Electronics Enclosures Thermal Issues
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Lecture – 17
Thermal management 2

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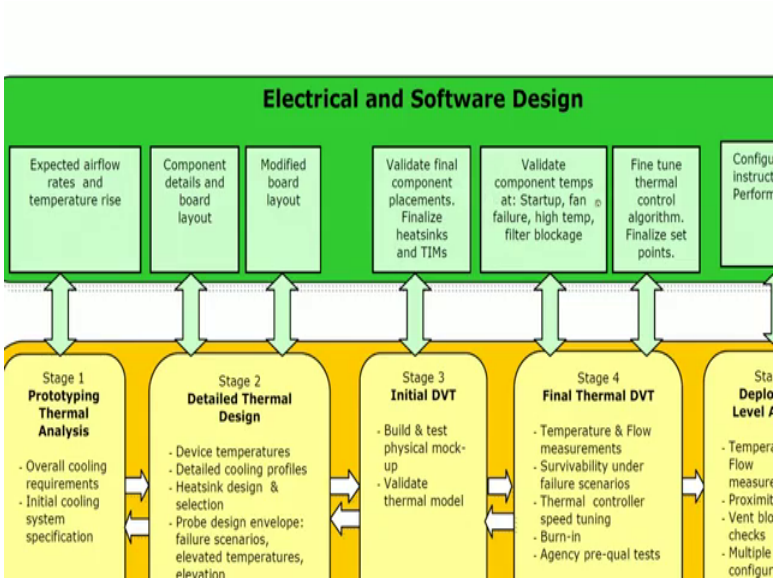

Is it goes left or right, expected airflow component details modified board layout validate component placement component temperature startup fan failure find tune.

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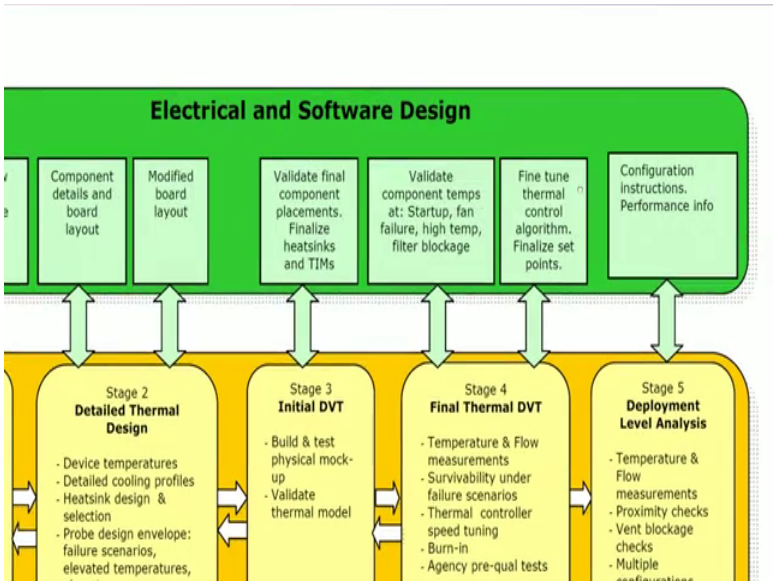

Configuration instructions.

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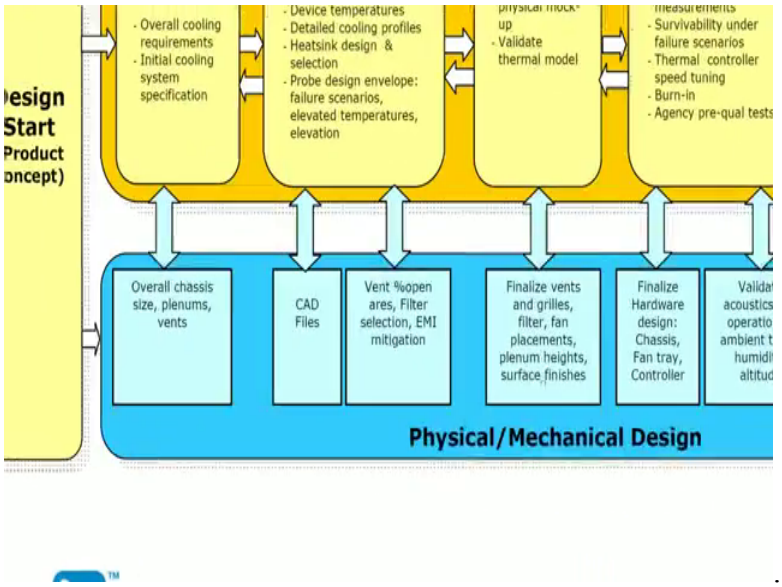

And similarly just like the those things are what do you call here it is as electrical and software, the mechanical point saying overall chassis size plenums and vents plenum means. So, the low pressure areas is called a plenum chamber, where you try to pull things cad files percentage open areas filter selection EMI mitigation very critical here this is what I telling you.

percentage of open areas while the cabinet itself or maybe big meaning you have say some 400 and 50 mm by 400 and 50 mm cross section the actual spacing for the air to move where barely be about 20 percent, again coming back if we have a vent itself maybe, maybe I got a 100 mm high and 400 mm wide and you usually have some griller something about it.

So, that is where the filter comes you cannot ignore a filter even on the outlet side you know why, you don't want to any things to enter it on the wrong thins thing including whether you like it or not several other living beings also live with us. So, and they don't abandon ship is sinking there is no sinking ship which you know these rats abandon they live their because they seem to enjoy chewing through the cables.

Then you see here most important is the mechanical design by which 1 may being what do you call product designer, and talk about physical and mechanical design where we

finalize the vents grilles filter fan placement plenum surface finishers finally, hardware design.

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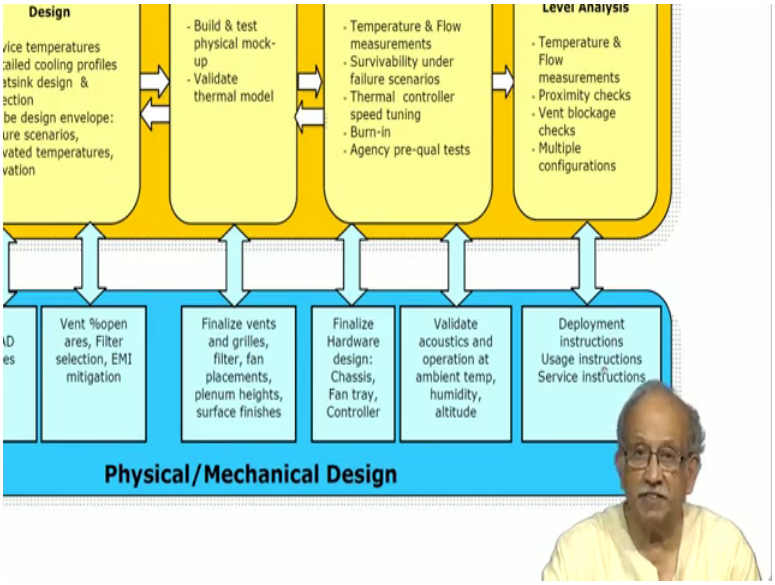

Validate deployment instructions usage and service instructions, very rarely anything is straight away wrong solve this inputs for example, inputs from the top here from the electrical same thing inputs from the bottom.

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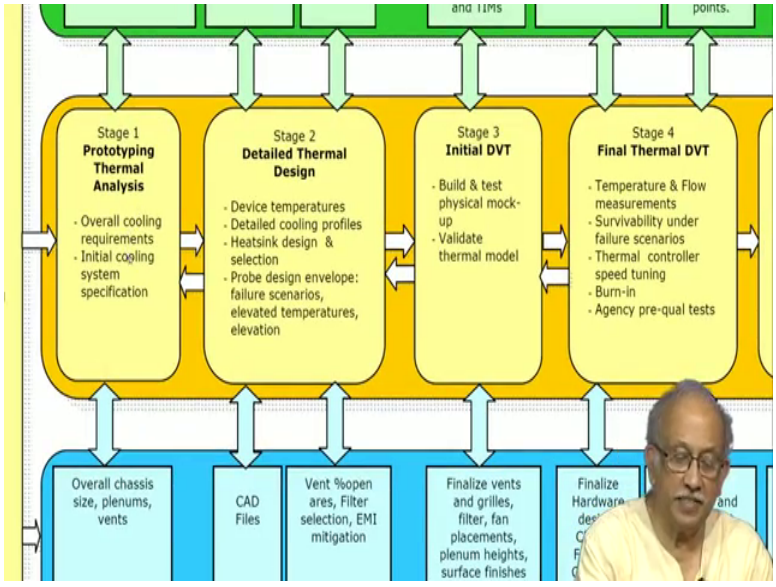

Comes to cooling requirements initial system specification this is your seen prototyping the thermal analysis, then detailed thermal design device temperatures and so on. So,

probe design envelope design envelop failure scenarios elevated temperatures elevations this is critical that's where I told you in case you have a fully closed system 1 failure leads to other.

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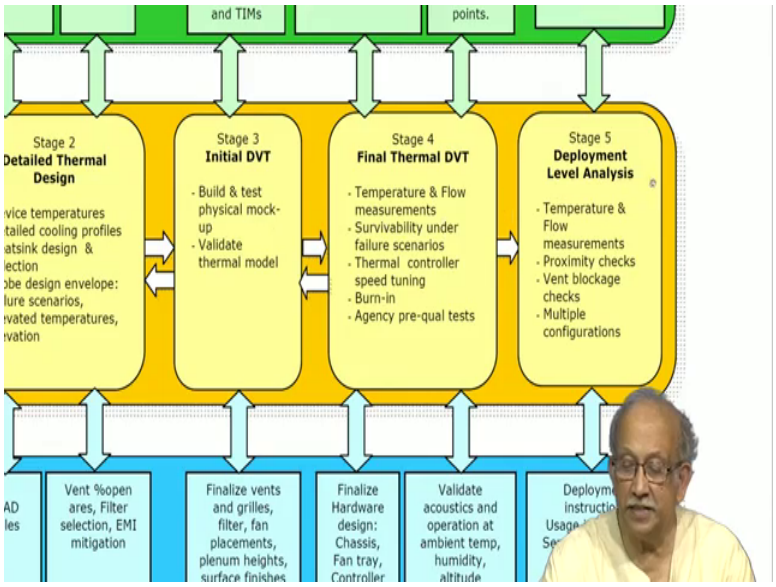

So, we have built and test the physical mockup validate thermal model. So, this design validation of the thermal model also know thermal design validation is very important and final thermal this comes to the thing validate acoustics operation at ambient temperature you are seen this here and altitude. So, acoustics and operation and thermal temperature in flow serve ability and under failure thermal controller burn in agency prequalifying tests these are not easy.

So, I will thank the what do you call the presenters are made this slide I suggest no you kindly go to this, their website engineering air flow degree controls and then maybe you can get in touch with them because where every item they have given reasonable tutorial type things.

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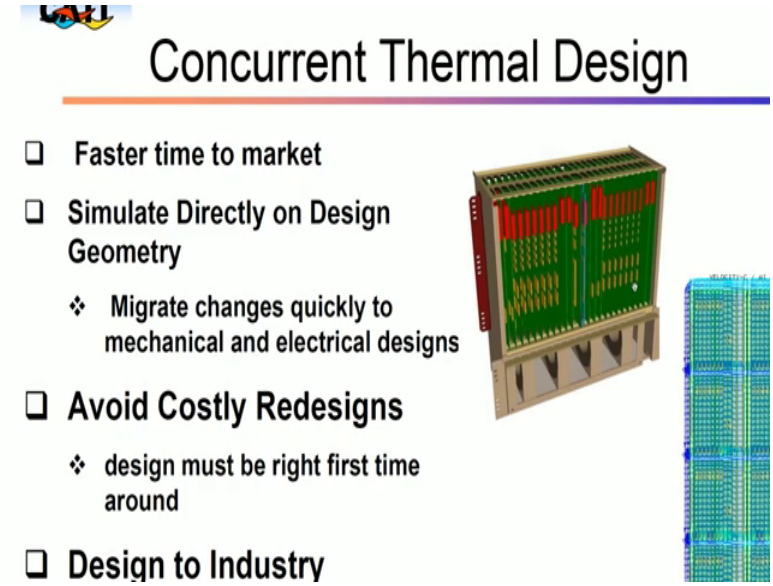

Now, coming back to the next slide, we come to a very, very beautiful concept I do not in actual (Refer Time: 04:32), but then we all of us do like that this is now a very talked about and common thing easier set done saying, why can't we have concurrent design saying talk with the other departments with those people who are not yet familiar with it and then those young stars we have two ways of doing things one is called over the wall design saying somebody who is an expert decides what is good for the circuit board and a reasonable thing he does and make some pcb or makes a circuit design.

And then passes on to the next to person, and the wall here refers to saying you just push it over the wall that person worried about the other thing his field and a eventually it comes to in the end it comes to the user and then suddenly we find that what was started then is not valid any more now so, we have problems.

So, these days instead what people are saying is if you avoid this type of what do you call specializing in that area, and somehow all of you work together saying it's not a about too many cooks spoiling the broth imagine there is a you know cutter who who has to chop the vegetables and put them inside and them imagine there is somebody who is preparing the stock, I do not know how stock is prepared and then there is imagine the kitchen equipment person who makes the kitchen equipment and finally, the master cook all of these have to remember under what conditions the thing is being made.

So, if in the final thing all the people come and keep on no everybody adds you know salt ticking the other fellow hasn't add it you know what happens to this. So, otherwise concurrent thermal is very much valid, saying right from the initial stage people all it's not like our Friday, meetings Friday meetings are still something to be desired because you end up with.

So, many bystanders and passengers a probably come for the snacks. So, the thing is you the person who is you know thinking about it you should know here it looks like a large this whole system no has been designed for a large rack, and then you see here this is sub rack probably is it in that usual.

So, called you know we call it 19 in sub rack, but you see very important thing you see there is a inlet here at the bottom it looks a little like a do not whether its a shadow or a actually it is there its looks like, intentionally they have left a an opening which is a multiple of the use they also looks little like a very old four u normally you have 3 u and most of these the equipment you come across these there are 1 or 2 u 3 u is fairly standard, because the plugins plug in pcb is have been standardized with the euro con just typically 100 mm high, if you have a 100 mm high by 150 160 mm depth.

You end up with a 3 u, so, usually it is very easy for us to add a inlet from the other side same thing in reverse you know. So, you have already this card and then these look like card pullers it is a card lock you open it and card pullers. And then we end up with the beautiful you have seen here you have air inlet and then air is going up and then they very conveniently maybe due to simulation.

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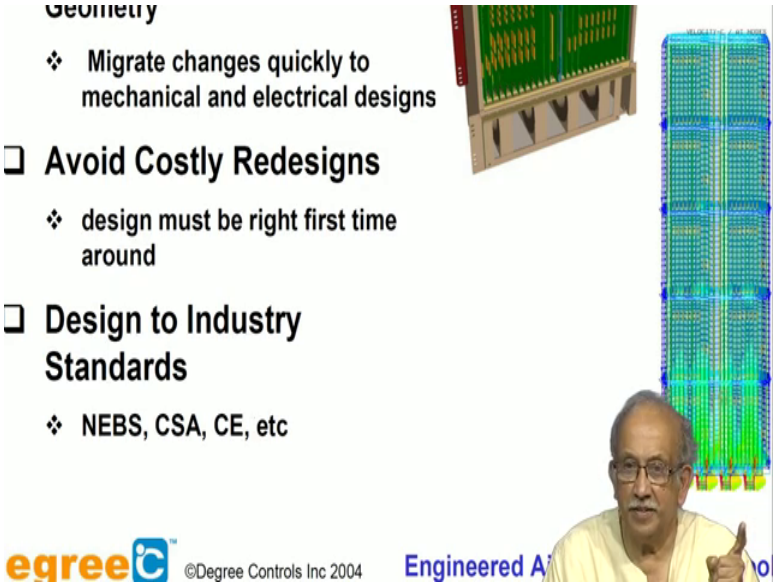

No it just shows how well you know everything is cooled in blue this you have heard I need not tell faster time, because you know avoid you know costly re designs, directly on design geometry saying you fix up an a design geometry.

So, parallel is somebody works on the both the electrical, especial electrical parasitic it looks like if you look at the whole thing the well understood part is a circuit design even you have analogue digital mixed mode analysis available at the circuit designs stage.

But what is even the next level in the board design level also no some part of you know thing is can be managed, but the moment it goes into a larger system, we have little problem it is not as it surmountable remember its working, my phone net very you know fortune moments my phone works I don't want it ring I am sure it will ring 1 of these thing that very fact shows that the tremendous amount of support from this is been done well, except that they have achieved this level after a little bit of having to do re designs most of the things what you have in place that probably that third time around things are done.

Even now occasionally you see for somebody taking what do you call a pedestal fan and trying to cool things, it is like over here in the drop you never see a big truck, usually they remove the there is a bonnet portion and then there is a small slider they remove it they run it in the open condition. Even if it blocks the driver drivers what do you call

immediate view will be reduced even then that is only way to run large trucks under our oppressive heat for us.

If we go on tar roads and those thermals and all that ambient just at the input may reach beyond 45 degrees and I have known places where it is a little higher also. So, redesigns can be avoided design 2 more important is we have all this. various standards enema and dollar electrical manufacturer then you have the drain standards then you have the various types of I do not know the expansion, but various industry standards where things are automatically inter changeable, if something fails somebody else is take over it is nothing to do with the contract it is about maintaining.

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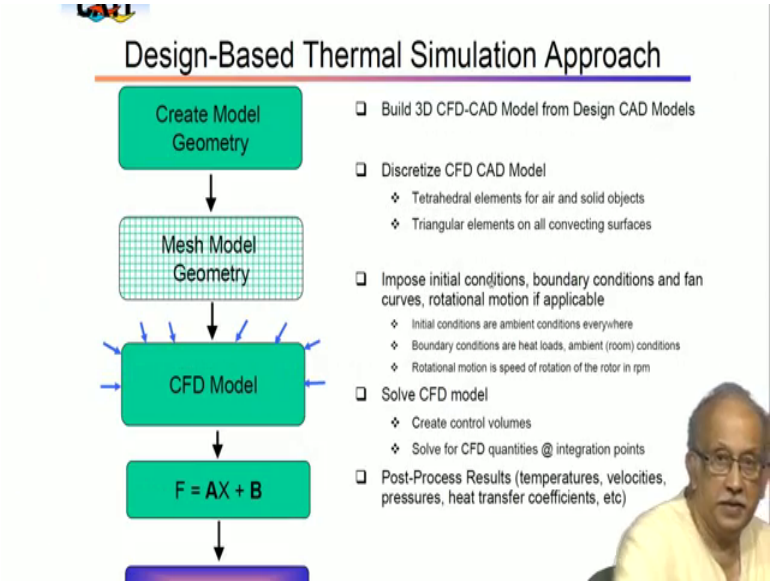

So, this is easy I will just, I will just try to be sure because this is not the lecture is about. So, we have this saying build a model and then discretize CFD cad model tetrahedral elements for air and solid object triangular for convicting surfaces.

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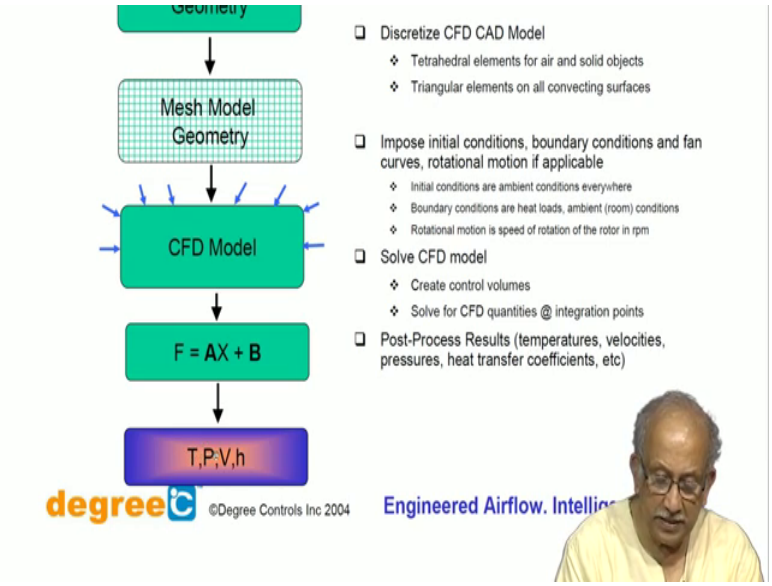

Impulse the conditions boundary and fan curves rotational motion.

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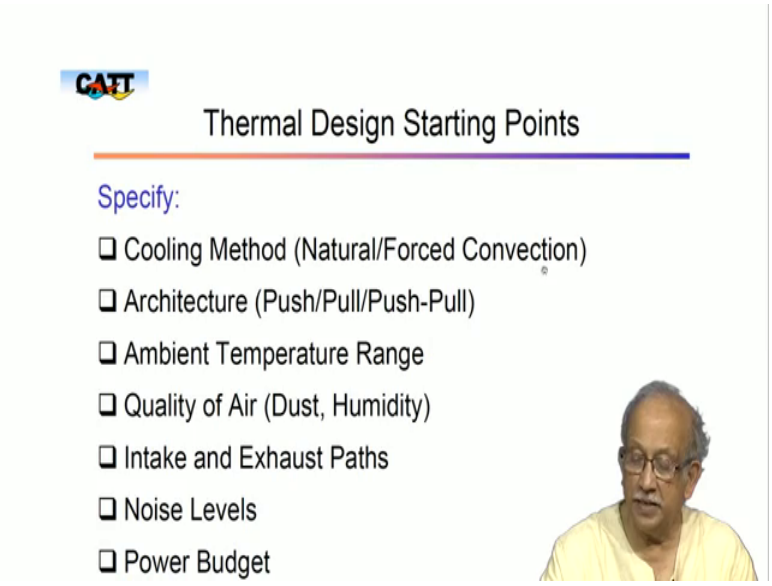

Ambient conditions create control volume solve for this thing post process result temperature velocity pressure heat transfer coefficients and all that advantage of this is things like temperature then you have this pressure then various h bottom you know that small subscript and then the what do you call velocities and all.

If there inside the industry inside the your own thing, if there are catalog didn't kept 2 things it is a must know. So, that you can always work backwards and find out where the

assumption should have been wrong second thing is if in a similar configuration you can directly use them 1 is to 1. So, I will withdraw the earlier remarks I have made saying there are no equations it will solve your problems these equations will solve your problems hm.

But they are not easily available and they are all valid only for only for, only for this physical configuration the model geometry say if a similar model geometry is there and if you know the amount of shielding and all that. So, you will be able to continue with it.

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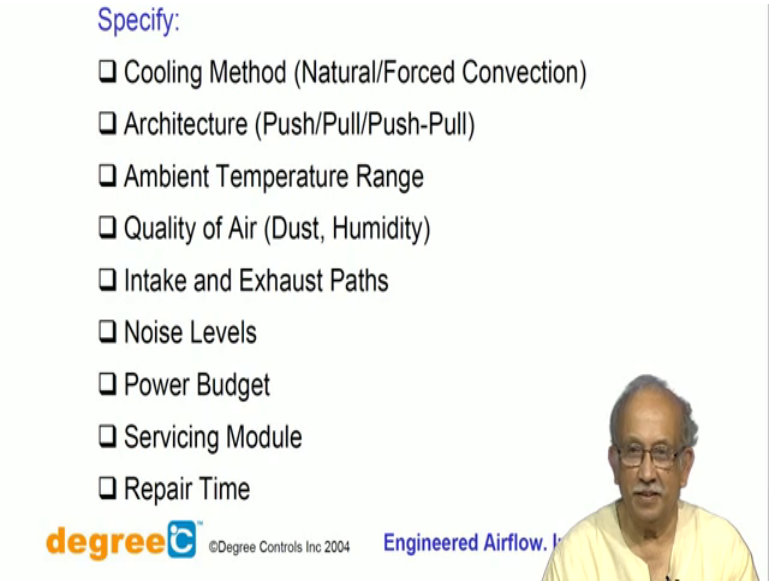

So, we have all these things saying what is the natural are forced architecture I will come back to it saying intact and exhaust path ambient temperature range.

We have this I mean at least I had no because I come from a beautifully almost air conditioned environment our temperature rarely even in the what do you call winter it goes below I think degrees celsius and in the summer at least in the places I know it is drearily hit a few degrees about my skin temperature, may be around skin is 37 skin maybe around 35 around 40.

So, 50 in to 40, in fact, you know it it is centered very much around the ideal 24 degrees it is a real beauty you have seen that no it is a beautiful temperature in which we work, but outside ambient temperatures especially in some places very tremendously

debonairly in a day itself things hit you know very low temperatures and hit very high temperatures especially in desert conditions.

And when you come to the sea shower only thing that seems to the temperature is fairly stable, but the humidity is ridiculous its rarely, rarely ridiculous its again. In fact, it is very easy for us to create drinking water that is you take any condenser and the water will be freely coming out to the ac concur you collect all that water and then typically that is much better than any commercially available de mineralized water, it is recycled and used for filling batteries that much of humidity is there all around.

And the place where I am talking from where notorious for being the heat and dust people, I to don't know how I am survived I am very sure there is some some being somewhere taking care of me there is a quality of air is air is not very good, and some of the places where your electronic cabinets work, there in very harsh environments they are not bunion environments any more if you go to the shop floor you also have other than things what I am talking about whenever you having flowing cutting fluids and all that besides the humidity.

Sometimes you have other materials typically in our case we have a grinder. So, that grinding dust is there in the air all the time. So, in spite of having the best what do you call a vacuum device which goes collect at we have a cyclone collector and all that still all round you can have the dust, and if you are working in a mill it was looks like a bakery is a very simple their device no all you do is get some dove.

And then you nicely make it and then allow it to rise and then you make beautiful, bread you live by bread the reality is handling that dove and all that no its full of dust and we have equipment very close to them of course, we need not talk about other industries like the cement and coal and other places where quality of air changes there the advantage for it is we will know about it and its no you deal with it places like you know what we think labs and all our benign places still things exist.

And then we have intake and exhaust paths, we have little bit of control on the exhaust the intake we are not very sure about it where it comes from noise levels then something which we come with push pull it looks very easy just put a exhaust fan in a room, in a room exhaust fan make sense, but inside an equipment and all that something which blows air in the direction we want seems to be much better.

So, a push air thing seems to be better because we know where to push the air to and we just put an exhaust fan chance are circuit will be in spite of the best attempt to make the you know the what do you call air flow around wherever you want it will find a leakage short circuit itself and it will go away. So, a beautiful noisy exhaust fans clocked filters and hot equipment.

So, somebody has to work about the push pull or push pull configuration ambient temperature ranges, and humidity ranges this is where important thing is in the case of highly humid and condensing type of environments peculiarly air is heated you would have seen if you are not will I mean normal driver you see that we have a wind shield and have a wind screen and then there are winds down.

And when it rains you will notice that all the you know things everything condensing on your wind shield sides you can ignore. So, they have hot air which is blown in side and the beauty is it works only if you heat the air and also run the air conditioner because the air conditioner when you run, when the cold air heats the air conditioner evaporator lot of the heat condenses comes out.

So, invariably dry their and in the case of navel and what do you call shorn mounted equipment there are also duct heaters, and I have given you 1 example of the domestic refrigerator it is a must to heat the side walls of a refrigerator now, because any condensation that takes place inside because generally.

You you don't leave with you know you don't enjoy living in a room which has forty degrees centigrade. So, ideally I think people enjoy around 20 to 23 degrees at that point, if it is humid what are all starts condensing on the sides of the refrigerator and if you take the old type of mineral oil insulation soon the insulation gets water locked even in spite of you are having a best what do you call poly rethyon formed in place insulation still condensation is real. So, they have found it much easier way.

So, they run the that what do you call condenser coil inside and which has a double thing you have much more area for the heat to spread and it also yields I mean aids in the anti condensation. So, we have this stuff about how to control the quality of air you remove dust you control humidity, similarly you control the temperature intake and this thing and something which we don't like is the noise levels, yep things are noisy much more noisy.

So, I have been endured with hearing it is for me the it is the matter of switch of the hearing heads, but for sensitive people are trying to sleep noise is noise and same thing in the case of our what do you call equipment tracks if all the racks start making noise, we have a problem and further not it is not well known that all the fans run about the same temperature and all the equipment the fan cooling devices similar ones run all way about the same speed and we have a beating effect imagine fan which is running at typically, I think they all run around 700 rpm low speed is around 700 high speed does around 1400.

So, imagine there is 1 2 devices running at 700 rpm and some other devices running a little higher or lower. So, all this sounds be together and unintended we cannot even predict where the sound is coming you have multiple harmonic beats riding all over the things, so that is reality.

So, somebody has to work about this something very related this power budget saying you really have that much power to effort the luxury of playing around the cooling, then servicing I told you about how to remove those filters and then take them out usually they have spares they put it in place. So, that the meantime to repair is minimized and depending on the conditions and depending on the locking of the data they have a servicing routine. So, I was only talking to you about how to clean the air filter, so it is will inside also you have.

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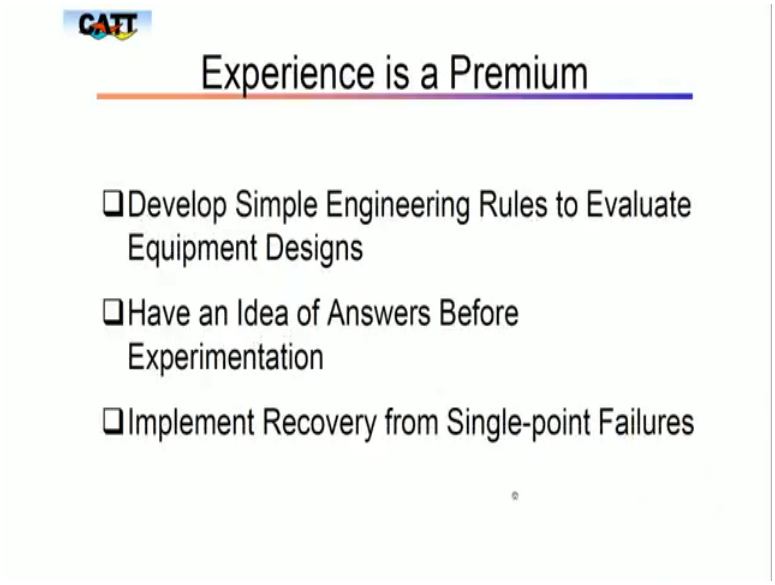

So, many dust and other things which are real you are seen this, experience is at a premium if you make something general it is only valid to that particular experience I mean sorry you cannot generalize across, so this thing. So, there is no way of extrapolating maybe a little bit of interpolating can be done. So, develop engineering rules evaluate equipment design.

So, engineering rules could be total cross section total volume, total heat generated and typically the range in which you have to adjust your cooling technique have an idea of answers before experimentation, I think you know about it these days with the internet you know the input somebody and then write somebody else saying, something somebody said like that it there is no internet. So, if the show Abraham Lincoln, or whether show others saying internet you know don't waste time in internet you know who said what, thing is checkup about it saying if you have a good theory it avoids unnecessary experimentation please check who said it and then check again and again and snoops mear may not help.

So, the thing is if you have a reasonably good theory and some little bit of model saying this because of the engineering rules already we have saying, if you follow this if you have this much of volume and all that unnecessary experimentation can be avoided and almost no first time the first run your very close to the answer, if you are making a what do you call a little next run you can do then what do you call you can optimize that implement recovery from single point failures. So, we know what cause the failure.

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So, you can probably try to improve things from there, I will try to see.

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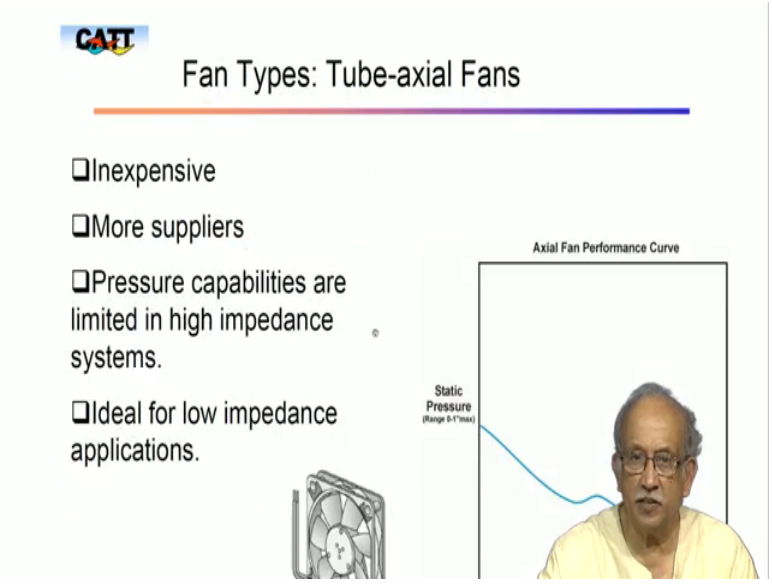

I will try to understand this fans which I have come across agreed earlier I have told to you why I am saying is you can go to several.

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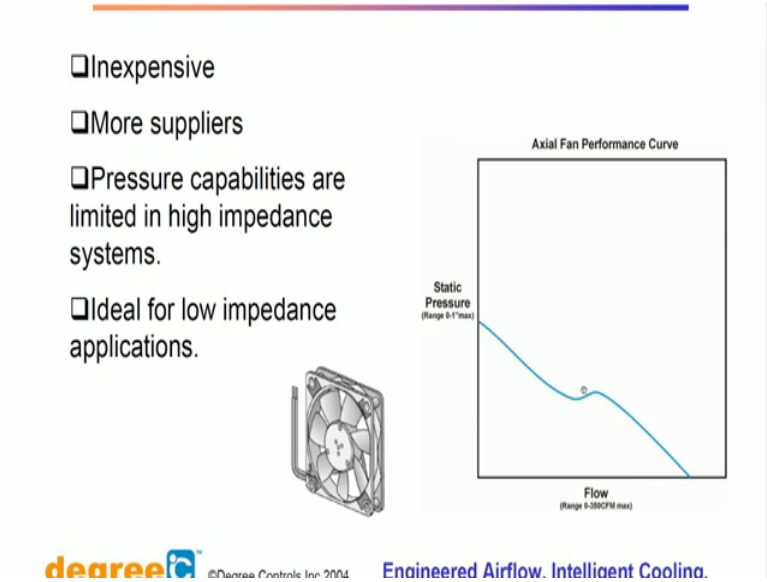

What do you call fan manufacturers typically the fan manufacturers they, they step up a cover what causes this is not my concern you see here what we peculiar detente and then this subsequent lectures talk to you about how an unstable region is produced.

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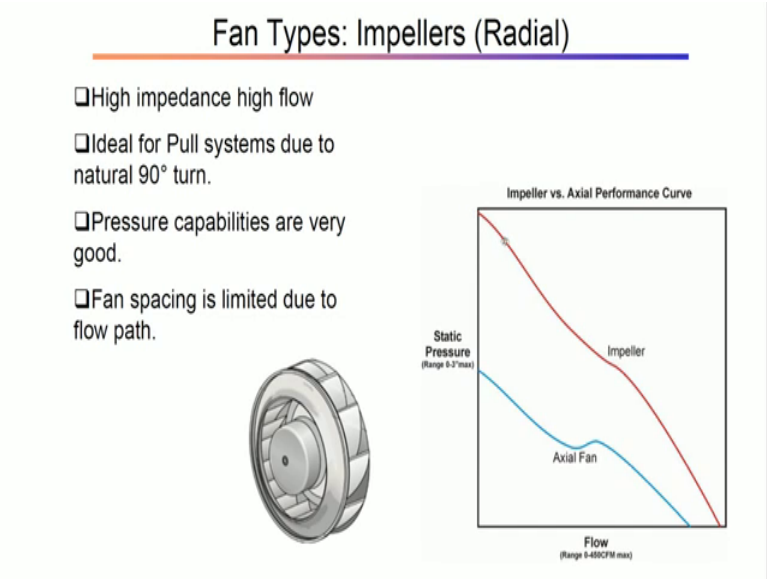

So, we have here radial impellers you have seen here. So, air air is enters here air goes way and again here you have so, many things saying forward and reverse, you know pointing fans the advantage is pull system due to natural 90 degrees turn.

So, if you mounted it on a on the roof of an equipment it blows everywhere. So, there is no curve inside there is no elbow which is taking the air. So, must have seen all those will leave early bird antennas on several roofs advantage of whirly bird is a naturally is there is something which is rotating air starts exhausting both versions are there, there is 1 which is helped by a small built in motor there are some which are motor less as the air from outside comes it acts like a natural what do you call wind mill yes, I too had the doubt a wind mill you know the air flow and at the bottom you already have air flow rising. So, that is a way whirly bird works.

But this is very, very low this is sort of if you see a fan like this you know typically average they are only about 80 mm. So, air about 100 mm also and then width you have starting from a 250 mm then 300 mm.

So, you have 300 mm by eighty mm beautiful circulate has are available, and then you see here it has probably have built in motor inside and then if those pictures show the it also shows the a rotation of the thing in this case, they vent seem to be cowed backwards I will stop it here the thing is pressure capabilities for example, static static pressure you know itself is twice as much if you have a typical impeller radial fines and then you have a reasonably straight curve compared to this the advantage of it is using what do you call similar power capabilities.

But the cost is very high and the power also its may be 2 times as much because it is a product, you have while this fan ideally works in this region this into this fan can work in a very wide region you know that much. So, total area under this is approximately four times as much only problem is fan spacing is limited due to the flow path.

So, you cannot cascade them you understand you know you can't put 1 more, but you have these axial blow fan you can put 1 fan other fan and so on. So, axially you can build up the pressure in this case it is not simple to make anything out of it.

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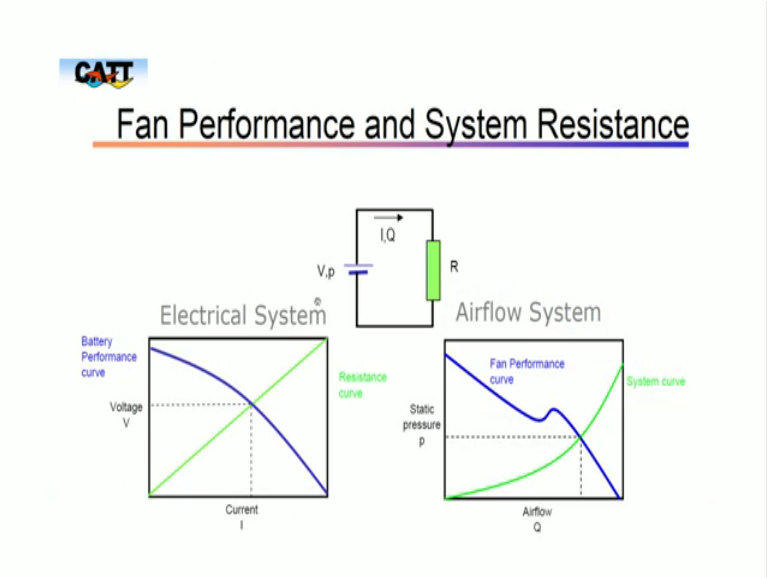

Alone it to just go forward.

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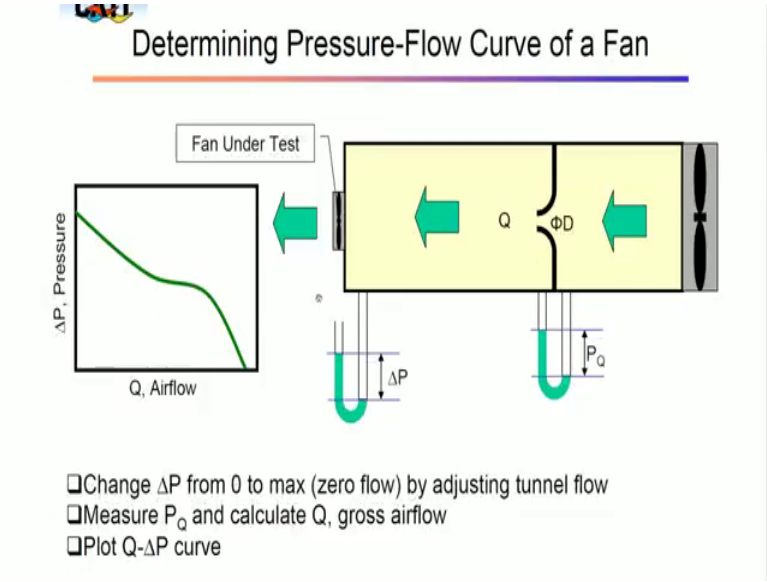

Because I don't remember yeah how to measure.

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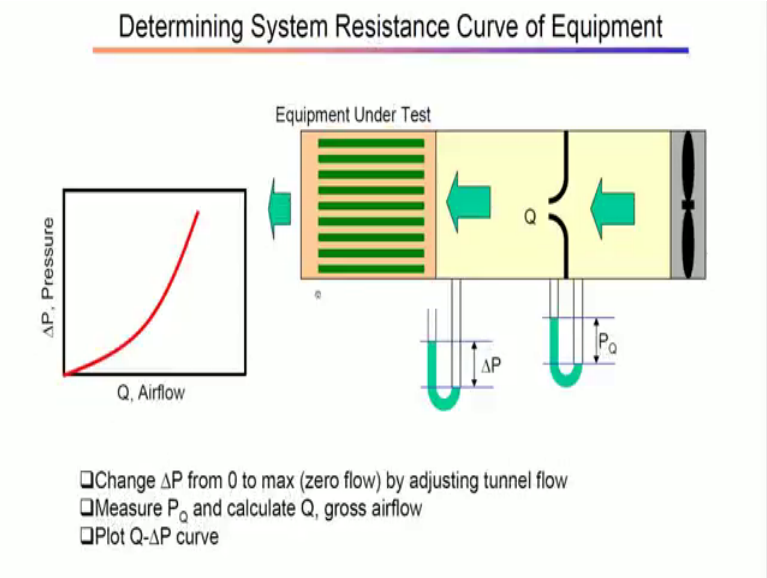

Ah system resistance.

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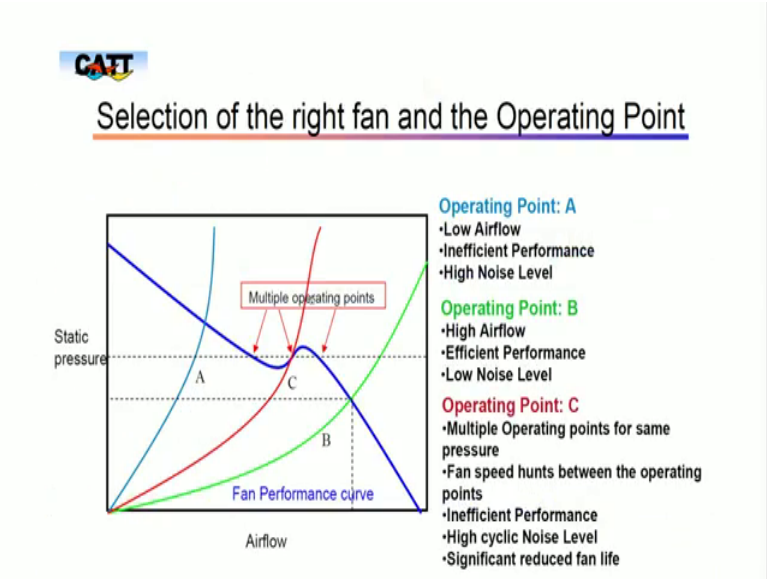

Right fan and operating yes good good, now our problem is how do you decide 2 things this is a typical something which we understand very easily typically this is a load curve.

So, as we know if you increase the voltage current will increase. So, let us say you have a source here in this case, we have a voltage and what do you call this thing in the current here very easy.

As you increase the voltage you know the current comes down and shown and all that this is the total we are talking about, the magic is even our things work like this our own if you remember that thermal we had a electro thermal analogue there similar work.

So, the air flow systems, so if you know the system resistance curve and if you know the fan performance curve you know which is the operating point this is what I keep harping about saying, this a little of curve you can get this curve is valid because it is all taken under very specialized conditions, understand I do not know this bottom portion a little of this is valid a little of this is valid, but inside I am not sure there is valid at all anymore end especially if you have a filter on this side imagine you have an input filter.

we still don't know how it works added to that we come to the system resistance curve because of the tremendous variability in the geometry inside the system is not that easily estimatable. So, typically they have given how to build a a device to measure a fan under test you have seen this no.

So, change delta p from 0 by adjusting turnel flow. So, we have I mean from various ways of measuring a plot here measuring a plot here and then try to find out the pressure difference across you know which will give you something here, which will give you something here, based on this q versus small delta p you can easily be measured I will you know talk to you little more about in saying another way of making it is imagine you create a buffering section, and you have an air flow sensor under pressure sensor and then you back plate increase and decrease. So, we know the air flow we also know the pressure across that and then you know the pressure from the inside this chamber to the outside chamber. So, the change in pressure versus this q you can easily be plotted out.

The next picture no talks about see while that is about the source curve this is this talks about the system resistance curve in the case of the system resistance curve the equipment and the test is kept here, and this fan is used to blow in the other 1 this 1 this fan is not used its only our other fan is there. In fact, it is removed here the increase and decrease the flow. So, we know the pressure from here to here.

And then they can measure the total thing using it is very easy to compute if you know the or if it is cd shell coefficient, and all that it is easy to do now we have a system pressure and we expect that if you put what do you call superimpose 1 of the 1 over the other its possible for us to find out which of the fans will work. So, operating point lower

flow in efficient performance high in noise level and then here low noise level because we have a fan which is there.

And then in between if you are not very you know sure about it chances are multiple operating point, fan speed hunts between the operating point which works a little even with our air conditioners, if I have four air conditioners in a room and for different thermostats because air conditioner temperature is monitored as the inlet of the device sometimes does the outlet of the what do you call the evaporator.

So, you see here the 1 which is set in a you know lowest or the highest cuts in and cuts out earlier which will ensure that it gives failing and somebody gets benefited by changing the fan. So, it is very much you know necessary for us to find out which is a good though initial cost is high overall you still have a nice margin to work with.

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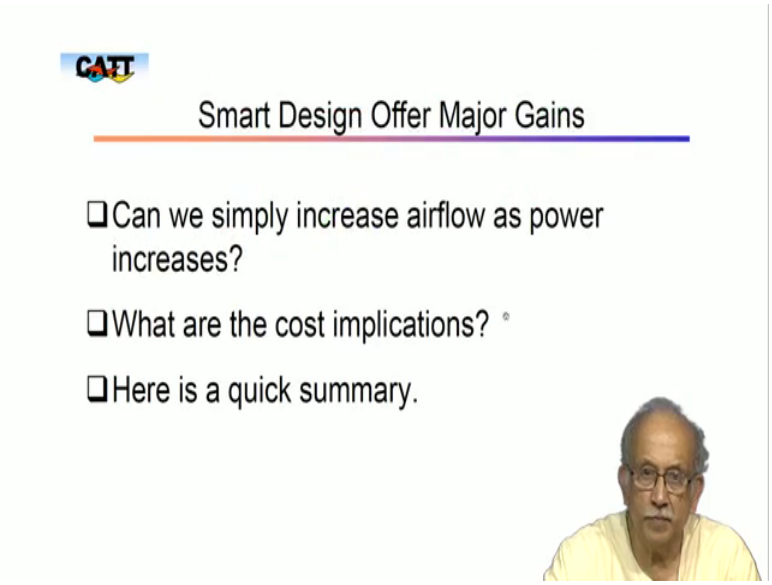

So, the can we simply increase air flow is power increases what are the cost.

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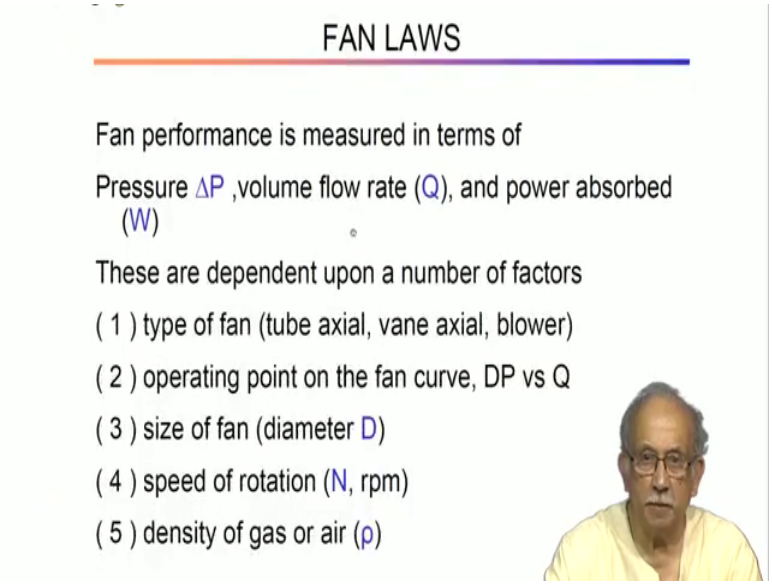

So, the next slide talks about a summary of all these things. So, I will stop here for the while and we will continue in the next lecture with the slide which I have stopped by.

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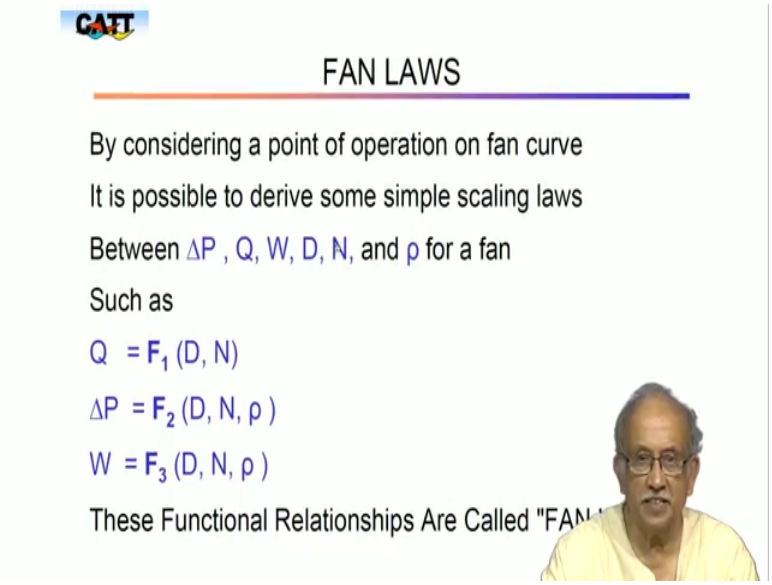

Because it is a lot of this thing, so, we have all these final hours from here and onwards it you know talks about, how to deal with forced convection and deal with actual air movers fan movers and general forced convection we already assumed that the you know the flow how the flow is created is not that much of a thing was that whole thing is held in a huge wind tunnel like device that wind tunnel device like device we have full control

about everything some of the even close circuit wind tunnels, but here we talk about a practical fan of an must be taken off the shelf. So, thank you I will start in the next lecture about it.

Thanks a lot,