Electronics Enclosures Thermal Issues
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Lecture – 16
Thermal management 1

Hello, allow me to continue. Last time, I left you with the; a paper which described; how cooling is done in a rack and it was early mobile telephone rack. It is slightly different from the cell phone thing, because when Jensen made that paper in 1972, probably they so called radio telephone was a little not as ubiquity as now. So, that was from there, since then things have come a long way and as I have told you about earlier the academic lot of analysis is; there most of them know tremendous amount of analysis and in the case of the what you call our actual industry, practices have hired professionals, who have had this experience, I would not call it academic Coronoid and a lot of it has not been freely available in the public domain.

So, it is worthwhile reading the public domain material that is available firsthand, if my; if I read it and repeat it again I may have a little bias. So, I am avoiding it and kindly I mean follow this is from a company called engineered airflow.

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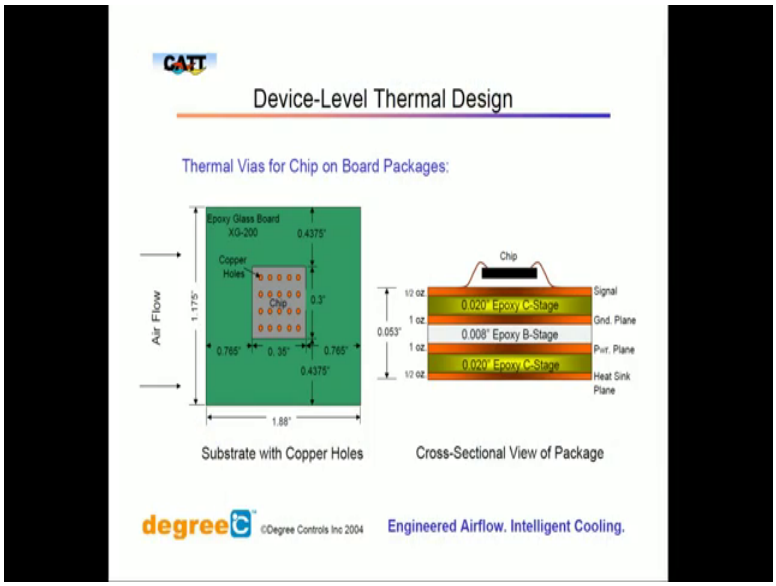

So, one of the first things is saying thermal, you also start at the device level. So, we have this; what are called thermal wires; what a thermal wire does is it from top to bottom, they have you know they can they put copper which allows us to conduct them.

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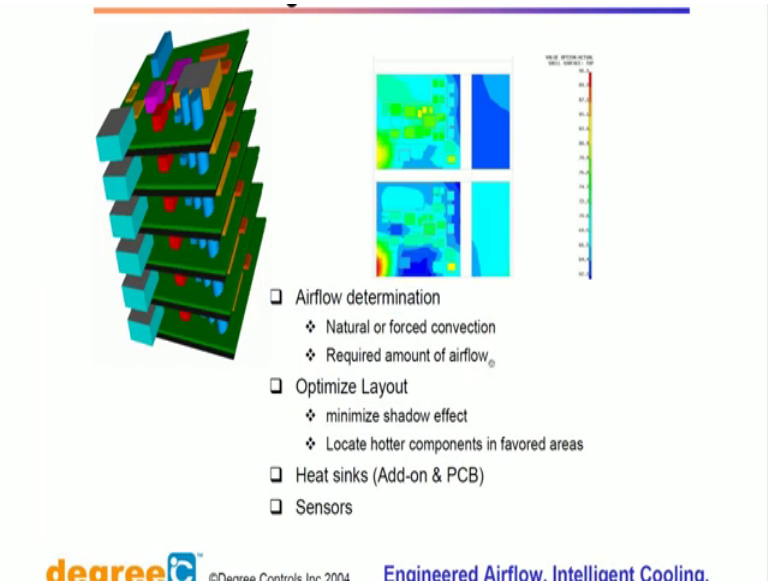

So, we have this very interesting nothing note saying first of all natural or forced convection you decide on it. Secondly, you also decide on required amount of airflow as I have told you in one of my earlier lectures, it is not as simple as saying you give this necessary thing, because it does not like a an experimental setup in an experimental setup, you will be able to pick things and you know decide, what are due in this case, even if you see a simple particular stacked rack like this, you will notice that there is a lot of shadowing from various things.

It may be loosely you know; top thing about saying that it blocks air flow which happens all the time. So, you have here at this extreme left here have several; what do you call, you have seen this no very large components and then you have certain capacitors and then, I do not know whether these are relays or you know heat conducting, I mean heat generating components and so on.

All these impaired effective heat transfer which will come to a very important issue that is about optimizing the layout, it looks like even before you attempt any analysis a preliminary layout is needed and sometimes, it finds counterintuitive if you put the hottest components at the beginning of the airflow, will the cold air enters, it looks that

they get the maximum what I call advantage, but the disadvantage is that they air in the trailing path is likely to be heated up no; that may be exceeding the inlet requirements were the next component in one way, it is a little intuitive and then counterintuitive. So, then how do we deal with it that is where you are not called design thinking comes in saying try various alternatives?

I have given you an example earlier saying we had a rack of so many; I think totally 6 sub racks and then the only thing, we could do is allow inlet air after the third sub rack and then try to exhaust the air that is already pre warmed up and we have taken it and it works like that we see here locate hotter components in favorable areas that is what just now talking about second is heat sinks, saying where all would you put them and finally, important thing we are coming to here is you need to look at sensors to see, how well things work, this you have noticed happens in already what I call highly optimized the aerobic waiters pc.

So, you notice that the chip itself no, probably has a way of measuring its temperature itself and then that is given to a fan and the fan can run it to speeds and why not the higher speed all the time when a nuisance is the noise they noises so ridiculous that you cannot afford to keep the fan running at all the speeds.

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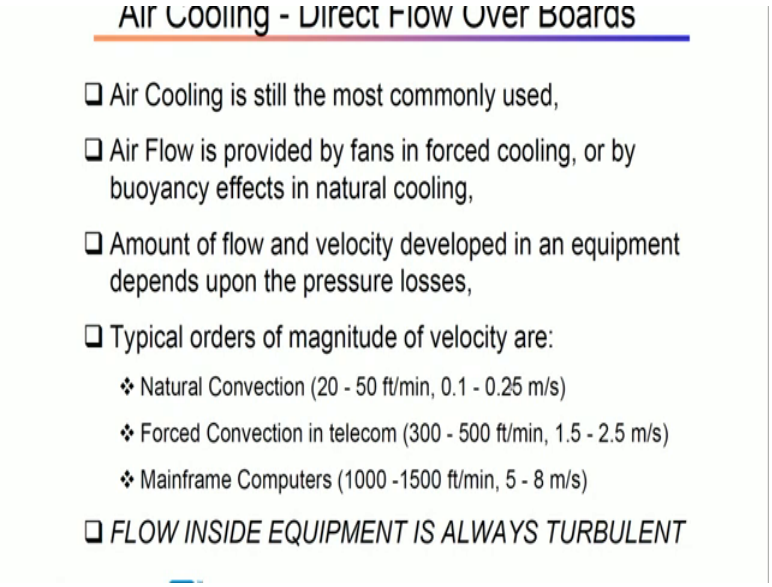

So, you can I will now see air flow commonly used provided by fans and forced cooling or by buoyancy effects unnatural amount of flow and developed in equipment depends

upon the pressure losses, this seems to be most difficult to estimate its easy you have a box and then you have a inlet and you have an outlet and then the just like, I would do in any other fluid control there is some idea of the system resistance, but in our case, we also have lot of blockages because of the component.

So, loosely, we can estimate what is the total of area if you have a cross sectional area I imagine you know this much of a cross sectional area and then we can. So, if I put it like this if I have this much of a cross sectional area we have various components and all that you can estimate know, what is the free area that is required compared to the fan inlet and then you have this free area and then it goes out easy to understand and just like you would do in plumbing you can also have certain estimates about length of the path, path length also is an estimate in the case of plumbing, you will notice that the requirement of the pump, the water pump determines on two things, one is the head that is required, another is the length of pipe.

So, you is this much length of pipe and you know how much of resistance it gives per running meter is enough, is it not and then next is several places, you have features like elbows, walls and all that nowhere invariably you have a small discharge coefficient. So, I have had all this discharge coefficient and if you add all the you know pressure drop across the length and you know your requirements of how much of fluid you want on the other side its possible for you to estimate the size of the pump it is a little like that which is absolutely no problem the place; where I have taken this from; obviously, they use both.

So, we have about 5 to 8 meters per second in computers and then in this case, they have 1 and half to 2.5 meters in telecom natural convection comes to typically 0.12, only 0.25 meters per second the good or bad, it is for us to decide my choice is if there is a way of your managing with natural convection design everything which natural convection, but give a little bit of aid using have loose fans are you know you have a little bit of assisted you know circulation and so on, then you have the mainframe computers mainframe computer has; obviously, noticed very high 8 meters per second and all that it is a it is a lot of sorry a lot of blessed. So, if you remember in one of the earlier slides which have shown from Sean Arthur- saying it looks like beyond this area of 5, actually, they have given 6, the rate at which things come down.

But equal varies drastically so; obviously, somebody has done the actual measurement previous slide talks to you about sensors related to sensor says how do you now take those sensors and use other preventive action saying can you make the whole circular design go little cooler.

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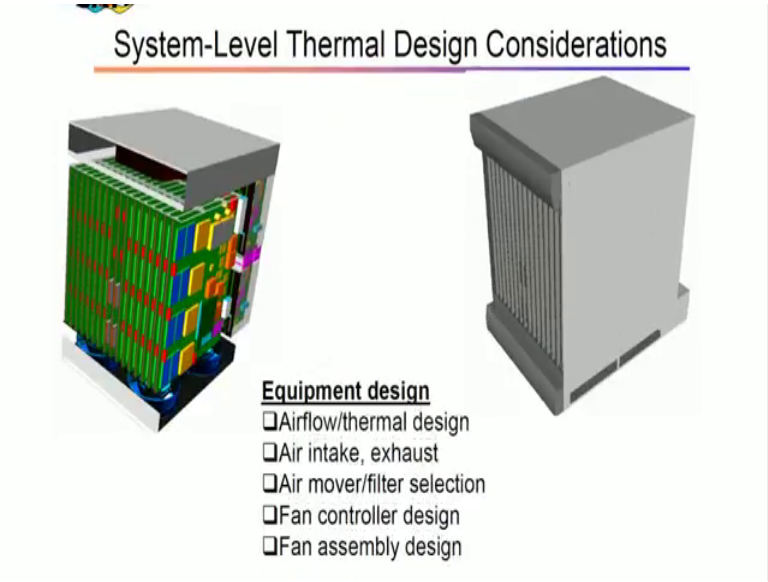

So, we have here. So, air flow air intake and exhaust air mover fan controller fan assembly, you have seen this no air intake and exhaust, it looks very simple, it looks very simple you pick there from the bottom and then blow it on top, or you take it at various stages.

If you remember, I have remarked you earlier saying you see here very conveniently you can say you have these four openings here at the bottom you see the blue colored thing is the opening you are trying to take it out and then at the top they have made a; some way of what I call exhausting things. So, anything which you keep close to the ground and whether you like it or not there is dust. So, it also acts like a very good vacuum cleaner and the more the velocity is or even if a low velocity of the more the pressure build up a is chances are these things know you will start picking up dust from outside.

So, where do you take the intake and where you exhausted do you directly send it out it looks over quite nice, if you can somehow no exhaust it directly on top, but you still have the problem of dripping water and things falling from the top if condensation and all takes place; obviously, a smooth channel is not easy to establish. So, invariably you end

up with having to exhausts them on the sides are at the back in the case know it this is probably the rare of the equipment they are picking all there and then blowing it the rare of the equipment so; obviously, location of air intake and exhaust is critical then we come to the actual device which moves there do loosely we call it a fan. So, you have axle you have a tubular to tubeaxial, then you have you know externally mounted fans with air filtering and something which comes here is filter selection.

So, we have seen often one of the thinks that seem to happen is filters get clogged. So, is there a way of having a filter which two things first of all it should not give a pressure drop straight away at the time of design itself pressure drop should not end then over the time it should not increase in pressure as it selects? So, we are all since we are all automobile rather know we have got used a little bit of automobile all of you I am sure have come across the air filter inside your car or a car motorbike. So, first thing you will the suspect is probably the air filter take it out and dust it off or better still you can probably pressure clean it and so on.

But filters are now air about as; what do you call as sophisticated as anybody else. So, one of them is you have a cascaded filter from my point from the right side that is where the air is coming in and here it is exactly, I mean exhausting itself a cascading filter typically has something which is a coarse filter on the hair inlet side in between the body of the filter is there and the last is the fine filter.

So, what they do is 1 or 2 of them usually the coarse filter can easily be dusted off and maybe depending on the construction of the body main filter that also can be probably you know you can disseminated nesterov plast fine filter is social discarded. So, this is typically cassette filters which specialty companies do, but all this leads to tremendous pressure drop.

So, next best thing is can we take that inlet or something have a bellows like thing, but made of some material which is loosely spaced, but can be coated with a gummy liquid typically. So, there are filters which have a corrugated construction made of a mesh and then they will give you a spray probably, it is a little viscous what you call oil like thing and then you spray it, evenly, let it rest saturate does not do and then when you put it back into the equipment as the air comes all the dust gets trapped there.

Now, comes the important part if you have a sensor two sensors are required one is pressure drop sensor. So, on the exit point if you put a sensor which shows you the pressure it knows that a lot of pressure is lost. Secondly, ultimate thing is if you have somewhere here, imagine somewhere here you have a hot air sensor a temperature sensor. So, the moment temperature is getting more you know there more heat is being generated or air flow is not sufficient and if you have a flow sensor here somewhere here the flow sensor can directly tell you two things if you have a pressure sensor it will tell you whether the pressure is low another is if you have a flow sensor it will tell you whether the flow is slow, it is a larger racks and you know where you can effort to have this all of these things are used together.

So, you have a wind switch then you have an extended pressure sensor and then here you have a temperature sensor usually something called a curies switch is there, there is a curie point what you called and I am sorry there is a magnet where the curie point is adjusted in a critical thing, if something exceeds around 80 degrees centigrade automatically it changes state it loses its magnetic field. So, that whole thing is probably put on a reed you have seen the glass reeds beyond a certain temperature that reed that you know either opens or closes and then that is an indication that there is something wrong in it.

So, it is a little bit of time is given and then you can do it. So, this is where you have this something no very critical thing called the fan controller design, as I have mentioned to you earlier you cannot effort to have a fan which keeps blowing a lot of air continuously. So, two problems it will pick dust second thing is a fans are noisy absolutely noisy while in isolation if you keep something in place in a test chamber preferably an anechoic chamber you cannot even hear this sound, but the moment you keep several of them and you know keep them in a narrow area and then you expect people to work there you will notice that it becomes very loud then related to fan controllers.

If an assembly saying how do you make the fan assembly different types of fans and so, on are there seen this hear this word I do not know if I have shown you already.

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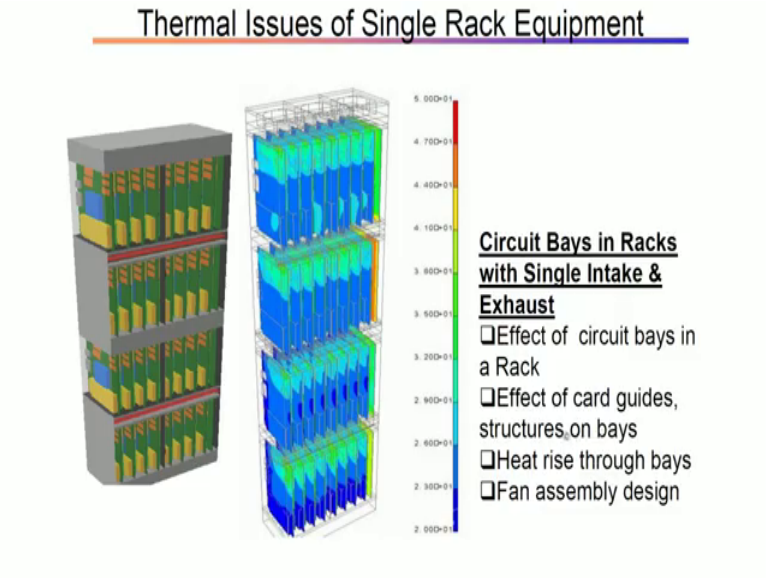

So, you have all this stuff card guide structures circuit base in rack fan assembly design all this no typically, again, I would like to acknowledge that the whole thing is made by degree controls and it is their copyright in 2004 and since this is a educational purpose, I suggest you try to retrieve it again or get in touch with them, in case, you need any more special assistance their application engineers will probably help you since, I do not get these examples easily in the public domain from the published sources, I am trying to use it.

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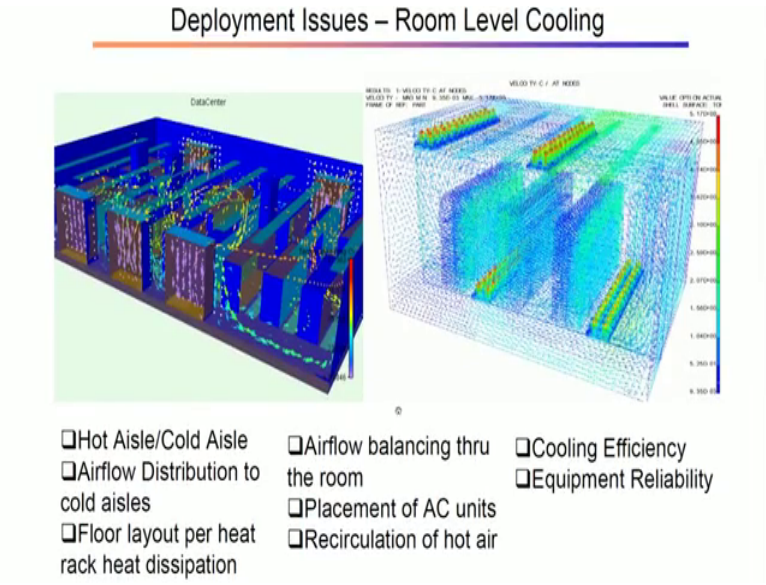

Next, we come to equally important thing have noticed it very rarely, we find such things a room level say very critical thing is it is not just about cooling a printed circuit board by attaching something to the die, finally, it ends up it how do you cool the whole room. So, we have here saying various type of hot air cold air system saying somewhere in the room itself, you have input l means somewhere, you can walk around and there is a hotel is they where the thing takes off. So, it is a little likes the manifold, you have except in the case of the manifold, manifold is fully closed and the variable cross section you can control in the case of a nail, it is an axis where people need to probably walk around.

And then so, we have all these various what we call things very neatly mounted here and we have air flow distribution to the cold air flow layout per heat rack dissipation. So, heat track; what I call heat dissipation floor layout itself, how do you space them and wherever you have communication equipment and such equipment amount of cabling and wiring is very high, you cannot imagine how big, it is if I get a chance, I will try to take a picture from our own, we are a very small place, we do not have many computers, but in spite of aid if you put, I suggest you goead and have a look or just check up on the now the bible the internet bible and you will see that they are very dense.

So, we have here things which are you know inlet into thing and then you see here this is from a data center data centers; obviously, lot of stuff is there, then you have airflow balancing through the room kindly what you call permit me to take a stupid take on these things while our interest is to keep the all this racks and all and I mean the peak temperature of the devices in a reasonable control generally our tendency is to stick a few indoor units. So, called split erases call the; what you call the person who installed this him and then he has his own estimate it says sir you probably require 8 tons, what we call cooling air conditioning unit and even the tonnage they specify as a little problem.

So, take all they bring that following then most important we end up is because it is a more like a firefighting. Now, we handle sticking the evaporator blowers in a convenient place in the wall, because the plumbing for the what we called referenced and plumbing also is equal importance and our bad luck is those units chill the operators people are supposed to do and then independent of those coolers the equipment continues to get hot and then; obviously, nobody wants to be you know like that girl who freezes are some of

the Christmas stories, first thing they do is play with the thermostat and raise the temperature the moment you have, it the whole thing goes.

So, here critical thing is how do you balance the airflow whatever that small low weights, they give in the indoor units may or may not be sufficient. So, it may be you know a more appropriate for you to put small there are fans which probably are about 200 to 250 mm diameter multi directional you put them somewhere and ensure that airflow is balanced throughout the room and placement of the AC units. So, it is not very easy, and then we come to recirculation of the hot air if there becomes hot.

What to do with the hot air in a very cold environment probably it makes sense in a hot environment like us what do we do with it do we exhaust the hot air, then when the inlet air comes from outside you still have problem about it then you have another important thing is; how efficient is your whole cooling system? I am talking from the electronic systems engineering department so; obviously, we take a systems approach saying attempt a top down approach then something very related is to equipment reliability one of the variability of this whole equipment second thing is what happens to the reliability of all the cooling equipment. So, I would not call it a; what we call trial and error or hit and miss you need to just consider it nothing great about it, but considering is more important.

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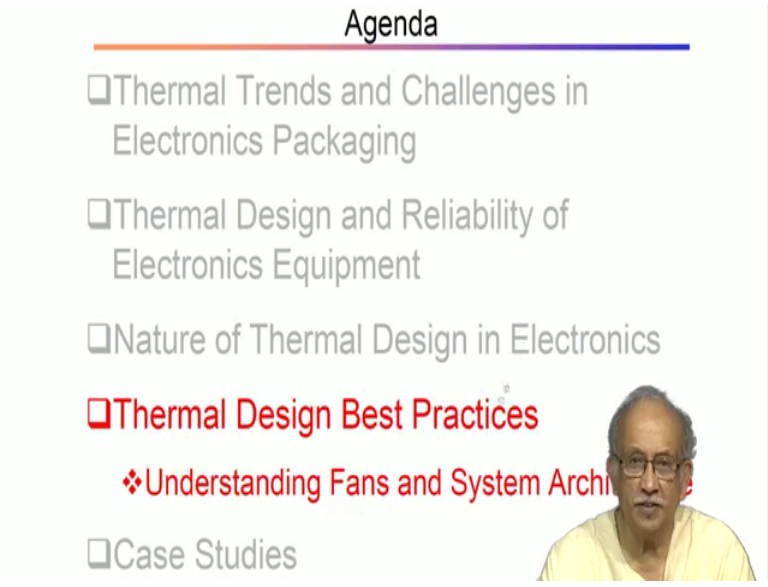

So, we come to important thing saying understanding fans and system architecture. So, next two slides are two or three slides that are quite important you will notice that I will try to go a little forward try to see if I can get the fan model.

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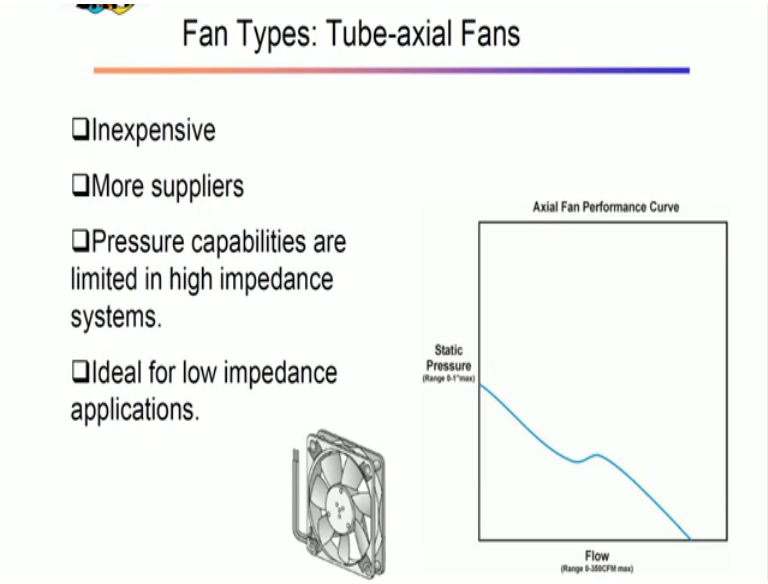

Yeah, I will go back again to where we started this is simple tube axial fans. So, you will see that earlier on in one of the lectures I did mention to you saying there are these fans where they mention the static pressure saying; typically it will be about one inch meaning when no flow is there it gives about 1 inch and they also mention a delivery no saying it gives you know 100 CFM, 200 CFM and all that main attraction is they are inexpensive.

So, you can have a full wall just like you have a video wall you can have a fan wall in which lets say every tile, it is just pasted say about 600-700 millimeters, 600 approx all our what you call false Olympus it is are all those 600 mm and all that know somewhere in the middle maybe, you can have all this there are if you see your cabinets here 19 inch racks and cabinets inside you have those 400 mm by 400 mm trays in which fans can be fixed have some of these things distributed freely wherever you want it is not very costly and depending on your type of operation you can have them working off 230 volts or with a controlled input, if you have a 12 volt input you can externally control the fan speed by reducing the voltage, but main issue is pressure capabilities that limited in high impedance systems, see here if you read the article extreme right of my curve very

drastically the flow comes down extremely drastically, it comes terms there is lightest this thing even if you put those normal heat sinks forget about space between the thing.

We have a little problem when they talk about low impedance it means free flowing you generally things are free flowing it is very easy I mean it is a stupid way of saying you know stick a few things down, but the thing is you can attach a few of these things on the bottom of the rack and then they manage, it no problem. So, it is ideal for low impedance cab pulses are seriously limited in the case of high impedance systems.

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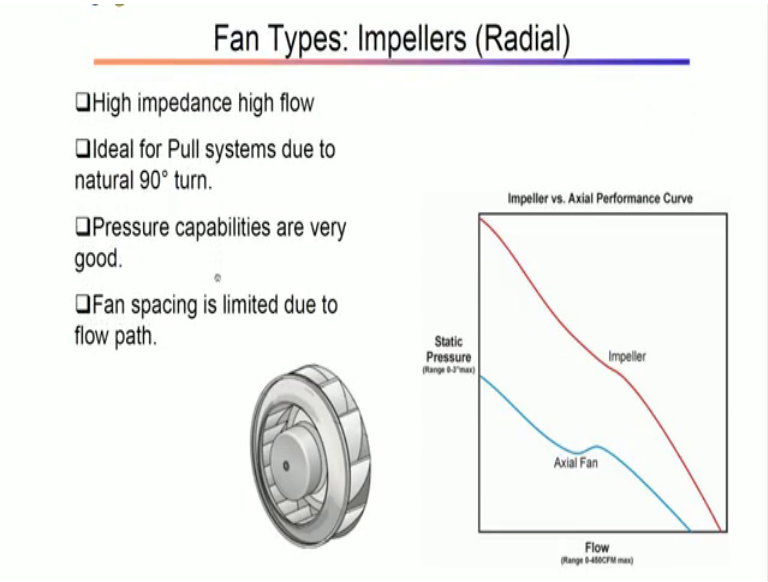

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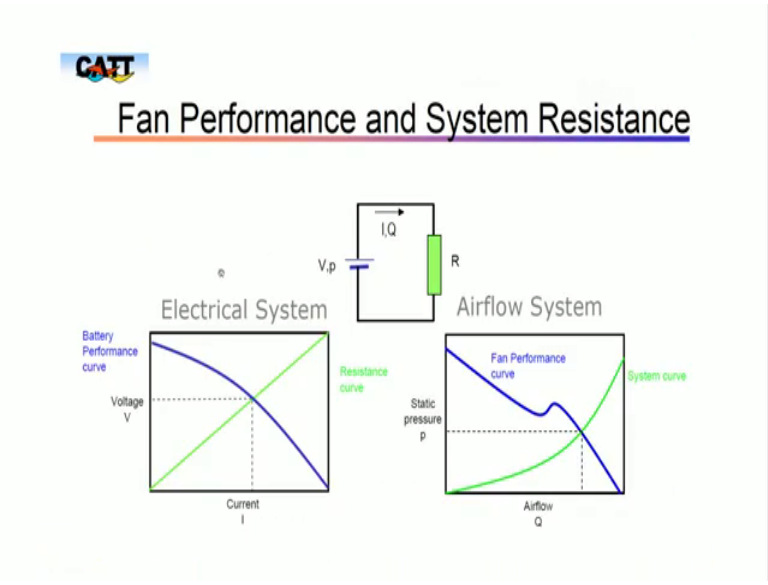

Next, slide talks about different other types of thing compared to axial fan and all that and then actually how does an airflow system work here.