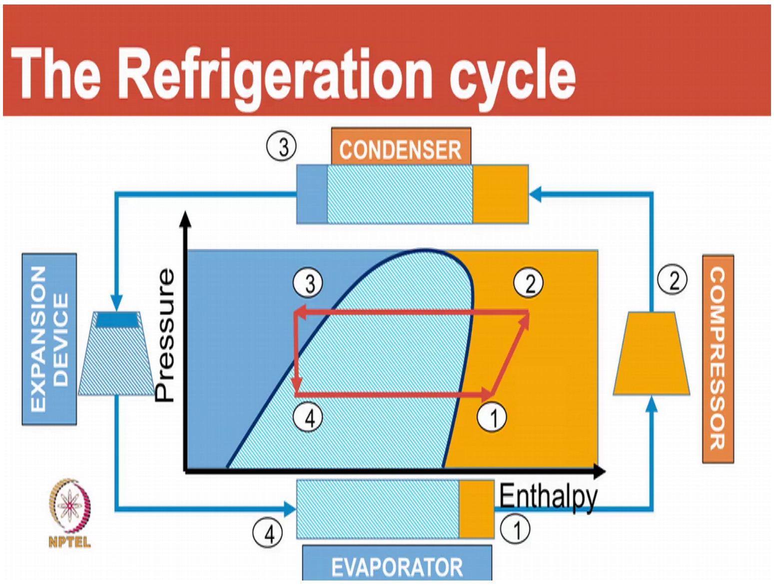
RAC Product Design
Prof. Sanjeev Jain & Bhupinder Godara
Department of Mechanical Engineering
Indian Institute of Technology, Delhi

Lecture – 09
Condensers and evaporators

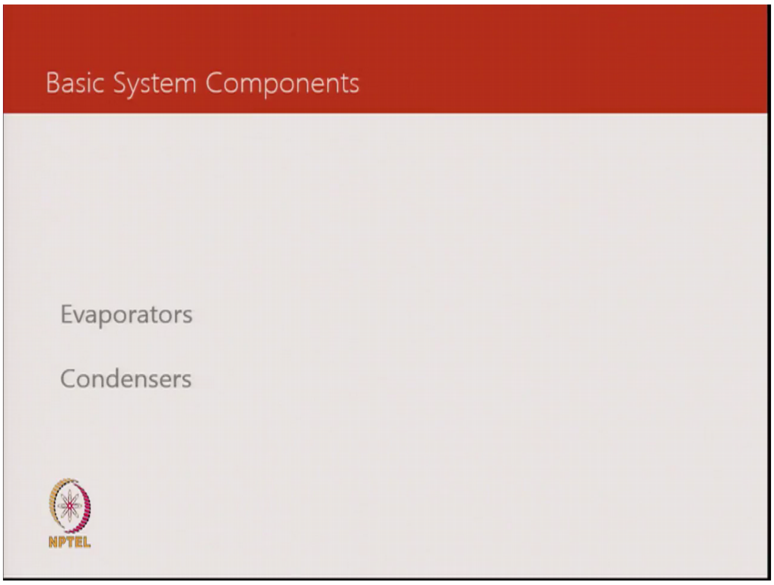
We have not done much about, what is an evaporator like inverter condenser like we do not discuss much on that.

(Refer Slide Time: 00:23)



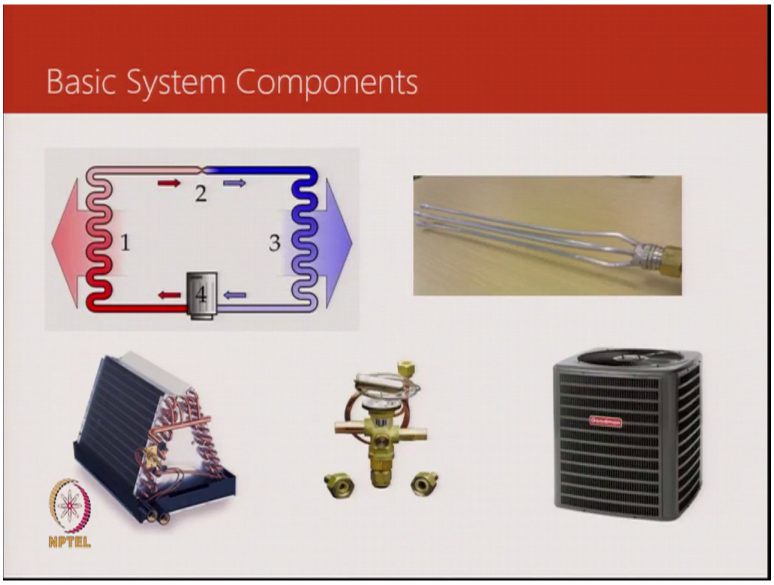
So, today we going to do that, again the basic system components we have spent time on compressors, we spend time on expansion devices and we want to not look at Evaporators and Condensers.

(Refer Slide Time: 00:35)



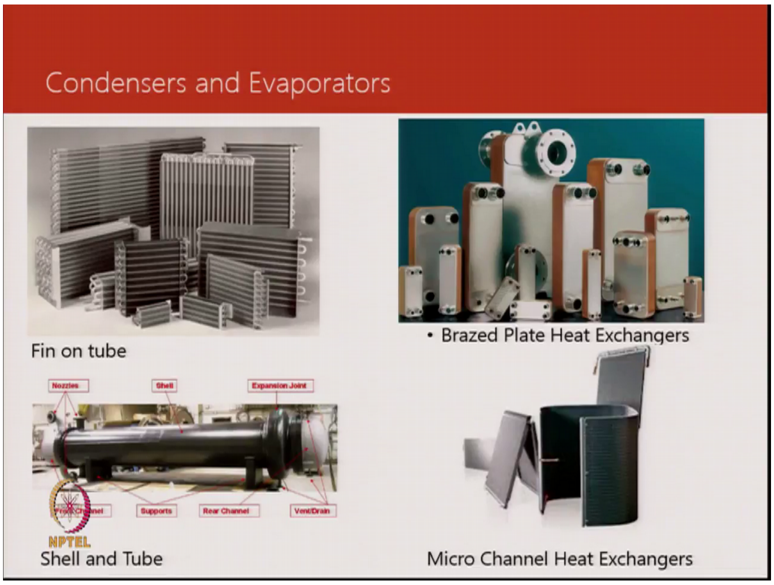
And, then we look at condensers sorry.

(Refer Slide Time: 00:47)



So, here in this picture we can see 1 and 3 represent the condenser and the evaporator is a process, we see some pictures of a ‘A’ shaped evaporating coil. We see an expansion device and we see a condensing unit and we see a distributor.

(Refer Slide Time: 01:07)

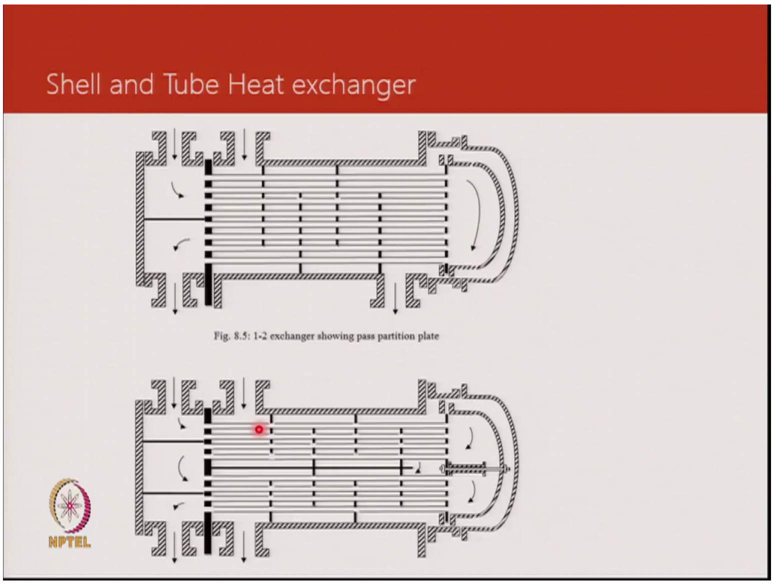


So, here we have several types of heat exchangers which can work both as an evaporator or as a condenser. While, there is a difference between how it functions in the evaporator and condenser. But, broadly there is there is a applicability of the same component with different sizing in the evaporator and just as it is in the condenser. So, what we have here, these are conventional fan on tube heat exchangers different sizes.

These are braze plate heat exchangers and I am going to put some more detail around how they function, in the one subsequent slides. This is the micro channel heat exchanger; it is similar to what we see in car radiators. There are a number of tubes inside a flat tubular section and there are fins brazed together between the tubes.

Then we have shell and tube condenser, these are the most conventional condensers have been in use for long. They are easy to manufacture and fairly robust, they can handle very high pressures and temperatures, but they are expensive to build. So, they have been gradually wherever the application permits they have been replaced by lower cost alternatives like brazed plate heat exchangers. Now, we look at what is our shell and tube heat exchanger.

(Refer Slide Time: 02:33)



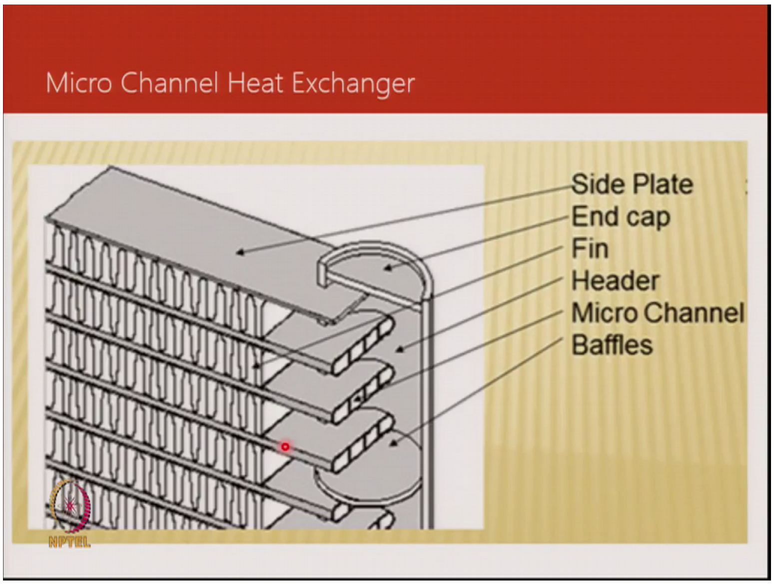
So, you know shell and tube heat exchanger we have one refrigerant or one fluid enter and pass through a cross section of tubes and come back through another bank of tubes. While, the second fluid is passing through baffles and again is exiting the heat exchanger. So, depending on how we design it, it could be two pass system or a four pass system.

And, and the baffles could be determined basically into how many times you going to have the fluid come in contact with the tubes. The space between the tube sheets is it is enclosed. So, the key thing here is that we must be able to see the two fluids apart. So, we do not want for example, water entering into the refrigerant path or vice versa as has that is a risk towards performance and product.

(Refer Slide Time: 03:31)

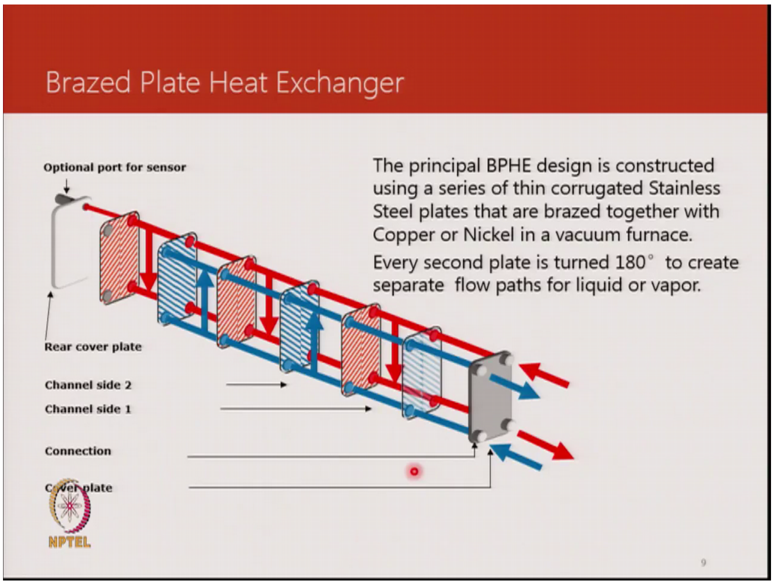
Then we have micro channel heat exchangers now, this is something recent like in the last 3 to 4 years these heat exchangers have entered applications in air conditioning. A part of this is been because; of refrigerant change R-410A has a lower pressure drop for a similar heat load per circuit. And, for that reason it is possible to use the small channels that are there. So, 410A 134A are all potential refrigerants where micro channel will be favourably applied because, they can allow a longer circuit length for the same heat load.

(Refer Slide Time: 04:11)



Ah Now, if you look at the inside of a micro channel heat exchanger then this is what it looks like. So, we would have a header within which the refrigerant enters and then it is distributed into different channels. So, each of these strips has within it some micro channels. So, we have a tube and within the tube there are small openings into which we push the refrigerant using the compressor pressure. And, then there are some baffles and the whole idea behind the baffles is to equally distribute the refrigerant across the whole cross section of the heat exchanger.

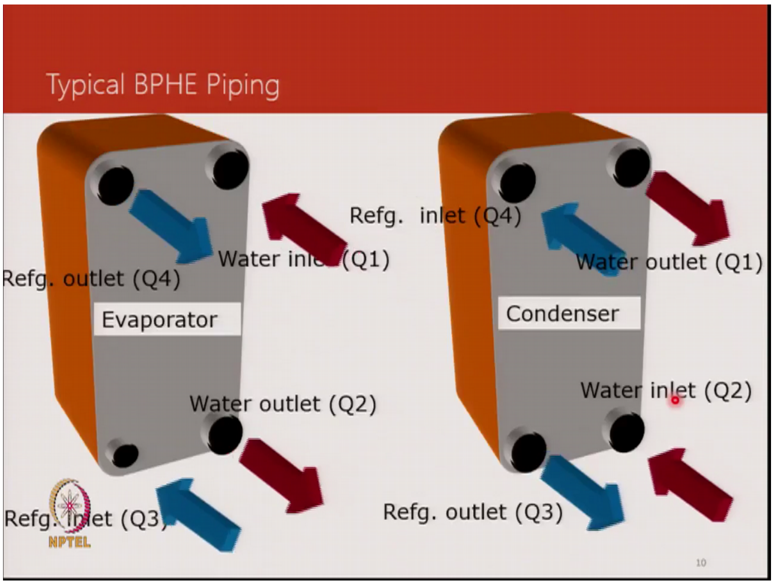
(Refer Slide Time: 04:50)



Then a replacement or an alternative for shell and tube condensers is a brazed plate heat exchanger. You know braze plate heat exchanger multiple plates with grooves for refrigerant flow are stacked together; they are welded together and makes for a very compact heat exchanger.

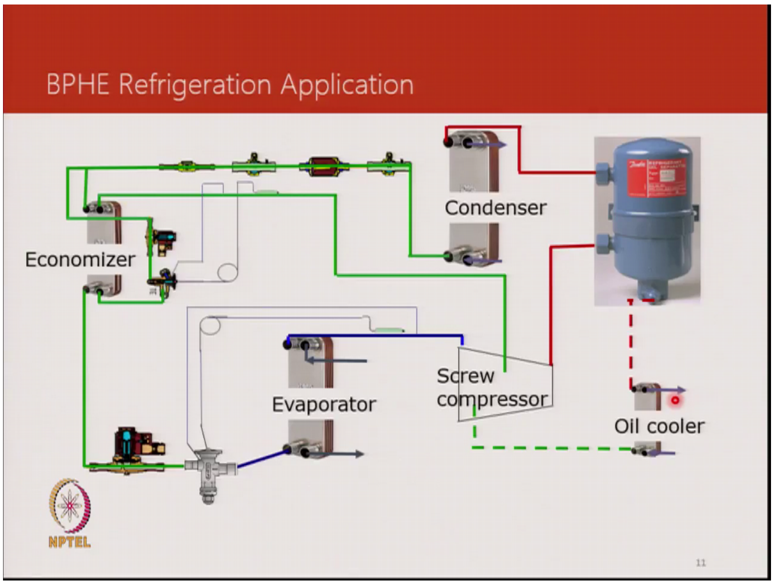
So, some of the most effective heat exchangers that we will see whether it is an application and evaporator or condenser would be the brazed plate heat exchanger. A typically used in chillers we have water on one side and refrigerant on another, but there is nothing which prevents us from using it as a heat exchanger between two refrigerant streams as well.

(Refer Slide Time: 05:30)



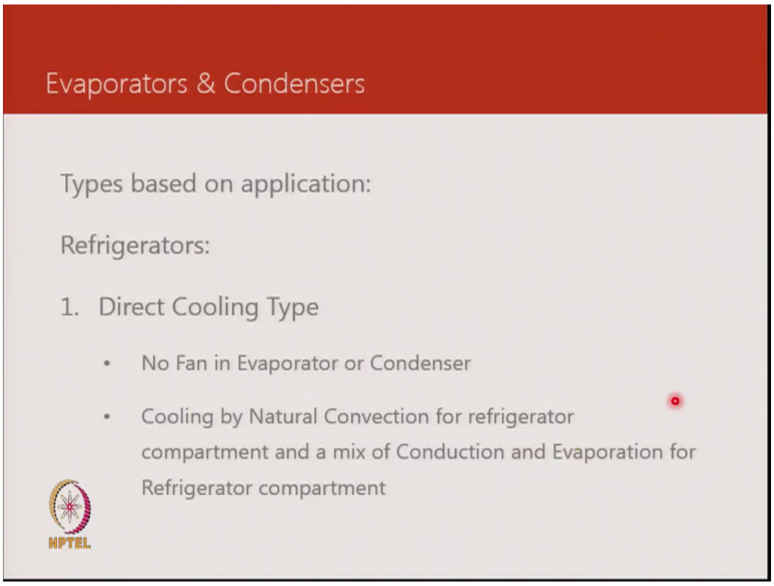
Now, a typical piping for a brazed plate heat exchanger and what we is showing here is the difference between the application in an evaporator and the application you know condenser. In an evaporator the refrigerant enters at the bottom leaves on top. We want to maximize opportunity for refrigerant to evaporate and they get the best heat transfer. And, the water enters on top and leaves on the bottom and it is just reversed in the condenser.

(Refer Slide Time: 06:05)



This is how a braze plate heat exchanger can be used in a refrigeration application. It can be used an economizer, it can be used an evaporator, condenser.

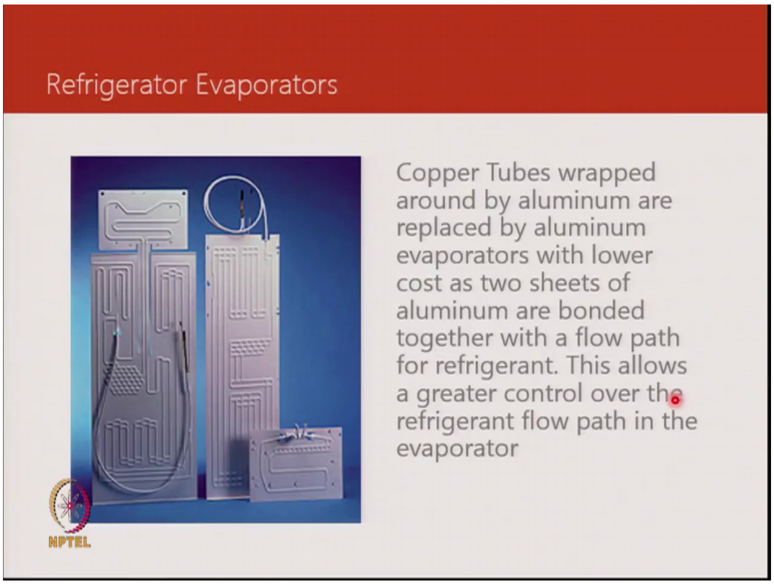
(Refer Slide Time: 06:17)



Now, we look at evaporators and condense more from an application perspective; so, if you looking at an evaporator for a refrigerator, what would it be like? A refrigerator is a low load appliance so; the cooling requirement may be 200 to 300 watts. In the in the lowest cost refrigerator we do not use any forced convection. If you looked at your refrigerator at home the basic one, the 165 litre which is most popular does not have any fan inside whereas, in the frost free ones would have a fan circuit circulation.

So, there the entire process of cooling is for the refrigerator compartment, where you store your food at above 0 temperature is all by natural convection. So, you have the evaporator on top cold air descends, whatever heated gains the heat the air rises back, comes in contact with the evaporator plates and the process continues. Then in case of frost free we have something different.

(Refer Slide Time: 07:25)



Now, when you look at domestic refrigerator initially when these products were made and when technology was not available to make roll bond evaporators of the type that you see here, then copper tubes we used wrapped around by aluminium and that would form the evaporator. And now, because of the costs of copper that have been rising consistently and the availability of technology where you could take two sheets of aluminium, bond them together with refrigerant paths that are created by expanding that metal.

So, it makes for lower cost and much more effective and reliable evaporator. So, this is what would be there inside refrigerators that are manufactured today. The main enabler to use of this is kind of evaporator is that we can weld aluminium to copper and allow for an extension piece, that the manufacturer can then build into the system. So, it is easy to manufacture because it is coming prefixed or pre connected with the copper piece that gets connected to the rest of the piping.

And, the piping if you remember the basic refrigeration cycle we will need to connect one end to the suction line and another end to the capillary. You know before the suction line goes to the compressor there might be an accumulator just to take care of any surge, any refrigerant that manages to have any droplets of R134A or R12 whatever fluid we using as a refrigerant. Now, when you designing a refrigerator evaporator, we are trying to define the flow path.

So, if you see there are lines can most of you see the lines on the role model evaporator. So, this is actually the refrigerant path and this is how it is shipped, when it comes into the appliance and it is on the line then it gets formed. So, you bend it around either into a C section or into a complete rectangular section. So, that you form the freezer which forms the basic heat transfer component inside the refrigerator.

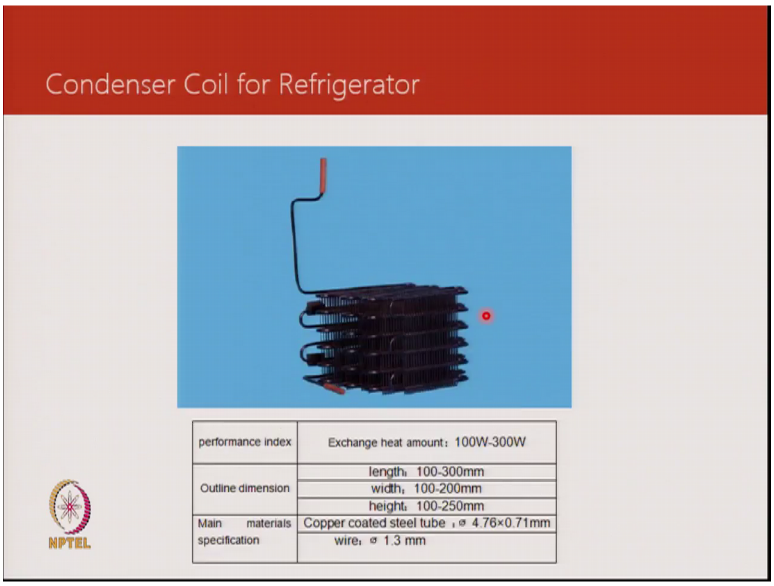
And, there are several iterations that happen before or refrigerator is cleared for maintaining the temperatures that are targeted inside an appliance. So, so, the plane field when you are designing a refrigerator evaporator is how you move refrigerant through these tubes. And, while companies have their own proprietary software most of the part has to be validated experimentally. So, you would get a sample, you would make your best guess on what would be the right distribution of refrigerant and then you would run tests. And, those tests would enable you to recalibrate the software results, if there is software being used or else you would use your judgment to move refrigerant from one portion to another.

What you are trying to do here is the amount of frost that gets formed during the normal or compressor cycle needs to be minimized. So, you do not want to cold a temperature and one part of the evaporator and to higher temperature on another part of the refrigerator. Then we also need to develop an understanding of the natural convection that is happening in the refrigerator, which part of the refrigerator evaporator is coming in contact with warm air rising from the components like warm air coming in contact because of door openings. So, all that gets included in making sure that, these paths are sufficient to maintain the product temperature and comply with standards for refrigerator testing.

(Refer Slide Time: 11:11)

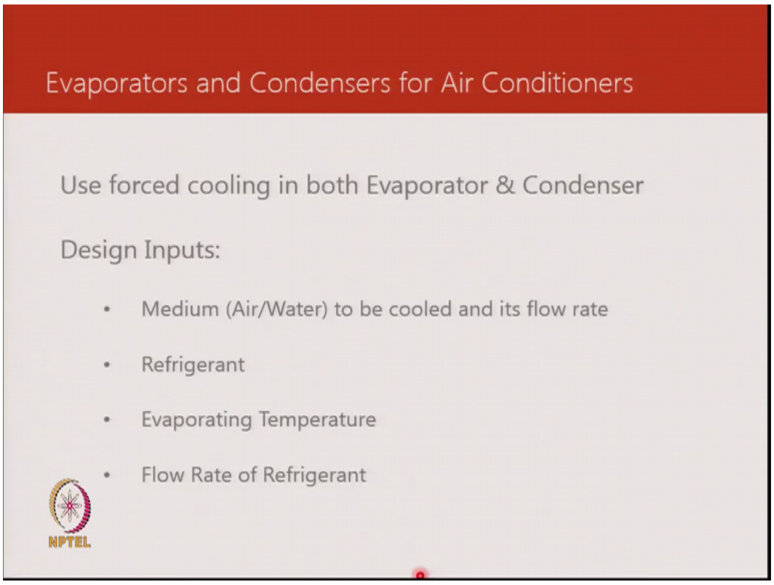
Then if you look at a frost free refrigerator evaporator, then we have something similar to fin on tube evaporators; only differences that this is again all aluminium. The tubes and the fins are in aluminium. This is an accumulator and then there is a short extension piece that will allow this to be connected to copper tubes at the manufacturers end. And, we will have some devices which are there like a sensor, which is used to monitor when defrosting cycle needs to quicken. So, this is an example of a frost free refrigerator evaporator.

(Refer Slide Time: 11:55)



And then we have a condenser coil for a refrigerator and this could be you know frost free as well as a little conventional depending on size. So, you will see this typically in large refrigerators say 400 litres and above. Essentially it is a steel tube with the wires spot welded on it, to increase the airside heat transfer coefficient. And, this particular component that you see on the slide has a rating of about 100 watts minimum to 300 watts maximum. And we allow this range so, that one component can be used with several models.

(Refer Slide Time: 12:41)



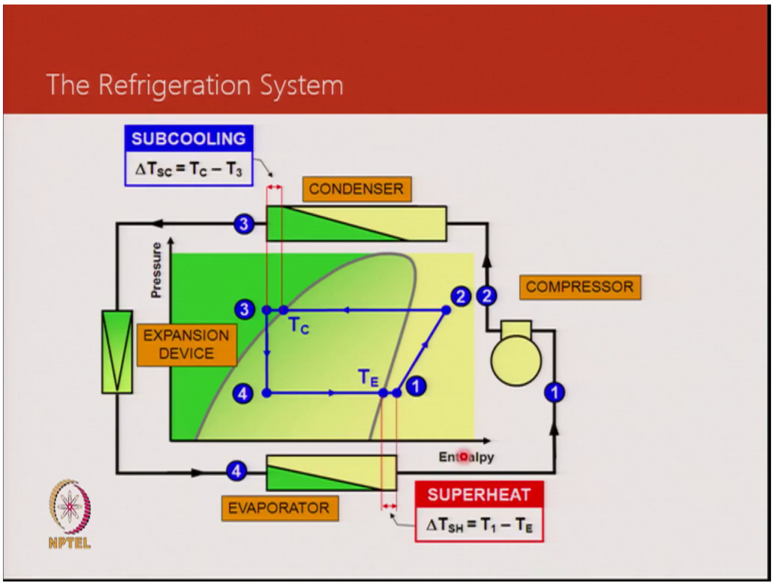
Then we come to air conditionals. So, in air conditioners we will most of the time see a fin on tube evaporator in use. And, before we get down to designing that we need to include in our assessment what are the inputs available to us. So, in one of the previous lectures I talked about the requirements like what is the cooling requirement. So, take for example, we have our residential application with the 5 kilowatt of cooling requirement that is the design input using that we would select a compressor.

So, we would make an assumption of the evaporating temperature that will be use and a good starting point could be the standard condition of 7.7 evaporative. At that temperature we would select a compressor that can give us 5 kilowatt of cooling. I having done that we come to the point of designing an evaporator and what are we going to do to design it. So, we will make an assumption because, the whole set of components are interrelated and we have not design done the condenser design yet.

So, we will make an assumption of what kind of a condenser we want to design. We could be designing for high efficiency or we could be designing for acceptable market cost, market price driven market cost. So, if you want to do that then we will make an assumption of a lower superheat. We know how the expansion valve performs and the expansion valve can always be selected in a way that we get the right pressure drop for the evaporator temperature that we have made an assumption. And, the condensing temperature which again we will make use of based on the ambient air temperature considerations and whether we are designing it for cost or efficiency.

So, if example designs condition 35 degree centigrade outdoor air temperature. So, for 35 degrees outdoor air temperature we could run the condenser at 55 or we could run it at 51. Now, if we targeting 51 we know for ourselves that were designing a highly efficient system and then be prepared for a condenser that will have a higher cost. So, we make that assumption. So, we make one of the two assumptions, let us say we make an assumption that we want to run at 55 right. Then with 55 with 2 degrees sub cooling or 4 degrees sub cooling an assumption of that nature, we can come to about understanding on where we will be on this pressure enthalpy diagram.

(Refer Slide Time: 15:13)

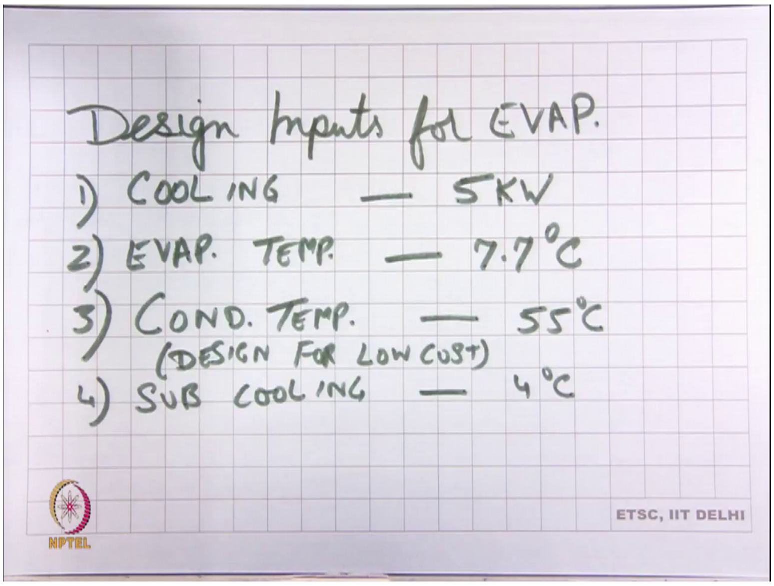


So, if we know the condensing temperature, we know the condensing pressure saturation conditions. Then we would define the sub cooling between 2 and 4, let us say 4. So, if it is 55 and 4, the temperature of refrigerant would be 51 right simple. And, we make an assumption that there are no pressure drops right be in the liquid line or in the evaporator. So, then the expansion device has on its inlet a pressure corresponding to 55 degrees condensing and then here we made an assumption of 7.7 evaporating.

So, corresponding to that for R22 we will have a pressure equal to 77 psi gauge and on this side it will be 300 psi gauge. So, the difference in the two would allow us to select the expansion valve for a cooling capacity of 5 kilowatt. We would put in the margins that we expect based on higher temperatures and lower temperatures lower ambient air temperatures. So, we would have come to the design of an evaporator coil knowing an expansion valve that will feed it sufficiently over a certain range.

Is this clear about making an assumption on sub cooling having a pressure? And then, a delta p across the expansion valve allowing us to select the expansion valve and, then we being prepared to do an evaporator coil design. Yes, thank you. So, now that we have all this yeah, before I move away from the slide let us also keep in mind that we will be targeting a certain superheat in the evaporator. So, while this may not come as an explicit design input, we will take note of it because you want to protect the compressor.

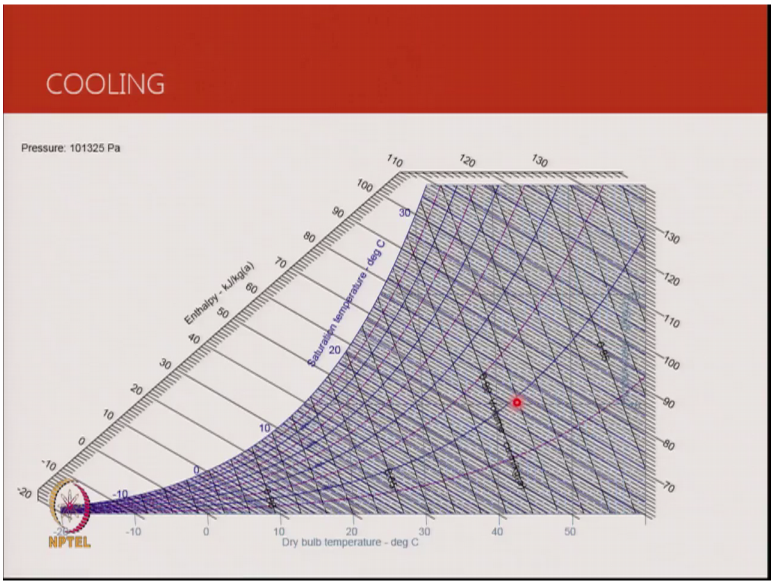
(Refer Slide Time: 17:07)



So, we said 5 kilowatt, evaporating temperature was it 7.7 he said and then we say we are designing for cost. So, we will use a condensing temperature which is little on the higher side. So, this is enough for us to choose an expansion valve. And, then come to an evaporator where we would be having an entering air entering refrigerant condition corresponding to 4 on the slide.

And, we will have an entering air temperature which will be a combination of dry bulb and wet bulb which will be corresponding to the temperature we want to maintain. And, if you have being very precise we could add some temperature gain in the ducts. So, let us say we maintaining 25, it could be that there will be a 2 degree temperature rise in the ducts and we could add that.

(Refer Slide Time: 18:53)



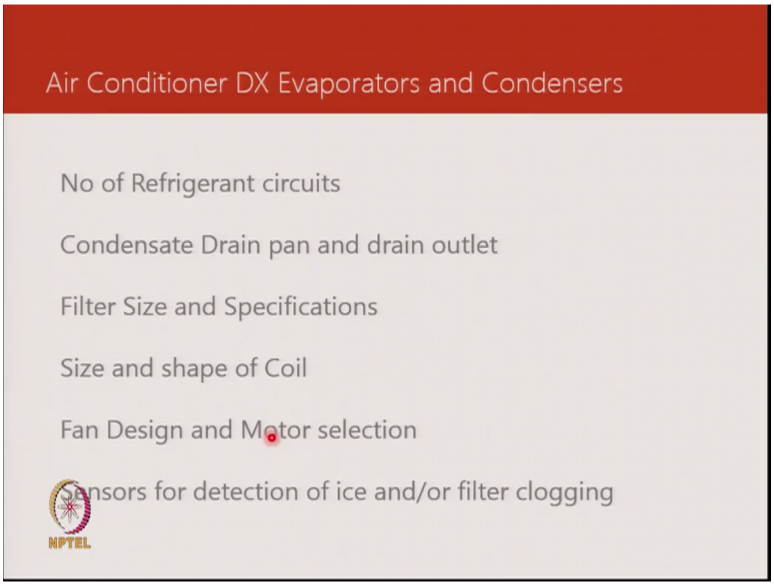
This I have included in my slides because, in an earlier lecture I was trying to demonstrate what happens to the air properties. So, if you look at where we are in terms of comfort or temperature of around 25 and relative humidity of 50 percent will be somewhere here. And, we go in to have an evaporator operating at 7.7.

So, there will be a combination of two processes that will happen in the evaporator: one is because of the delta t between air and the refrigerator, the evaporator coils the evaporator coil. So, we can assume that the evaporator coil will be at a certain temperature which is 7.7, that will drive heat transfer that is sensible heat transfer. At the same time there was also going to happen condensation because, the temperature is 7.7 will usually be below the dew point of room air yeah.

So, what drives that? So, moisture condensation would be driven by the property of air which is corresponding to the moisture content which is expressed as grams per kg of dry air. So, corresponding to 25 and 50 percent which will be somewhere here, we would have a certain w. And, then we would have a certain w corresponding to 7.7 which is the temperature we are assuming the evaporator coil to be at.

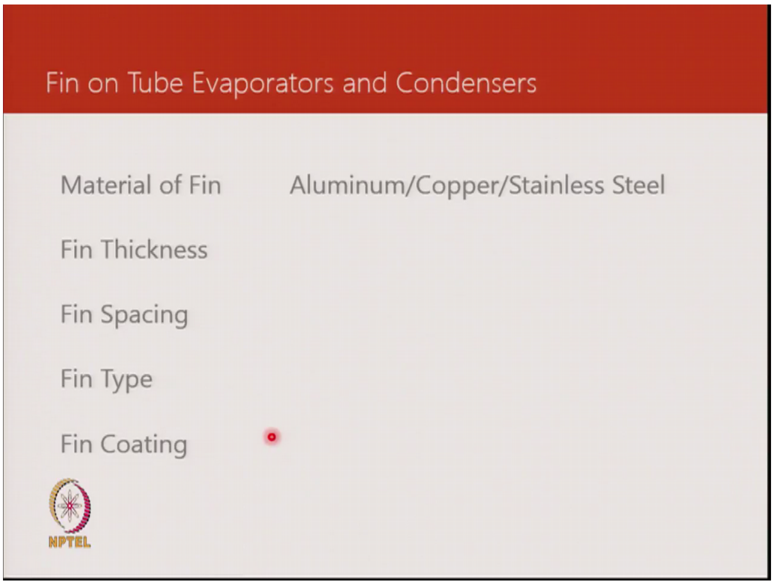
So, this will give us that the slope in this line will give us a combination of the latent load and the sensible load. And, the difference between the two humidities well drive the rate of condensation, look at what are the key drivers. So, humidity difference and the difference in moisture content and temperature difference will be the driving factors for design of coils.

(Refer Slide Time: 20:45)



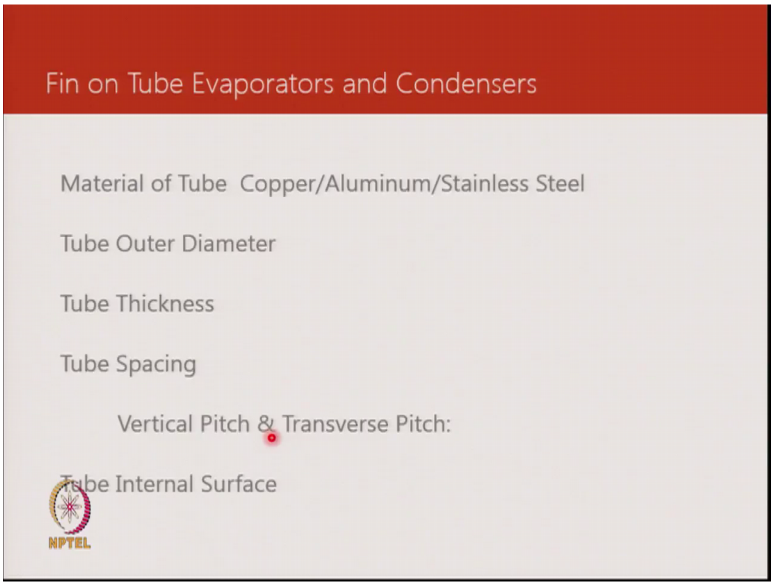
And then now, what are the thing that we are having as a set of variables that we can play with. So, I have included some things over here.

(Refer Slide Time: 20:59)



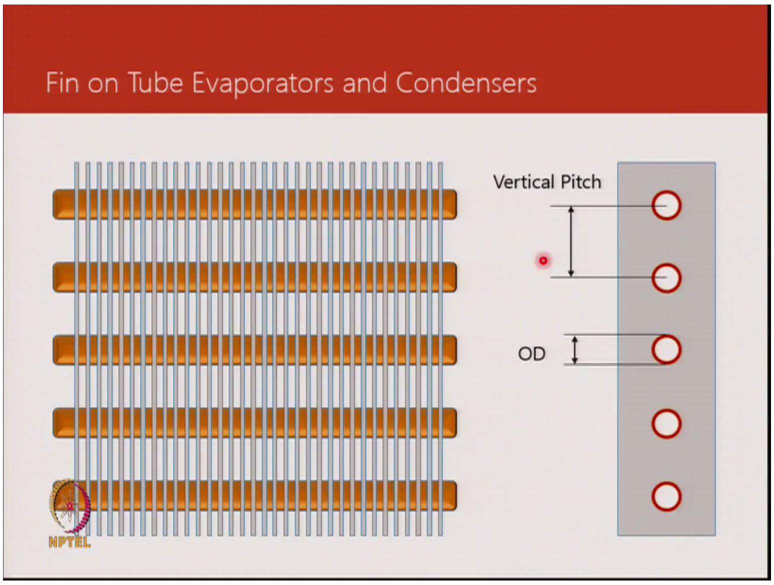
So, for fin and tube and these are the things that we need to define for the target heat transfer and for the assumption that we made. So, material of the fin, fin thickness, fin spacing, fin type, fin coating.

(Refer Slide Time: 21:09)



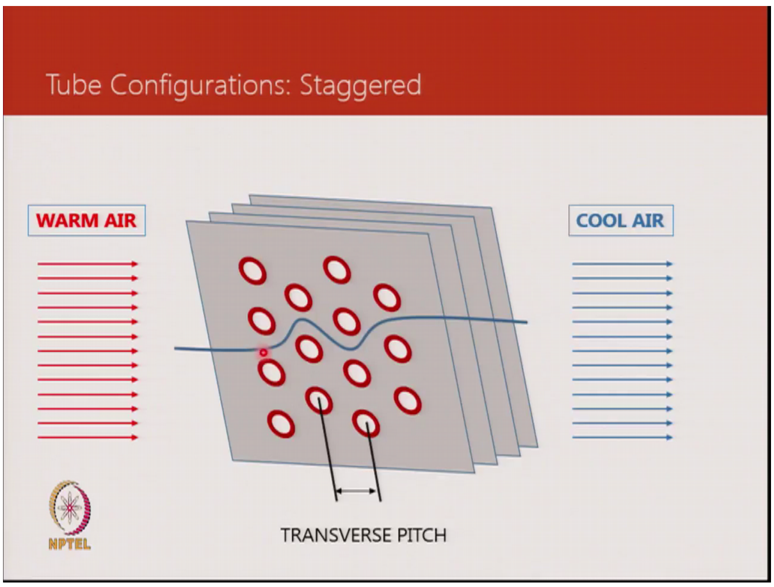
And, then the copper or aluminium tube that you going to use or is it going to be some other material. In some special cases we might use stainless steel and that is primarily for corrosion resistance. It could typically we required in marine environments or defence applications, where a higher level of robustness is preferred in favour of low costs. So, they are not really concerned about price, you know the concerned about reliability. Then, we need to define the vertical and transverse pitch. So, to get a whole idea and a whole world around what these fin on tube heat exchanges are, I will try and look at some of these slides.

(Refer Slide Time: 21:47)



So, what you see in copper colour is essentially the copper tube and what you see in gray are the fins. So, the variables that we looking to define are a combination of the number of tubes: the OD of the tube, the vertical pitch of the tube.

(Refer Slide Time: 22:05)



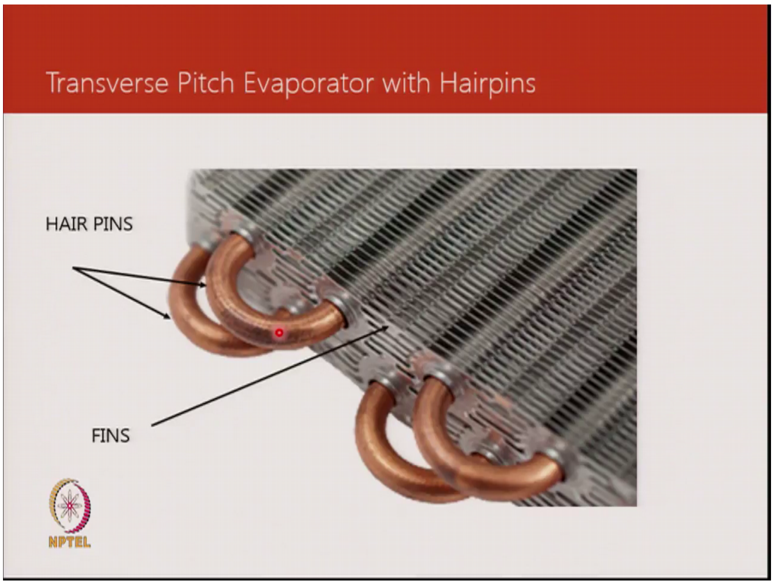
And, in an evaporator what is going to happen is warm air is is going to come in contact with cold surface of the fin and the tubes and leave air temperature, which will be around 12 degree centigrade and the relative humidity in the region of 95 percent because, there is condensation that has happened. Now, how do we maximize heat transfer? As you can see this is a simple fin on tube construction, where the tubes are in line. So, this tube is in the flow path. So, it is in the shadow of the earlier tube.

So, we would see refrigerant just some of the air, sorry some of the air just flow through like this while, the refrigerant is flowing through all these tubes. Now, the task we have is what would be the optimum combination. Diameter, thickness, thickness of the fin, placement of the tubes, distance from each other so, that we are able to get optimum value for what we invest in a heat exchanger. And, to keep an eye on costs what you could remember is that copper being an expensive material, the copper tube or if you want to use aluminium tube the length of the tube used is going to be one variable.

So, when we looking at face area, we are looking at essentially a certain dimension which is the fined area, the length of the fined area of the heat exchanger and the height which would mean the number of tubes in the path of air flow. So, this would constitute the height of the coil and this dimension which should be the full length of the heat exchanger would constitute the fin length or length between tube sheets. These are two terminologies that I have used, you know window air condition of example you could have about half a meter of coil width.

And, somewhere in the region of 16 tubes vertically is for you to have a certain sense of 5 kilowatt coil and the pitch there is vertical is 1 inch. So, 25.4 and the tube diameter 3 by 8, then you will look at for purposes of improving heat transfer we look at a staggered configuration. So, instead of tubes being right in front of each other they are alternate and we are making sure that air comes in greater contact and there is a penalty air and the penalty air is the pressure drop. So, the air side pressure drop will go up maybe you will have more heat transfer.

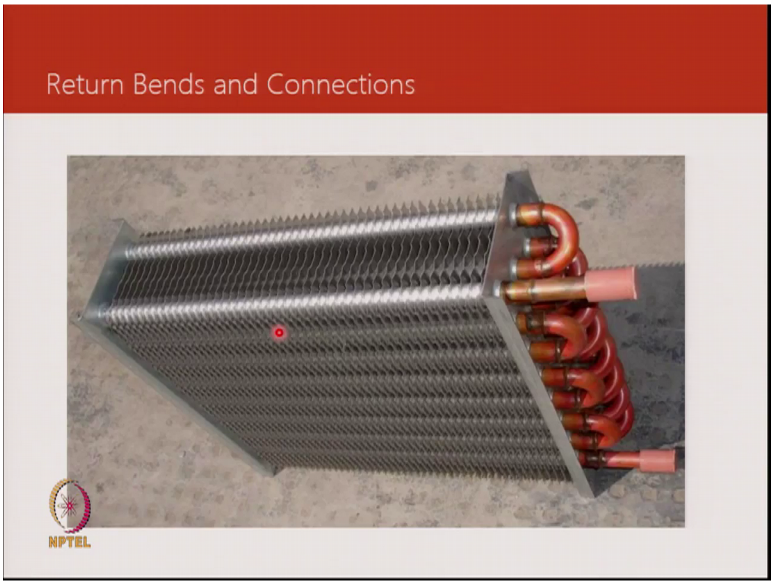
(Refer Slide Time: 24:47)



And, now from these diagrams if you want to look at physical coil, this is what it is going to look like. Right, now it has not been fully manufactured. So, we can see the fins and then one of the tasks we have is to define the gap between the fins, where we are going 2 millimetres, 5 millimetres. Conventional aspect is to define the number of fins in 1 inch; it is also finding to define the distance between two fins depending on what you are comfortable with. And, then these tubes are referred to as hair pins because, they manufactured in a way that a long tube is bent folded automatically.

And, allows for eliminating connectors on one end of the heat exchanger. What we need to be aware of is that between choices for a longer heat exchanger versus a shorter one with the greater height, the hair pins will add to the refrigerant side pressure drop. So, so in making our designs we must just keep that factor in mind not to make the heat exchanger too small, in terms of the length between tube sheets and make it too high because, you would spend some of the power without any gain; in overcoming the pressure drop across the happens.

(Refer Slide Time: 26:01)



Now, once we manufacture it, this is what will look like. So, the other end is whether hair pins are and here we have the fins. Now, this fin spacing is much higher than what we saw in the previous slide and that was a more like on mini split application whereas, this is more of a refrigerator kind of application or design which is meant for low pressure drop. So, here these parts are referred to as return bend and in the manufacturing process, after we manufacture the coil they are brazed in an automatic process which uses multiple guns brazing guns in.

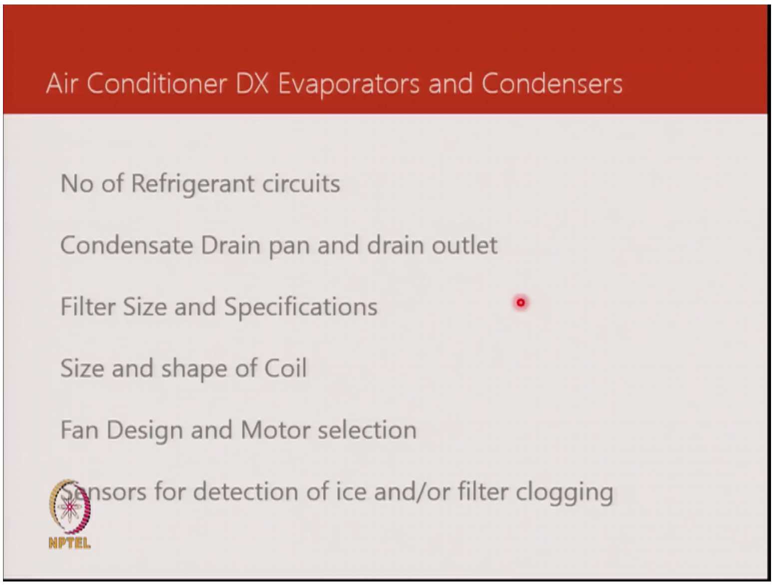
Now, before we go forward we also need to understand how this is manufactured. So, we saw in the previous slide we could just slide in these hair pins and there would not be great solid contact between the hair pin and the fins. So, this is a process of expansion or process use for expansion could be either hydraulic or they could be a bullet used. Or today most coil manufacturers make use of a bullet expansion, which means there is an expander whether which goes through the entire length of the tube and expands it. So, that it is firmly bonded to the aluminium fins and that also allows for adding strength to the heat exchanger.

So, once that is done then we come to brazing the return bends and after that brazing processes completed, then the coil is subjected to some leak testing. And, also on a random basis at a certain frequency burst tests are done to make sure that the coil integrity is intact, we are going to experience leaks or any unfamiliar situation during operation. So, it is not uncommon to perform a burst test once in a month or once in 15 days for a fairly large manufacturing facility; just to make sure that none of the variables have gone to a point where there is a weak tube anywhere.

And, to develop an appreciation of where those weaknesses come up: one is when you bending this hair pin and there is a process used you could thin the outer part of this hair pin. And, that wall thickness reduction could lead to a compromise on the strength that it can withstand. So, if you using it in condensers, we would like to make sure that this does not lead to a burst or a hair pin leak and a consequent loss of performance. Then when we are expanding again there is finally, it is a machine it depends on how reliable and repetitive it is and how well it has maintained. The bullets could cause uneven expansion and to prevent against that again.

So, this becomes like a consolidated test which will point out that the everything going fine, no need to worry keep producing. Or if we have a failure then we know we need to revisit and adjust parameters so, that the coil meets the spec. Now, I would add to the earlier discussion about the design inputs that we will also have some requirements in the evaporator for managing condensate.

(Refer Slide Time: 29:11)



So, if you going to condense moisture we willing to find a way to drain it; the same time you also want to make sure that while, we are condensing moisture we are not carrying it through into the supply air into the occupied space. So, one thing we addressed by design; so, if we go to keep the phase velocity on the coil in the region of 2.5 metre per second, we can be sure that there will be no condensate carryover. And, then the angle at which the coil is positioned also determines how well the condensate flows into the drain pan and then we would design a drain pan. And, in certain units which are a cassette type of units which are installed in the ceiling, it becomes a challenge to drain the condensate and therefore, pumps are typically put in.

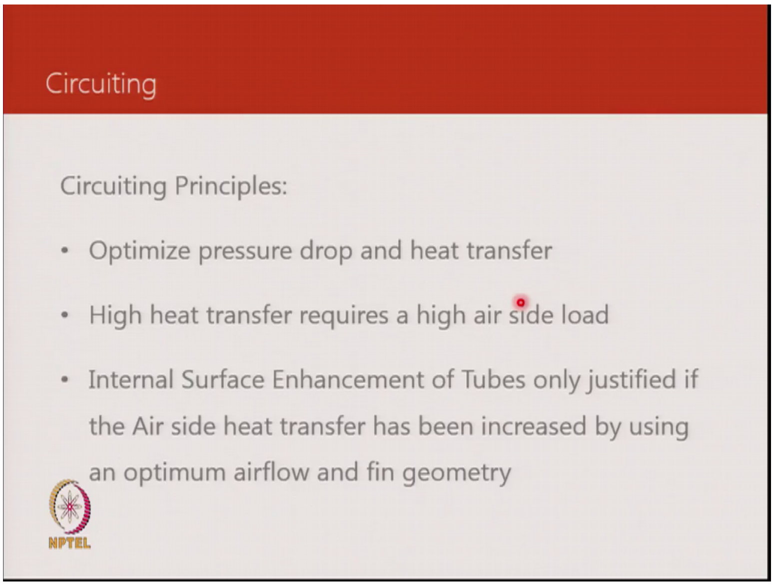
So, there is a condensate drain pump which is coupled to a sensor and it would ensure at all moistures thrown out into a drain. Then, while we are looking at coils we will eventually also need to look at designing the fan to overcome the pressure drop, the air side pressure drop in the coil and also address delivering the required air flow in the occupied space. So, that needs to be done right, we when we look at a split we have a certain airflow, we can look at a window air conditioner or a chillier or an air handling unit we would need to deliver that.

So, it gets included in the design of the air conditioner, not necessarily the evaporator coil, but there interrelated and for that reason we must keep that in mind. Then in some cases we may want to put in a sensor and that is to protect the compressor or the one the user, if there is any abnormal condition that has come up. What are the normal conditions that will come up? If we have a customer a user using an air conditioner without cleaning the filter, there will come a time when air flow will reduce to maybe 30 percent of what it was designed for or it may even get blocked totally. While, the compressor continues the temperature in the evaporator will begin to drop.

Because, there is nothing to add heat to the refrigerant and in that process it could reach freezing temperatures. So, if that were to happen and if we put in a sensor that detects that, it could alert the user call for service or just clean the filter, whatever that can happen. Another case that happens is that if you have a leak in the refrigerant circuit, a minor leak over a period of time it could lead to a drop in evaporating temperatures. And, since it is minor the compressor would continue to run and run at low evaporating temperatures causing build up of ice. And, again if we put in a sensor there so, that would be helpful.

Now, putting in a sensor also means adding cost and complexity because, then we need to have a controller, we need to have a controller that will trigger a relay. We need to have an LED or a display device that tells us that yes something is wrong, this is this needs to be attended. So, when system is go larger in size, it makes sense to put in all these controls and benefit from the convenience of diagnosing any faults that show up.

(Refer Slide Time: 32:23)

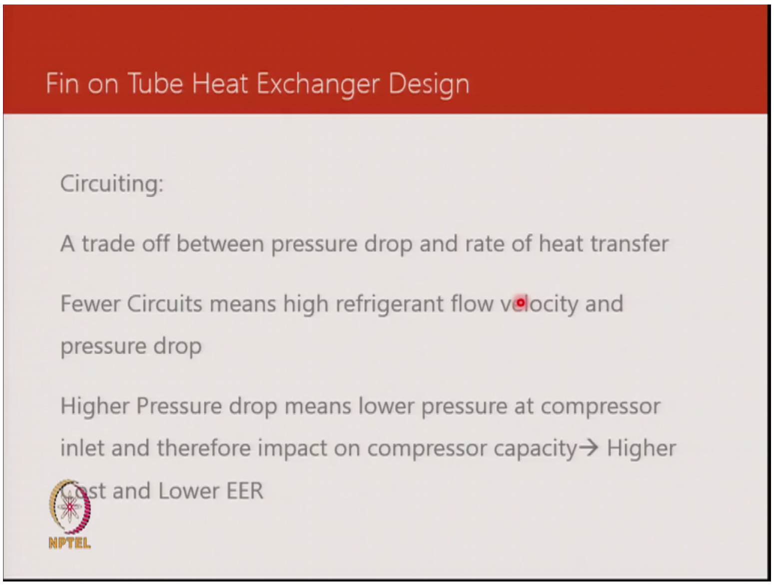


When we looked at the hair pins we also need to define how many circuits. When I say circuits that means, how many parallel refrigerant paths we can put in a coil. So, for a tube diameter of let us say all times one half inch of diameter, which is not in use in smaller systems anymore you would go to 16,000 BTU per hour; which would be about a 1.3 tons are converting it intosay about 8 kilowatts. You could go to 6 to 8 kilowatts per circuit, with 3 by 8 it is fine to go to 0.75 tons per circuit or say about 2.7 kilowatt per circuit.

And, these are thumb rules these are based on experience in the help start with the design which will come to convergence earlier, if you are going to use a program. Or it will also the desired result much better, much quicker with fewer investment and prototyping and alternative designs. So, what else do we need to consider when we are looking at circuiting, is the pressure drop. So, there is a pressure drop in the evaporator and we want to have the right trade off between pressure drop, leading to a drop in performance of the compressor and the benefit we have in terms of a higher heat transfer.

So, these are the two variables that if we if we get into details of developing an optimizing program, then we will manage these two together and then internal surface advancement of tubes would be justified. So, just like we can increase the airside heat transfer coefficient using fins, we could increase the heat transfer coefficient inside the tube using enhanced geometries. Now, I am going to show you some pictures how that is done, but that means, we can again for the same size of the heat exchanger deliver more heat transfer variable. So, these are the variables that we have in our hand, when we were to target delivering 5 kilowatt of cooling using an evaporator.

(Refer Slide Time: 34:31)

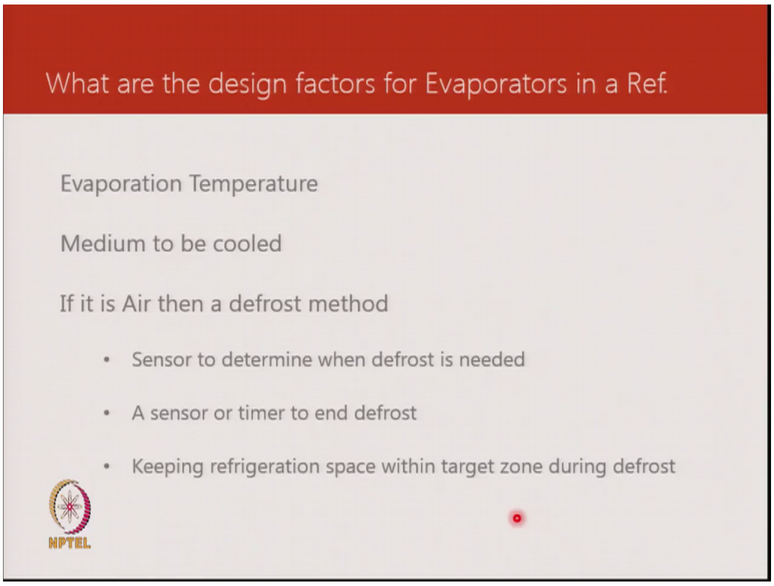


So, another added point is if you are targeting a high EER we would be willing to invest more in the evaporator and then we would select a design with a higher evaporating temperature. Or another point would be, if you looking at cooling some equipment may there is hardly any latent load. So, let us say a computer room cooling or telecom equipment cooling in shelters so, then the sensible heat factor is as high as 0.9. So, in those scenarios it does not make sense to keep the refrigerant temperature in the 7.7 region.

We would bring it more towards 10 degree centigrade, allowing us to benefit from a higher energy efficiency ratio and eliminating investment in latent removal of latent load, which is not there. This we covered another part, we would not it look at is the air distribution over the coil face. So, when you designing the airflow path, air is going to enter the air conditioner through some opening and then there is a blower that is going to draw air over the coil. So, we need to space them in a way that there is a uniform air distribution. When I say uniform it is an ideal, it never really happens in real life. We try to maximize in the evenness and the rest of it would be taken care of by circuiting.

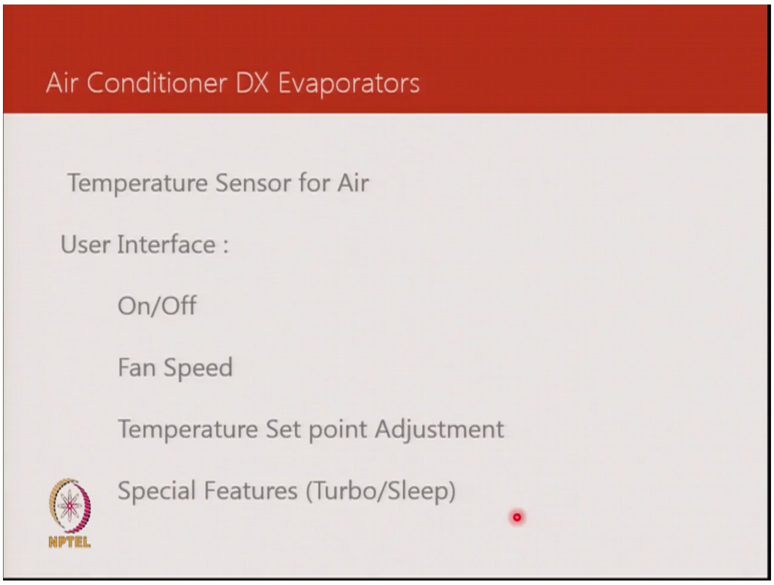
So, if you look at evaporator, these two ends on the top in the bottom would usually be starved of air because of insulation, because of the way it is manufactured there might be a cover, there may be some part of the drain pan. So, one of the ways when you look at circuiting is to add additional tubes in the top and the bottom circuit and equalize the circuiting in the rest of it. And, then make an assumption that yeah air flow in the centre of this heat exchanger is going to be even.

(Refer Slide Time: 36:41)



And, then we also need to keep in mind whether it is an air conditioner or a refrigerator, we need to have a controller that senses the temperature of air and modulates the compressor. So, it could be as simple as relay that is switched on and off or it could be as complex as a variable speed compressor that is modulating and speed adjusting itself to the changes in demand cooling demand.

(Refer Slide Time: 37:15)



Now, we look at controller, we look at user interface and it needs to have an ability to switch the unit on and off. We need to have means of regulating fan speed; we need to have some means of adjusting the temperature and then we could look at some special features. So, there are manufacturers would deliver a unit with a special feature like turbo cooling. You enter a room you want quick cooling, you switch that mode and the fan runs at its highest speed. If the variable speed compressor you will run at the highest speed and give you know quick cooling. And, then you could also have a a feature which is like a feature that reduces the cooling at night when you are sleeping.

Because, the metabolic level comes down so, you can make an estimate you could put in an algorithm which is a timer based algorithm. So, after 2 hours you raise the temperature by 0.5, after another 2 hours you raise it by another 1 degree. And, then the user does not need to intervene by either switching off the AC or changing the set point or covering himself of all that, that is all within the entire scope of the window unit. So, you gone a little beyond the evaporator, but all this are linked to how an evaporator is going to function.