

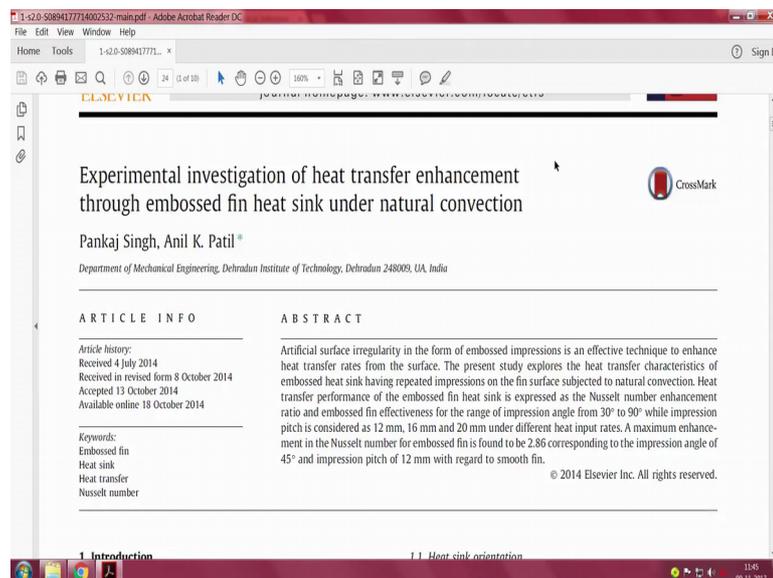
**Electronics Enclosures Thermal Issues**  
**Prof. N. V. Chalapathi Rao**  
**Department of Electronic Systems Engineering**  
**Indian Institute of Science, Bangalore**

**Lecture - 30**  
**CAD detailed design of profiles**

I will continue from where I left off earlier. I was trying to show you that for you to start making a layout of an equipment, you probably have to do what we do in most of the other two conditions. In the case of design and when you want to patent some of your whatever creations, what you do is you check you shall need analysis and all that and then since we are down in the embodiment design phase of it, one of the first thing when you do the embodiment design is also check for prior art I do not know kindly put up with my accented language.

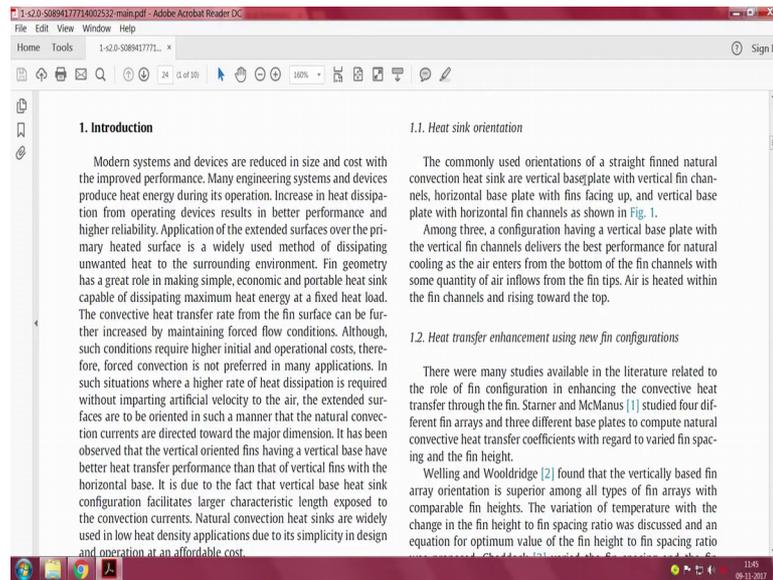
Prior art refers to saying what is already existing, this is part of the intellectual property this thing. So, this is not about copying, copying is something else you can always license synchronal. So, one of the thing in prior art is you go and check on the existing solutions which is already there. So, if you can adopt some of the techniques, which have a what you call validity and they have been around for quite some time nothing like it equivalent of it in the academic field or all the published articles. In both the cases most important thing is we acknowledge what you call the source and so on.

(Refer Slide Time: 02:04)



So, allow me to start with one of the things which is shown here, this is a very what you call large thing saying a investigation of heat transfer through embossed fin and so, on there is an abstract, a reasonable thing, I would like to acknowledge the people from Dehradun 2014 and so on.

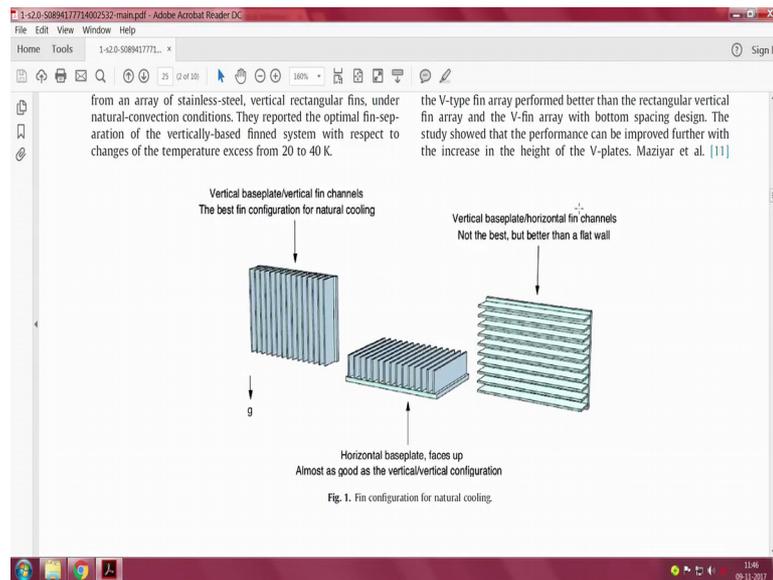
(Refer Slide Time: 02:21)



One of the starting points which you need to do is, commonly used orientations of a straight fin natural convection heat sinks are vertical base plate with vertical fin channels horizontal base plate with fins facing up vertical base plate with a horizontal fin channels as shown.

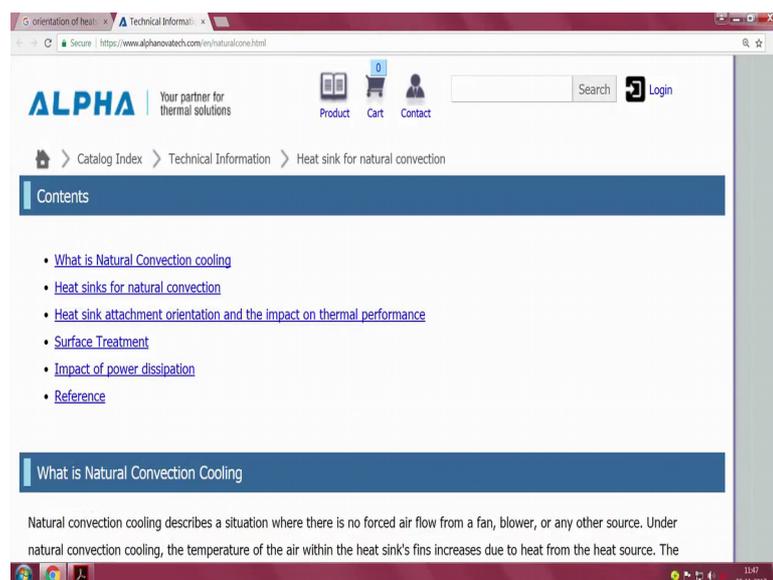
So, a vertical base plate with the vertical fin channel delivers the best performance for natural cooling. So, I would like to just take you to the figure because it is convenient.

(Refer Slide Time: 02:51)



I think it looks almost intuitive. Vertical base plate best configuration vertical base plate horizontal fin channels not the best, but better than a flat wall, horizontal base plate faces up as good as the vertical and vertical configuration. So, I mean I will allow me not a comment on it now working towards it I will just minimize this I will go back with something which is there in the background here, then there are several industry catalogs.

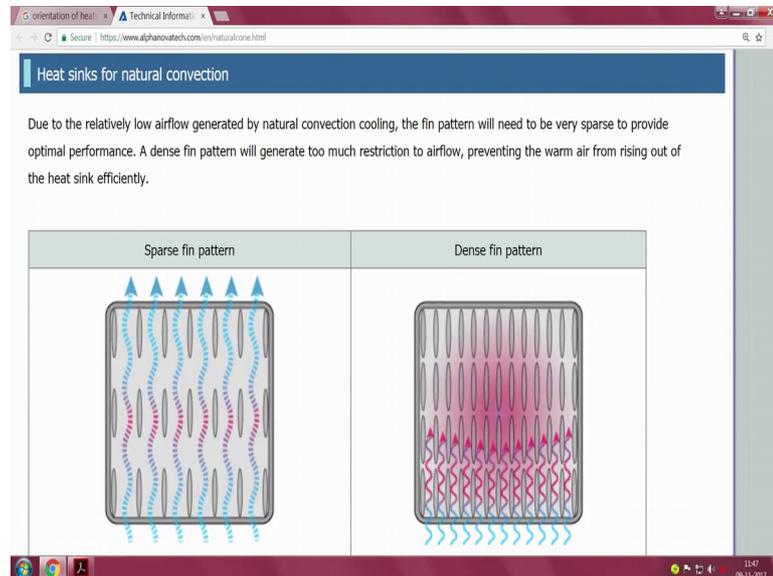
(Refer Slide Time: 03:58)



Same thing repeated again which I have shown you earlier except that this is from a commercial source that is somebody who supplies all these things.

So, they have written a little about what is what you call convection cooling and so on this is what I have kept on repeating to you earlier.

(Refer Slide Time: 04:20)



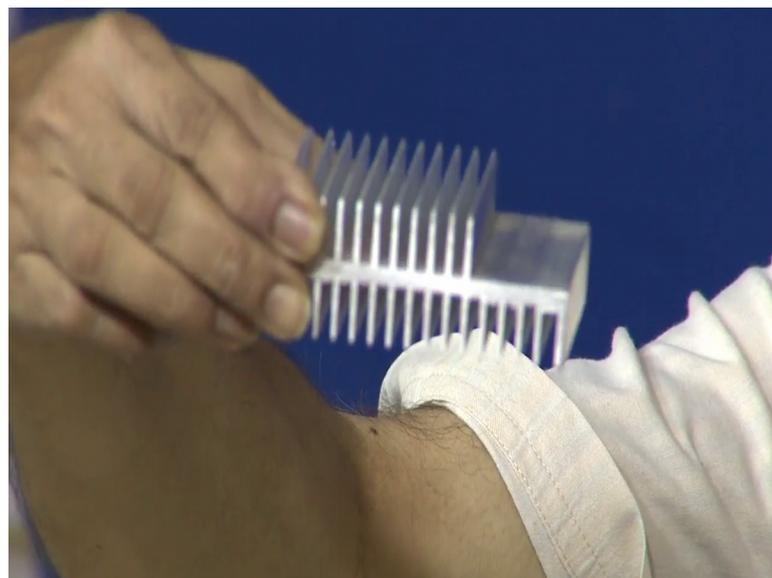
Due to the relatively lower phase generated by natural convection, the fin pattern will need to be have know very sparse to provide a optimal performance a dense fin pattern will generate too much, it i not exactly true it is just the you know slightly what you call there is an optimum a thing which is there. So, it is obvious, this you know figure just shows you how the hot air comes and all that heat is trapped between fins and so on; so LPD series and so on.

(Refer Slide Time: 05:00)



Now, this comes to the other way of a looking at these things. So, we have you know vertical and horizontal; so 1, 2, 3. So, they have given here based on our testing if the heat sink is the thermal performance is 25 percent worse than in the other figure meaning. If you oriented something vertically meaning the fins are like this. So, I have a thing here, I will just show it to you I have a sample here.

(Refer Slide Time: 05:31)

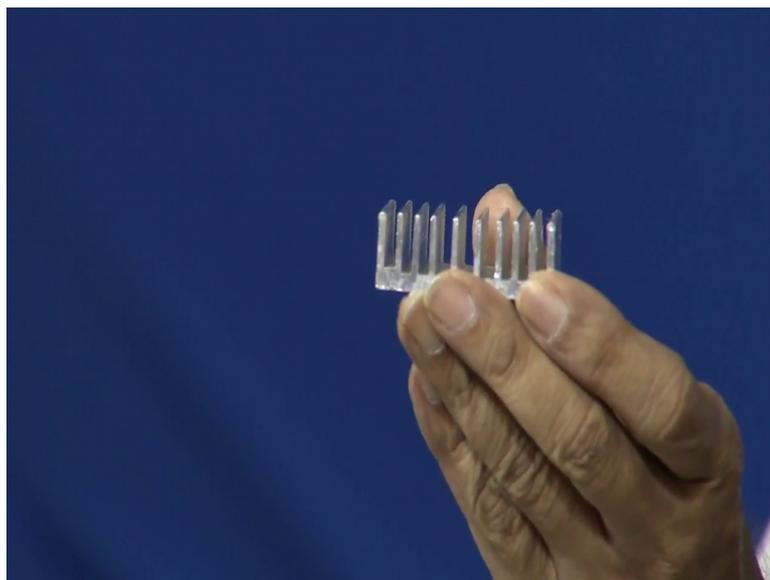


So obviously, there is several ways, one way is making it like this one way is making like this and then one way is make it does not really matter which way are it is.

So, I think it is very intuitive and correct saying know, this is best this is not so great. If it were to be vertical like this, you need spacing here you understand know you more like a pin fin configuration should be there, then the configurations will work now. We come to some things like this which are on both the directions. So, if you mount a participating component here, it does not look you know intuitive that you know this there the one in the bottom I doubt whether it actually can do any good at all you seen this.

So; obviously, such thing there is only one way to mount vertical, end in vertical again we need to provide some sort of what you call cover over this and then after that neatly it just sits there like that. Now when we keep it in horizontal, now we know that this; obviously, not at all designed for such a condition yes provided you give relief, best keep it like this not a proper way of doing it, which in this case can you put this.

(Refer Slide Time: 06:57)



See in this case all the other things are we can put it like this, we can put it like this or we can put it like this.

Now, comes the thing is how do we integrate these things and what you do and also.

(Refer Slide Time: 07:15)

The screenshot shows a webpage with two main sections. The first section, titled "Impact of surface finish on performance", discusses how surface finish affects emissivity and heat dissipation, recommending an anodized finish. The second section, titled "Impact of power dissipation on performance", explains how power dissipation affects thermal resistance and provides a formula:  $W = \beta \cdot \Delta t^{1.25}$ . It also mentions that thermal resistance can be calculated from power consumption and temperature rise.

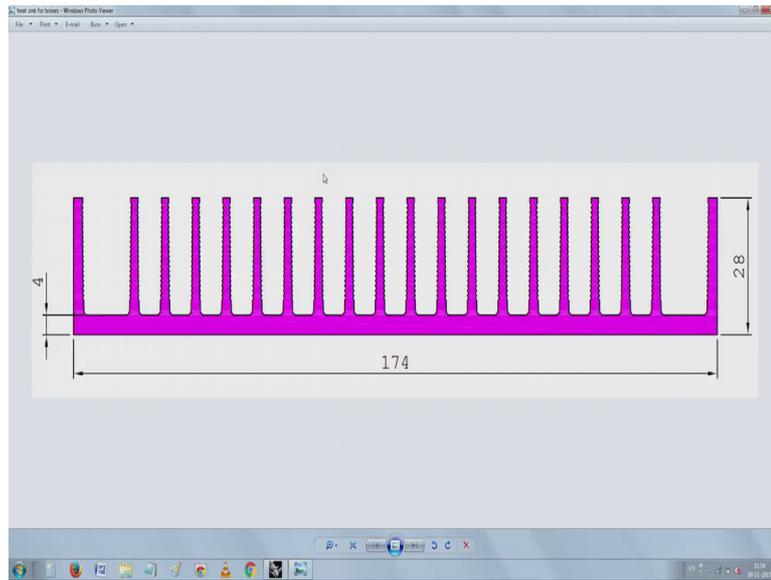
A lot of stuff about power dissipation and so on under a natural convection so many of these correlations have been given here.

(Refer Slide Time: 07:22)

The screenshot shows a Google search result for "Schematic diagram of a rectangular porous media". The main image is a 3D schematic diagram of a rectangular porous media block with dimensions L, W, and X. The top surface is labeled "Porous media". The search results also include a snippet of text and a "View image" button.

If you go to several of this is what you call sources and all that know enough information is available. Now I thought I will start here with sir we can kindly put.

(Refer Slide Time: 07:42)

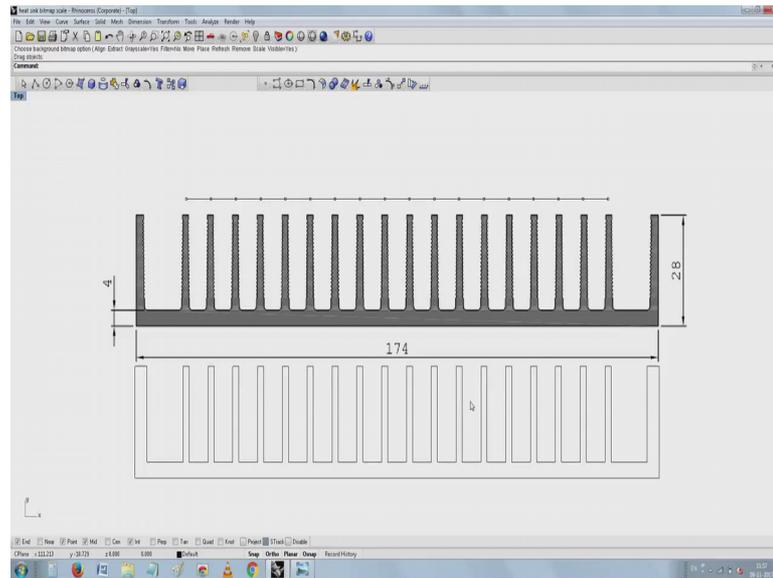


I will start with having estimated what is the loss in your equipment, meaning if it is a maybe a 10 kilowatt a device and then you expect that steady losses steady state losses at the appropriate loads which we know. Partial load its very inefficient, overload is an efficient at correct one load the efficiency will you know the optimal or we know the probably the best efficiency, you can get is about 90 percent.

So, 10 percent losses will be there. Now based on this 10 percent losses we can choose a heat sink as a starting point saying when the heat sink is kept in the fins vertical position and you select something from the catalog, and then you see here I wanted to jump from here to the way how do you create this heat sink from the catalog and then how do you try to use it in your equipment.

So, we are randomly picked up something which is a profile which is 174 millimeters wide and 28 millimeters high. So, if you see here most likely from here to here this dimension is about. So, if you if you remove this four from this know, typically about an inch which is about 25 mm deep, and then this 4 mm typically corresponds to a little more than a one eighth of an inch ok. And 175, I think if what you call equivalent it should be about 7 inches.

(Refer Slide Time: 09:43)

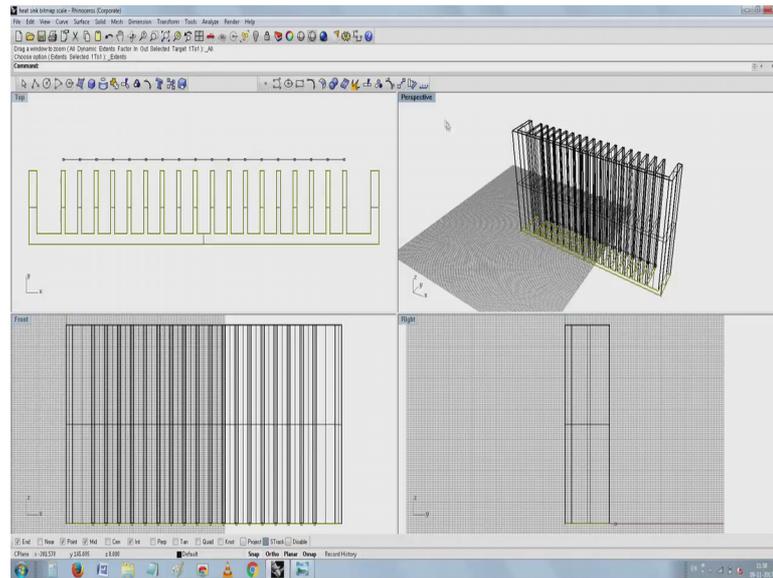


So, starting this point I thought we now need to try to create the 3D module in this. I am using what you call free or a trial version of what you call cad which you can we of course, have the licenses for this. Another place which I work which I teach this has the licenses this has been taken from here. So, if you see this, this is typically any package from any source you can use there is no problem and I would prefer something know which is relatively easy to work. So, one of these things is here we have for example, I have started with this beautiful background bitmap which is already placed there for me to trace.

So, those numbers at 174 4 in 28 it is exactly what we have had there and then over in I tried to trace and then I try to make something it is a little what you call just to show that you know how well it is how well it is not I just move it out can you see it is not actually a very good not a very what you call very accurate representation, but good enough for us. Main thing is everything has been rounded off. One of them is the width of the fins another is a thing, but total number is maintained dimension 28 also is maintained, and when I if I go put it back where it belongs you see here it is almost it covers the I think so, I have now a starting point for a heat sink and then I will now hide the that bitmap.

See I have this beautiful heat sink profile which is there. Why I am doing this is, now if you go into the three d point version of it.

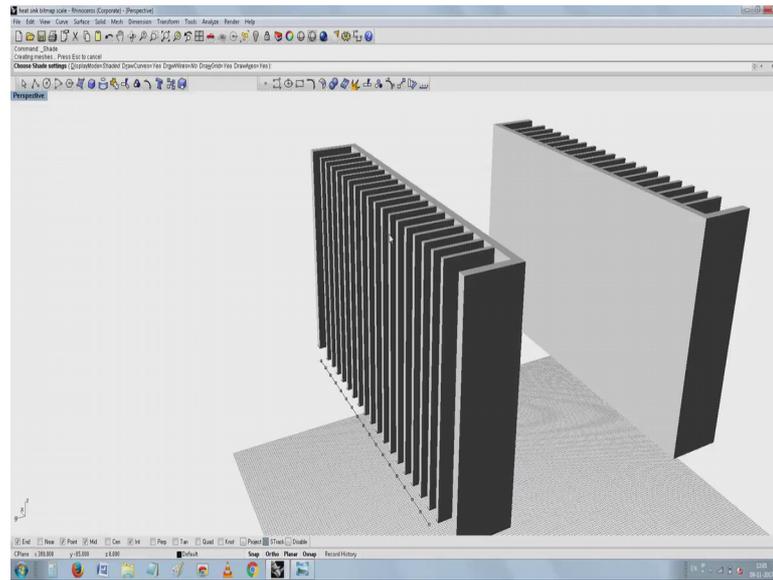
(Refer Slide Time: 11:57)



See I have this beautiful a heat sink, which is extruded in the z direction. Why I need to show you this is now this is probably our starting point of various products which we want to do. Once in your; what you call career whether you are a packaging person, electrical person or you are a manufacturing person, if you create the drawings for these profiles, you can use them everywhere else because typically if you notice the fin spacing fin proportions are all about the same and things have been built on this. Now just for this thing about it, I will start with what you call this a profile.

Imagine now I need to make an equipment which needs some what you call cooling or anything, top view looks like this is the front view then this is the side view and we have various things like now that is a matter of my.

(Refer Slide Time: 13:54)

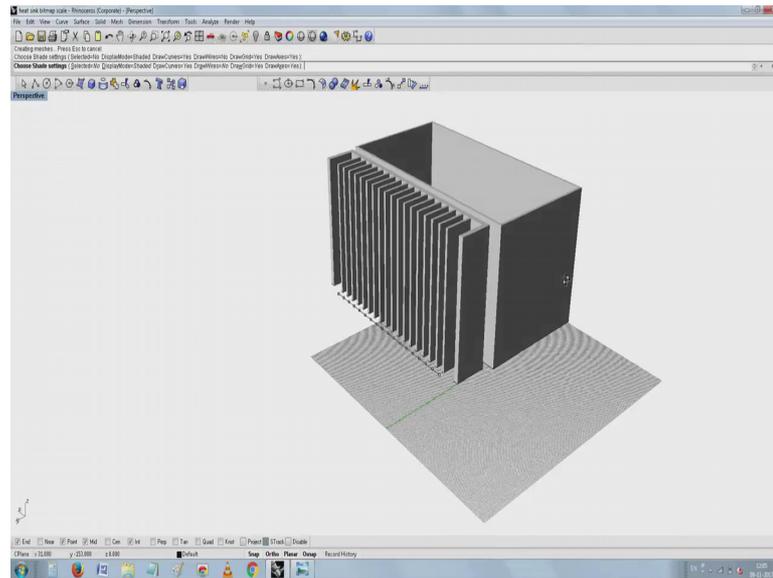


Placing the heat sinks symmetrically, on see my starting is slowly getting ready. So, I have two heat sinks which are in the vertical direction, and then if I choose the appropriate method of demonstration, you see I have a beautiful starting point for all these things to heat sinks in the vertical direction, and then the dimensions are probably determined by the other proportions. If its a rack mounted equipment usually the front is a 19 inch panel, inside what goes inside is if you take a 426 as a width 19 is as the width usually if you leave 20 mm for the flanges remaining happily goes inside the rack. These standards you need to verify you should not take it from me now.

So, if you verify the standards you will know the width. Similarly if you take the height it goes in terms of us 1 u is 44.45 and then generally three u typically three u rack will be 132.5 and this is a good starting point for a rack with heat sinks in the vertical direction on the face back things. Now while this is one of the what you call conditions, is not the only way you can do it its very much possible for me, I will try to go out, I have a single what you call heat sink this at the back it is possible for me now to make various types of; I will just try to see what best I can do here.

Now, I will start with a another what you call. See here I have something which forms the base as the unit. So, all I need to do is now I can just do the extrusion is I have done before.

(Refer Slide Time: 18:00)



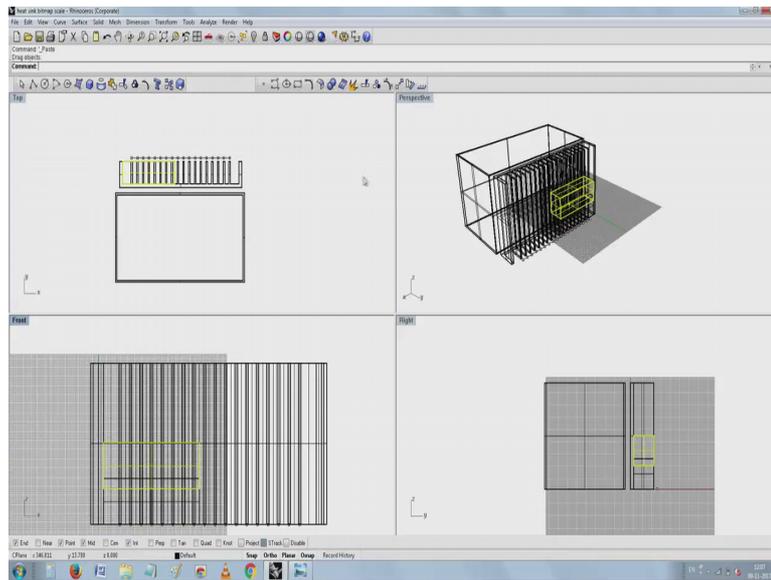
I have my enclosure getting ready very interesting thing know? What I have started with is just a profile of the heat sink now two variants I have shown, one of them is saying the heat sinks can be on the either of the sides left and right. So, at the back we have this extrusion which is going up.

Now, you need to place the various controls on the front panel and start working on it, which is the relatively easy way of doing it. Again the starting point is that you need to trace or create a library and generally within a particular what you call area of work or a the area in which the enterprise or the design house is trying to work will be trying to deal with certain you know a sizes certain things and all that, I showed you yesterday what is called the one eighth brick, half brick, quarter brick and all which comes from probably naval and aircraft power supply.

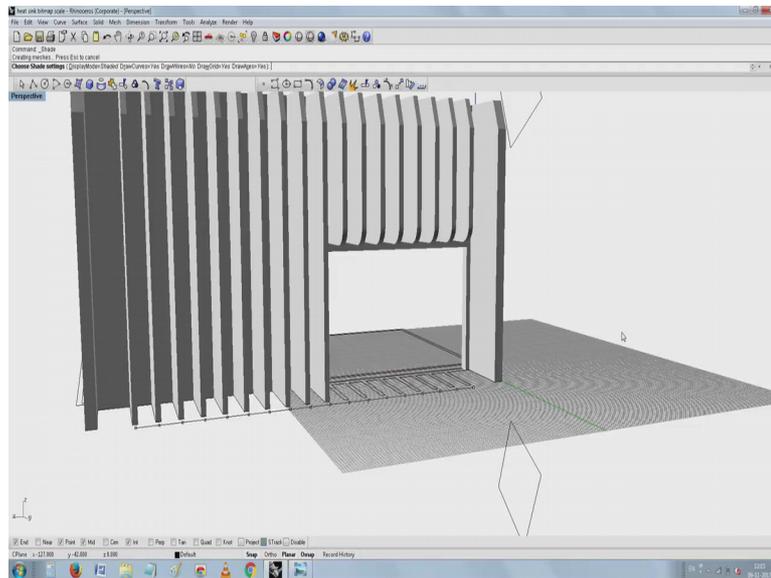
So, if you take the brick power supply it has certain proportions, and you have a orientation. So, vertical and horizontal here, I have shown you what is; obviously, you know a really what you call a nice way of seeing these things seen this know. So, I have got a heat I mean got a device which is a heat sinks at the back. Now this ought to be the starting point and not the there is no equation know, which directly gives you how to do it. Everything depends on your product design. So, in this case you can have them on the side or you can have this any other way as possible of course, otherwise possible nothing restricts are saying you need to keep it at the back.

Sometimes it happens as in the case of equipment which are directly mounted in a rack and, you have no access to the remaining parts of the rack. So, even heat sinks come out onto the front of the rack. I am sure if you are a professional you will probably agree. Now at this point it is very much possible for me to start working again in this ok.

(Refer Slide Time: 21:13)



(Refer Slide Time: 21:41)



See what we do is now I will try to make something and remove ha you see how a neat little front panel, where I have made a little bit of space so that my, it could be a now we

have a full flat what you call capacitive or a resistive display alternatively, earlier used to have various types of knobs.

This is typically how equipment at the turn off what you call just about you know just before the Second World War were all beat. Now we play around not play around I am sorry now we try to adjust for total amount of space available and whether you know the spacing is sufficient or anything, but the starting point is the profile which I had started there now you see here very neatly I have everything almost worked up for me and I can continue to the these adjust know look a little sharp which I do not need such sharpness. So, I will see if I can cure the unwanted sharpness problem, I will try to one more time I will try to create I just wanted to chamfer it, there are so, many other ways of doing it is there I am sure now if you are one of the persons who enjoy this sort of a what you call solid modeling methods.

I do the same object which I have done earlier, see now I have got a much more presentable and smoother way of easier way of managing with my profile which I have started. So, this can continue without the any this thing otherwise, you also have solid things like if you go to be solid editing, in solid we also have these things like what you call filleting the edge and so on filet edge and then I make a what you call 6 mm filet, see there it has become rounded there, because way what I expect is when you are trying to operate a control most likely we would like to have a smooth rounded edge and not a chamfered edge.

Now I can continue this filleting with all the surfaces that are present here saying. Now if I have to take it out further a is in this I have got a nice partly protected enclosure, which is not harsh on the operator. And from this point is when know where your analysis need to take place. Now you see suddenly what we know about this height of this heat sink and then the depth of these fins and then the spacing and all that is probably valid only for this section of the heat sink.

And if you now go to the manufacturers catalog, the remaining thing it is for you to make the nearest approximation that is probably total length available for use about half and there is unlikely that we have used this back surface, the surface will not be used for mounting anything that will be a new sense know. So, it is likely that this whole thing is

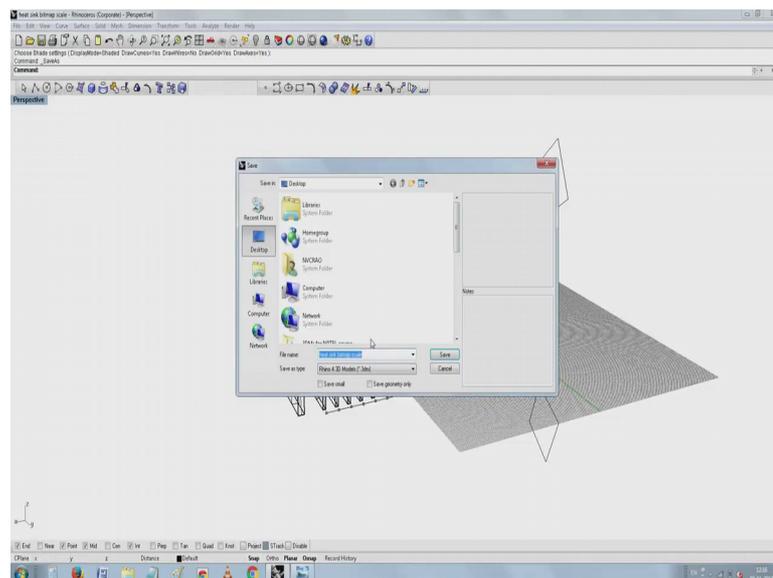
actually can be an opening. So, we have I will again go to the front and then see whether I can create a proper this looks like a better option.

So, behind that we can continue to have whatever control or display systems we have, but the heat dissipating part is only the little bit of heat sinks in the top of it and the heat sink which is there on the side of it, but only remember is on the front surface same thing is equally valid when it comes to the a rare of the equipment. Now if you go back and check some of these audio equipment or even this routers and all, you will notice that this is exactly what they would have done especially if you are trying to mill something out of an existing solid or some of these new plastics, they tolerate higher temperature.

So, sometimes you find that the panel is plastic and inside there is a small opening, probably the heat sink fins project out of it or in the case of a things like of or what you call power supplies and those things, there is a heat spreader and this bridge which directly touches the surface of the cover. So, when it touches the surface of the cover and things that come out, you will be able to clearly see that heat is allowed to dissipate through the otherwise inert plastic case, which is not you know thermally conductive.

So, this is only one instance of my telling you. So, what I will do at this point I will just save and then open the earlier drawing, which I have started with.

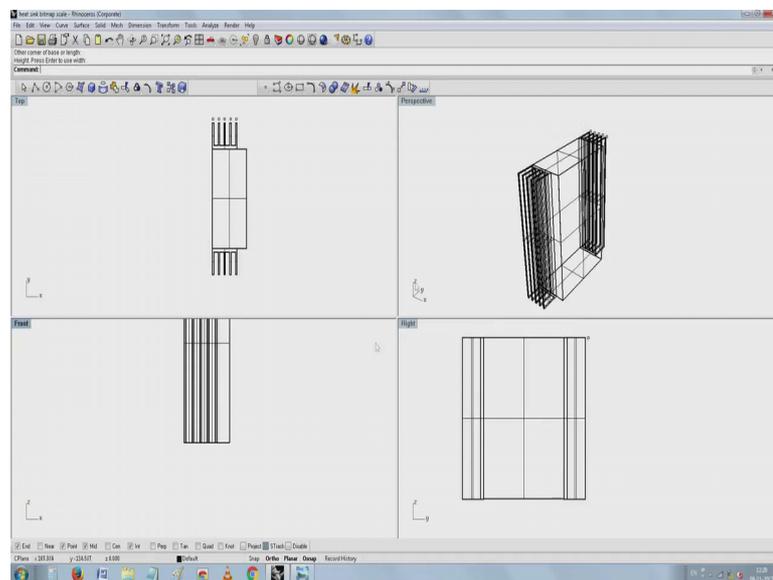
(Refer Slide Time: 29:55)



See this I have shown you that when we can keep them on the side or we keep them on the back and so on and oh one proportion. Now let me go to another slightly different way of doing this, what I will do in this case is because of various of my necessity of this demonstration, I will try to take a heat sink which is slightly smaller. In this I will remove these two mounting plates here probably I will remove this also.

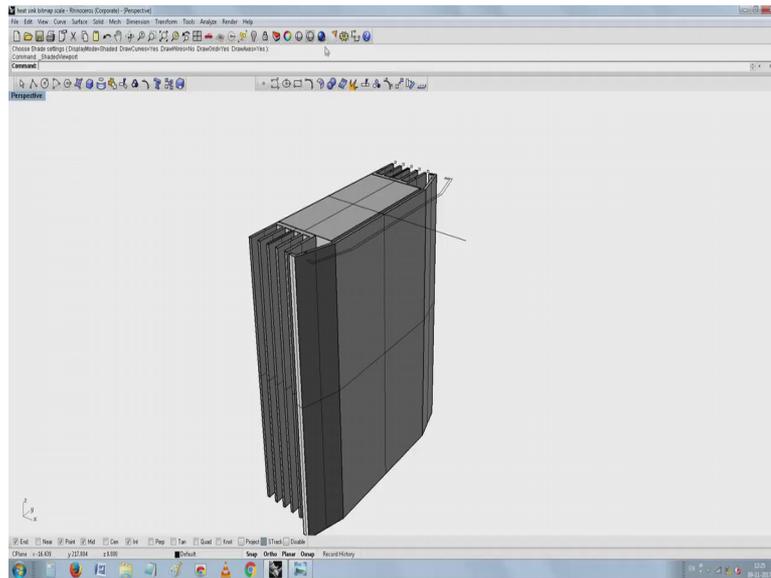
And then I will just leave a couple of fins and then see whether its possible for me to make something which is equally interesting. You see where I have started now one more time I will try to make the extent command and try to trim this object and attach all of them together.

(Refer Slide Time: 31:51)



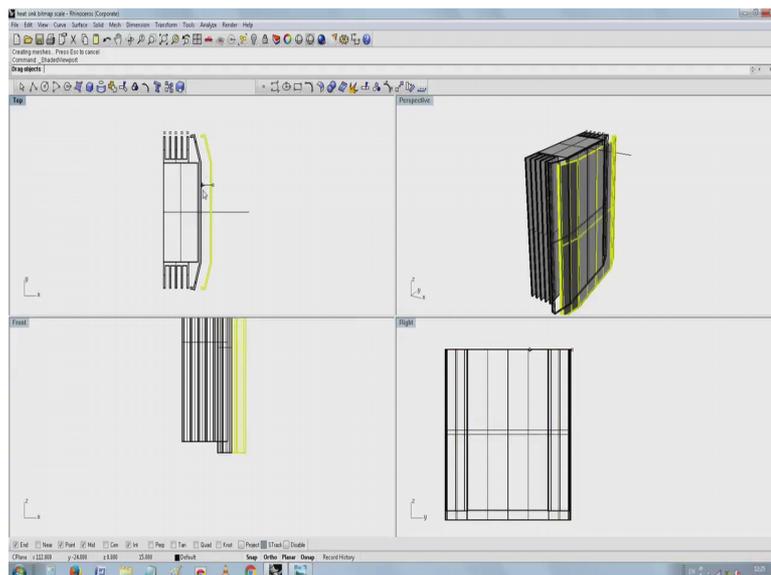
See here I have a beautiful profile which about looks like this. I will just switch off this grid is a little you know destructing, now this being on the top surface I will try to do something else. What is done here is this is now starting of a different way of making it as before what I will try to do now is saying see whether I can build an equipment which is you know see here, if you see this is where we are talking about one more time know I will to make try to make a solid a box corner to corner.

(Refer Slide Time: 34:01)



See quite good it looks a little like the vertical mounted inverters which I have shown you that solar inverters. So, we have here a sides of it which form a vertical heat sink and they are running on the side. So, the back can be mounted directly, in the front you can have a front panel as you like. Now several options are there one of them is I can try to cover the whole thing in the front with a equally interesting thing which I will try to see whether I can make something here.

(Refer Slide Time: 34:39)



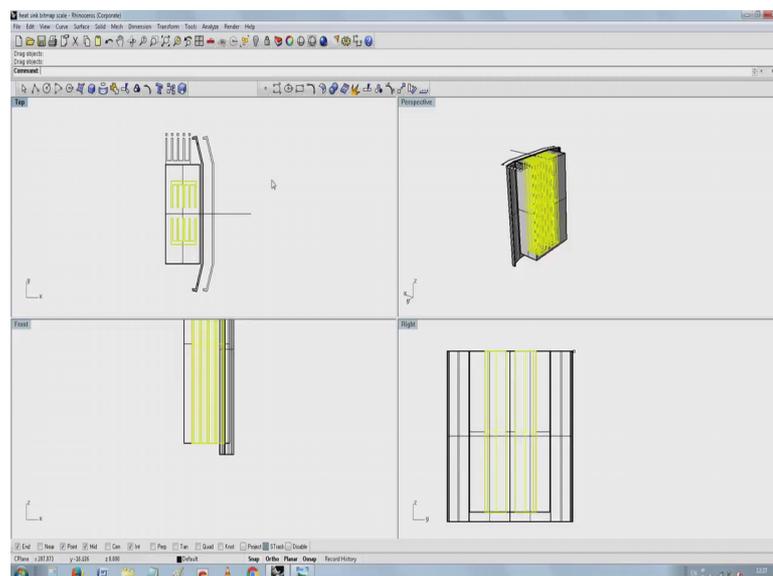
You see here I have a small section, which I can now try to do the various you know trimming operations and so on.

I am sorry see I have got a cute neat front panel slowly coming up, I will try to join this into a single what you call poly line now mirror it like before. See I have got what is obviously, nice curve here and if I see where it is, this curve is sitting on top of it here can you see here? So, it is firmly very much possible for me now to try to extrude the curve, see slowly my equipment is getting ready.

So, one of the things you will notice is, I have a front panel here I can do various operations with the front panel including. See here see beautiful nice equipment is almost ready, but if you see the starting point was the same profile, which I taken off from one of the manufacturers catalog which is probably once again based on prior art saying what the other people have been using. Now in this equipment, I have what you call left side and the right side what to call access to the various devices then I have a front panel here and still I have the back panel which is open there.

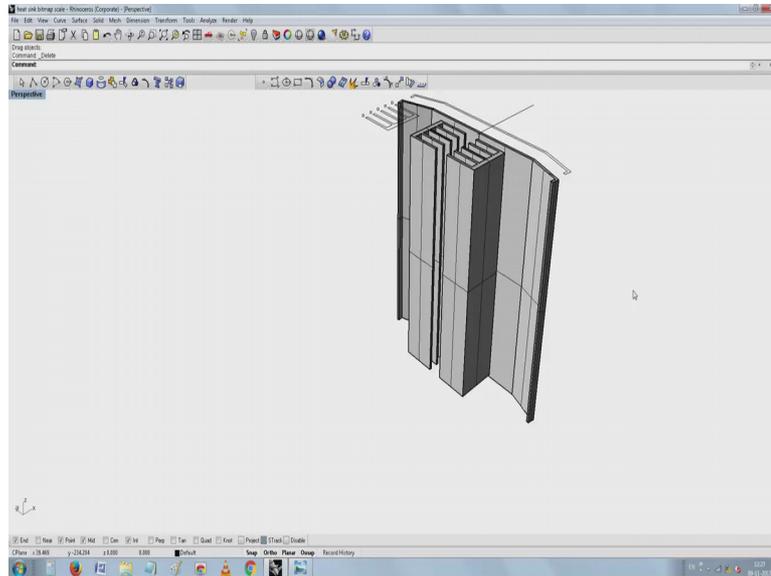
Now, it is for me to once again know decide whether I cover the back panels also with heap sinks or one more thing which I thought know which is not so, great is since the top surface is still available can we do something with it. Other options are also possible for example, this heat sink can be kept back to back and then we can provide a small fan and then what you call make sure that the you have seen this know I have a heat sink here.

(Refer Slide Time: 40:53)



What we will do is I will take the heat sink here, I will take this heat sink there move them both to the close.

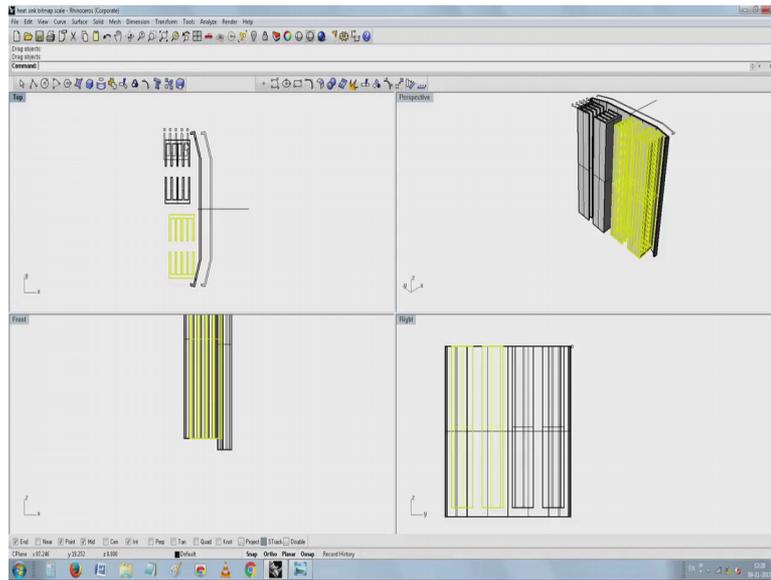
(Refer Slide Time: 41:27)=



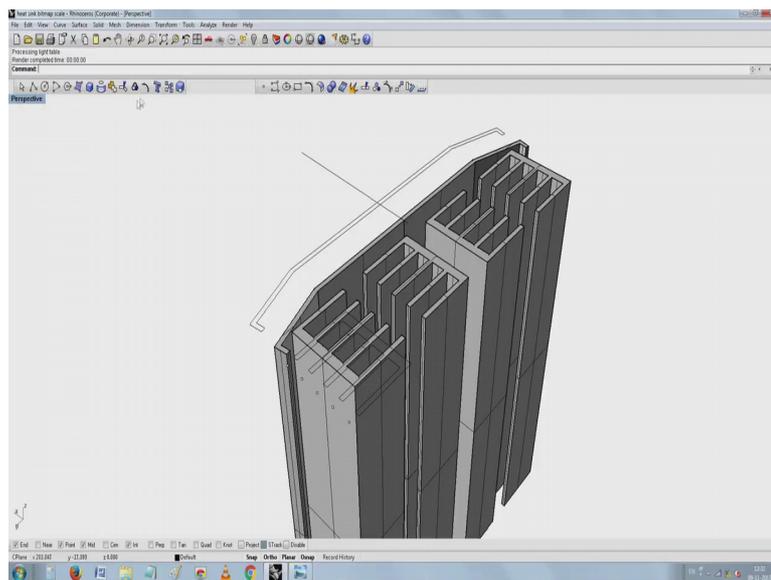
Temporarily I will delete the; you have seen here now I have got a configuration where the heat dissipaters are all facing inside and outside there is nothing and then its very easy for me to provide a small fan at the bottom or on the top and use first cooling.

Advantage of this is in the smaller size density you know, tremendous amount of a what you call heat or the order of up to four times can be accommodated. And probably we can have two channels of it like one channel is here same, I can now use this for have one more of it here, which is a which is probably one of the reasons you know I had started with.

(Refer Slide Time: 42:32)



(Refer Slide Time: 42:39)



Seen this I have got a nice tolerable project coming up. I have now a device which can probably have two small fans at the bottom in the blow position or two exhaust you know position in two fans and top and this whole thing forms a module that is what I was talking to you about.

This is probably exactly how these things have been generated. The common thing is probably a profile like this which has been tried and tested, then somebody has been what you call experimenting on this where this profile, and in the normal condition if

you were to make them in the vertical what you call a orientation and then adjust the total length and the power dissipation.

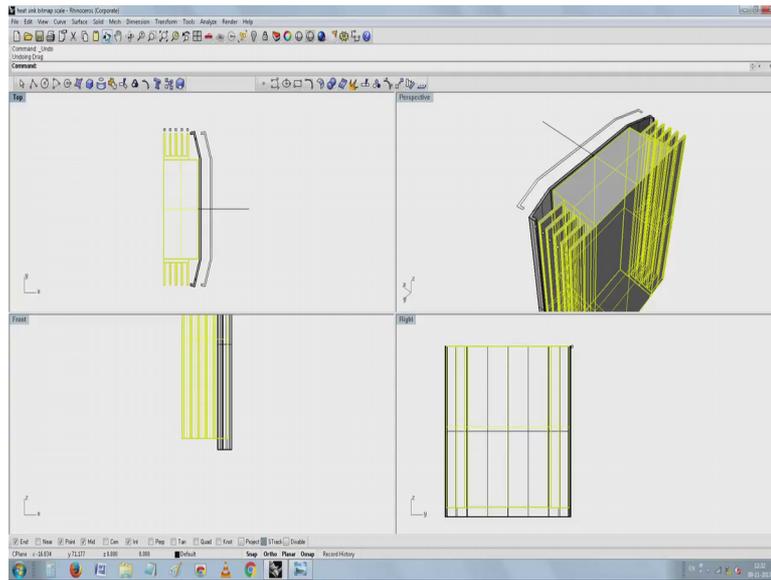
Another very critical component is there especially regarding convection and from the device. These heat sinks have one peculiar what you call issues which we talk about. If the heat sink is cold meaning the temperature is low final steady state temperature, a rate of heat transfer from the devisor inside will be highest maximum temperature differential and we are; however, if this is low it cannot really transfer any heat to the ambient looks a little anomaly.

Now, the other option is if this is high, it can transfer the heat directly to the ambient very well, but inside know you will have a problem of not able to take. So, more by experimentation a little bit of thing by hand calculation, we need to find out which is good. So, some people have suggested approximately half imagine you are inside ambient is likely to be around 80 degrees all the device and all and ambient outside ambient is likely to be 40. So, if you have to maintain it 60, 60 to 40 you still have a differential only inside 80 to 60 also you have a differential, probably one of the reasons why there are fins on the inside also got it know.

So, these fins transfer heat from the inside the equipment and this forms the enclosure. So, two of them back to back from the enclosure, you have things you know recirculation and inside you do not need of find directly here, all you need is something which recirculates the air and then removes the hotspot and outside conducts a heat away to the atmosphere, and inside things are equalized and then things look very neat and very clean inside. So, the starting point is we can always start with things like this, oh I am not able to enlarge it to full, but we have a beautiful a rendering frame.

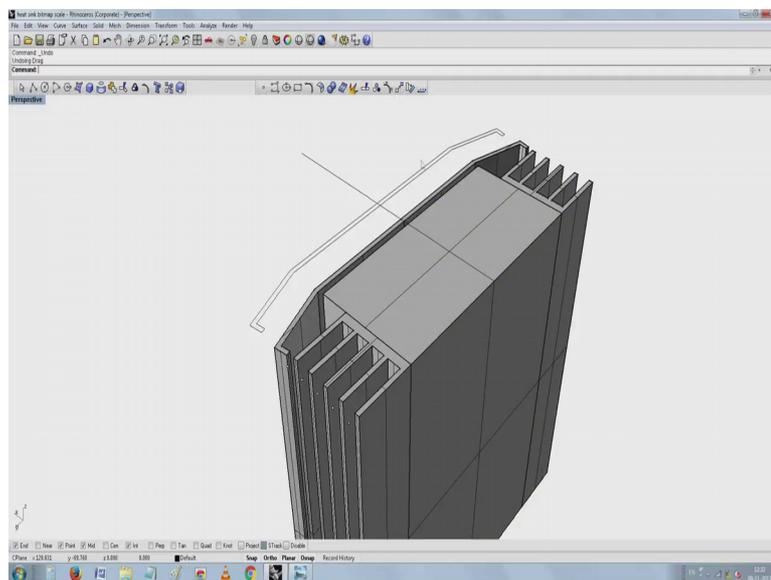
So, several of these things you will notice are this way of trying all possible configurations. So, I have shown you something and this point you know I will try to go back and try to undo remove one of these things which I feel know is not very useful for me.

(Refer Slide Time: 46:41)



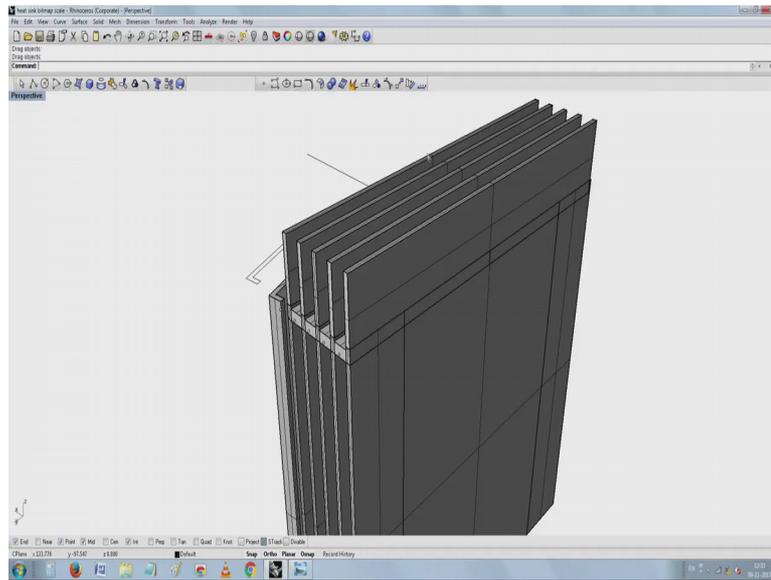
See this where we have started.

(Refer Slide Time: 46:44)



Now I leave why do I leave? Oh I mean there a no necessity for me to leave it like this because stop service is still available. So, why not provide one more of these devices directly on top here?.

(Refer Slide Time: 47:38)



Now if you come back here you will notice I have an equally interesting configuration of fins being there on the top of the equipment also. So, at this point depending on what I have told you earlier, it is possible for us to now provide some what you call slits and all that and make an interesting industrial design or you know very interesting what you call prospect, when having an equipment in which you know the top and the side surfaces are also used, and at this point you can start doing the actual calculations about what will be the net result of the this thing what will be the thermal resistance of it and so on.

Next time if you look around every configuration I have spoken about probably already exists ok. While its novel and probably you cannot patent in you can what you call address your problem and then try to solve these problems like this. So, this is I have told you about you know something is on the side, then I told you something about the front with the clearance and something about this and the very starting point is saying, we can even have with this fins directly at the back which is what a lot of this electronic cooling at the equipment level is about and the depending on the volume that you make for example, on these solar devices and all that this configuration in the earlier configuration we have made a solar pump.

Some I am not able to get the picture of it, because this what you call drive for a solar pump is to be used in the field where you do not want a distracting what you call things like voltage current and you know whether its following the maximum power point

season and all that is not interesting, that had only one switch in the front. Who press the switch if everything is fine the motor starts and the pumping starts, if it does not start we have an error saying probably there is not enough sun or anything just one indication saying wait for the sun and then the user just needs to wait and then press one more button and it starts and pumps and MPPT is built into it maximum, but power point is about tracking the impedance not about tracking the position of the sun. Tracking the position of the sun is what you call somewhat wasteful and only in very extreme I mean special conditions probably that is need to be done.

Otherwise simple clockwork will work and probably three portions is enough something you have to start of the day midday and then what you call end of the day probably some the three positions and then a very tiny very low power mechanism, which orients it like this. That coupled with my design here is probably how in reality projects are made and then yesterday I showed you one picture of a data acquisition system. That other modules which were talking about also had a similar look or a style, which all had this front panel like this and then there were this heat sink. So, that heat at the back or anything on the side and at the bottom if you recollect there were two connectors and the connectors have been made such that they cannot be confused with each other.

So, the input to this equipment is through a cable which has sockets at the end sockets generally you know that comes from the solar this thing sockets is where always you take the power out and they connect to plugs in this unit. Other side where it goes to the pump sockets are mounted on it again one more small probably it was a three pin or four pin device which will go to the pump. Now moment you have these sockets and things like this which are also typically mill grided they can tolerate much higher temperature.

So, you can afford to have an enclosure like this probably whole thing made out of an aluminum diecast aluminum, and you just need to there is a cavity like thing with milling I mean milled fins everywhere open the cavity mount everything closing. So, it has the second benefit of being fully waterproof and if the connectors of the correct grade, making IP 66 67 is not an impossible task and instantly these devices will help us in realizing these things.

So, I think that will be enough for today. I will stop; I will try to continue little more about these things in the subsequent lectures.

Thank you.