Design for Quality, Manufacturing and Assembly
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Lecture-34
Systematic DFA Case Study – Controller Assembly

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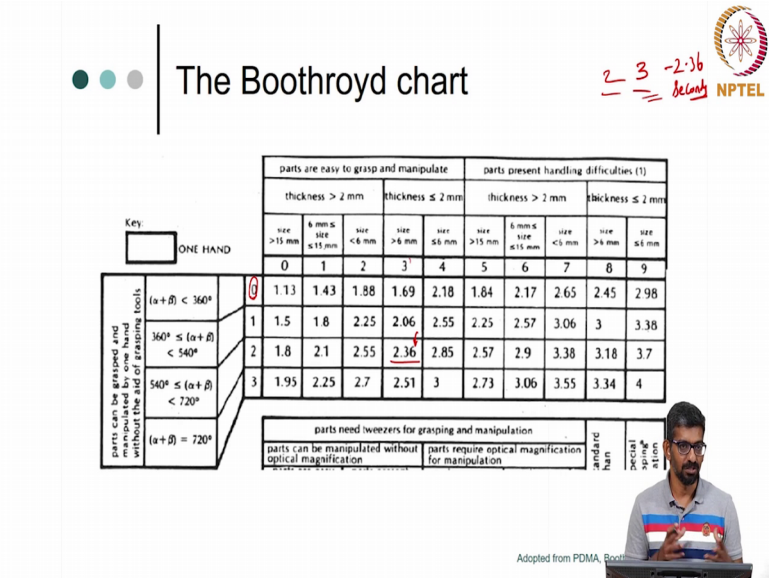

This is what the Boothroyd chart says ok. So, it says you can analyse a particular assembly based on you know your alpha symmetry, your thickness and all that ok. So, I will just; there is some scheme that they say ok, they give you a two digit code that you need to look at, and finally it will give you the time and all that. So, I will just take you through this I mean this is a larger chart, for projection purpose, I am just showing you like the top part of it ok. I will just take you to a couple of rows, and then we will look at a case study.

So, what this says is there is key it says ok. So, here it is one hand and below this, there will be a key that says it is two hands are required. So, right now we will just imagine one hand, what this one says is part can be grasped and manipulated by one hand without the aid of grasping tools that is what it says. The second one will be still two hands or one hand with tool or something like that ok. So, this particular stuff it says, first can your part be handled without a tool, can it be handled by a single hand. Yes, then you need to look into these are the options that you have that is all.

So, the first one, it is asking is what is your alpha plus beta, is it less than 360, is it less than 540, is it less than 720, is that equal to 720, this is this you know how to do that. So, once you do this, this is going to be the first digit. You are going to have two digit code, the first digit is based on your symmetry, whether it is 0, 1, 2 or 3, let us say it was 2, I am just giving a number ok. Now, you need to figure out what is your second digit.

What you are going to do, you will have to see all the way in the top column, it say sorry top row, parts are easy to grasp and manipulate part present handling difficulties, so you decide whether it is easy to grasp and manipulate. If yes, then you answer whether it is thickness is greater than or thickness is less than or equal to 2 mm. If you say thickness is less than or equal to 2 mm, then you look at what is the size. You remember, we spoke about symmetry number 1, we spoke about thickness number 2, we spoke about size number 3, so that is the reason I discussed only that, but there will also be other things, when you go into this. See parts need tweezers for grasping and manipulation under that you will have restricted access, restricted vision for all that you will have time based information.

Then what you do is this you look at this and let us assume in this case, the size was greater than 6 mm, then what happens, your 3 your second digit code is 3. So, for 23, what is the time, the entries here are time 2.36 seconds ok. This is always a question, how do you come up with 6, the second digit in seconds; microseconds ok. So, it says for a particular stuff, where your first digit was 2, which mean this was the symmetry, and the thickness was less than 2 mm, and the size was greater than 6 mm, the time required is 2.36 seconds ok.

Now, the beauty is you have not gone to the late, you have not gone to the workshop, sitting on your can model, I can tell you this is what is the time, it is going to take ok. Then you can say 2.36 seconds I am going to make hundred such components, so it is going to be I do not know 236 seconds ok, and then one labour is going to cause me so much money for one second. So, for 236 seconds what is the cost, so you can do that. So, assembly cost, you can actually accommodate it during the design stage itself that is the beauty of this ok.

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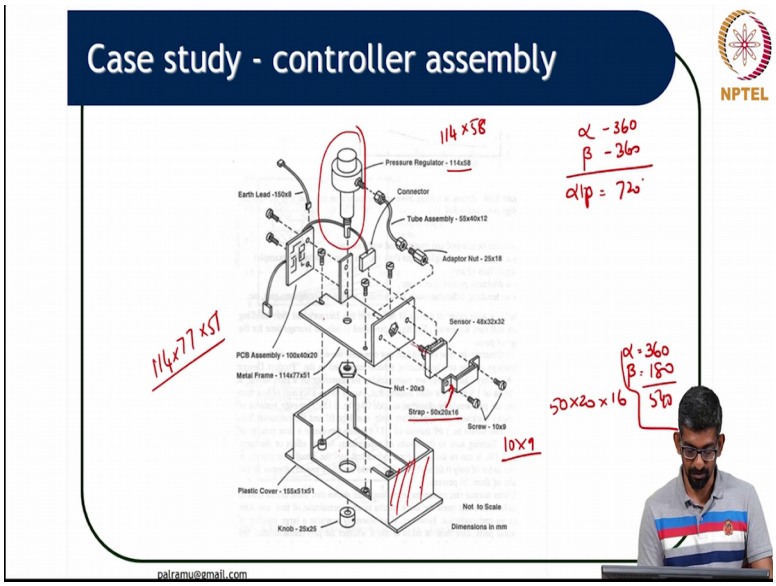

So, here is a controller assembly case study. So, this is also adopted from the book. So, you can go and detail, you can look at it.

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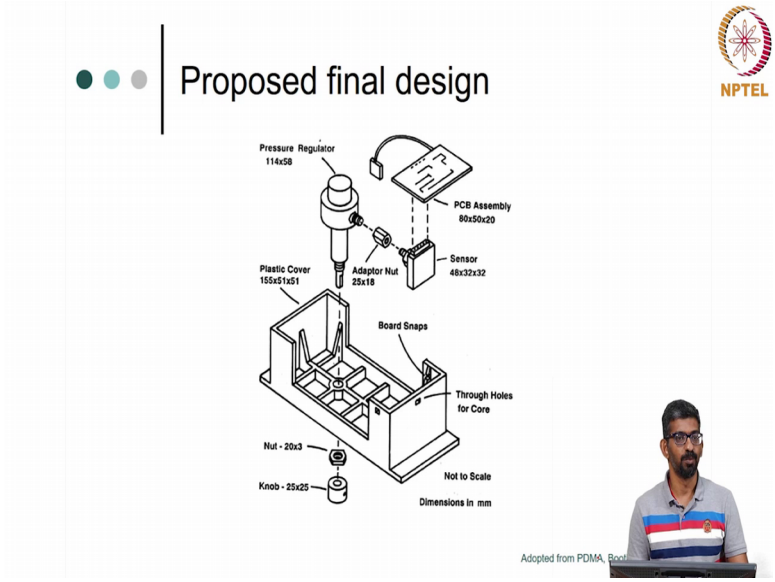

So, we will go through this, but before that I will tell you; this is what they came up with, the final proposed design. Please watch this, this is where they started ok, they analysed this whole set up, then they figure out what can be eliminated, how can you eliminated, what can be replaced and all that. Then they came over this reduced design ok. So, naturally the assembly cost was much lesser than this compared to the other one, both of

them do the same function ok. So, we are going to look at the study of a controller assembly particular thing right, it is an exploded view it is an exploded view, it is a compressed controller assembly kind of stuff.

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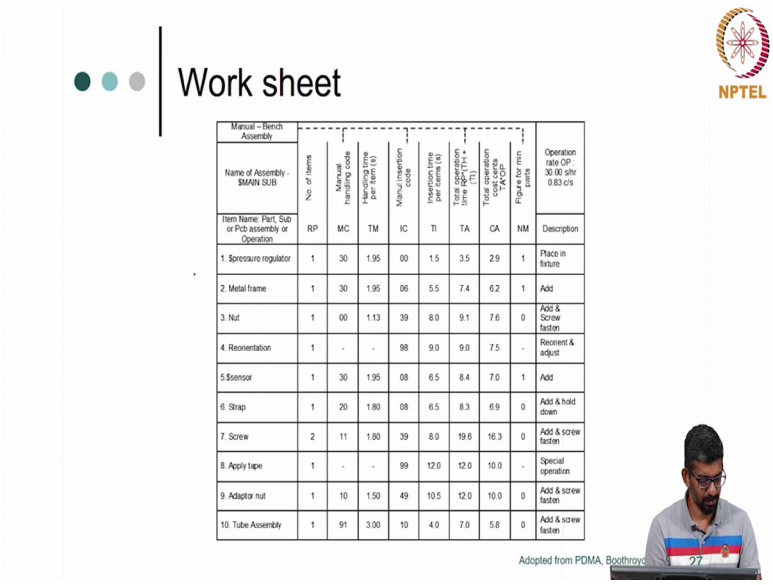

We are not going to go through all the parts ok, probably I will look into it ok. So, the deal is first thing I guess that they are taking this pressure regulator ok they are taking the pressure regulator.

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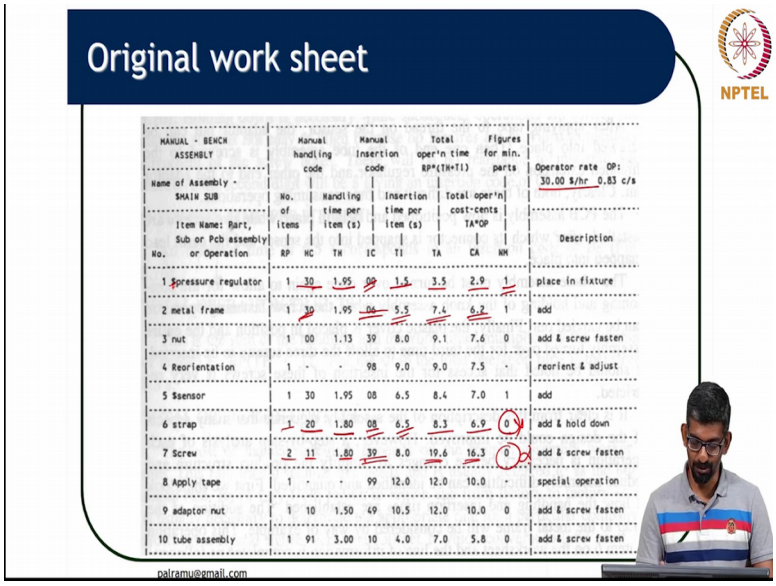

Name of the assembly is the main subassembly, and then they are calling all the parts right. So, if you go back to this, they have a pressure regulator, they have a connector, they have a tube assembly, pressure regulator tube assembly, and then the metal frame nut everything, they have put it here part by part. Then what they are trying to do is this they are asking the number of items ok. For instance, the pressure regulator it is only 1, and the screw there were 2 screws, so it has to be multiplied by 2 at the end, then similarly all other at least in this particular page is 11. Then they ask for the manual handling code, so this is just the sheet. You start by filling each one of the rows, we will figure out how they came up with this 30, we will look at that.

Then handling time per that is 1.95. And then this is the handling part, similarly you will have a insertion thing also. So, in the insertion, the code is 0 0, the corresponding time is 1.5 seconds, then the total time is the total handling plus the total insertion which is 3.5. And the operation cost, they have some numbers, they multiply it say it is 30 dollars per hour, this is way back ok. Now, onwards for 30 dollars now so, 3.5 sorry 2.9, and then the figure for the minimum number of parts, you remember whether this part is required or not in this one.

See for instance, nut as we discussed fasteners are not, minimum they do not qualify as minimum number of parts, so it is 0. Strap, the screw, thereafter in the tube assembly, they do not need to be so anyway. So, now what we will do is this, we will just look at this pressure regulator for instance ok, this is the pressure regulator. What it says, it is 114 by 58, which means the length is 114 and the width is 58 in this case, so that is the will be useful for your size, your thickness estimations.

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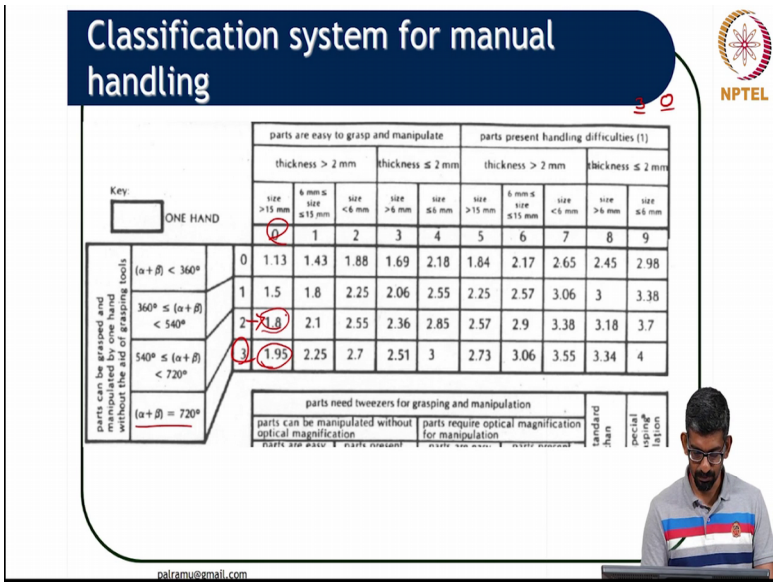

Now, what you need to do is this you need to go back to the guy, what will you ask here, can it be handled in one hand. I guess in this particular the case it can be handled in one hand ok. So, for that pressure regulator, what was yours what do you think is your symmetry, this is your pressure regulator. What is your symmetry, what is your alpha, what is a beta?

Student: alpha is 360.

So, this is your insertion angle right this is your insertion angle. So, your alpha is something that is perpendicular to it so, in order for so it is 360 ok.

Student: Beta is (Refer Time: 08:44).

You have to be careful, because there is a tube assembly ok.

Student: 360.

And the tube assembly has a hole in the side, where it is connected to the sensor ok, so it is not 0. Meaning like if this was not there sorry if this particular part was not there, then probably it is 0. But, in this particular case, I mean there are two ways of looking at that it could either be 180 or it could be 360 provided, but then the whole setup needs to come to the other side, this entire setup needs to come to the other side ok.

Student: Sir; since, the other setup is similar to a wire, can you wind it around?

No hold on, that is design guideline further. Right now in the existing setup, you need to say what is the code and all that, so that it will give you a estimation of the time that is required for this particular assembly. In this particular assembly itself, you are suggesting something.

Student: Yes sir.

What is it? This is a tube assembly.

Student: Yes sir, that tube are which are may parallely we rotate as in parallel to the axis.

Ok.

Student: Which are we rotate the tube will get adjusted.

No, the tube will not get adjusted, because you see here there is an adaptor nut, which will go through this, you can see this thing, it comes through this correct, which connects to a sensor, the sensor is clamped. So, if you change this guy from here to here, the tube need not necessarily come that far, at least the way it is drawn ok. So, if I remember the user 30 right, so it should be alpha plus beta equal to 720 right. So, this guy is 360. So, alpha plus beta was equal to 720 in this particular case.

So, what I do is this, I go to this chart, and then I say this is the one ok, and then I choose this is to be the sorry this is to be the first digit. So, there are going to be two digits, the first one is 3. Now, what is the second digits? The part is easy to grasp and manipulate. What do you think, it is easy to know the height is about 114 mm which is 11 to 12 centimetres ok, and the width is about 6, still it should be easy for us to hold it.

The next one should be your thickness and then the size right. So, what is the thickness is this is a cylindrical part or a non-cylindrical part, it is not a regular cylinder, so whether it is cylindrical or not. So, one side, two side, three side, four side more than five sides are there that is one thing. And what else was the condition?

Student: The length should be greater than the (Refer Time: 11:59) dia.

Is the length greater than the dia? Yes, it is ok. So, it can be considered as a cylindrical part in that case. So, what will be your thickness then?

Student: The diameter.

The diameter yes; this is 114 by 58 ok, so that 58 is what ok, I guess. So, if you go the thickness is greater than 2 mm 58 right yeah greater than 15 mm, because it is 38 sorry 58, hence your second digit will be 0 second digital will be 0, did you get it, yes or no fine. So, now this is 30, you go back to this chart now, and the corresponding time would have been 1.95 there if you had seen one 30 is 1.95 seconds.

Similarly, there is a chart for the insertion ok, then you can go and you will find out, it will be similarly in that you will find out the code to be 0 0, and then the insertion time will be 1.5. So, if you add both of these guys, you will get 3.5. So, this is close to 2, 1.5 is 3.5, and you can just put the operation cost, the minimum part is it a minimum theoretical figures for minimum parts right sorry.

So, the question is, is it rotating with respect to the other parts all other parts, I do not think it is rotating ok. But, we do not know the details, we need to go through the you know the controller assembly details to (Refer Time: 14:08) but probably this is supposed to be made out of a different material compared to any other material that it bonds with. Hence, it qualifies as a theoretical minimum number of part; hence the value 1 ok.

So, we will see the strap. This guy is a strap ok here what it is written is 50 times 20 times 16 ok. So, naturally 50 is the length, 20 is the height here, and this thicknesses 16 ok. This one what is a manual handling code for this guy. Can the strap be handled by one hand?

Student: Yes.

Yes. And then what was its alpha plus beta, let us see here ok. So, it is getting inserted this way it is getting inserted this way, so the axis that is perpendicular to that. So, if you are going to rotate it, how many times?

Student: 15, 16 plus.

So, alpha is 360; beta is?

Student: 180.

180 so 540 ok 540 means it is 2, because here it is less than 540 less than greater than or equal to is here, so it is 2. And is the part easy to grasp and manipulate? Yes. Was the thickness greater than 2 mm or was it less than 2 mm?

Student: 16 mm.

It is greater than 2 mm. Was it greater than 15 or less than 15 or less than 6?

Student: Greater than 15.

Greater than 15 so, it is 20 that is the handling code.

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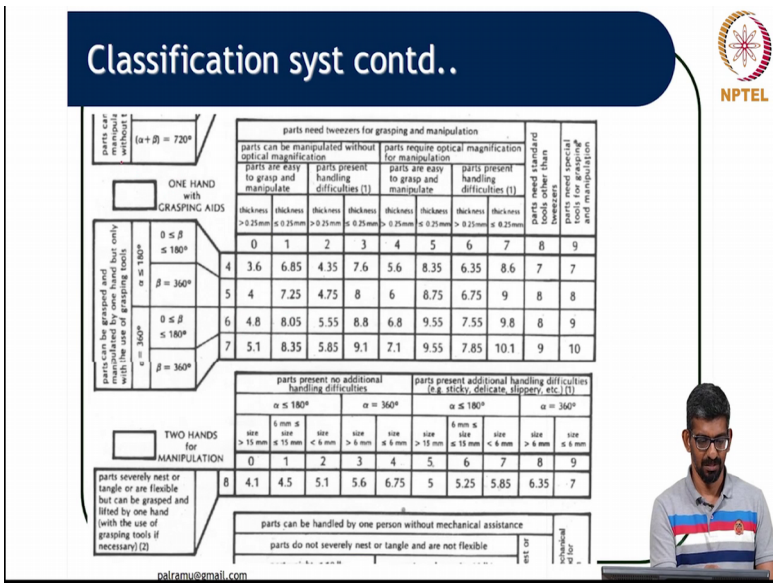

We should actually look at this, I will just this is small digration. But, I will show you what is the continuation of this one ok, this chart you just saw this right, the continuation of this chat is this, this is the last part 720 right. So, the second part is it says parts need tweezers for grasping and manipulation. The legend I mean the key is one hand with grasping aids, you might still be able to handle it with one hand, but you need grasping aids. Then you look for the symmetry, and then you go through this.

The last one is you need both the hands for manipulation ok, then parts present no additional handling parts present additional handling difficulties such as sticky, delicate, slippery, etcetera so, all this come into here. Parts present handling difficulties it is even written here, parts needs standard tools other than tweezers, parts need special tools for

grasping with a regular screwdriver or you need a 5 point screw driver and all that is specifically ok, the numbers increase accordingly. The final one is parts can be handled by one person without mechanical assistance ok, parts do not severely nest at tangle or not flexible.

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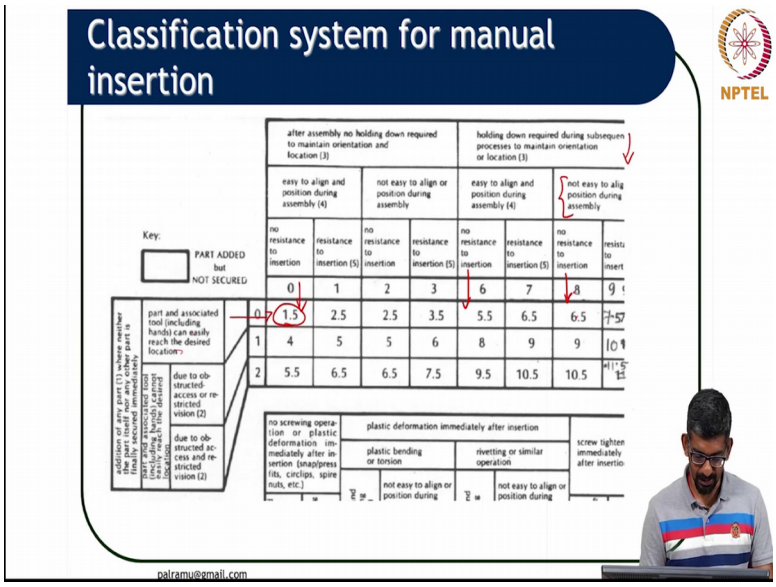

The part is added, but not secured; this is insertion. So, we just spoke about assembly right a handling. Similarly, there is also a table for insertion, the key in this is first one is the part is added, but not secured.

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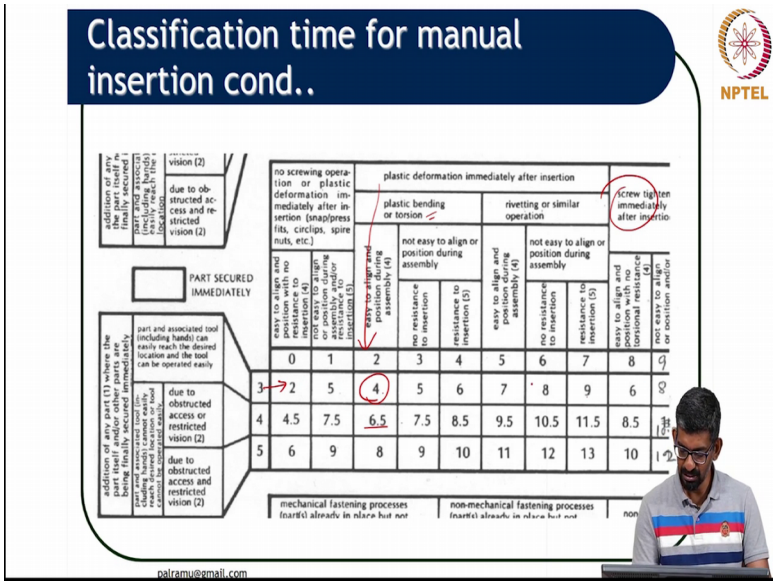

In the second one, the part is secured immediately just because you are going to put two parts together, it does not mean that they are secured ok, they might still be dancing. So, then you still need a hand to hold it, so that you can put the next part to it. In the second one is the part is secured immediately.

We will look at this guy, the manual insertion code for the first part, the pressure regulator itself, we will revisit this. What it says is the part is added, but not secured. There is a somewhere there is an explanation to this. Addition of any part, where neither the part itself nor any other part is finally secured immediately, because you are currently taking only one part right now, so it is not secured, so it will automatically fall into this part.

Part and the associated tool cannot easily reach the desired location that is not true in our case right, it we can easily reach out to that. So, part and the associated tool can easily reach the desired location, hence it is 0. And the other one is after assembly, no holding down required to maintain orientation and location. For that particular part, it is ok at this point in time; the one that gets bounded on it or passen on it is what we need to check next. Easy to align and position during assembly, no resistance to insertion, so it is 0 and 0 that is why they had 0 and 0, the time was 1.5.

Now, we are looking at the strap. So, alpha plus beta and it was 20. So, we will look at it. Strap is 20, the corresponding time would have been 1.80, we will see what it takes for the manual insertion ok. So, this strap the question is the part is added, but not secured; is that true? You see the part, this part is added to this. Is that part itself or the one on which it goes either of them are secured?

Student: The part will be secured.

Yeah, the part is secured right. But, is that secured immediately? There is also the question, careful. This guy you put the sensor through this hole and after that you place the strap on top of it, is this secure?

Student: (Refer Time: 20:25) we need to pass screw.

Yes, you are right; just trying to make sure ok. So, be careful the screw is what is going to make it secure just because you put the strap, it is not secure, this strap will enable, but

finally, the screw is the guy, who does the job. So, in that the part is added, but it is not secured, because the screw is a different part, and tightening the screw is a different action ok. The part is added, but not secured. So, you still I mean the part can easily reach the desired location, there is no problem, hence it is 0.

Then what you do is this you look at after assembly, no holding down is required to maintain the orientation and location that you tell me. Is this correct? This guy, are you able to read that or no?

Student: No sir.

Ok, I am reading it, it says after assembly no holding down required to maintain orientation and location.

Student: We need to hold it.

We need to hold it so, it is go to the second one. Holding down required during subsequent processes to maintain orientation or location, correct so, we are going to look at this particular one, yes the one that reads out; next is easy to align and position during assembly, not easy to align or position during assembly.

Student: It is easy to align position.

In my opinion also, it is easy to align and position during assembly, but then they have chosen not easy to align and position during assembly ok. And then they say there is no resistance to insertion, which is correct for us, we also would say there is no resistance to insertion. So, they have chosen 8, we might have ended up choosing 6 by which we are losing about 1 second, which is fine. We need to go through the details I even I kind of have not done, we can just go through that, and then it will tell you, because they would have discussed each part in detail. So, it is not easy to align for some reason. Then they have chosen 8 I guess, so that is why you will have 08 here.

Student: We need straps, suppose to hold on other parts.

Maybe ok. So, as a designer, you will know, because you are the one, who is designing right so, it is 6.5. And then you are going to add 6.5 to 1.8, you will get 8.3 the corresponding hours. Whereas, the strap is not a rotating part and it need not be of a

different material, hence it is not a theoretical minimum number of part, it is not a minimum number of part, it is not an absolute requirement.

And then let us take the metal frame for instance ok, this guy. I am not going to do the entire stuff I am just doing a couple of things right. So, this is the metal frame here that we are talking about ok. And this one it says 114 by 77 times 51 that is for just for your this thing. So, this one is going to go through this through this metal frame, through this plastic cover, and then it will be tightened using the knob. So, for the metal cover, what is your alpha plus beta to say l shaped stuff, 360 plus 360, it is 720, and then it is easy to grasp and manipulate greater than 2 mm. So, it is 3 and 0, 1.95. So, let us worry about the insertion thing ok.

Now, the part is added, but is it secured? No, it is not secured. So, the part is added, but not secured. So, we will have to look into this, correct. After assembly, no holding down is required to maintain orientation and location, holding down is required during subsequent process, which one is correct?

Student: It does not require any holding.

This does not required any holding down.

Student: Holding required sir.

It will require right, because this goes and then there is a screw, there is a nut that goes and tightens it, and after that the plastic cover comes, and finally you have a knob ok. So, it does require holding down is required easy to align and position during assembly, not easy to align and position. So, I guess, you would choose 0 and 6. We will see what they have done; they have done the same thing 0 and 6 ok. So, 30 and 5.5, and then the total would be 7.4, and the cost is 6.2. So, just before I wrap up, we will just look at probably the screw ok. These two screws that we are talking about, it say 10 by 9 ok. So, there are two screws. The handling code is for a screw, what is your alpha plus beta?

Student: It is 720 and 180, 720, 360.

Screw is being inserted this way. So, your alpha symmetry is how much?

Student: 360.

360. What is your beta symmetry?

Student: 0.

Has someone ever told you that the screw has to be put only in this axis in this direction, you cannot be put in this direction, can put in, so it is 0. So, it is 360, which means it is 1 ok. So, we are going to look into this one. And this is a part easy to grasp and manipulate.

Student: yes.

Yes. Is it greater than 2 mm?

Student: 10 cross 9.

What did we see, 10 cross 9 so, it is greater than 2 mm. And is it greater than 15? No, it is between 6 and 15 so, it is 11. So, we are looking at this guy, I do not know I said right, yes ok and the insertion manual insertion code. The part is added, but is it secured or not? I will read this again, addition of any part, where neither the part itself nor any other part is finally secured immediately. Upon putting the screw is the screw secured or does it secure the other part?

Student: The first screw does not secure. If we put one screw, it does not secure the other part. If we put both the screws, it does secure.

You are actually talking about the both the screws, because you are taking two at a time. You are not taking screw 1, you are not taking screw 2, you are you are taking two screws at a time.

Student: It secures.

It secures. So, we are going to look at part secure immediately ok. So, I will just read this out, addition of any part, where the part itself or other parts are being finally secured immediately, part and the associated tool can easily reach the desired location and the tool can be operated easily, correct. Just put the strap, and it is the outermost part, so you can do that. So, we will take 3 ok and then no screwing operation or plastic deformation immediately after insertion, bracket it says snap, slash, press fits, circlips, spire nuts, etcetera.

Easy to align and position with no resistance or insertion, not easy to align or position during assembly and or resistance to insertion, it is neither of these two, correct. It is not a snap fit, there is a screwing operation that is required it is a screw. There is a separate thing that says screw tightening immediately after insertion; this is a separate thing ok.

And under that easy to align and position with no torsional resistance, not easy to align, and they have chosen that part of it ok. They have chosen 3 and 9, which is 3 9, and the insertion time is 8 in that the total time is 19.6 and 16.3, but fast nuts are not counted as theoretical minimum number of parts, so it is 0 the two parts ok. So, finally, why are we doing all this to get what?

Student: (Refer Time: 29:29) sufficiency assembly efficiency.

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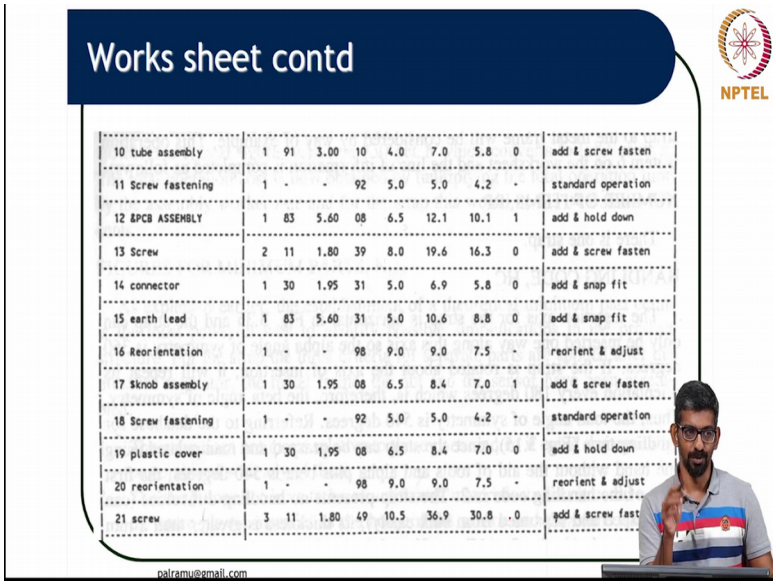

Assembly efficiency exactly so, what you do is this, you do all these stuff, you add up all these guys, finally that will be your theoretical minimum number of part. Times how much time does it take for the original assembly to be done that is the denominator, and the one in the numerator that is the ideal time.

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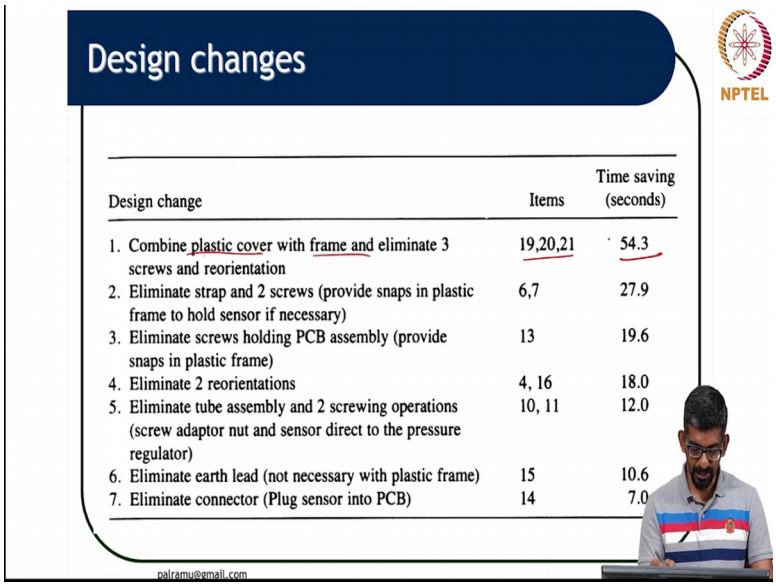

The ideal time is usually less.

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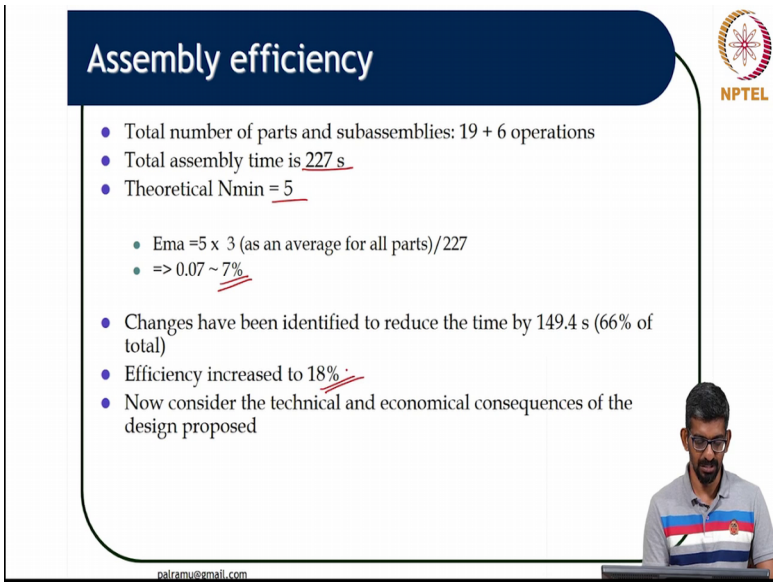

So, the total assembly time was 227 second, the theoretical minimum number of parts was 5. Finally, what they did is they kind of say that it is a 7 percent efficiency ok. After the change the design change, they have been able to increase the efficiency to about 18 percent ok. So, we will see how they go about doing it ok. So, what they did is they look at all these stuff and. So, they are also giving some description ok.

What you can do actually ok, for instance, the earth lead can be a snap fit ok. And for the PCB, you need to add and hold on, so they are doing all that. And based on that they kind of come up with the design change, where they say combine the plastic cover with the frame and eliminate 3 screws and reorientation plastic cover and frame. This is the plastic cover ok, this guy is the plastic cover, and the frame; this is the metal frame. So, what they are telling is you can kind of integrate this guy into this guy, so that you can get rid of this, and kind of get rid of this, and you can get rid of this. So, 3 screws you can get rid of, but you need to integrate this guy into this guy.

He is a metal frame made out of some material, and this is a plastic cover that is made out of some material ok. But, you have to try to integrate this; it might mean that you will have to change this material. So, like that eliminate the strap and 2 screws, instead you provide snaps in plastic frame to hold the sensor if necessary, you do not need a separate strap and then tighten the screws and all that ok. Eliminate the screws holding the PCB assembly so, like that they look at all that. So, they also seeing what are the items that are getting affected, and what is the time in savings, if you end up doing that ok. This is just by removing the 3 screws they have saved about 54.3 seconds.

And then finally, they come up with this design, which is implemented ok. This is a original case study that they show ok. So, they of kind of the it still a plastic cover, they have removed the metal frame, but now this guy directly goes and sits on that it does not have a metal frame in which it sits, which is finally knob and all that is coming, it is directly goes and sits into this. So, that is just to give you an idea on how to estimate the assembly efficiency, and how it can be used to come up with a better design.