Chemical Process Utilities
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Lecture – 46
Component and Material of Construction and Applications of Cooling Tower

Welcome to the next aspect of cooling tower. Here is the; we are going to discuss the various components of cooling tower. Apart from this we will discuss about the material of construction and various applications of cooling tower. Now, before we start let us have a look that what we discussed in the previous lecture

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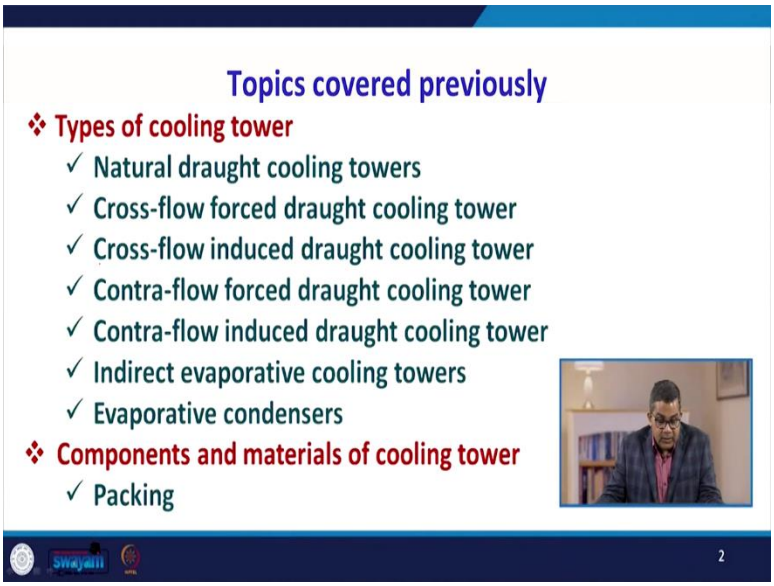

In the previous lecture, we discussed about the different type of cooling towers. For convenience I am again reading out all these towers like natural draught cooling towers, cross-flow forced draught cooling towers then we discussed about the cross-flow induced draught cooling towers, then contra-flow forced draught cooling towers, contra-flow induced draught cooling towers, indirect evaporative cooling towers, evaporative condensers.

Now, if you recall in the previous lecture we discussed about the various components. Because if you see, if you recall the figure of any cooling tower there are so many things in the cooling towers. So, and every component is having its own importance in the cooling tower so what are those components? We started the discussion discussing about this one then the materials different type

of materials of cooling tower. So, when we were started the discussion, we end up with the packing concept.

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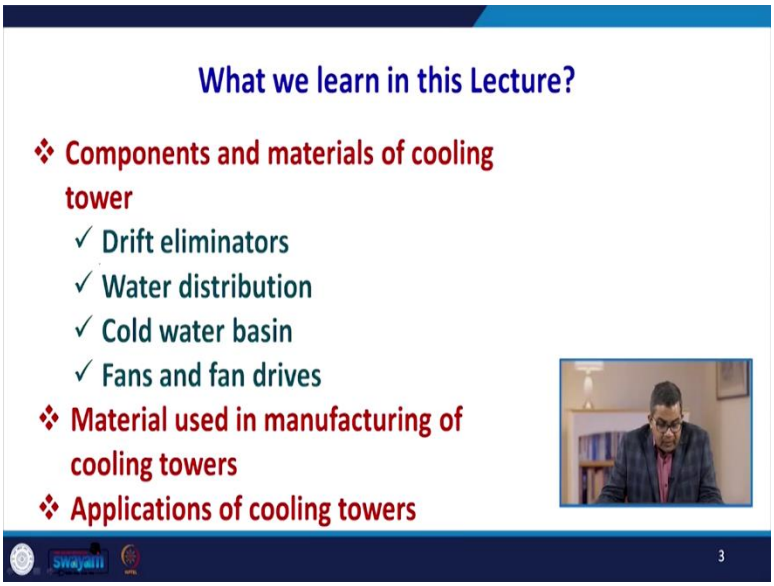

Now, on in this particular lecture we will have the remaining discussion related to the components and materials of cooling tower. We will discuss about the drift eliminators we will discuss about the water distribution system, then the cold-water basin and fan and fans types. If you recall that these are the integral part of cooling tower. Apart from this we will discuss about the material used in manufacturing of cooling tower and lastly, we will discuss about the various application of cooling tower.

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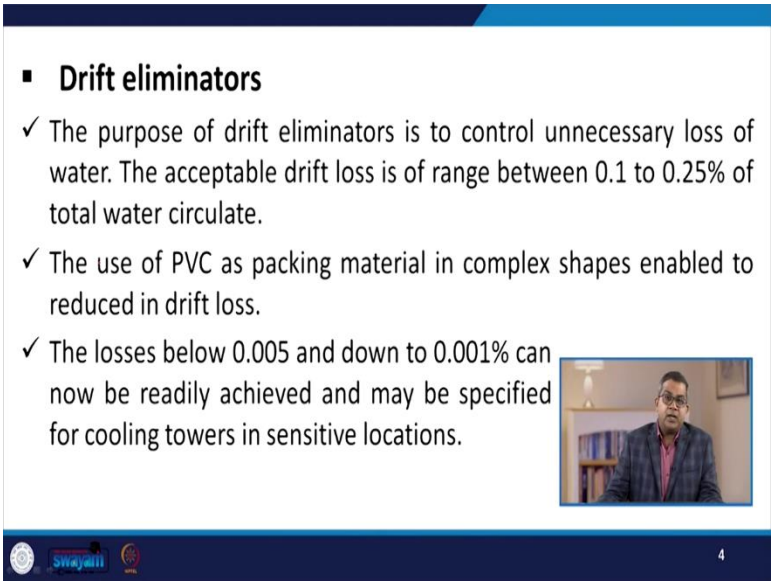

So, let us start with the drift eliminators the purpose of drift eliminator is to control unnecessary loss of water because water is the key component in the cooling tower. So, the role of this drift eliminator is to avoid such kind of loss may be attributed to that during the operation of the cooling tower. The acceptable drift loss is the ranges between 0.1 to 0.25% of the total water circulate.

The use of PVC as a packing material in complex shape enabled to reduce this kind of drift loss. The losses below 0.005 and down to 0.001% can now be readily or easily achieved and may be specified for the cooling tower in sensitive locations. Now the drift loss expressing in terms of percentage this may misleading as implies this loss in the milligram per meter cube rises in the proportion to the flow rate of water.

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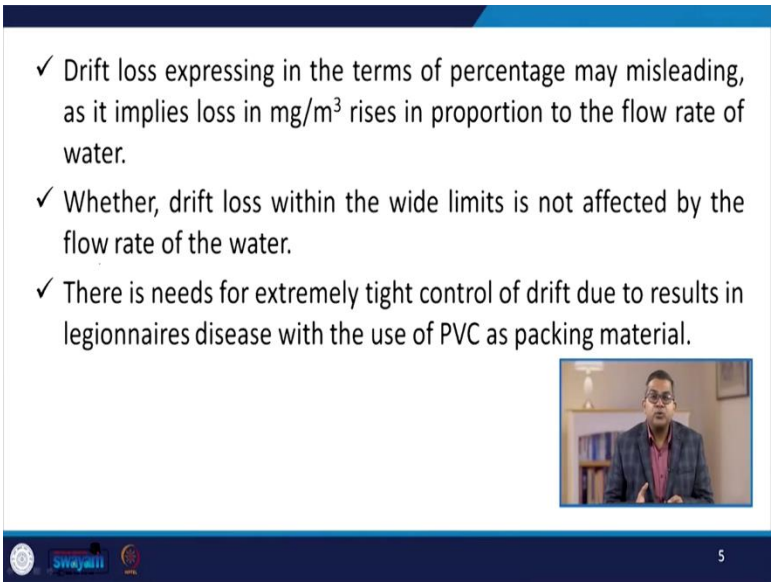

Now, whether the drift loss within the wide limit is not affected by the flow rate of the water. Now there is a need for extremely tight control of drift due to result in the legionnaire disease with the use of PVC as packing material.

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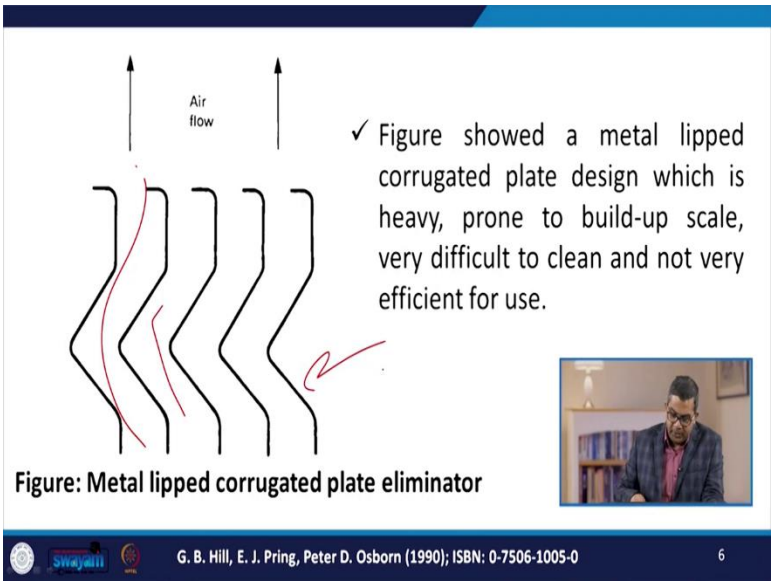

Now here this particular figure representing a metal lipped corrugated plate design which is heavy, prone to build-up scale and very difficult to clean and not very efficient for use now this is you see this is the metal lipped corrugated plate eliminator

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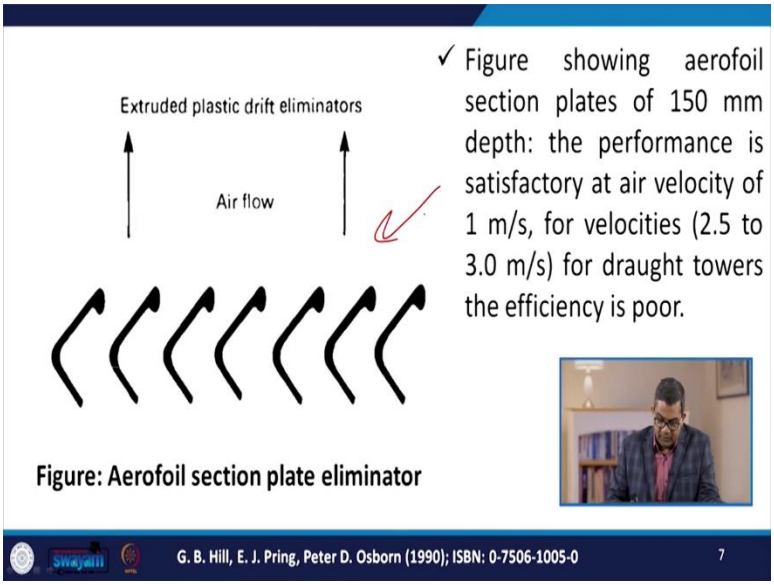

Now, this particular figure shows the aerofoil section plate eliminator. Now this aerofoil section plate of 150-millimeter depth. The performance is satisfactory at air velocity of 1 meter per second for velocities, ranging from 2.5 to 3 meter per second for draught tower. Now the efficiency is extremely poor in this particular type of air force section of eliminator.

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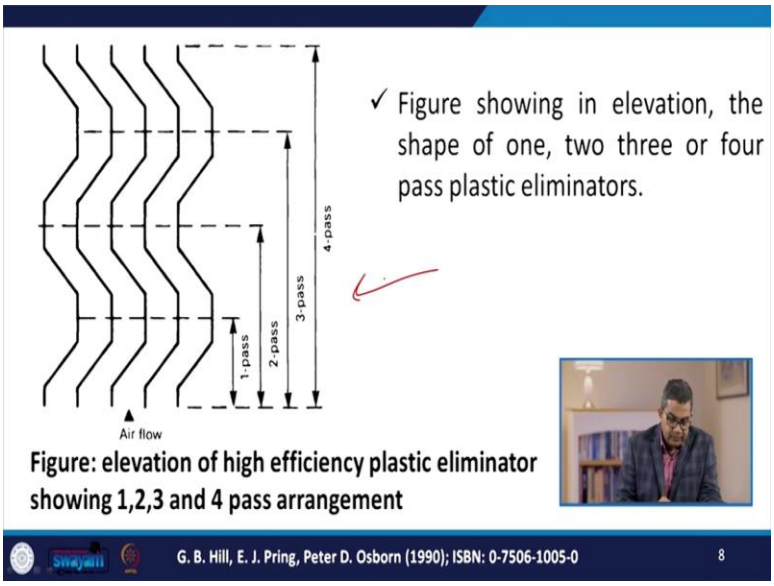

Now, this particular figure shows the in elevation, the shape of 1, 2, 3 or 4 pass the plastic eliminator. Now here you see that this is the one pass and this is the two pass and a three pass and a four-pass type 1, 2, 3, 4 pass type of eliminator

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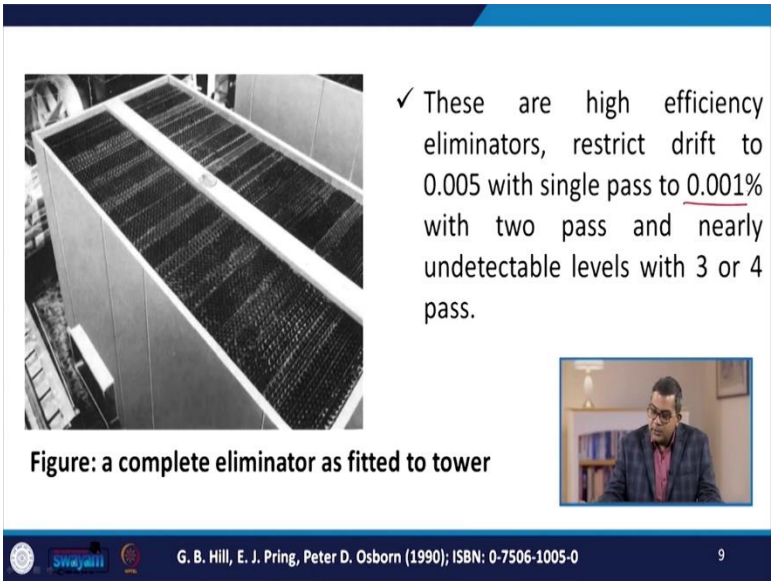

Now, these types of eliminators are highly efficient and they restrict the drift to 0.005, with the single pass of to 0.001% with two pass and nearly undetectable levels with the three to four passes.

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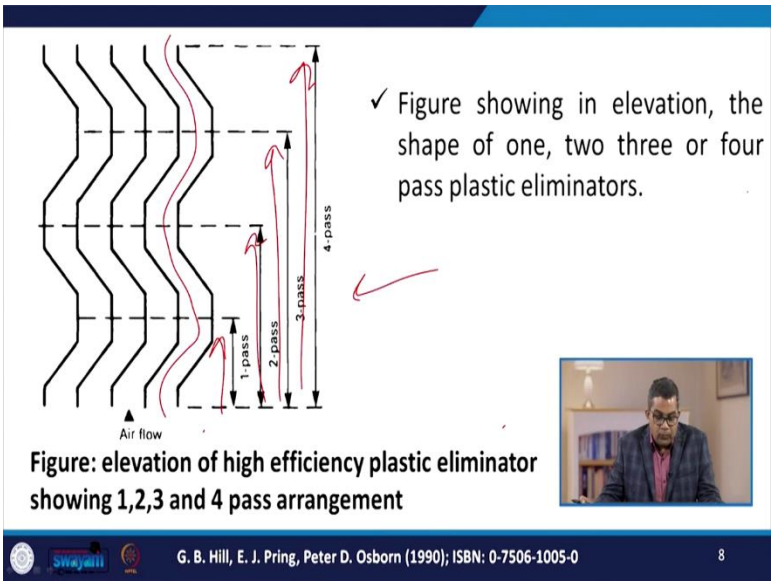

Now this is you see that this is the photograph of a complete eliminator as fitted to a tower.

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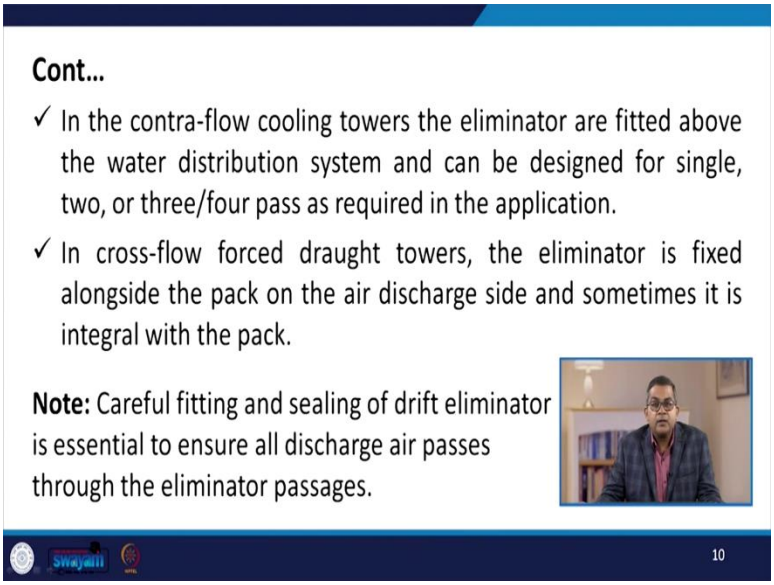

Now in the contra flow cooling towers, the eliminators are fitted above the water distribution system and this can be designed for single or two or three or four pass as per the requirement in that particular application. Now in cross-flow force draught towers, the eliminator is fixed alongside the pack on the air discharge side and sometimes it is integral with the pack. And one must be very careful about the fitting and sealing of the drift eliminator.

And it is quite essential to ensure that all discharge air passes through the eliminator passage. Now, let us talk about the water distribution. Now in contra flow towers either forced or induced drought have hot water distribution system below the drift eliminators.

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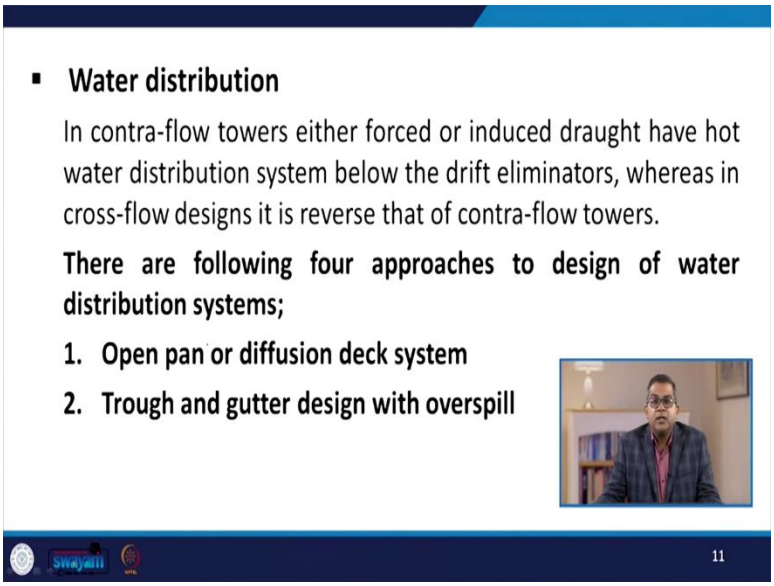

Whereas in cross flow design it is reversed that of the contraflow towers there are four approaches of design of water distribution system. Now one is open pan or diffusion deck system. Second, is the trough and gutter type of design with overspill.

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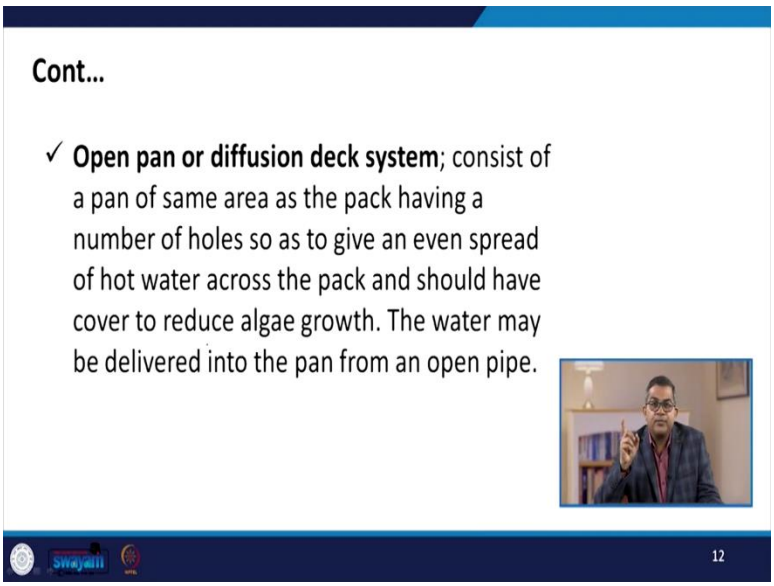

Now, let us talk about the open pan or diffusion deck system usually consists of a pan of same area as pack having a number of holes. So, as to give an even spread of hot water across the pack and

should have covered to reduce algae growth because algae grow sometimes it creates a massive problem and the water may be delivered into the pan from an open pipe.

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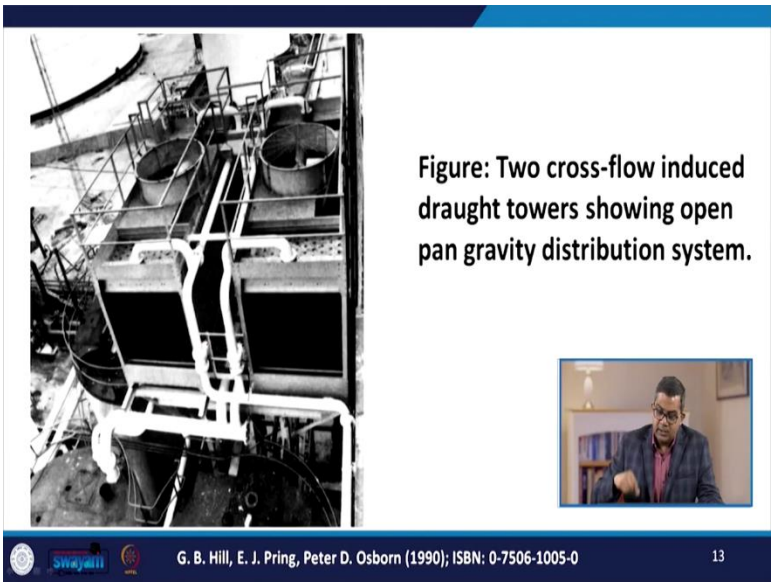

Here you see that this is the two cross flow induced draught tower. This is showing the open pan gravity distribution system.

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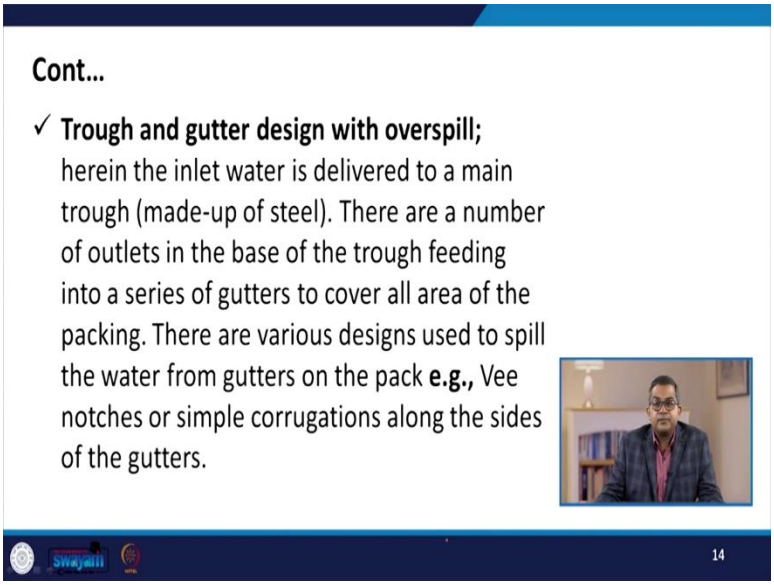

Now trough and gutter design over with overspill. Now, this is in this particular type of system the inlet water is delivered to a main trough that is usually made up of steel and there are a number of outlets in the base of the trough feeding into a series of gutters to cover all area of the packing.

Now there are various designs used to spill the water from gutter. On the pack may be Vee notch or simple corrugation along the sides of the gutter.

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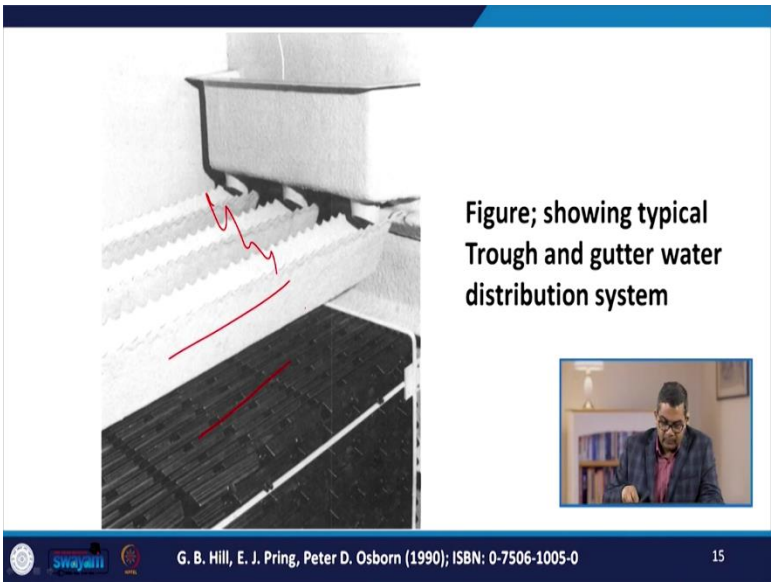

Now here you see the typical trough and gutter water distribution system.

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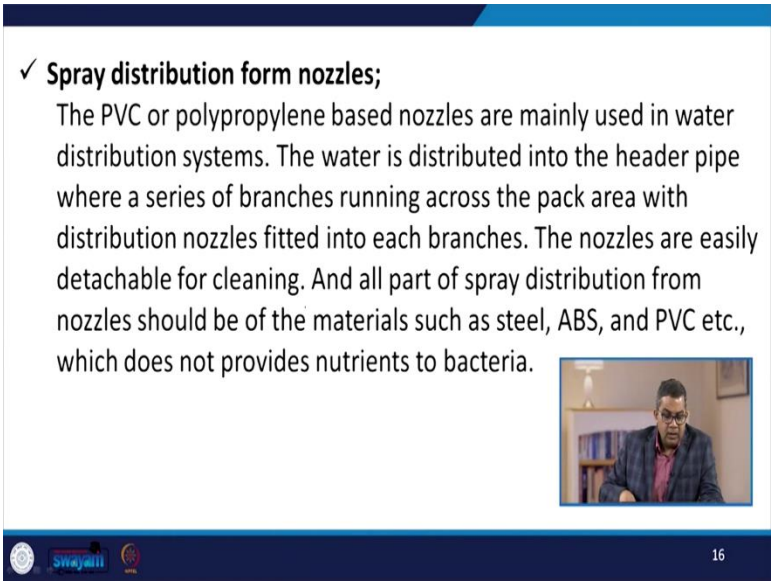

Now let us talk about the spray distribution form nozzle. Now the PVC or polypropylene based nozzles they are mainly used in water distribution system the water is distributed into the header pip where a series of branches running across the pack area with distribution nozzle fitted into each branches the nozzles are easily detachable for cleaning. So, the any kind of I mean cleaning or any kind of a replacement or wear and tear can be the problem of such kind can be resolved easily.

All parts of state distribution from nozzles should be of the material like steel, ABS, PVC etcetera which does not provide nutrients to bacteria. Now, because if the nutrients are there then definitely the microbial growth may be there and in that case the problem of efficiency and the wear and tear may arise.

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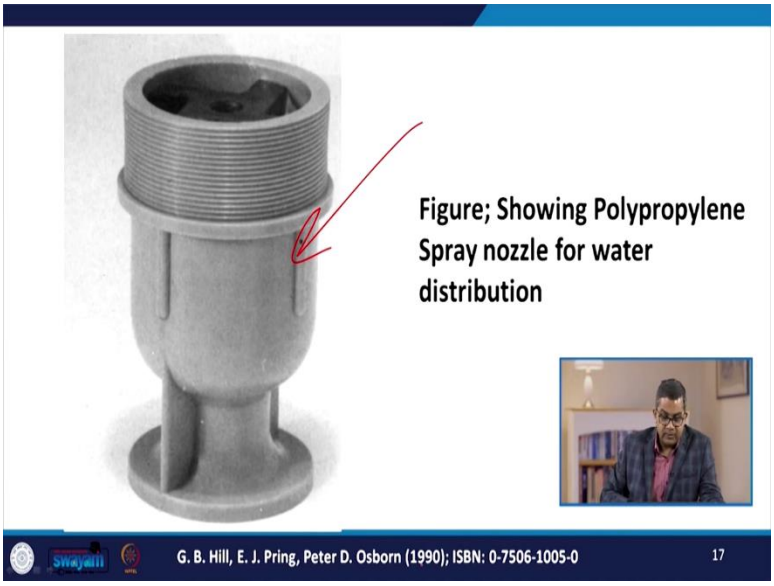

Now, this is the figure which shows the polypropylene spray nozzle for water distribution.

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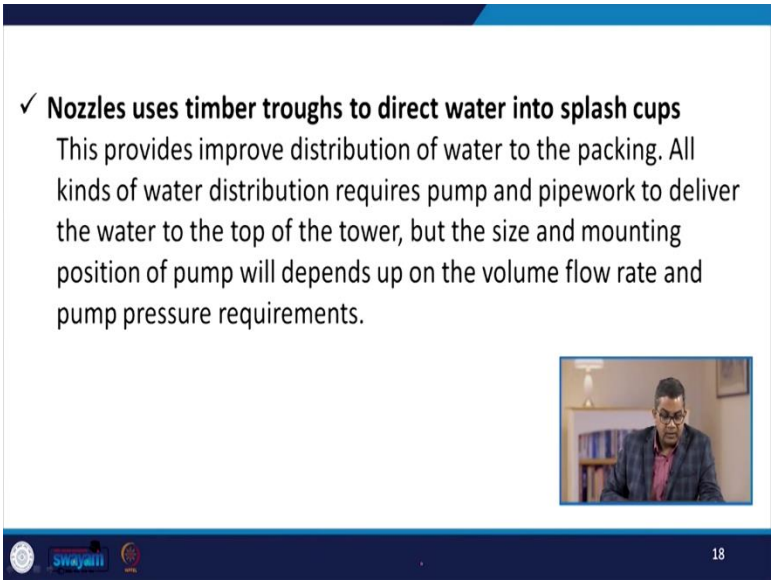

Now, nozzles they uses use the timber trough to direct water into splash cups now this provides improved distribution of water to the packing. Because improved distribution of water in the

packing is quite essential for the proper efficiency of the cooling tower as well as it imparts the energy efficiency aspect too. So, the cost of running of the cooling tower may be lower down.

So, all kind of water distribution requires pump, pipe work to deliver the water to the top of the tower.

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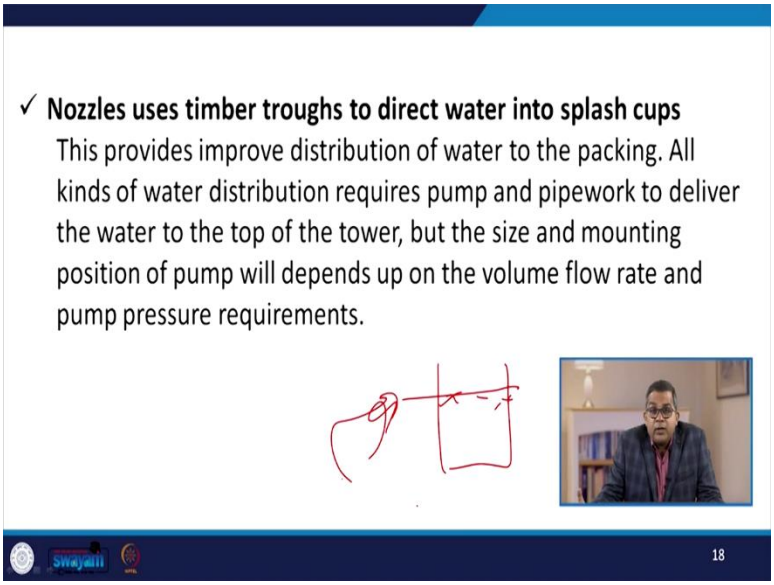

Now, you see that if you recall that we are having the water distribution network. So, you require the pump and a pipe work which can deliver the water to the top, but the size and mounting position of pump this all depends on the volumetric flow rate. What kind of volumetric flow rate you require and what kind of the pump pressure you require and that two depends on the other thermodynamic factors through which you can design the things accordingly.

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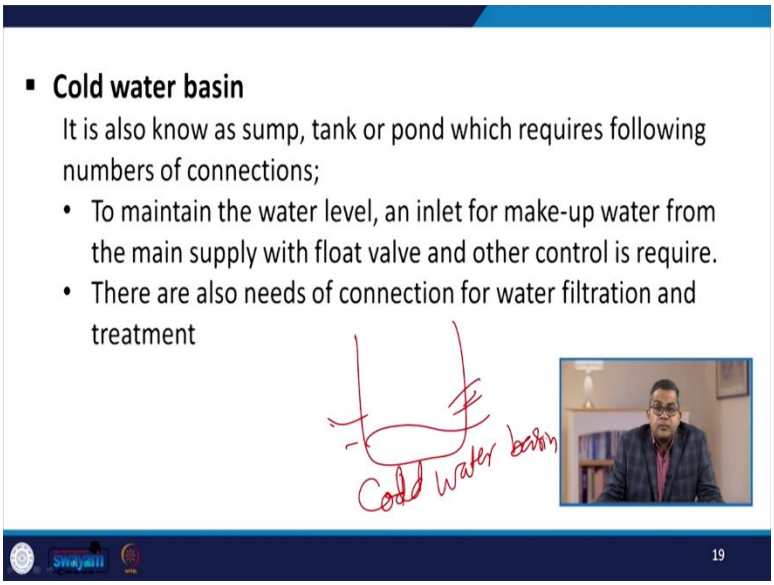

Now, if you recall that at the bottom of the cooling tower there is a cold-water basin. Now, this is sometimes known as a sump, tank or pond which requires different type of connections. Now, one is to maintain the water level because appropriate water level is essential and that is why the walls or the floating walls are there and inlet to make up water from the main supply with the float wall and other control which is required.

Because an optimum level of water is quite essential for the smooth functioning of this cold-water basin fitted to the cooling tower. Now there is also need of connection of water, filtration and treatment. Because sometimes debris and other things may present there. So, a water filtration and a treatment device should be there to remove the dirt and dust whatever I mean incorporate during the course of action.

Another thing is that to prevent the freezing of pump suction outlet, there is a need of a provisioning of thermostatically controlled electric heater. Because if the temperature is not maintained at the appropriate level, then the circulation of this water would be extremely difficult. And especially this type of thing is needed in the cold countries.

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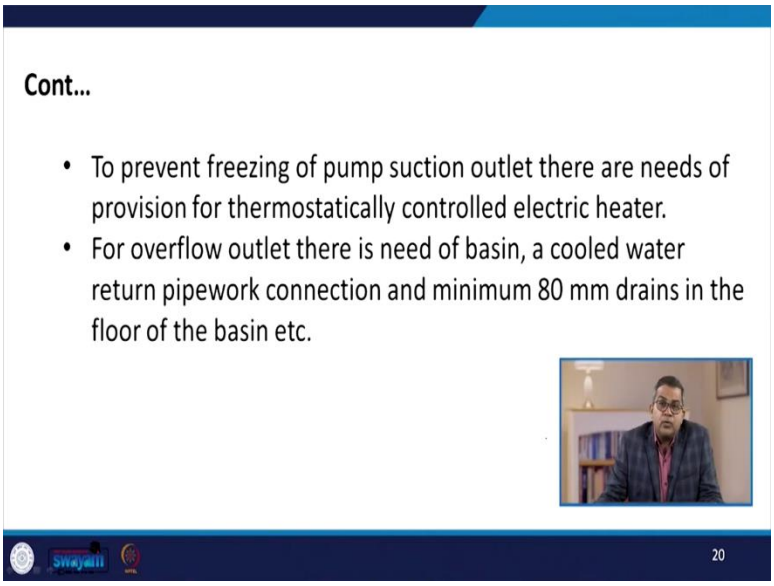

For overflow outlet there is need of basin a cold-water return, pipe work connection and a minimum 80 mm drain in the floor of basin.

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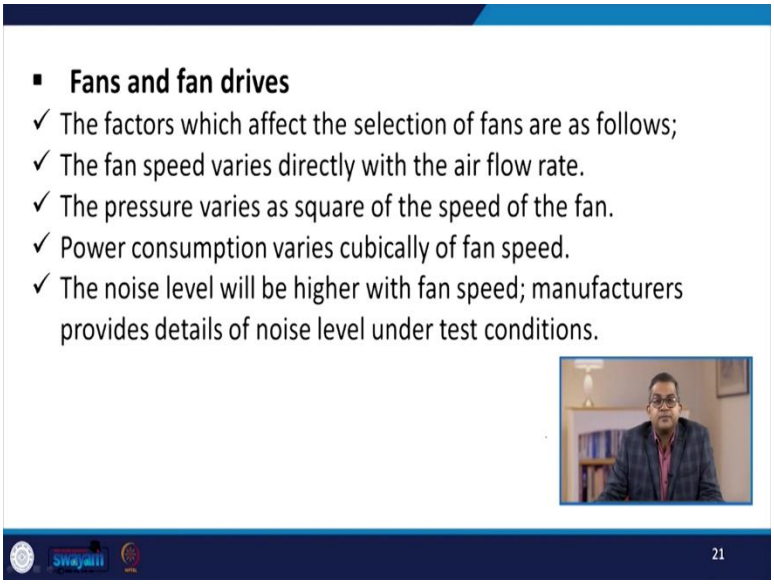

Now, fans and fan drive as we were discussing in the previous lectures. They are again the integral part of the cooling tower the factors which affect the selection of fans they are quite complicated and we need to address for the proper efficiency of this cooling tower. So, there are various factors associated with such kind of selection criteria one is that the fan speed varies directly with the air flow rate.

So, how much air flow is required that is one of the deciding factors for the proper fan. Second is that the pressure varies as square of the speed of the fan. So, how much pressure you require? That is again one of the deciding factors of your fans and fan drives. Then the power consumption varies cubically of fan speed because ultimately basic objective is that every operation should be cost effective or economically feasible.

So, we must look into the power consumption aspects too. So, we need to look into this aspect and this is again one of the major criteria of the fan selection. Then the noise level will be higher with the fan speed the manufacturer provides the detail of noise level under the test condition. See noise pollution in different chemical industries again a very crucial aspect and all the pollution control boards they are very critical about the noise level.

So, if you increase the fan speed, then definitely the noise level will be on the higher side and usually the manufacture provides the detail in decibel about these noise levels. So, if it is within the acceptable limit then you can select the appropriate fan. Otherwise, you need to go for the optimization with respect to the air flow rate, pressure and power consumption. Now the greater the air flow rate can be handled with a larger diameter of fan, but sometimes the space restriction they also play a very vital role.

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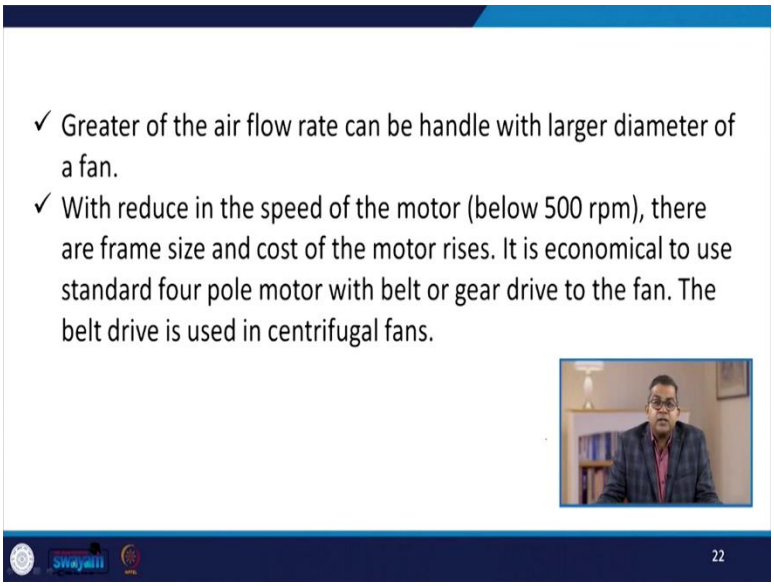

Now, with the reduce reduction in the speed of the motor below say 500 rpm there are frame size and the cost of the motor rises. So, you have to look into this while optimizing the appropriate fan. Now, it is economical to use the standard 4 pole motor with belt or gear drive to the fan and the belt drive is used in the centrifugal fan.

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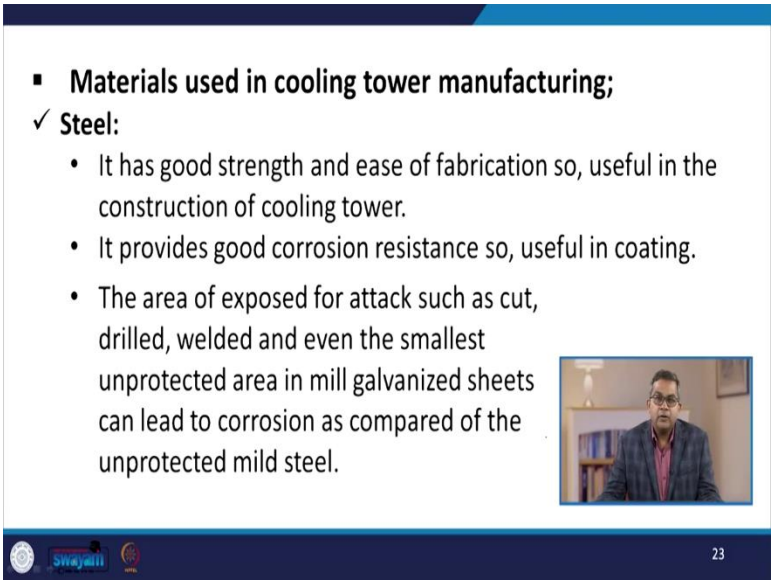

Now let us talk about the materials used in the cooling tower manufacturing one of the foremost choices is the steel. It has good strength and it the things can be easily fabricated. So, therefore it is quite useful in the construction of cooling tower. Apart from this it provides a good corrosion resistance so, useful in coating also. Now the area because the corrosion is again very important thing because the area of exposed for attack such as cut sometimes drilled or welded or even the smallest unprotected area in milli galvanize sheet.

This can lead to the formation of corrosion as compared to the unprotected mild steel. So, one must be very careful about this particular aspect because sometimes it can create a dent into the system. Other finishes such as bitumen plastic coating, rubber coating these may be useful, but thorough cleaning and degreasing is essential for better use. Stainless steel is used for manufacturing of the cooling tower with 11.5% of chromium content.

It is corrosion resistance is superior to untreated mild steel by the factor of say 250 when used in say marine environment the use of steel pipe work in conjunction with the plastic piping. This

should be avoided due to the differential expansion problem. See because of the temperature difference the plus the expansion issues pertaining to the plastic will be more prominent towards the with respect to the steel.

So, in that case there may be a problem of compatibility issue. So, to avoid this, we need to avoid such kind of a combination in the fabrication.

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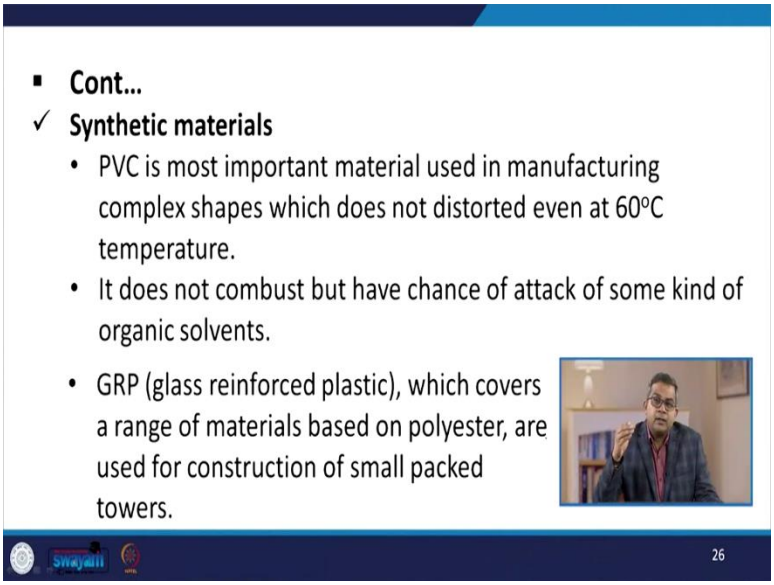

Another is the synthetic material the polyvinyl chloride is the most important material used in manufacturing of the complex shapes which does not distort even at say 60 degree Celsius temperature. Even it does not combust but have a chance to attack of some kind of organic solvent. Those who can dissolve or who can deform the shape of these PVC structure the glass reinforced plastic which covers a range of materials based on the polyester they can be used as the construction of a small packed tower.

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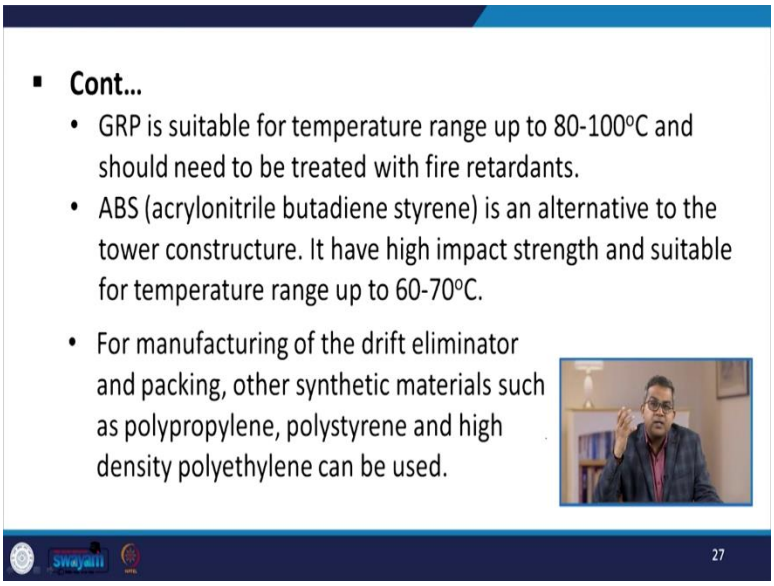

The grass the glass reinforced plastic is suitable for temperature range say up to 80 to 100 degrees Celsius and should need to be treated with different type of fire retardants. Acrylonitrile butadiene styrene, sometimes referred as ABS is an again alternative to the tower construction. It have the high impact strength and suitable for the temperature range say up to 60 to 70 degree Celsius.

For manufacturing of a drift eliminator and packing other synthetic materials such as polypropylene, polystyrene and high-density polyethylene these can be used. Like polypropylene this can be used in the manufacturing of fan blades. But with the glass reinforcement it has higher softening temperature.

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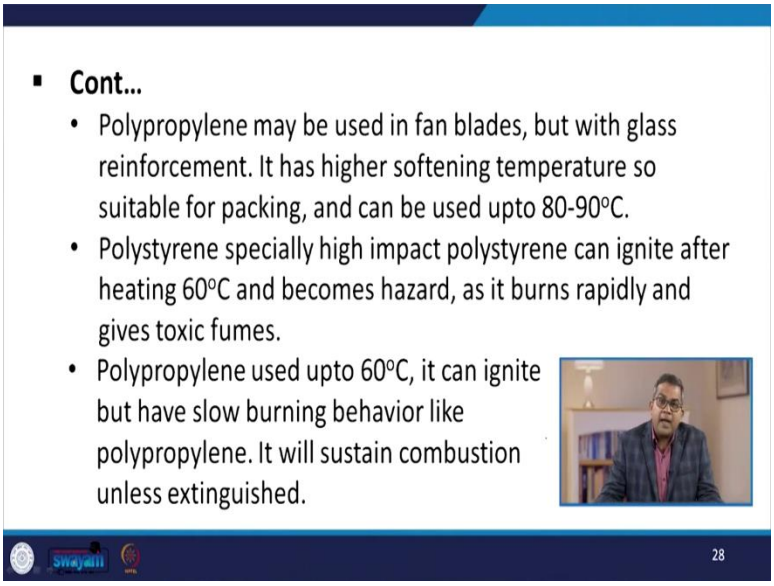

So, it is suitable for packing and can be used up to say, 80 to 90 degrees Celsius. Polystyrene especially high impact polystyrene can ignite after say heating to 60 degrees Celsius or more and it becomes hazardous as it burns rapidly and gives the toxic fumes like dioxin etcetera. The polypropylene used up to 60 degrees Celsius it can ignite but sometimes they have a slow burning behavior like polypropylene.

It will sustain combustion unless extinguished. Another important material of construction is timber. It is cost effective material for manufacturing of tower structure such as timber frames, cladding, packing etcetera. It is used after fabrication with the suitable preservatives.

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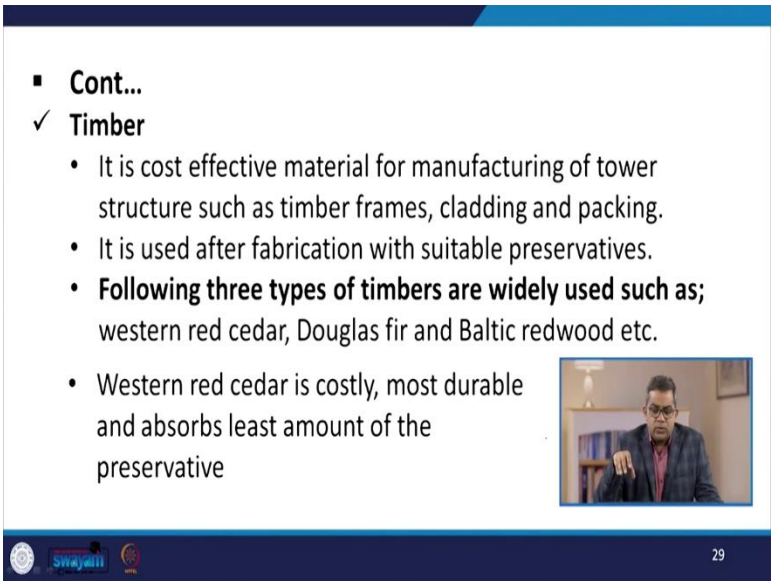

Now, there are different type of timbers those who are widely used like western red cedar, Douglas fir, the Baltic redwood, etcetera. The western red cedar is costly, but simultaneously it is more durable and absorbs least amount of preservatives.

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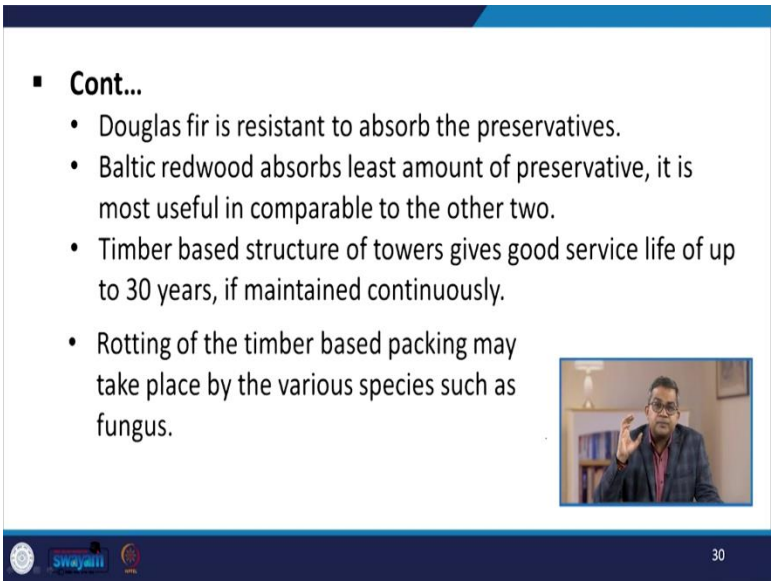

The Douglas fir is the resistant to absorb the preservatives Baltic redwood absorbs least amount of preservatives. It is most useful in comparable to the other two. Now, the timber-based structure of tower gives good service life say up to 30 years. If maintained rigorously and continuously. Sometimes rotting of the timber may takes place and rotting of timber-based packing may takes place by the various species and such as fungus and moulds etcetera.

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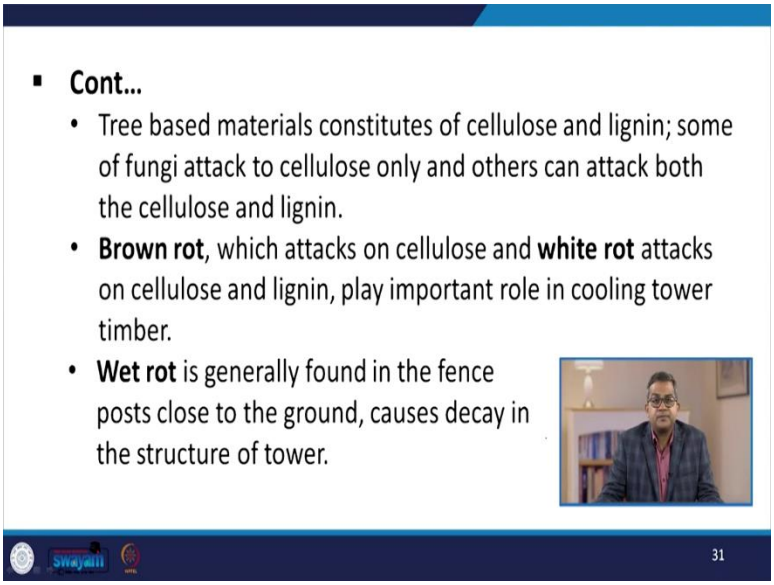

Now, the tree-based materials constitute of cellulose and lignin and some of the fungus they do attack to cellulose only and other can attack both cellulose and lignin. The brown rod which attacks on cellulose and white rot attacks on cellulose and lignin both they play a very important role in

cooling tower timber. Now, wet rot is generally found in the fence post close to the ground and causes decay in the structure of the tower.

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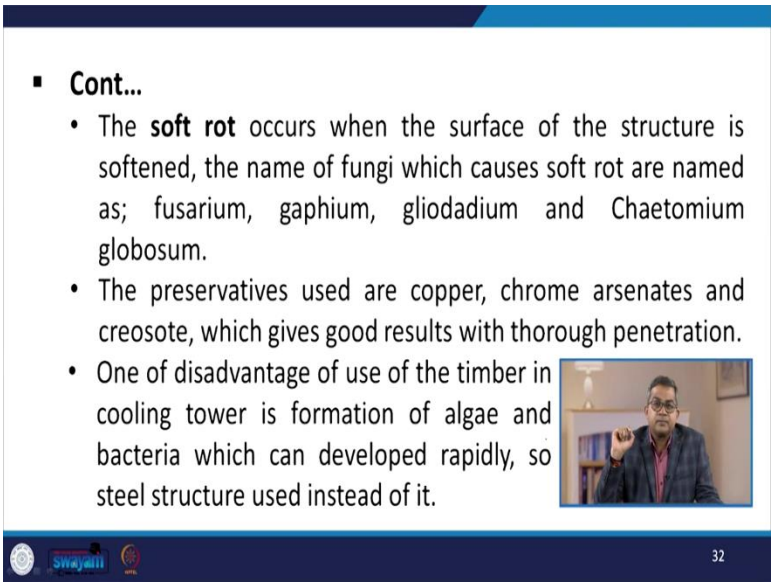

The soft rot occurs when the surface of the structure is softened. The name of fungi which causes the soft rot are named as fusarium, gaphium, gliodadium. The preservatives used as a copper, chrome, arsenates, creosotes which gives good results with the thorough penetration. One of the disadvantage of use of timber in cooling tower is the formation of algae and bacteria which can develop over the period of time.

And they can develop, so, rapidly the steel is and so, steel structure is sometimes beneficial compared to the timber structure. Now, let us talk about the application of water-cooling tower. Now, this it had the diverse application in which each require the special requirement in terms of temperature level layout of pipe work and methods of control. Now there are some applications of cooling tower like application in refrigeration, plant air compressors, engines, metallurgical processes, chemical and refinery plants, turbine condenser, cooling etcetera.

One of the foremost you can say the application is in the refrigeration plant so, cooling tower they have important application in the various refrigeration plant for each ton of refrigerant that is 3.5 kilogram of cooling. The rate of heat extraction from condenser is roughly around 4.2 kilowatt.

The factors of cooling tower designs such as water temperature and overall heat transfer coefficient of condenser they affect the performance of the refrigeration plants.

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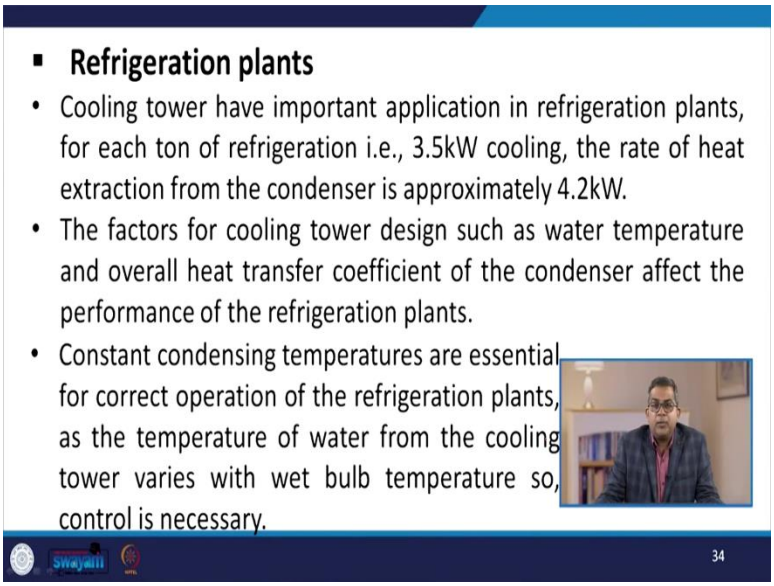

The constant condensing temperature, these are essential for correct operation of refrigeration plants such as the temperature of water from the cooling tower varies with wet bulb temperature so, the control is necessary.

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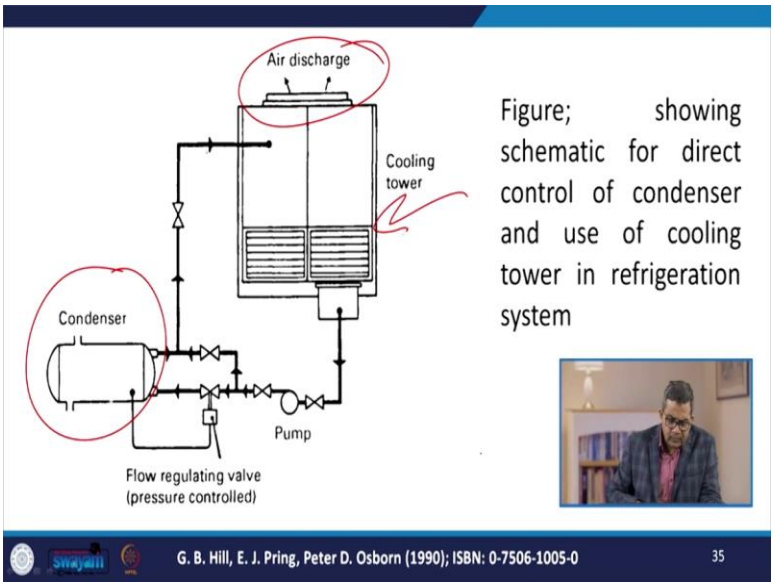

Now, here you see that the schematic diagram for direct control condenser and use of cooling tower in the refrigeration system. Now, here you see this is the condenser and air discharge

assembly and rest other things are common which we have already discussed in the previous lectures.

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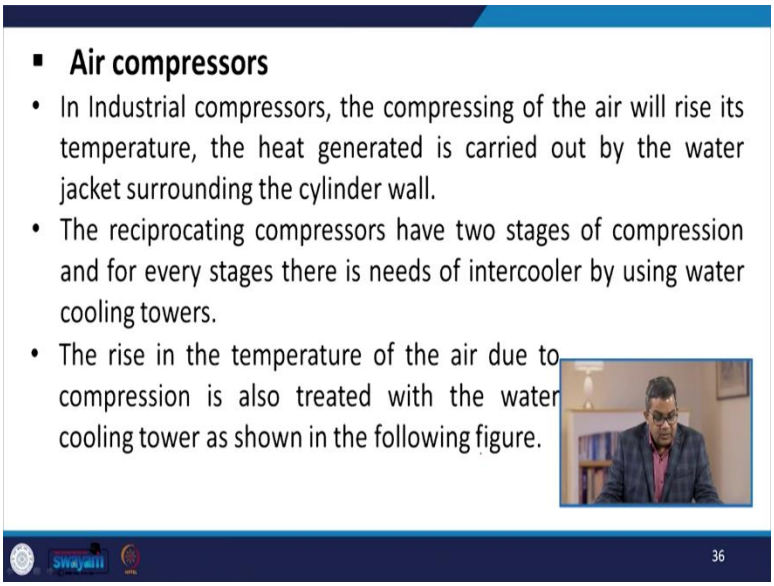

Air compressors: In industrial compressors, the compressing of air will rise its temperature and thereby the heat, excessive heat may be generated. So, the heat generated is carried out by the water jacket surrounding the cylinder wall. The reciprocating compressor, they have the two stages of compression and for every stage there is a need of intercooler by using water cooling tower. The rise in temperature of the air due to compression is also treated with the water-cooling tower as per this particular figure.

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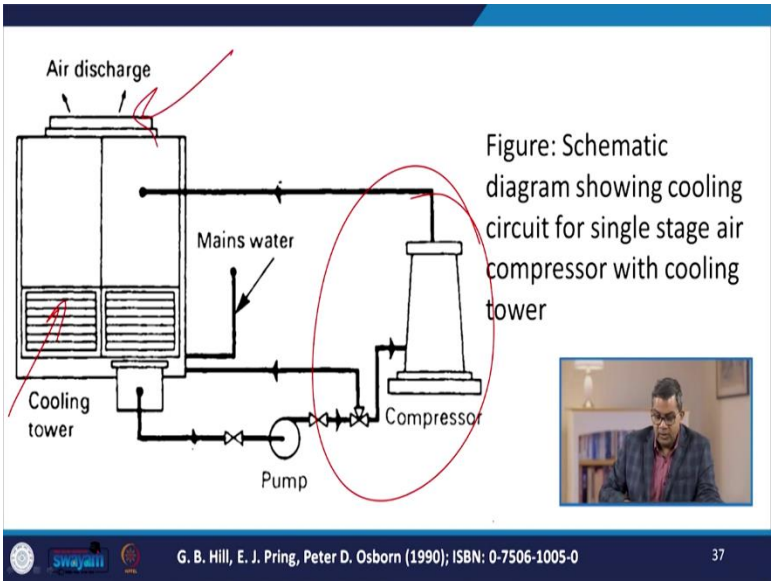

Now, here you see that this is the schematic diagram for showing the cooling circuit for single stage air compressor. Now here you see, this is the single stage air compressor and rest other things like packing air discharge. All these things as usual which we have discussed earlier

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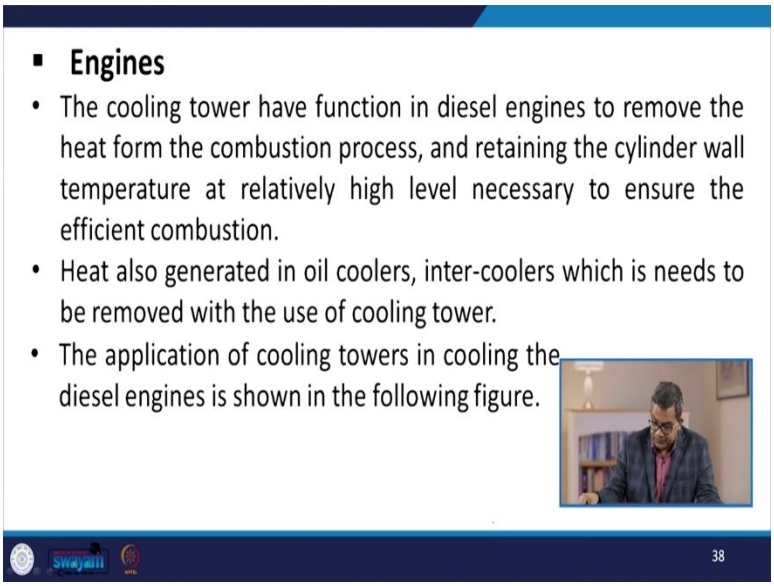

Next is the engine, the cooling tower have functions in the diesel engine to remove the heat from the combustion process and retaining the cylinder wall temperature at relatively high level necessary to ensure the efficient combustion. Heat also generated in oil coolers intercoolers which is need to be removed with the use of cooling tower. The application of the cooling tower in the cooling the diesel engine is as per this one.

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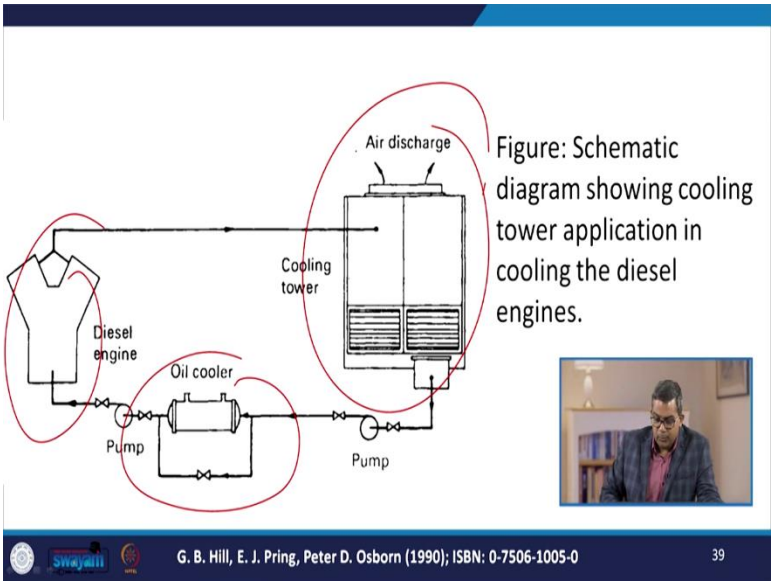

Now, here this is the diesel engine and with the help of this oil cooler it can be removed with the help of this cooling tower.

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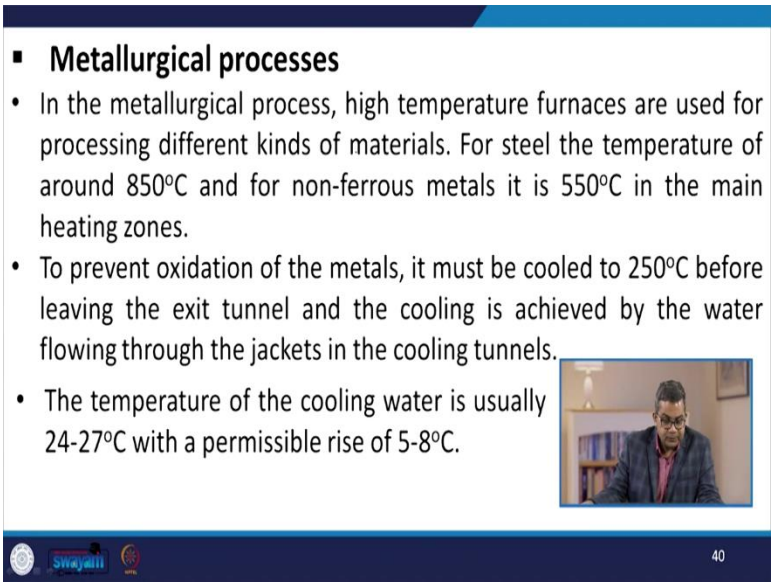

Another application in the metallurgical process. In the metallurgical process the high temperature furnaces are used to for processing different kind of materials for steel. The temperature is around 850 degrees Celsius and for non-ferrous material it is around 550 degrees Celsius in the main heating zone. Now, to prevent the oxidation of metal, it must be cooled to 250 degrees Celsius before leaving the exit tunnel.

And cooling is usually achieved by the water flowing through the jacket in the cooling tunnels. The temperature of cooling water is roughly around 24 to 27 degrees Celsius with a permissible rise of 5 to 8 degrees Celsius.

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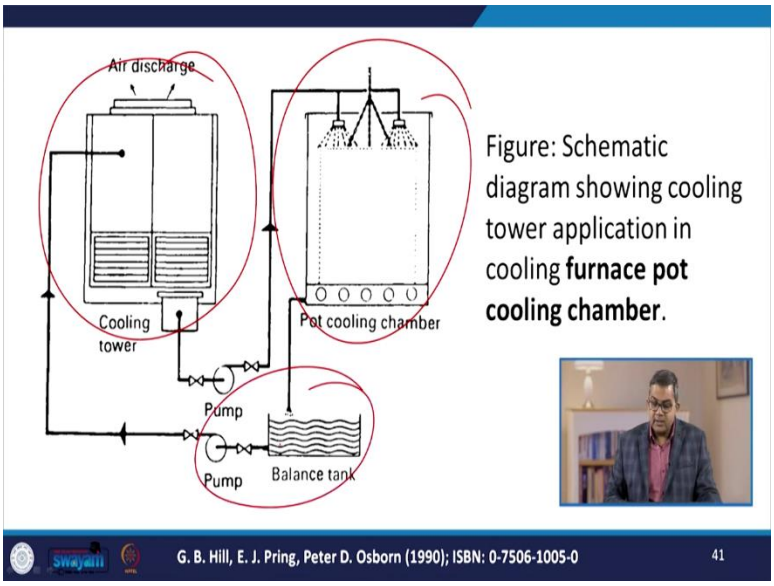

Now here you see that this cooling tower is same, but this is the pre-cooling chamber and this is the balance tank. This is a stigmatic diagram, showing the cooling tower application for the furnace spot cooling chamber.

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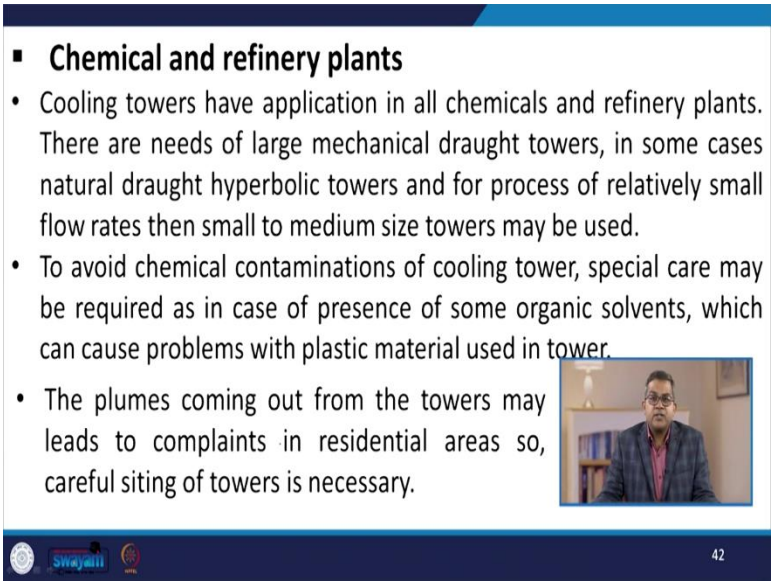

Another application is in the chemical and refinery plants and the cooling tower they have wide application in all chemical and refinery plants. Now there is a need of a large mechanical draught tower in some cases natural draught, hyperbolic tower for different processes and for the process of for relatively small floor rates, the small to medium size tower can be used. Now to avoid the chemical contaminations of cooling tower the special care may be required.

In case of the presence of some organic solvent which can create a problem where we are using the plastic material in different part of tower, whether it is a packing or whether it is in terms of the fan blade. The plumes coming out from the tower may lead to complaints in the residential area so, a careful sitting of tower is necessary. So, the during the designing of the tower these aspects need to be addressed.

Now, another application in the turbine condenser cooling in power plants the turbine condenser cooling this requires the use of water-cooling tower which may be a natural draught or mechanical draught tower. The cooling ranges may vary between the small industries and a giant power station condenser this ranges from 6 to 12 degrees Celsius.

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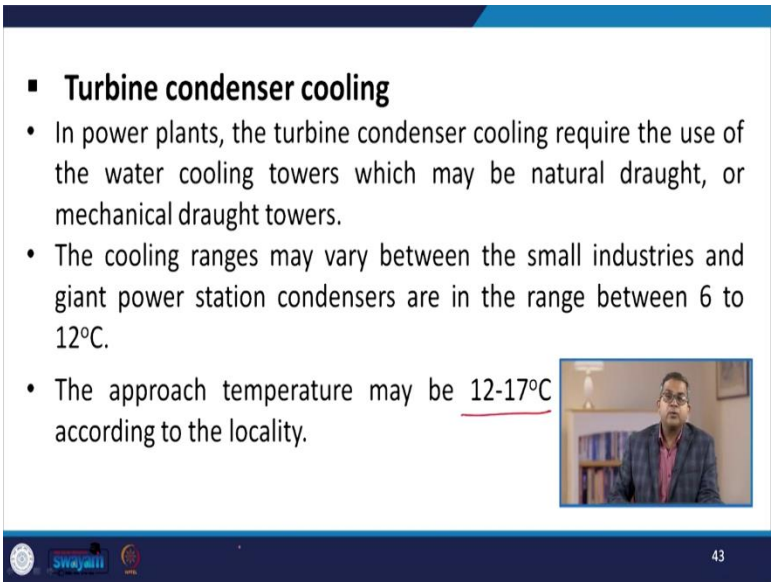

The approach temperature may be 12 to 17 degrees Celsius according to the locality. So, at last in this particular lecture we have discussed about the various components of cooling tower. We had a broad discussion about the various application of these cooling tower in different industries for your convenience we have been listed couple of references.

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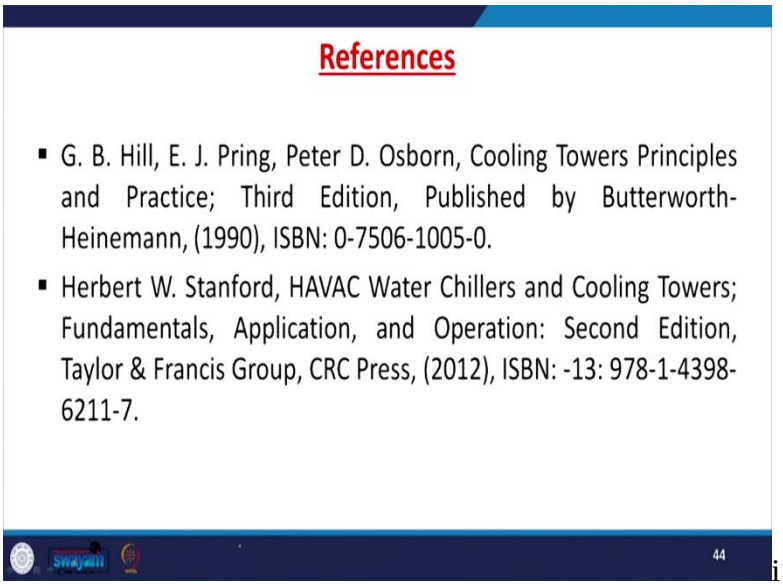

If you wish, you can have a look of all those references for further reading. Thank you very much.