Enclosure Design of Electronics Equipment
Prof. N V Chalapathi Rao
Department of Electronic Systems Engineering
Indian Institute of Science, Bangalore

Lecture – 01
Enclosure design for Electronics Equipment Introduction

Good morning I am N V C Rao Chalapathi Rao from Indian institute of science in Bangalore. I am basically equipment and product designer and then I wanted to share my almost 40 years of what you call various tips and tricks with the public and especially practitioners so, want to do convert their electronic design and ideas into a product which is probably marketable and all that then. I have been a equipment designer with the defense electronics later on I am in this what you call Indian institute of science center for electronic design for the last over 33 years.

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So, I will start with the first slide which is what exactly industrial designers, because invariably a any product that has been created to be manufactured in industry in goes through a process called industrial design. Sometimes industrial design is only confused as an add on what you call cosmetic effect at towards a what you call middle or end of this lecture I will just try to point out what more it can be. To start with there is something called the international council of societies of industrial design, they have gone through a tremendous what you call class of iterations for the last 50 years and have

come down about saying it is a lot about concept development it is not easy to develop a concept of a product which eventually satisfies a human need.

And then another clear is there is this thing about a function value and appearance of products which is what most of us are after. If you ask a first time designer of a small electronic equipment one of the first thing he will say sir the concept is good, but it is not presentable meaning nobody wants my product. So, and. Secondly, you would have seen around your own house their products which have several specifications which are either not sufficient not enhanced or not used at all.

So, I will show you an example of our normal obey quitters cell phone, you seen this cell phone and in fact, it is also a branded cell phone there is something about it now these days we do not think as of a cell phone as a simple communicating device anymore to us the camera then the screen and the battery life seem to be equally important for that. We have the screen then at the back you have a camera then it is also branded plus most important is how well you can handle it how well you can operate the keys.

This seems to be one of the very very important aspects of it; however, this whole thing is a very professionally produced highly engineered and you know it checked and you know made sure that by the time it reaches the consumer the consumer may want it. There are people who stand outside the apps what you call iphone store hoping you know they get a glimpse of the future iphone.

Now, I will get back to my slide again in the slide you will notice most important is products and systems.

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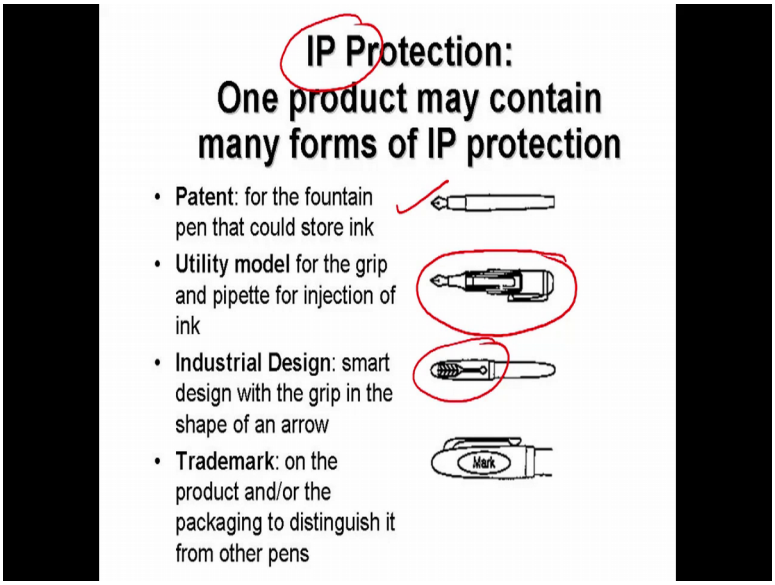

For the mutual benefit of the user and manufacturers, this seems to be the important thing. Now what is so, great about the words that are said here the beauty is these days anything that you can design you can make and all that is protected by an intellectual property.

So, all of us know the moment you look at this you look at this arrow you know who makes it and you think it is worth it then you can also in case you want you can have a logo also here something is provided there, and then the basic utility model of how to use the product and the original fountain pen are also protected.

So, you will see that there is no straightforward what you call a set of I know steps if you follow automatically you will get a new product, that is very very tough to make a book. It is a little like a person who makes a book now saying how to become a millionaire if the millionaire right side in the set of conditions that he has a written it there probably valid since then conditions have changed same it is with products now I will go into the next slide.

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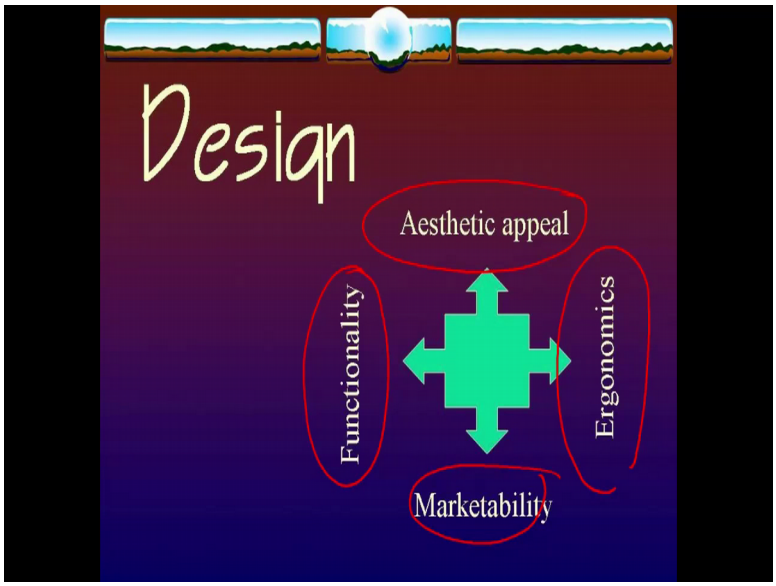

You will know that in general design has to have all your basic things of functionality is very very critical, without a functional product chances of our using of the product will be minimum very very what you call very little utility of a particular product unless it is basically functional. So, if you see a mobile phone the function earlier used to be a simple function of communication there used to be clarity and then there used to be a thing in all that.

Now, functions have changed; a mobile phone is expected to also transmit pictures get you into the social media. Something which is related to the usage is now ergonomics. Ergonomics is the one that makes people want to use the product. So, I have here I have here what looks like a pen actually it is a stylus it has a pointer here it is everything similar way I also have my hearing aid while hearing is only a functional part of it you will notice that it goes into my ear and it works extremely well, without this I cannot survive any more. Functionality here is one is this thing and then I will point out towards my glasses you have seen that no you see the way they seem to destroyed. So, this is a progressive lens I can see close I can see distance and when I buy this I do not buy it only for the functionality of seeing through it I also buy saying how well it goes with me, it gives a it carries an image of myself saying he is a person of this type and so on.

So, ergonomics also makes is comfortable it also makes it useful for me it makes the other person want it and if a product has everything next we move on to what is called

the aesthetic appeal of this product so; obviously, some things are more beautiful than the others it is not just the eye of the beholder, we know things which are currently more beautiful sometimes ergonomically they may not be very very they may not be very very what you call pleasing. If you look at my shirt it has a high collar have you noticed it may not be very useful outside, but people expect to into wear a high collared shirt in certain things, at home I do not wear a tie wear a what is called a t which is banned everywhere.

Similarly, I have a watch here you seen this watch if you see this watch this is a waterproof watch, it has a seal here plus it has a it has a peculiar orange color dial which is also has a what you call indiglo function in the night, if I just shake it goes on like this. So, I have a beautiful what you call strap or a clasp then it has a watch case which is waterproof plus I have a dial and then there are other features like this.

Now, coming back to the slide again we will notice that everything depends on how well it is marketable. Marketability is not about just about how you supply all these products directly to the store, marketability is people must want it the marketing person decides that these are the features they want because anytime you take any of the successful products they seem to be just one jump ahead of what was the product which is already there. Classic example given for this is saying if in a horse carriage age is somebody were to ask what will you want they will probably want more horses are there probably want to what you call make sure know that they do not smell so much while that is changed the customer does not know all the time what you wants in the future, but if you show him he will be able to this thing.

While the horses have been got rid of the allegorical representation saying I am pulled by horses has not changed we talked about a horse power we talked about I have my thing has more horse power than it is and even if the critical thing like the suspension what is called the horse carriage and the leaves fringes have not changed, they are worth the money that is how they continue to be used.

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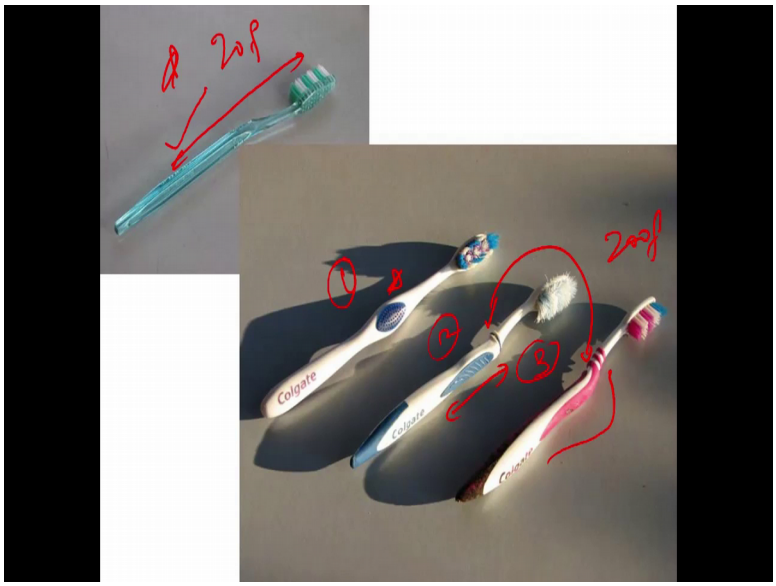

Now, we will get into a very routine normal slide, but things which we see around in the house. This is an ordinary toothbrush I am not promoting a particular brand if you see this functionally probably this toothbrush is about the same as this, this and this all three are about the same, but you notice that suddenly things have changed what was a simple transparent handle is not sufficient anymore.

Similarly, even the grip where you hold the grip this has one type of a grip this has only a spot grip, this has a little longer grip with some hashes and all that and this is a continuous flow thing like this where the grip has been made to look a little thing that that this if you seen know this portion and this portion have been integrated into this. So, it looks much better and now having done that; obviously, there is a line in which know if you see this these line is aligned here can you see both of them are about the same line. Same thing is done here nothing is compromised the functionality is not compromised, but aesthetics have been made important and as part of this even the material the grip everything has been changed.

Now, when you go to the shop, the first the this the first one item number one is available maybe for 20 rupees while this thing if you want to take a this thing, there also available all the way up to 200 rupees that is a random at a symbol. So, do not get worried about it I wanted to avoid it if something is 20 units up to 200 units you have it may be powered may not be powered it may have special angle things and all that.

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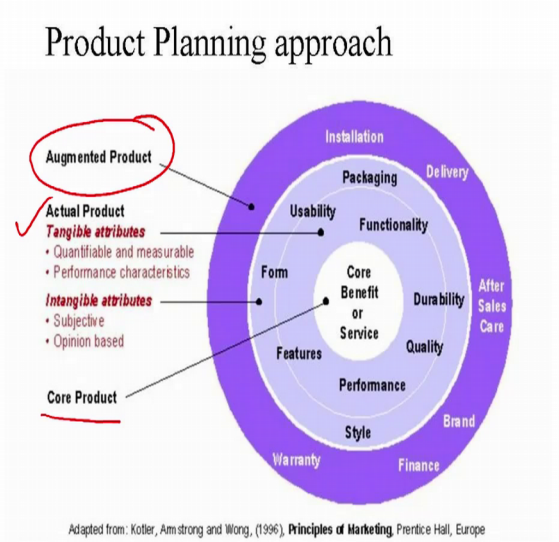

So, if you go onto the next slide in this particular group of lectures, I wanted to cover saying it is not a simple design for design sake it involves product planning because basically I am also a management and product oriented person. At the core of every product like in this case if you see the toothbrush or if you see the other products which I am going to show we have the core benefit main purpose of the product is that it should do it is basic work.

So, in the case of the what you call toothbrush it should obviously, clean teeth then there are intangible attributes subjective and opinion based. So, part of that intangible are then there other actual product tangible attribute saying how is it is to grip and how is it is stored and then can we wash it and then can we sterilize it and then I hope I do not use somebody else is similarly somebody else does not use my what you call device for a cleaning. Eventually we have tangible quantifiable and measurable performance characteristics saying typically what is the weight of the product typically how long does it classed then some are subjective and opinion based.

When we say subjective and opinion based it is not as simple as saying I have an opinion you have an opinion collectively if a lot of people agree a group of people agree is saying this is important it becomes a more useful attribute to I think. So, you see here earlier on when car started they started with as you said know four wheels for traction I am sorry two wheels for traction and two wheels for steering and then there one more wheel for

steering and in new cars we came about a very important safety aspect saying you have a horn and in a place like covers you know the horn appears we more important than the what you call brake and the clutch and the other thing.

Next logical thing was saying do we need a power break and an eventually right now nobody buys a what you call personnel transport unless it has all the what was called bells and whistles, including a power staring power windows steerable outside rearview mirrors and then you have an automatic transmission, then you have a camera for parking at the back end now some places even a dash cam is there. So, these are all the eventually argumented products. So, in an eventually argumented product you will knows notice here that all the other thing now including after service branding finance warranty installation all these are involved for it.

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Now, when you make a product do you concentrate and all this yes and no not everybody can do everything, but if you work with the people who do it will be able to do if you I will take you an example of a next slide what does this look like those of you of course, are in touch with the design you will recognize what it is those of you are not, I will just like look play around know saying yeah it looks like an alien and it looks like a aliens have come to invaders. I think you all know it is not of course, definitely not aliens and then where are the eyes does it go by something else suddenly you will discover in the next slide see this is what it is.

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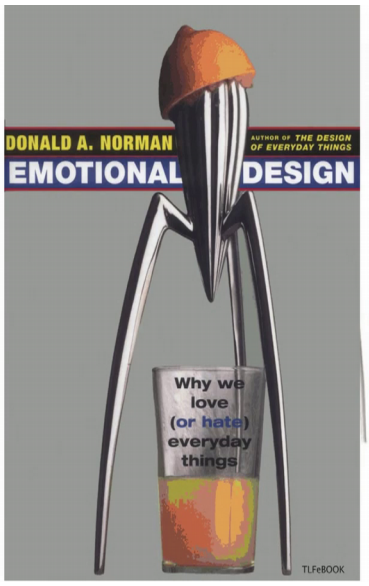

Its self explanatory the function is self explanatory, the what you call why it is why all these grooves are there you take a and the top you take a citron citrus fruit, you rotate it and squeeze it nicely the whole thing no trickles down and we have thing filling up what was what looked very different suddenly you know there is an emotional aspect of it. Here now as a novelty product it is useful you may not find it everywhere, it is just a novelty product, but then what you call doctor Norman he has worked on it and he says the design of everyday things his definitely it is going to be emotional appeal and an experience, you will like products if the experience is good whether it is apparel whether it is you know some other thing or whether daily use product know including your automobiles or in case it is your shoes all these things there is an emotional appeal of the product.

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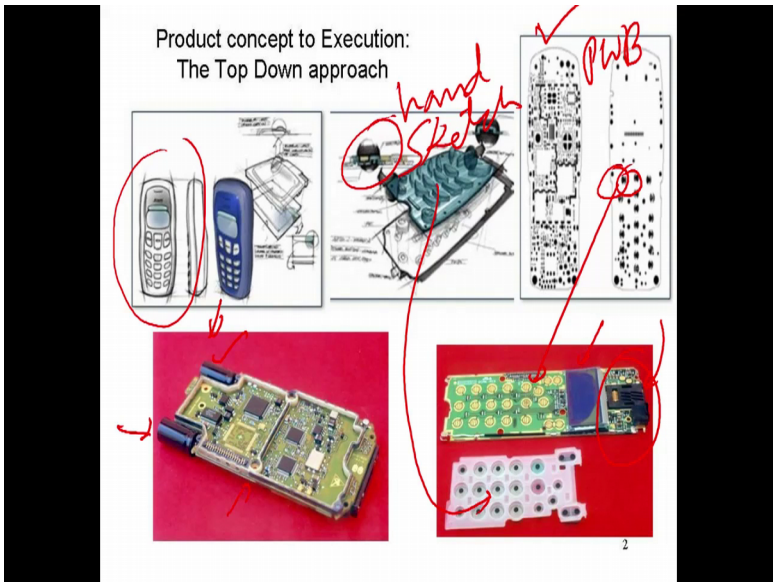

Now, I will take you to the more subject matter in which you know you all may be interested this is typically the insides of an old phone mobile phone; thing we would like to stress here is somewhere somebody should stop I mean a should start with a concept and eventually executed such that the product is working. I have basically taken an old example because this can be easily transformed or escalated into the current products you see here when somebody has done it the one of the important thing is they have sketched out the product and the design at it is so, good that nokias old phone including the 1 1 0 or then the 3 3 0 they have stuck. So, well in the market they trying to introduce it back again.

So, there is a place for good design has a place will never forget it if you see a kettle a kettle is there which has the handle and then it has a spout then it has a thing and when you pour that option come off it never happens to a kettle; however, if I have a salt shaker imagine you have a salt shaker you got a hotel and all that no it does not fall if you do will little more, you get more salt than you are needed you can as well be in the middle of an ocean because you have food then too much of salt. So, somewhere here somebody has start with a top down approach saying this is what we want eventually work out all the details, but you see here even at this point this is still a sketch this is still hand sketch.

It is rendered well it looks nice and so on based on this concept somebody has made a printed wiring board this is a PWB, and part of the printed wiring board is if you see all the contacts are placed here this contacts come here and then this keypad is part of this while a conceptually the keypad is you will notice that certainly several ways of making these things are there and having done all this we also have some large components in this case now we have two large capacitors which is of course, an old thing and then you have something to hold the phone together there is; obviously, a barrier here and then there is a this is a damaged one. So, you have a display here, and then you have all sorts of there is a place here for putting your sim card and all that, and in the end you have a product which works and you can never forget it.

Things change this is probably a 20 year old I do not know Nokia sim and phone and things have changed a lot.

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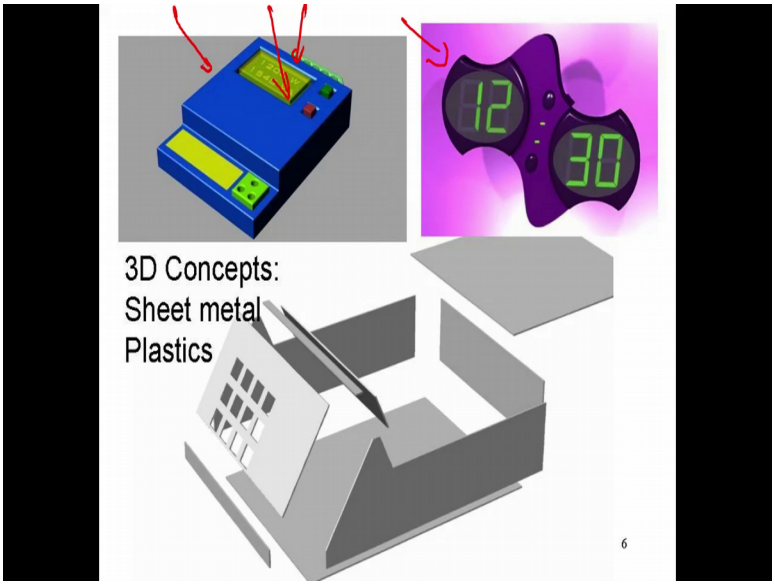

Now, the next slide talks about something which daily you yourself can make in your lab or in the case of a home workshop or if you are in a better thing, and the lit this is using it is possible for us make all these things using normal sheet metal it can be you can be hobby workshop you see here at this point.

One student has made a concept of a power meter, this power meter has a handle here at the back to hold it we have a handle here then we have a power output then there is something here about a designation and thing what we need safety instructions, and the

two buttons here which shows what is the power being consumed, but remember this this particular picture was made 25 years back before we have the small electronics switch on directly plug into a socket, and the other side we have another socket and you plug your load you can measure everything.

Some of the concepts are good, but this particular thing has been made rugged. So, the idea is any in case there is any trouble in your house the service provider typically an electrician or the what you call people from the electricity board they come and check what is the think. So, in case you have a small charger we can plug it inside and check whether it violates some other thing a charger can be a small mobile phone charger, it a charger can be like what I have for my hearing aid or it can be a ups.

Because these days the ups are big for the whole house you know we have a 3kilowatt ups and the important thing about it is maintaining this wattage versus this what you call reactive power thing you know is very very critical about it. While these are you see a beautiful concept made by one of our design students they wanted a wall clock the wall clock nest (Refer Time: 21:05) ashore time and it should be decorative it is something we put it on the wall and people should be not just you know it should not be another some random you know box with the number stuck in the wall, it should look presentable more than anything else suddenly first of all these pictures you would have seen first thing you are noticed it there is a very interesting clock there and there is some buttons; obviously, the scroll and do and all that I feel there is a timeless design which can go on like that end very peculiar theme has been used here.

This part of it is a circle that two circles and the whole theme you rotate it and it holds like that. The idea of it is eventually in case there is no place you can align it and make sure you can make it longish you can make it like this or into a particular you know the three by four format which she has fitted.

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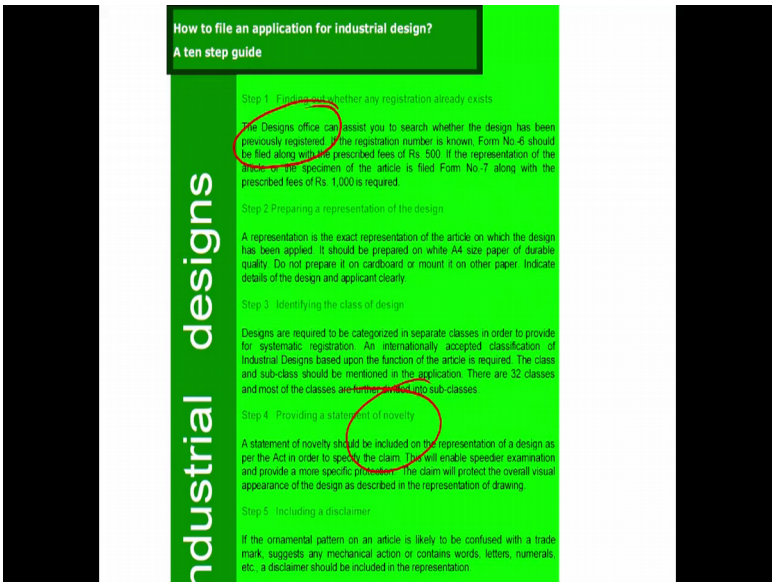

Now, I will go into the next slide in our what you call in our big to capture all these various things and protect our thing protect our ideas from others freely copying it we have this concept of patenting we have a designs office, which can identify the type of design and then most important is the novelty part of it has somebody else done the same job. In the case of products we would like to do what is called a such for the patents or such for the approve designs which others have used within the case of our academic thing again let me repeat in the case of products we try to look for what you call if somebody else already has made that particular product, if something is old you can always acknowledged that. And if it is already patented, but released for the manufacturers like if you see the old compact cassette all of us know if I say walkman you know what I am talking about a walkman is a walkman Discman is not known so, well and all of us know what an mp 3 player is it may play mp 4 also, but we still think it is an mp 3player.

After having established what is the state of the heart and somebody else is making it already we can go ahead and try to patent the products. If you do not want a patent a simple design registration of the external shapes can be done and sometimes there is of course, there is a what you call overlap, but that is excused more than anything else.

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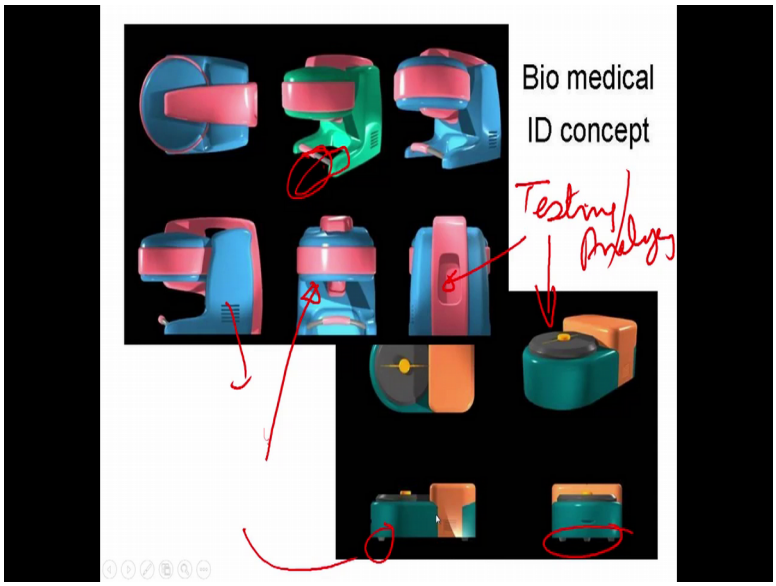

Now, I will show you here some concepts which see some of our students have made in connection is some biomedical equipment, this particular thing is meant for what you call testing analyzing large number of samples which could be dangerous meaning external environment contaminate that I am things are the internal the contents can be you know they may pose a risk to the outside people.

So, at one extreme of the right side bottom corner you will just see a simple thing which you know around there is a carousel in which load several test tubes and all that, but the disadvantage of this is where it simple in construction and all that handling it is not easy and there is no real way of cleaning all the wells and all that. So, some people have come out with alternate concepts saying the carousels can be fitted from the bottom we fit the carousel from the bottom.

And similarly there are operations here now which you can carry on and then there is a cooling effect there is a handle because desktop space is limited even on a in a wet lab and then all the time the wet lab things are wet by definition. So, if this thing in spite of their providing some what you call spaces here, if we try to clean it underneath in case of a spill we are in a problem. So, to prevent this what they have done is they have made make sure that only the minimum amount of coverage you see here, only the minimum amount of space is provided you can just tilt it without disturbing the whole setup and go on to the next one.

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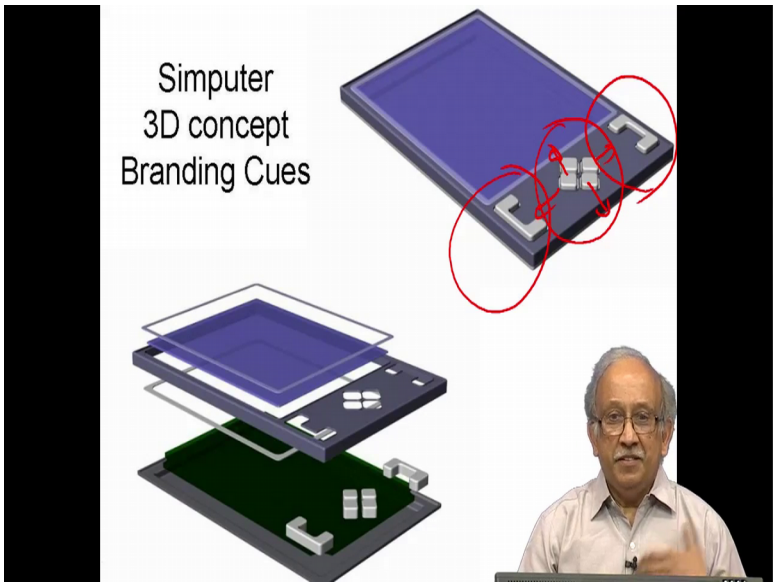

At one time we had something called a what you call a beautiful concept called the simputer in India. If you see here carefully this is one of the concepts developed for the class it goes a lot with our cdt is emblem we have done this is the c part of the thing this is the d part of it these two instantly can also be used as keys. So, you see here there is a cover on top of it this goes other than that we have the normal what are arranged as a scroll keys, it typically looks quite a lot like the what you call a joystick keys which are likely to use comfortably. In the new keyboards however, we see that left right and bottom are all line end up at the bottom up only is put up.

But once upon a time now this concept was very good. So, this will make things move up this will make it move less and then this will make it here and then the other thing is center if you press any two of them together know either it will hold or move on to the next thing, and the way the whole thing is prepared there is no wiring board inside there are no connectors inside nothing else it is just a concept people work on these concepts all the time.

Sometimes it is implementable, sometimes it is not implementable, but nothing prevents me from dreaming the future.

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Which will now bring me back to an important slide while there all things which are done inside the lab and indoor equipment, we also end up with this very important thing called environmental protection can we take them out in the field.

So, I am happy to say four of my colleagues know also helped us in what I call giving me an opportunity to do this now this is an agricultural sensor it is a soil moisture sensor and then the hall sensors are all embedded in the ground and then after that we have something for the data aggregation, then we have boxes here which ensures you know protection of that then you say here it runs with it is own battery our battery backup and then we have moderns inside and so on known even this comes under that.

So, whenever a student or a hobbyist makes a simple product. I will repeat whenever a hobbyist or a student or a normal researcher makes a simple product it is not very safe environmentally and in fact, if you go near one of the person they will says sir please do not touch why because some wires will become lose it is not very reliable and it will work only in specified conditions probably reproducible. If you say ambient is so much and the main voltage is so much and then the signal has so much and then in favorable conditions it works, but when you go to unfavorable conditions like this in the field one of the first things you will notice is interconnections fail things fail inside in the very bad conditions temperature is one of the things even solar radiation effects extremes of you know relative humidity effects and so on like that.

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The next slide we will show me a very interesting thing called the classical pigeonhole problem. There are lot of pigeons they all end up in pigeonholes unfortunately design of electronic products you cannot pigeonhole things, you cannot say you have a electrical engineer who does the electrical part of it, then you have a what you call packaging engineer who packages the various items, then you have a systems engineer who integrates it and so on for a large system it is partly true.

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Everybody has to work with each other; however, we have to have a approach like a busy bee you have seen this now all for one one for all. If you attack one part of the this thing we have this fantastic stinger here. So, it is not just the soldier bees or a drones or anything no you will be stung by any bee all the bees. In fact, will sting you then we have this know saying it could be hornets nest.

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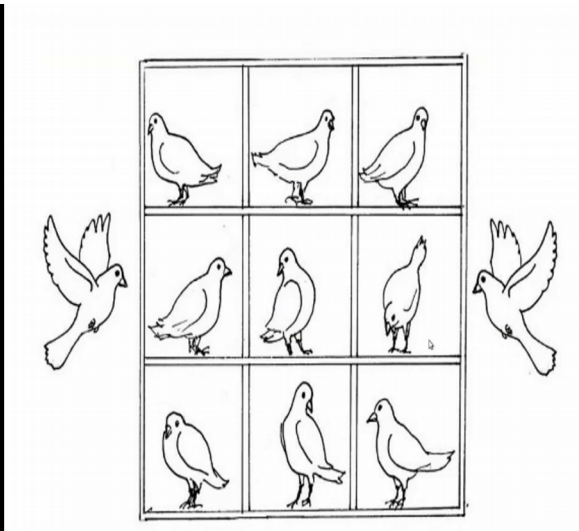

Then you see this is the classical what you call pigeonhole problem. Imagine there more pigeons then there are places which they can hide first thing one of the first things you will notice is some of the pigeons now have to share, why I use this allegory is that product engineers have to be good in more than one aspect things.

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Like this products you know which are now ancient; however, you notice that all of them have come not by their effect of either only the packaging designer or the effect of other what I call only other engineers and all that you see here.

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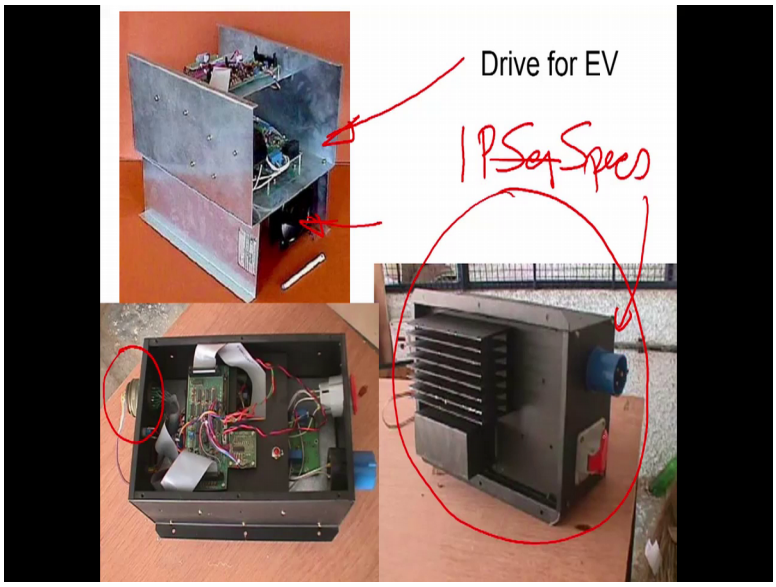

An example of a drive for an electric vehicle which along with the other team members I was involved in it the rod drive look like this it works, but obviously, you cannot take it out into the field with all the thing and then you see here we have a I do not know probably it is a fan, and then you have some parts over flange here it works extremely

well under testing conditions, but the moment you want to take it to the field obviously, you want something which is fully enclosed forming some IP specs.

In this case it is called the index of protection, it needs to make sure there is no splashing and then the all the interconnections and all are safe and nothing is there and then as much as possible no external air is injected into that system you see here know same thing has all been reengineered and put inside and at the back we have a military or ms shell connectors right now it is only used for monitoring as such know we do not use it for anything else. In the unlikely case we want it for something else we can remove the cap and make our own shell otherwise this thing is the dummy thing which is closed and then you have a input and an output probably input part of it is what comes from the battery or other portions of it, and the output part of it is what goes to the traction motors of a vehicle.

This is standard procedure anybody follows and then if you see even this connectors also know they all belong to particular class of connectors, some of the connectors you can expose it because it is indoor there is no issue about it, some of them you cannot effort to expose the connectors outside when it is a use it needs to be used when it is not used it needs to be covered. So, that particular connector has the facility or as soon as you withdraw, whatever plug or socket arrangement know, immediately it closes inside you see it is a standard industry practice everywhere.

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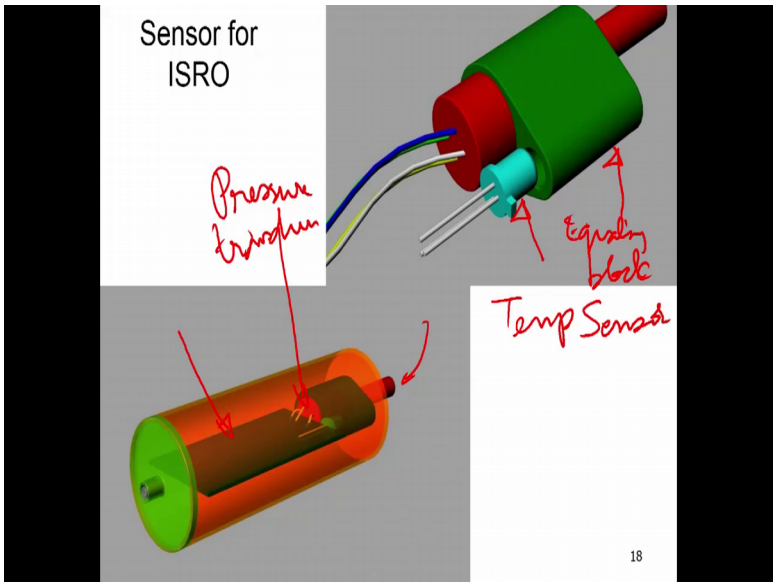

Now, I will go onto another thing know which is used by space people this is a temperature compensated pressure transducer. In the case of this temperature compensated pressure transducer; obviously, you have a pressures and I mean what you call a temperature sensor then this is a equalizing block. This ensures that the temperature is equalized all over and then it measures as much as there they actually the core element this is the pressure transducer.

Seen that then there is an orifice here even the orifice also there are several options are there if we want we can have isolated one front to the other, other ways we can keep it open in this particular reason this is the actual electronics seen that know the electronics also have been made to show that the whole thing and the whole thing is completely sealed depending on the method of operation we want, it can be vacuumized, it can be there or we have a small orifice here which will enable us to do any of the pressure calibration things.

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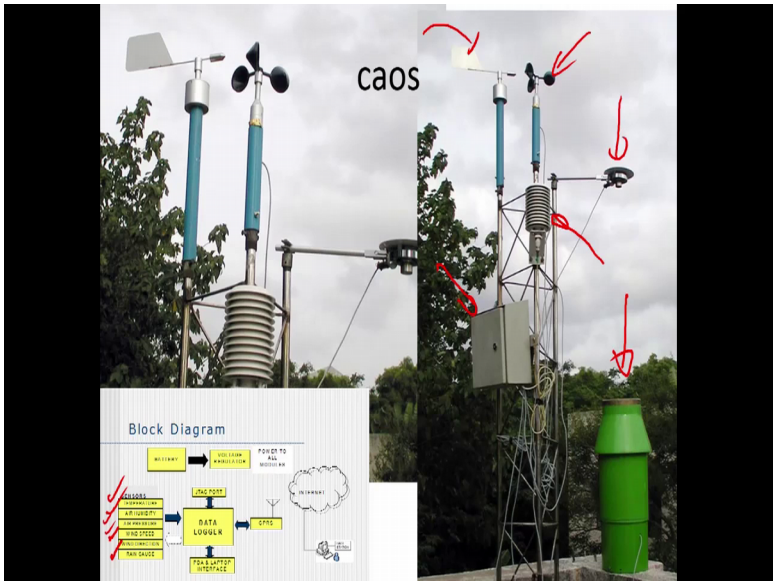

And then at this at the extreme things you have things like the weather stations. Weather station; obviously, know has to withstand weather. So, no issue about it, you see that we have a beautiful column here this what you call mast we can amount it here and then this I am sure all of you know what it is it is a rain gauge and then we have radiation gauges and then we have a wind what you call anemometer, then there is a direction in a meter, and then inside here now you have a temperature sensor and the whole thing has boxes

and boxes of stuff. So, you have a big thing know you can always measure temperature, humidity, pressure, speed, direction and then finally, amount of wind that you want to have and the magic is the whole thing can be data logged and kept there these are also electronic items they are expensive, and you know why they are expensive because it is not easy to make something which is rugged.

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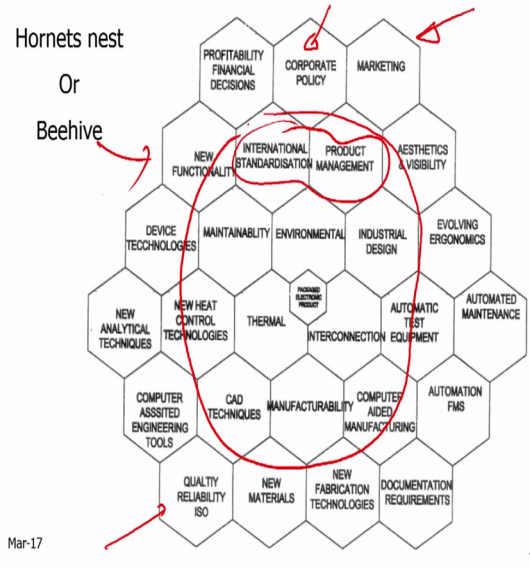

So, now we get this important thing not depending on whether you would like to see any of these products as a full hornets nest, meaning you can gets stung and better avoid a hornets nest or you can think of it as a beehive of activity where you can also contribute. So, obviously, outermost things you know are not directly related to the designers thing so; obviously, financial profitability is there who will back your product even if you are a startup company you probably need an alternate job until you can make it and then we have this policy also.

We all know that drunk driving is not good there is in fact, mothers against drunk driving, but very rarely we see anybody carrying alcohol breath analyzers I am looking for an alcohol breath analyzer like this. I take this I glow into it immediately it will tell me do not drive two options saying your people in your I mean home folks find out another is you are likely to injure others do not drive like that as such you know a pen style personal breathalyzer is not yet very popular probably they are available like that you know, some bars are fitted with this breathalyzer before leaving your expected to

breathe into it for your own satisfaction it is not as if the door gets locked or anything just to make sure in case you have missed and unnecessary things you know.

Obviously government has a policy here as part of this policy government has a policy either to implement it or not implement it and so on and the corporation themselves from may or may not want to get into it like this. Then most important is marketing always you know seems to come out with certain requirements and decisions other things you know is we have this quality and reliability and then all the time new functions people want and then there is standardization in product management which is seems to be very important for you otherwise we will not have so many new variants of products that come all the time. So, we have all the time you know somebody is thinking of products which are a few years ahead of it and coming out with this. So, as you narrow it from this now if you just narrow it you will slowly come into.

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This is swamp swamp of a anything it could inches locust it can be birds it can bees or anything you see all of them are a little alike, but the thing is when the time comes they are able to collectively go towards something attack a particular thing or anything you know. So, it is a swamp.

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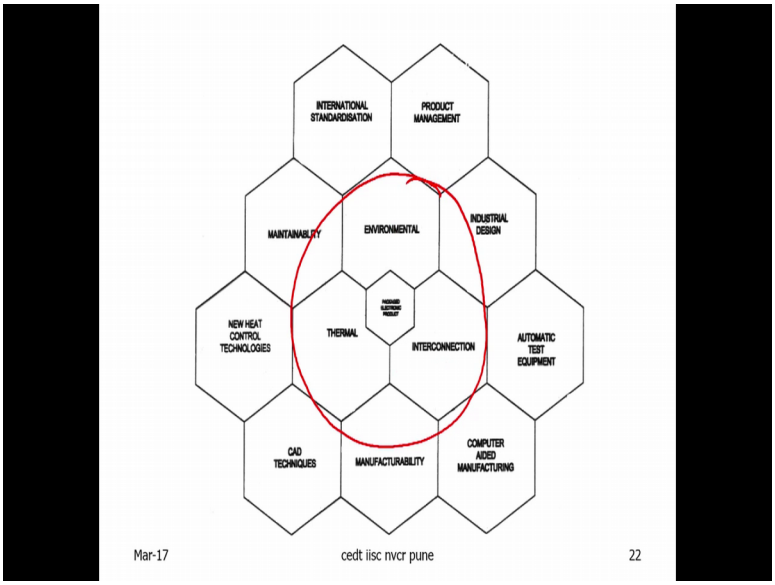

So, it is that given all our activities you know, invariably all the people have to work on these things we have standardization then we have the particular thing our box is going to be or our casing is going to concentrate only environmental thermal and interconnection possibilities.

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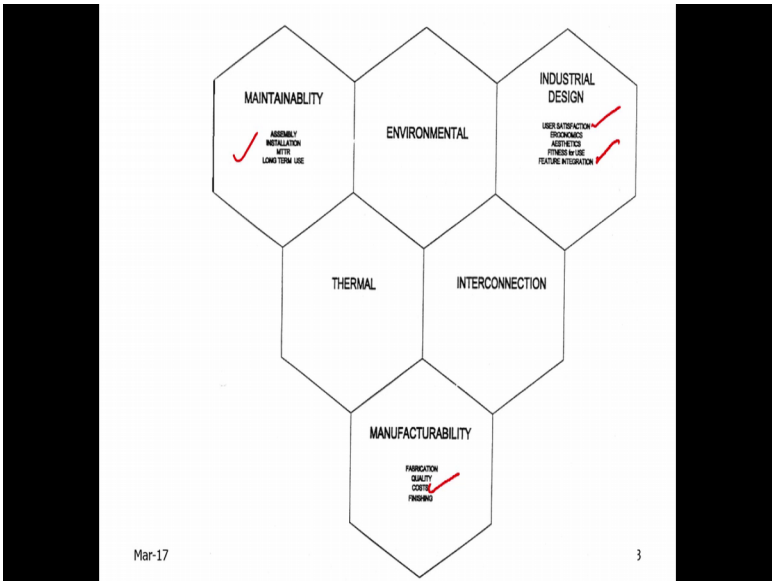

So, you see here in the case of industrial design you know most important is; obviously, user satisfaction and listing out and feature in what you call integration of the features this seems to be very very important. Similarly in the case of the anything which needs to

be done know can we use it for a long term use and then finally, important thing is cost in the case of manufacture you know speak to market and cost and all that how quickly that is reason probably why 3D printing and various types of computer aided flexible manufacturing have come into place on the same line we can make different things here.

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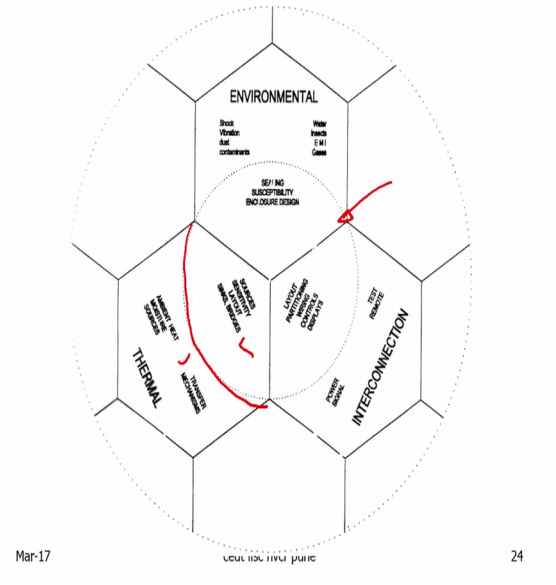

So, I have put a dot here outside showing what could be either thing and then this inside one know this typically shows us the enclosures where we make sure that things are not you know what you call equipment is not susceptible to it. All the time we keep wondering that we have a thermal interface here how can something which is inside in especially sensitive things and so on know, the isolated from the outside if you come close the box things become hot if you open it things become while they can be cooled not very comfortable. Is it not so, various way of using what are called bridges and then different other type of what you call transfer mechanisms it is possible for making it same thing happens about sealing and susceptibility then most important is this interconnection it has to see the outside world, not all things are like a mobile even in a mobile two connections are still essential. So, if I take my mobile here you see that for the interaction you see two of them one of them is at the bottom obviously, I have a charging socket, you have seen that know have a charging socket.

similarly at the top I have a headphone socket you seen this here know a small headphone socket and at the back we also have a speaker in this case I am not able to see

there is a speaker here. Similarly in the front also you know again we have a speakers and then and somewhere in the bottom it is probably hidden we have a microphone here and then we have various types of in this case you know there is also sensor which shows a approximate a thing if I am hold it like this, it will adjust various levels to make sure that it still safe these are all very very critical in the case of our designs.

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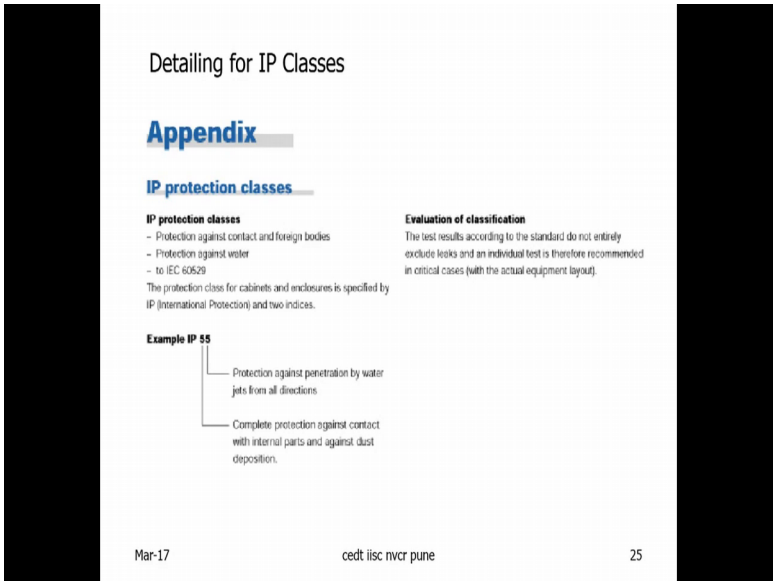

Next slide I will come back to it in a later in a different class it is about this IP protection; what IP stands for you know various types of classes saying against water and all that.

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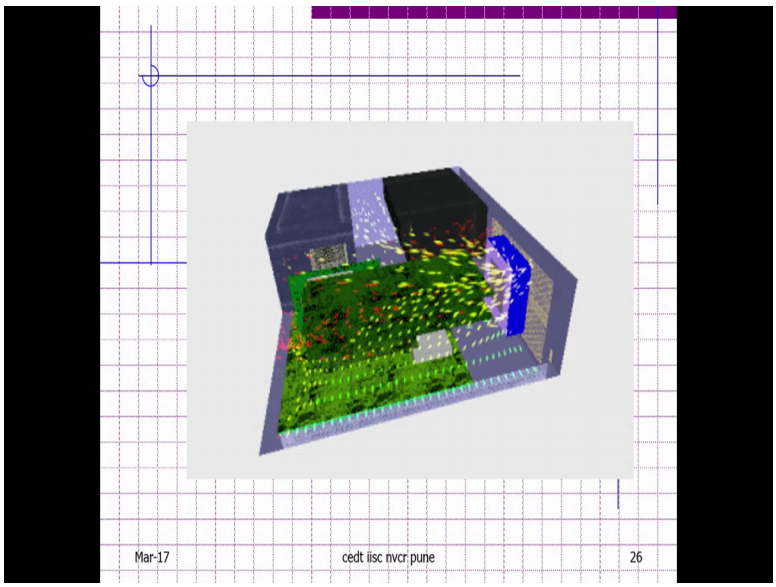

And then one of the simple wave there a tabletop thing it is possible for you to put a fan. So, you see the picture here you know it just shows a fan being put here or in an extreme case if you see this thing.

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What looks like I mean it is complicated, but you see that you have a heat pipe there evaporators here then there is a condenser here and then there is something which blows are and it works beautifully after everything it is sealed there is a beautiful seal here the whole thing works very very well.

I will stop here because I almost covered around little more than half an hour next slide next class I will probably come and cover many more things related to how you can actually productionize or a manufacture your product or even it is a one of number how we can make it into better things.

Thank you.