Manufacturing Guidelines for Product Design

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Lecture 14
DFMA Guidelines

Namaskar friends, welcome to session 14 of our course on manufacturing guidelines for product design. Just to have a brief review of week 3 we have covered the concept of robust design, we have covered the basic aspects for design for X and in the last class we have seen that there are guidelines which do exist that we must follow when we are designing a product.

And in that case that we have covered in the previous class the product has to be manually assembled. So, those were the design guidelines for products that have to be manually assembled. Today our target is design for manufacturing and assembly, so there are 2 words here design for that is common, manufacturing and assembly. Now all of you know we have seen DFX, now X can take any alphabet, X can be m.

So, we say design for manufacturing X can be a, so we say design for assembly X can be r, so we say design for reliability, X can be q we say design for quality, x can be c we say design for cost, x can be s we say design for safety. So, 2 terms are really important when we talk about the manufacturing aspects of the product design and these 2 things are design for manufacturing and design for assembly.

In our second session where we talked about design for X we have seen towards the end design for manufacturing. And in design for manufacturing we our target was to analyze the product design in order to optimize the cost. We have seen that we can reduce the number of components, we can reduce the number of assembly operations, we can reduce the overall cost and come up with alternative designs come up with better designs, come up with creative designs which are easy to manufacture.

So, the design may comprise of 3 or 4 different sub components, so we focus on design of these

sub components in such a way that each one of them is easy to manufacture. As well as that these 5 components can easily be assembled together into a product. So, that is the basic concept with which we do the design for manufacturing analysis for any product.

On the contrary we have design for assembly and in the previous session we have seen that if the product has to be manually assembled what are the design guidelines that we must keep in mind. Now coming on to design for assembly very easy we can say design for assembly is to ensure ease of assembly, ease of assembly means that there are fewer number of parts and it is easier to assemble them.

They are fool proof assembly operations or they facilitate fool proof assemblies operation. For example this is an example that I usually take, in your TV set or in your TV monitor you have to connect a external device, external device can be suppose a VCD player or a CD player. Now there has to be a wiring arrangement which will connect to the CD player and it will connect to the screen or it will comes to the panel of your TV set.

There are guidelines there are color codes, so we have a 3 pin maybe shoe and then the green color has to go into the green color slot, the there are 3 colors I think that is the standard 1 is red, yellow and white. So, the red color pin has to go into the red slot, the yellow color pin has to go into the yellow slot and the white color pin has to go into the white slot. So, that is basically the ease of assembly anybody who has not studied engineering.

Anybody who has not studied design for assembly, anybody who has not studied manufacturing can easily assemble those 2 different parts together. All can easily connect these 2 different components together the TV as well as the CD player through a wire which is color coded. So, that is basically the concept that for worker he may not be a super intelligent human being or maybe doing the work in a very very we can say simplistic manner.

So, we have to ensure that simplicity, we have to ensure that the products are self aligning the parts are self aligning, the parts are self mating they are maybe a snap fit type of designs can be easily made. And these days these are possible every assembly operation you will see or a every

assembly of parts that you see will definitely will and try to ensure the ease of assembly. But still we see a number of different parts which are very difficult to open many times we see in case of toys for our children we buy a toy becomes difficult to open it if we have to fix up same thing.

So, it is difficult maybe for children the design is such that they do not want to ensure, they do not want that the toy must be opened by the child and therefore they make it slightly complicated or difficult to open it. So, that a person can just observe it may require certain kind of skill to open the toys . So, there the design consideration or the design requirements or the design specifications are entirely different.

But if the product has to be assembled or in that case disassemble we must take care of the design guidelines. So, that assembly as well as the dismantling or disassembly is easier, so that has to be ensured. So, there are 2 different points that we have discussed, design for manufacturing already discussed in session number 12 and design for assembly I am trying to introduce today.

So, these 2 things are integrated together in design for manufacturing and assembly or design for manufacturability and assembly. The source is also even the product design for manufacture and assemblies second edition by Geoffrey Boothroyd, Peter Dewhurst and Winston Knight. So, this book is a good book and maybe if possible you can try to purchase this book a number of other topics are also very well documented and mentioned in a very exhaustive manner with lot of we can say examples.

So, this session we have tried to include from this good book on product design, so DFMA guidelines we are going to study today. So, let us now try to see the similarities between design for manufacturing and design for assembly.

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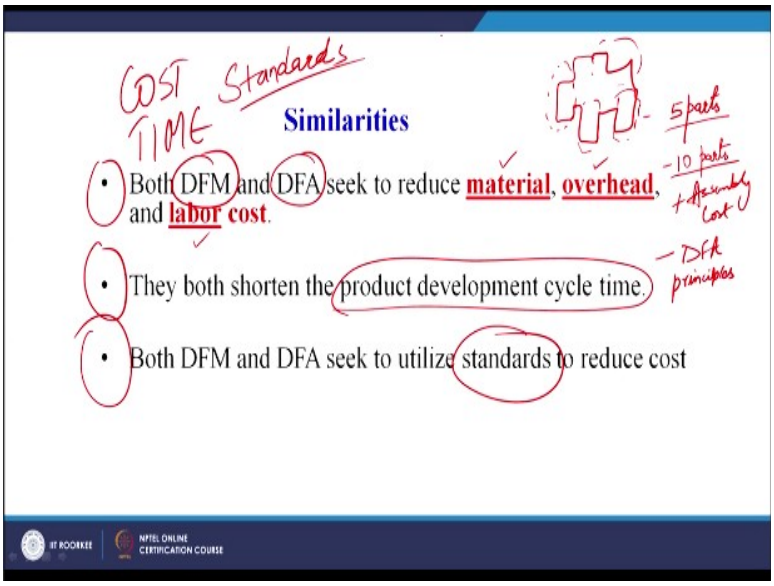

Now both DFM and DFA seek so what is the target of DFM and DFA, so let us see one is DFM already seen ensures use of manufacturing, DFA ensures ease of assembly. Now what is the conflict or the similarities between the 2, design for manufacturing will say that we must uncomplicate, we must make the process of manufacturing the individual parts easier.

So, if we make a product into 10 different sub parts or sub constituents which have to be finally added up to make the final product, it will become easier to manufacture the individual parts. Now suppose this is our product which we want to produce, now as per the design for manufacturing guidelines we will say that let us break this product into sub parts which are easier to manufacture.

So we divide it into suppose 5 parts which can be manufactured and which can be easily manufactured and finally assembled. But when we divided into further number of parts maybe 5 parts easy to manufacture as well as easy to assemble. But further if we divide it into 10 parts the individual parts may become further to produce each part individually may become even more simpler to produce but it will add up the assembly cost.

And may can have a conflict with the DFA principles, so DFA principles say that we have to minimize the part count. So we have to reduce the number of parts, we have to make a modular design, so that it is easy to assemble. So, DFA says minimize the number of parts, so that they are

easy to assemble, DFM says that or maybe it tells us that the individual parts that we are manufacturing must be easy to manufacture.

So, if there is a complicated part you divide it into simpler parts and these simpler parts are easy to manufacture and are easy to assemble. So, there is sometimes a conflict between the design guidelines established by design for manufacturing and as established by design for assembly. So, therefore we try to overcome this conflict and try to find out that what are the similarities between the 2 approaches.

So, both DFM and DFA seek to reduce the material overhead and labor cost, so less amount of material, less overall overhead cost and less labor cost which means that for ease of manufacturing also it is easier to produce the part. So, the labor productivity is more and the overall labor cost is economized. Similarly the number of assembly operations are less again the worker produces more number of assemblies per day, so the labor cost is taken care of or is economized.

So, the both shorten the product development cycle time, so 2 things have come out of here. The first 2 points first one is cost taken care of, second one is time taken care of, so you take less time if you take care of these guidelines during the design stage of your product. Both DFM and DFA seek to utilize standards to reduce cost, so third thing are the standard, so we need to use the standard techniques and materials as well as components for reducing the overall cost as well as the manufacturing time for our product.

So, these are the similarities objectives of both the DFM as well as the DFA guidelines are more or less same that they want to economize on materials overhead cost, total cost, labor cost. They need to economize on the time also how by using the standard tools equipment materials and machines, now what can be the differences.

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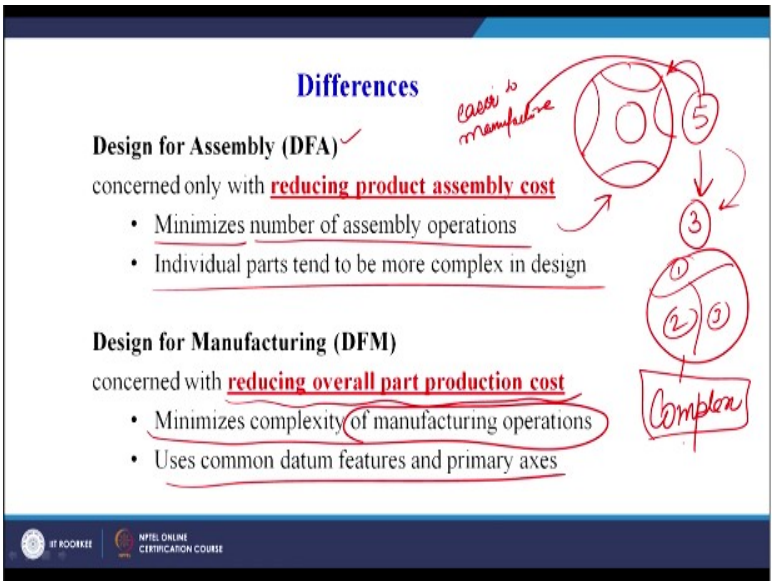

Now DFM says it is concerned only with reducing the product assembly cost, it seeks to minimize the number of assembly operations as I have already told it will say that **if there are 5 different parts to be assembled together** if there are 5 different parts to be assembled together as per DFA it will try to seek to reduce it to 3. So, from 5 parts we need to come to 3, so that it minimizes the number of assembly operations, second one is individual parts turned to be more complex in design.

So when from 5 parts these are 5 parts assembled together to make a product but now we try to reduce them to 3. So, when we are making the same product suppose with 3 parts only the 3 parts may tend to be complex and difficult to manufacture. So, the parts become difficult to manufacture and therefore there is a conflict between the DFA and the DFM. So design for manufacturing on the other hand is concerned with reducing the overall part production cost, reduce the overall part production cost.

So, what it aims at it minimizes the complexity of manufacturing operations, uses of common datum features and primary axes. This is another objective of design for manufacturing, so DFM says that maybe 5 parts are easier to manufacture **easier to manufacture.** But if you bring them to 3 then it may become difficult to manufacture because these parts becomes complex. So, therefore there is a conflict between the design for manufacturing and the design for assembly.

And we have to find out a trade off between the 2. And try to design our product in such a way that the individual parts are easy to manufacture as well as the assembly of the parts is also taken care of as well as the assembly is easier and it can be easily implemented, so individually we can first focus design for manufacturing take care of the guidelines and design the part taking into account the guideline.

Design for assembly maybe we design some of the parts, so that they are modular they require less assembly operation and finally we can follow the design for manufacturing and assembly guidelines. And see that what further modifications can be done in order to ensure that the **product realization or the** product realization time or the product realization life cycle is optimized. So, today we will try to see the DFMA guidelines, the guidelines are fairly simple and they have been explained in the book with very good examples.

So, we will just rush through the slides and try to see the examples. But the concept is very very important, the design for manufacturing what is the objective, design for assembly what is the objective, what is the conflict between the 2. And how to resolve that conflict, so DFMA somehow helps us to resolve that conflict.

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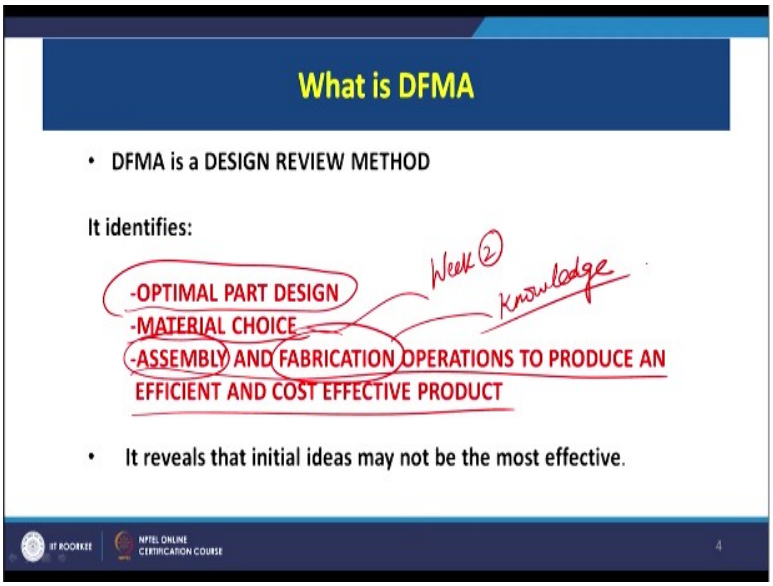

Now DFMA is a design review method it identifies as I have already told the optimal part design even the material choice that we have already covered regarding materials in week 2 of our

course, assembly and fabrication operations to produce an efficient and cost effective product. So, as we have seen our course the title of our course is manufacturing guidelines for product design.

So, the both the assembly guidelines as well as the fabrication guidelines must be known to the product designer. So, as per the **DFM** DFMA method it identifies the assembly and fabrication operations. And this knowledge is very very vital and we are trying to develop this knowledge for the product designers, so that they are able to produce an efficient and cost effective product.

So, assembly and fabrication is the overall objective of our course, so that every designer must have the basic idea about these guidelines. So, that while designing he or she takes care of these guidelines and the is able to produce a effective and efficient product. So, it reveals that initial ideas may not be the most effective, now sometimes the product designers may come up with the design.

But that may not be the most optimal most economic design from the manufacturing point of view also from the assembly point of view. So, those are the things that we want to address that we want to cover.

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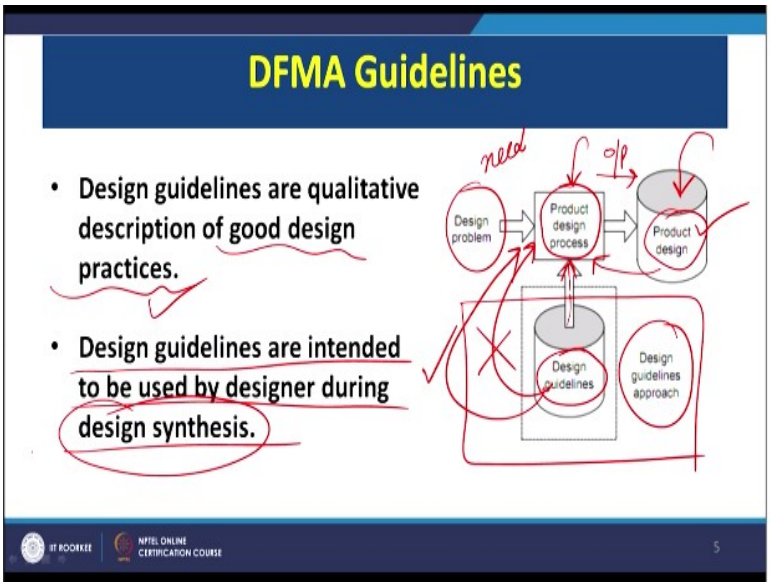

So, basically what are the DFMA guidelines, this is something what is been discussed here, these

are the design guidelines approach. Now where these design guidelines fit into the overall product development cycle, so there is a design problem which may be related to the need or it may be related to the requirement in the society. So, their need is identified by the designers, then the product design process.

So, we have already done a course on product design and development there is a standard step by step procedure for coming up with new products. So, we are not going to **going to** that, so the product design process is there which is a standard process and then it gives a output which is our product design. So, before we achieve or arrive at our product design all these guidelines must be taken care of.

We have to take care of these design guidelines when during our product design process and if we do not take care of these guidelines during the product design process, it will become iterative process you propose one product design it may have some limitations in terms of manufacturing. Sometimes the manufacturing guide details that are provided in the product design may not be possible.

So, guidelines have not been taken care of sometime it is difficult to assemble the parts together, there are difficulties in manufacturing some of the individual parts that are there in the product. So, therefore it will come back to the product design process for modifications but if these guidelines are taken care of during the product design process. So the product design that we realize after undergoing the various steps or after following a various steps of the product design process will be a successful design.

And will not require any iteration at all because all guidelines related to the manufacturing related to the fabrication, related to the assembly have already been taken care during the product design process. So, design guidelines are qualitative description of good design practices and this is our target to discuss the good design practices in context of the various manufacturing processes.

You will see when we subsequently move forward in our course in the subsequent weeks we will

be seen design for machining guidelines, design for casting guidelines, design for forging guidelines, design for injection molding guidelines. So, not only for the metallic parts we have seen in our week 2 that there are a large number engineering materials which are available to the product designer today to come up with innovative product.

So, we will try to focus on the metallic parts we will try to focus on the polymer parts or the plastic parts also. So, these are the good design practices, so what are these guidelines that we are trying to understand. Design guidelines are intended to be used by designer during the design synthesis. So, design guidelines are intended to be used by designer during the design synthesis.

So, during the designing process these guidelines must be taken care of and as you are already aware now I think I have taken this name number of times the title of our course is also manufacturing guidelines for product design. So, these are the guidelines that we are trying to understand and here with the help of an example we have try to understand that where these guidelines come up in the overall product development cycle.

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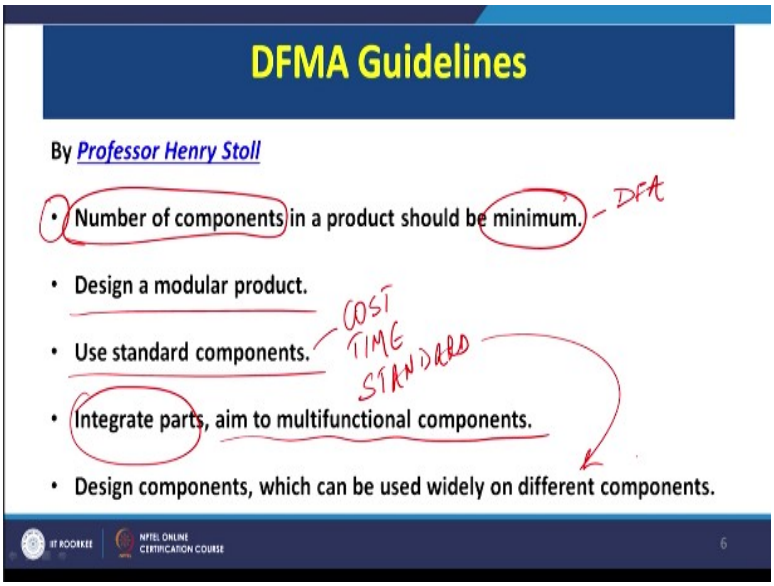

Now this is by professor henry Stoll some of the guidelines which have been already established. So, with due acknowledgement to professor we are trying to see the guidelines which are already listed and highlighted first guideline is number of components in a product should be minimum, number of components should be minimum. So, if the number of components are minimum the

number of assembly operation **were** will also be minimum.

So, this is something related to what is already established in design for assembly, design a modular product requiring minimum number of assembly operations. We will see that what is the modular product use of standard components which already we have seen that both DFM and DFA try to economize on cost. They try to economize on time as well as they propose the use of standard tools and equipment and material.

So, use the standard components, integrate parts aim to multifunctional components, so we must focus towards the multifunctional component as well as integrate parts into the modular designs. Design components which can be used widely on different component, so that is again related to the process of standardization on also. And the other word can be interchangeability design components which can be used widely on other components or on different components.

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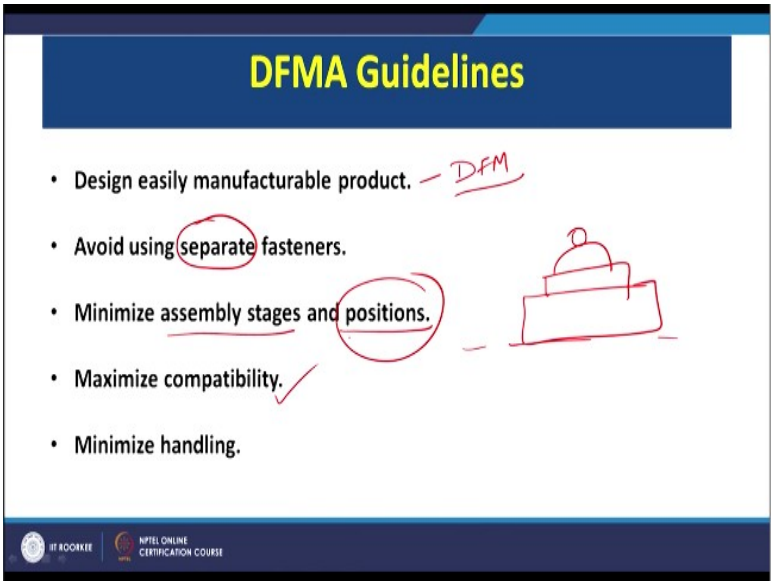

Design easily manufacturable product related to already what we have seen DFM guidelines design easily manufacturable product avoid using separate fasteners. So, the fasteners that we choose must be standard what we fasteners that we suggest for to be used in a product must be standard fasteners. So, we must not have a wide variety of fasteners because that will add cost to their manufacturing.

Minimize assemblies stages and positions, so assembly stages and positions which is very important. So, what we can do is we can have a larger part and on top of that we can think of assembling the smaller parts. So, we must have a single position or a single datum and then do the assembly operation. We must not have change the position during the assembly stage **missing minimum** minimize the assembly stages and positions.

Maximize the compatibility or by interchangeability must be ensured, minimize the handling that is also very very important. So minimize handling specially in case of that are assembled manually **then** human intervention must be minimum. Now these are the guidelines were professor Henry Stall, now let us see what are the according to Boothroyd and Dewhurst what are the ideal characteristics of part assembly.

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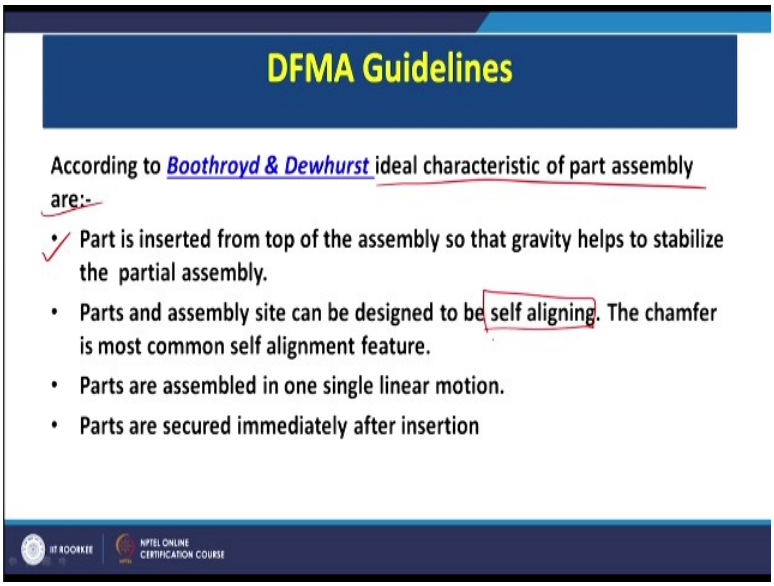

Let us try to see the part is inserted from top of the assembly so that gravity helps to stabilize the partial assembly. So, this is top down type of assembly approach part is inserted from the top of the assembly. So, that we can make use of the gravity, parts and assembly site can be designed to be self aligning, self aligning features must be taken into account, so maybe if you if we see that there are 4 protruding parts in the top plate.

And there are 4 holes in the bottom plate, so we must be able to fix 1 hole maybe 1 protruding part into the hole the other 3 must automatically get fixed at their respective locations. So, that

kind of precision and accuracy has to be ensured in the design, so self aligning parts can be put. Sometimes there can be chambers or cuts on the different parts, so that we can easily understand that this has to be fixed in this manner.

Because of the chambered part on 1 corner of the part and the opposite on the other part on which this part has to be assembled or mated together. So, these type of self aligning features must be there parts are assembled in 1 single linear motion. So, that even the assembly is in a 1 single linear motion only, parts are secured immediately after insertion.

So, we have told in the previous class also we have seen that the part must not be released before it is secured at it is position. So, parts are secured immediately after insertion, so these are some of the guidelines we will try to see.

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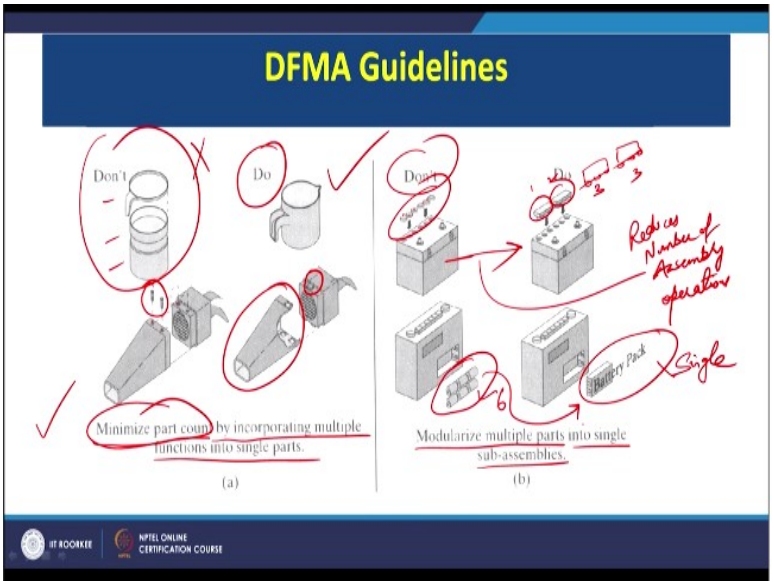

These are the guidelines which are given with examples now minimize the part count by incorporating multiple functions into single parts. Now here we can see this is do which is correct design of the part and here we see it is don't because there are 2 or 3 different parts which are assembled together. So, what is our target as per DFMA guidelines when we are designing a product, we have to minimize the part count.

So, this is the minimization this is not the right approach this is a right approach single modular

produce there with minimum number of parts. Similarly the second also here we see there are 2 fasteners which are coming here there are 2 holes to be made here. Then there are 2 places to fix the fastener there whereas we can redesign this part with little modification in the top part here.

So, that we can have a push fit type of a fastening as compared to using the separate fasteners here. So, this is again reducing the n**umber** of parts that are being used in the final product, so minimize the part count how by incorporating multiple functions into the single or the individual parts. So, this is one thing second guideline, 1 guideline already discussed, second guideline modularize multiple parts into single sub assemblies.

Now here we can see this is do not 1, 2, 3, 4, 5, 6, 6 different sub parts have to be assembled on top of the base part. But here what we can do, we can club these into 2 modular parts each carrying 3 sub parts, only 2 modular part each carrying 3 sub parts has been redesign. So, here we will see it **it** reduces the number of assembly operations, **reduces number of assembly operations** which is one of the important guidelines for design for assembly.

Similar is the case here there are individual cells here how many maybe 6 in number and then you can have a battery pack which is single modular part. So, this can be directly fixed there, so modularize the multiple part these are multiple parts, you modularize them into single part or a single sub assembly which will significantly reduce the number of assembly operations.

If the number of assembly operations are reduced your labor cost is also less as well as the labor time save, the labor becomes more productive as well as the product from maintenance point of view becomes easier as well as we can easily disassemble the parts also.

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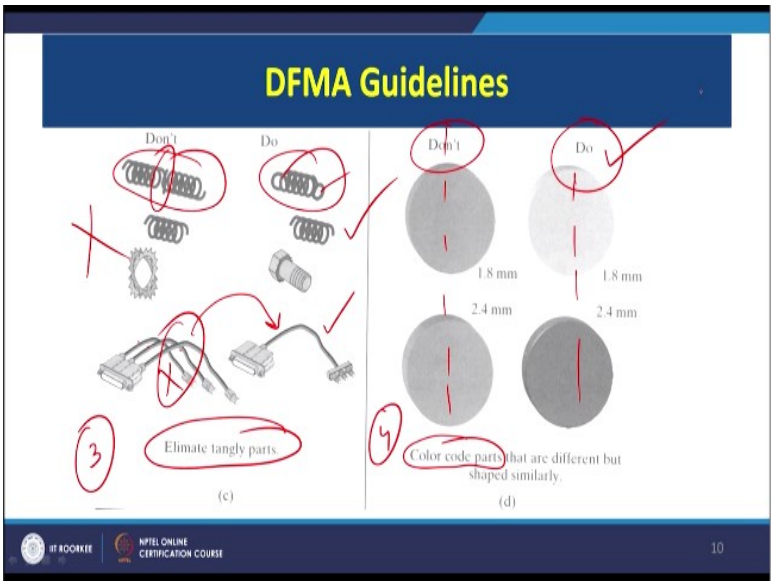

Then there other guidelines this is eliminate the tangly parts already we have seen that we have to avoid the entangling of parts when the products have to be assembled using manual assembly in our previous session. This is similar to that only, so there are parts which may entangle into each other at this point. So, we can redesign them in such a way that they do not tangle into each other.

Then here we see that these 3 wires have the tendency to entangle into each other you may have to first unwind them and then you can use them. So, there can be a modification of making a bigger wire including all the 3 sub wires here. So, here we can see this part can be easily redesigned into this part, the modified part. So, this is what is required and this is what is not required, so we have to avoid the entangling of parts.

Now second one is this is third guideline, the fourth one is color code the parts that are different but shaped similarly. So, you can do the color coding of the parts in order to avoid their intermixing. So, this is 1.8 millimeter, **1.8 millimeter** so this is don't this is do, so color code parts that are different but shaped similarly. So, when they are shaped similarly then we must give them different colors.

So, here we see both are shaped similarly, sizes are different but the color is same but here the color is different, so this is what is suggested.

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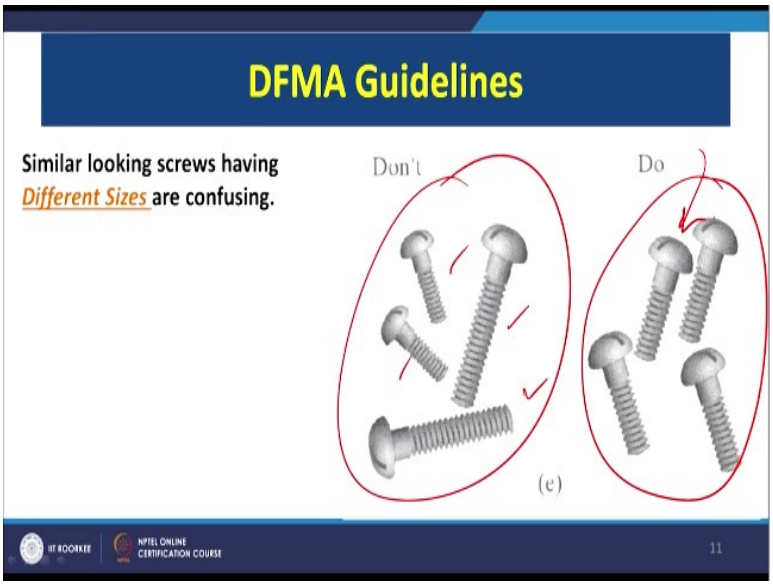

Then different looking screws having different size are confusing, so we have this is related to standardization bigger one slightly bigger one smaller ones. We can try to standardize them into same size, similar looking screws having different sizes are confusing. So, we can make them into similar sizes as per the design specifications of the product.

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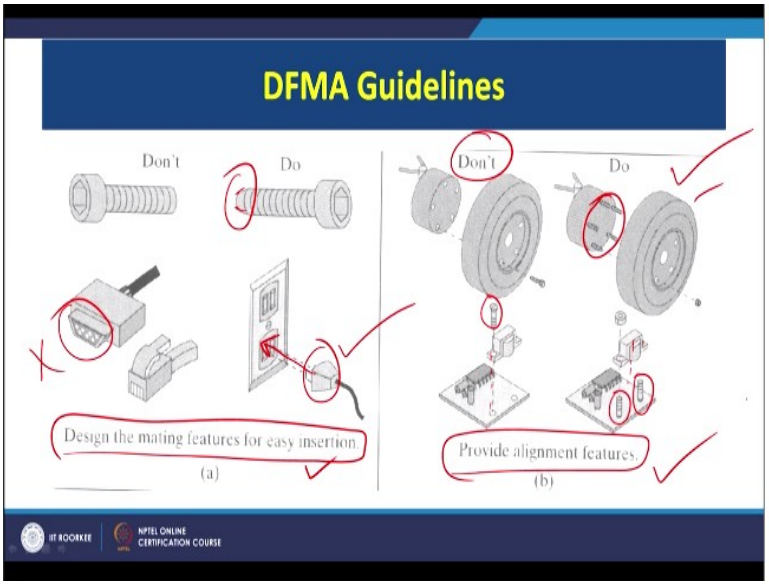

Then they here we can see that design the mating features for easy insertion is in the previous class if you remember we have seen 2 types of guidelines 1 were the handling guidelines another one were the insertion and fastening guideline. So, for easy insertion guidelines we can see a chamber is given here as I have told in the previous session also that for easy insertion a chamber

can be created at the end.

And similarly here also you can see the shape is such difficult to make or difficult to assemble. So, it can be changed into a different type of shape which can easily be inserted. So, design the mating features for ease of insertion, it is easy to insert it is difficult to insert. So, this is another case provide alignment features, so here we can see it is difficult first we have to fix it here then the screw is have to go there.

We have to hold it then only we will be able to screw the 2 parts together, so this is not advisable. So, here we have seen self aligning pins are there provide alignment figure these alignment feature it can easily be put into this part and then this part and then from this side we can do the fixing. So, first it is fixed or inserted and then we are doing the fastening operation but here is it is a difficult first we have to hold it also.

We have to locate it also and then we have to do the fastening also difficult approach which is this one is a modified as well as a better approach for doing the assembly operation. Here also you can see this part has to be first placed here brought here then you have to ensure that it is right on top of the hole. So, that the fastener can be use nor the right approach but here you have self aligning feature here it will directly come this part will come down get fixed here and then you can easily do the fastening operation. So, we must provide the alignment features wherever possible.

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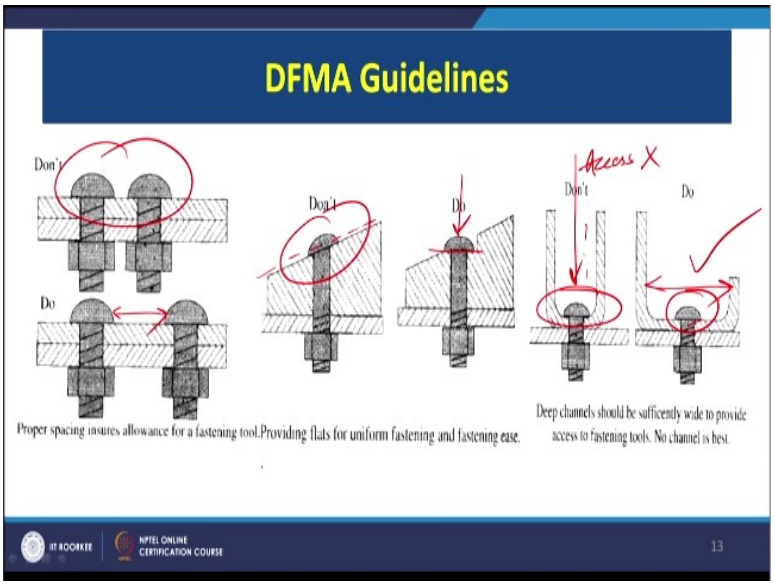

Then here we see that the proper spacing ensures allowances for fastening tool, so here you can see these are very close, the 2 fasteners. So, we can space them appropriately, so that we our fastener our holding tool or the fastening tool can easily fasten them. So, space has to be provided for fastening this is providing flats for uniform fastening and fastening ease difficult to fasten here because of the inclined surface.

So, we can provide a flat surface on which the fastening can be done easily, similarly deep channel should be sufficiently wide to provide access to the fastening tool difficult to fasten it. Because of the difficulty in excess, so is it is in excess is difficult but here the excess is easier. So, deep channel should be sufficiently wide, so this is a deep channel here, so this must be sufficiently wide to provide the excess to the fastening tool, so in case there is no channel that is even better or the best.

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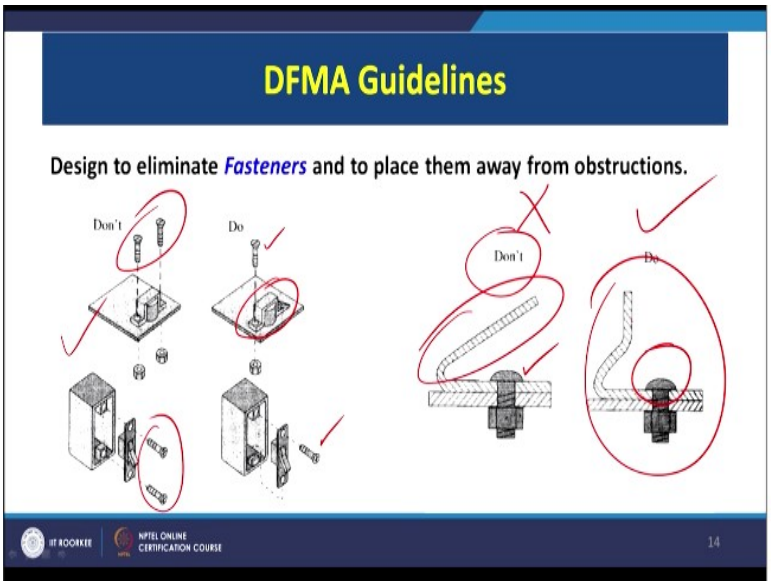

So, with these guidelines if we take into account these guidelines we follow the book and we maybe keep these guidelines in mind during the product design process, we will come up with designs which are easier to manufacture. So, these are the further guidelines design to eliminate fasteners and to place them away from the obstruction. So, this is we can see this diagram already was explained, so design to eliminate the fasteners.

So, here we can see here there are 2 fasteners but here we can design it in such a way that there is only one fastener required instead of 2. Similarly here also we can see instead of 2 fasteners we can help we can use it with a help of 1 fastener only. Design to eliminate fasteners, the use of fasteners must be minimize and to place them away from the obstruction. So, this is an obstruction here which there for this fastener it is difficult to hold the fastening tool and do this fastening operation.

But this design is very good because here this is the fastening tool will have a direct access to the fastener and can easily do the fastening operations. So, this is something which is not required this is what is the design modification required to ensure the fastening of the parts. So, with this we conclude the today's session but there are lot of other guidelines which a product designer must keep in mind while he is designing the product.

So, we have seen today to summarize that we have to take into account this guidelines we have

to minimize the use of fastener, we have to minimize the use of sub parts, we have to do modular design we have to ensure that each and every part is assembled in the most timely as well as cost effective manner in the most efficient and effective manner, in the most productive manner.

So, all these guidelines will help the product designer to design the part which is easy to manufacture as well as easy to assemble also. In our next session we will focus our attention on another tool which is really important why ensuring a good design which is going to be successful in the market. So, with this we conclude the today's session.
Thank you.