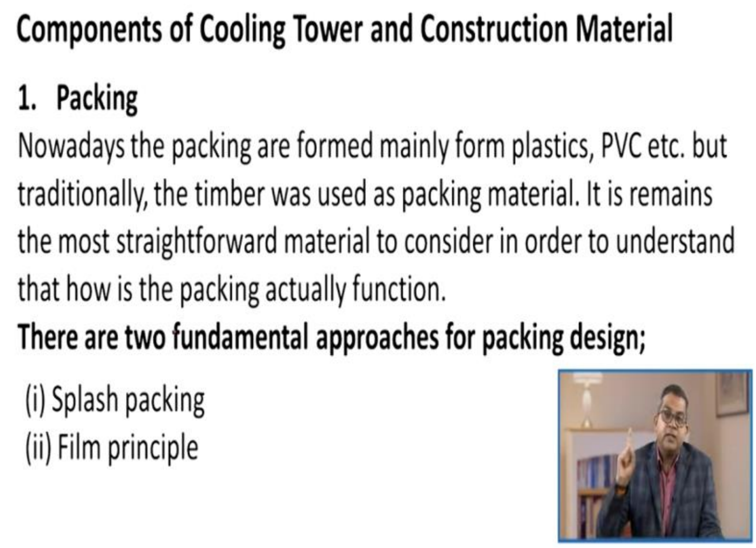

Now when we talk about the packing now a days the packing, they are formed mainly from various polymers polyvinyl chloride etc. But traditionally the timber was used as a packing material in the previous era. Now it remains the most straight forward material to consider in order understanding that how the packing actually functions. Now there are 2 fundamental approaches for packing design one is slash packing and second is the film principle.

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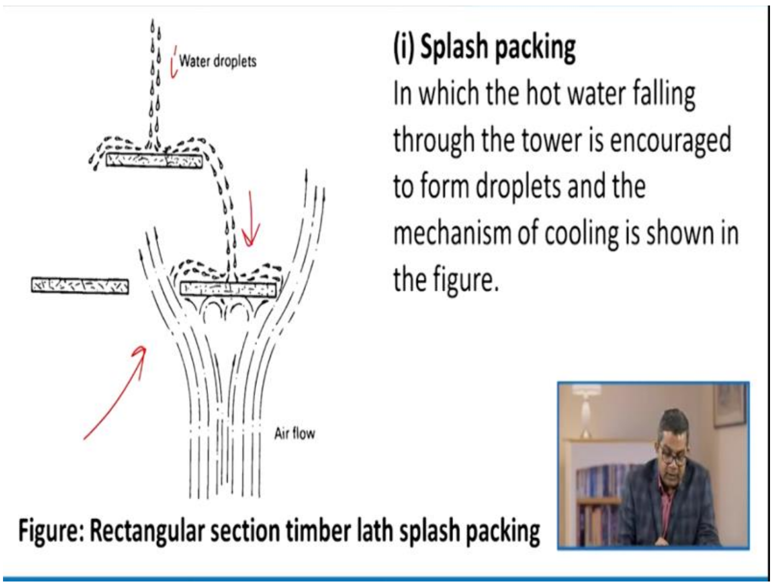

Now this is the splash packing in which the hot water falling through the tower encouraged to form a droplet and the mechanism of cooling is represented in this particular figure. So, these are the water droplet and once they are formed in those water droplets then obviously the surface area enhances and thereby this promotes the heat transfer.

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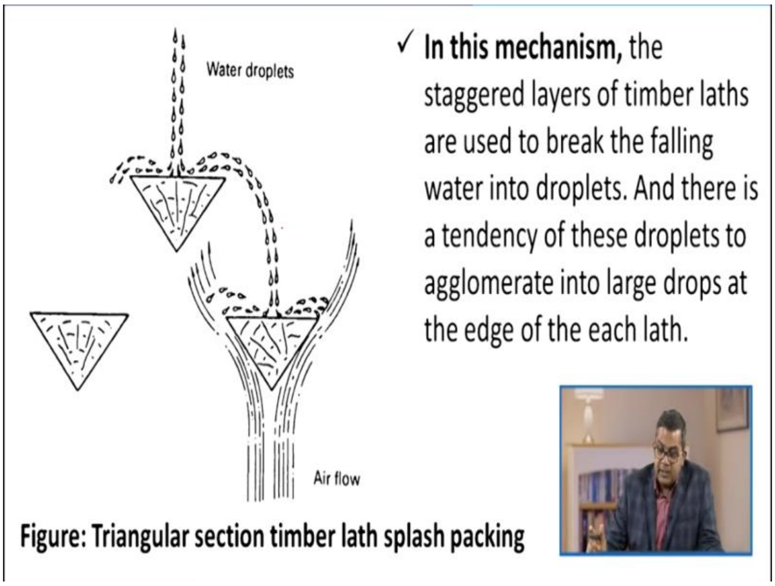

And then it goes to this channel and this is your air flow now in this particular mechanism the staggered layers of timber they are used the break the falling water into the droplets. And there is a tendency of these droplets to accumulate into the large drop at the edge of each let.

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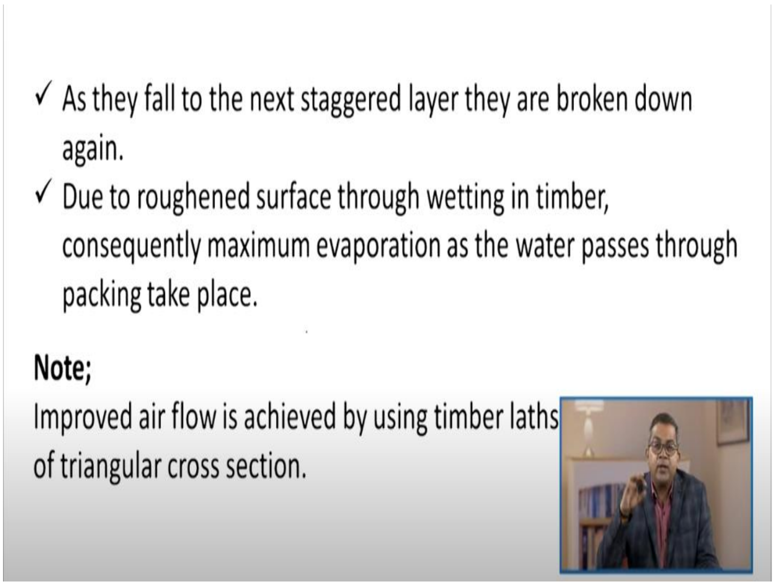

Now as they fall to the next staggered layer, they are broken down again. Now due to the rough end surface through the wetting in timber consequently the maximum evaporation as the water passes through the packing take place. Now improved air flow is achieved by using timber lathes of triangle cross section let us talk about the film principle. In this the hot water encouraged to spread out on the surface and form a thin film thus providing the maximum surface area for evaporation and allowing cooling to take place. Now in early design that timber grid they were used to maximize the film cooling effect.

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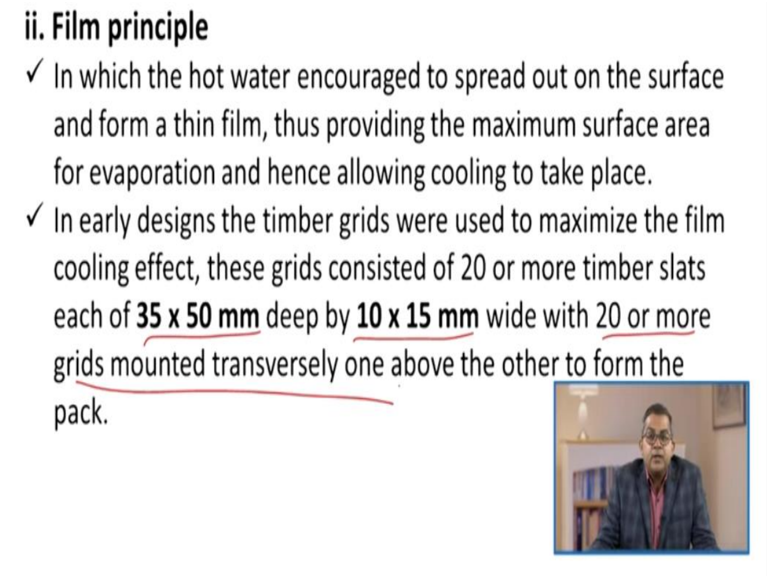

And these grids consist of 20 or more timber slits and each of 35 into 50 mm deep by 10 into 50 mm deep with 50 or more grids mounted transversely one above and other to form the pack.

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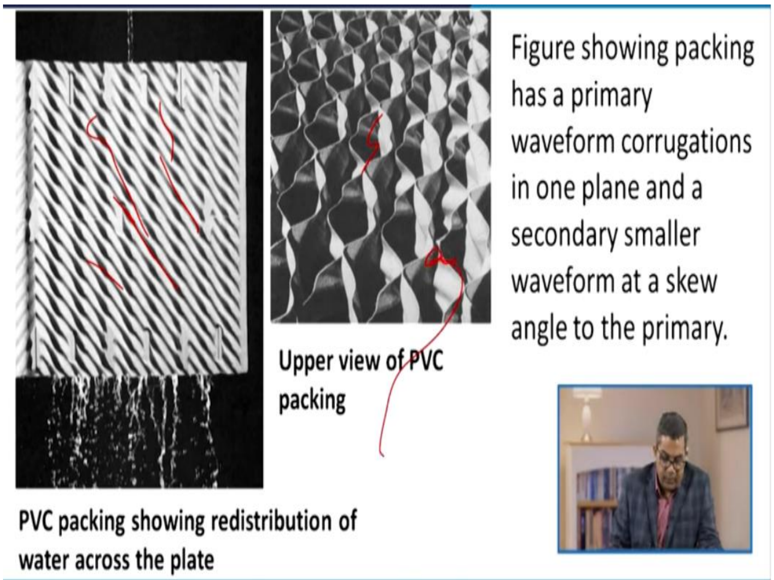

Now here you see that this PVC arrangements now this shows this particular figure shows the packing as a primary waveform. Now see this is the waveform or you see this corrugation in one place. And a secondary smaller wave front at the skew angle to the primary now this is the upper view of PVC and this is the side view of the packing.

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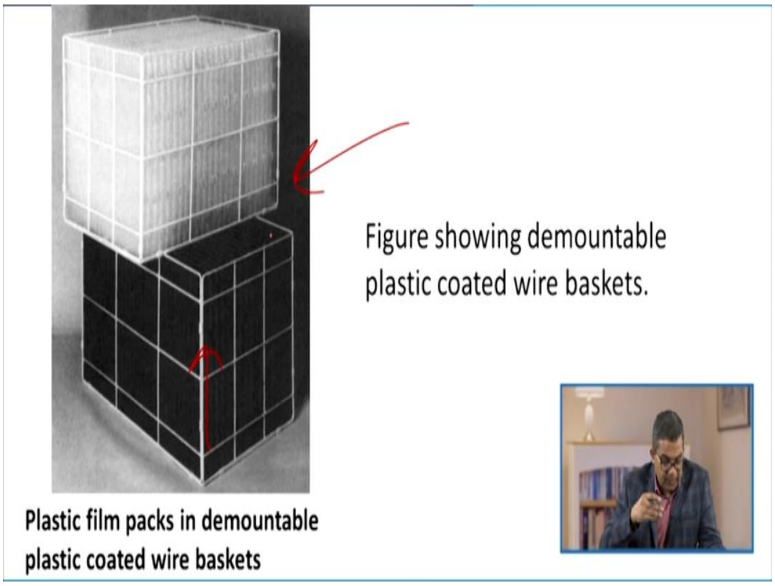

Now this particular photograph shows the demountable plastic coated with wire basket. Now these plastic film packs in demountable plastic coated via baskets.

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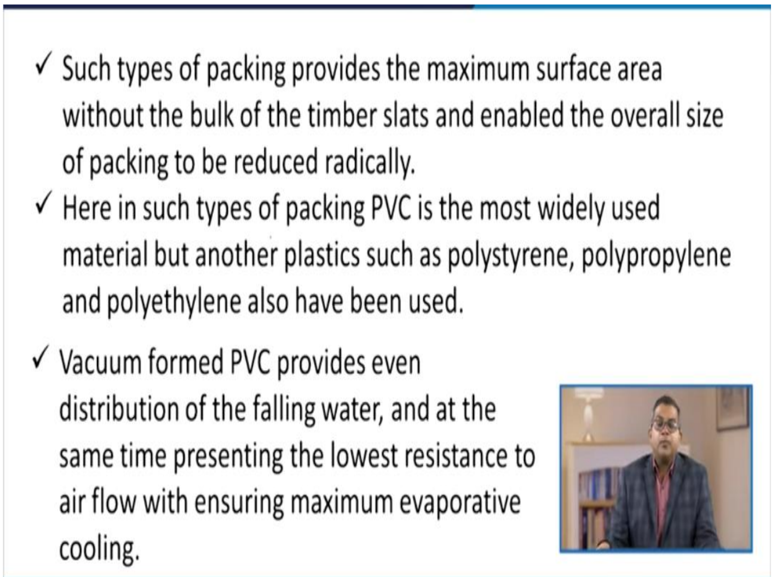

Now such type of packing is providing the maximum surface area without the bulk of that timber slates and enable the overall size ok packing to be reduced radically. Now in such type of packing PVC is the most widely used material but another plastic like polystyrene in polypropylene, polyethylene they have also been used. Now vacuum formed polyvinyl chloride this provides even distribution of the falling film.

And at; the same time the presenting the lowest resistance to airflow with ensuring maximum evaporating cooling. Now there are various advantages associated with the use of plastic packing.

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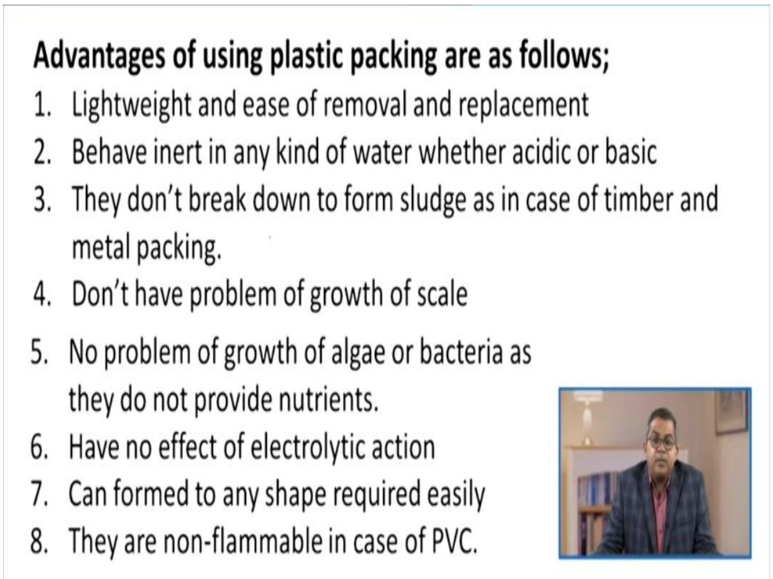

One is that they are light weight and ease of removal and replacement it is quite easy they behave invert in any kind of water whether acidic or basic they do not break down to form the sludge as in the case of timber and metal packing. They do not have a problem of growth of any kind of scales there is no chance or no problem of growth of algae or any kind of a microbial activity.

Because they do not provide any kind of nutrients, they have no effect of electrolytic action they can form to any shape required easily by just simply change the mold etc. They are non-flammable in case of PVC. So, at last this particular lecture we discussed about the different parts of cooling tower apart from this we discussed about the different type of cooling towers.

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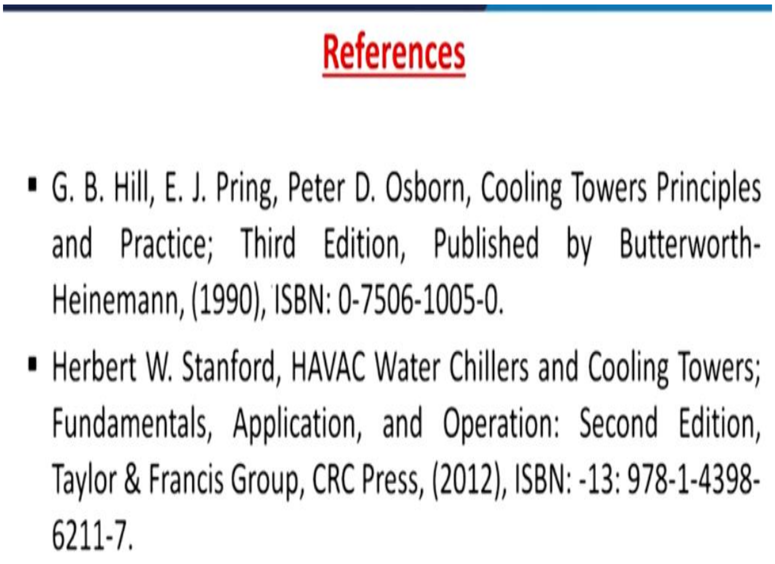

And for your convenience we have enlisted couple of references you can see them if you require any further assistance thank you very much.