Product Design and Development

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Lecture - 16
DFMA Guidelines

[FL] friends, welcome to week 4 discussion related to our course on Product Design and Development. So, we have already finished the 75 percent of our discussion 37.5 hours more or less on an average, we have already discussed on various aspects related to product design and development and now we are left with the last two and a half hours discussion related to the other aspects or important aspects related to product design and development.

So, our overall objective was to understand that what is the need of product or what is the need of product design, what are the design stages, what are the various tools and techniques that our product designer should know in order to be well prepared to undertake this product process of product design as well as development.

So, we have seen different terms related to the course on product design and development. Very briefly we have touched terms like value engineering, fast diagramming approach, reverse engineering, concurrent engineering, computer aided design, quality function deployment, then we have seen design for manufacturing, design for assembly and now we are focusing our attention on design for manufacturing and assembly guidelines.

Now, all these tools and techniques will come handy when a designer will start to conceptualize a product and then he will take the product through the various stages and finally, we lead to the development of a prototype of that product. So, our focus is to help the designer and each at each and every stage that when he is taking the input from the customers that what the customers want what tool he can use. For example, he can use the quality function deployment there and take the input from the customers as the voice of customers and then give the relative weightage to the voice or to this individual input from the customer and then try to relate this requirements with the technical specifications of the product.

So, right from the conceptualization to the different stages or through the different stages we have seen that what tools are helpful for the product designer. For example, computer aided design in also a tool which is helpful for almost all product designers. We have also listed the types of softwares that can be used, then we have seen that when he has to design a product he should take into account the manufacturing and the assembly guidelines also. Why? Because when the product will go to actual manufacturing the manufacturing you can see facility or the people at the manufacturing facility should not feel that the design is not adequate and it cannot be manufactured or the feasibility or manufacturing feasibility of the product is questionable.

We have seen with the help of examples that DFM and DFA guidelines are really important and should be known to each and every designer. Similarly we have seen that we have to ensure that the product design is a robust design and the design is insensitive to the variations in the noise factors. Also we have seen that how principles of ergonomics can be helpful for the product design process and how a human being interacts with a product and how we need to ensure that the product delivers to the customer for what he is buying that product or the function for which the customer is buying that product. So, we have learnt in totality the tools and techniques which are helpful for the product to be designed successfully and the product to be manufactured successfully and the product to be used successfully. So, we have tried to learn different techniques.

So, in our last part of discussion may be we will have five sessions of almost half an hour each we will try to further learn the guidelines which will help us in all these three stages. Like how to design what are the tools applicable there, how to manufacture the product maybe we will see some guidelines that should be taken into account during the design stage only to ensure a good quality manufacturing of the product and finally, when the product will be used by the customer what are the kind of things that need to be taken care, we have already seen the ergonomic aspects of the products should definitely be incorporated at the design stage only.

So, today we will discuss the DFMA guidelines and try to understand that how what are the simple examples of these guidelines that every designer should keep in mind while designing the product

Now, DFMA stands for design for manufacturing and assembly. So, already we have taken one session on design for manufacturing and design for assembly separately and we have taken examples also in DFM we have taken one example and in DFA we have taken two examples. Now how these two techniques are similar and different, as well as how DFMA can be helpful to a product designer for designing a successful product that is the target for today's discussion.

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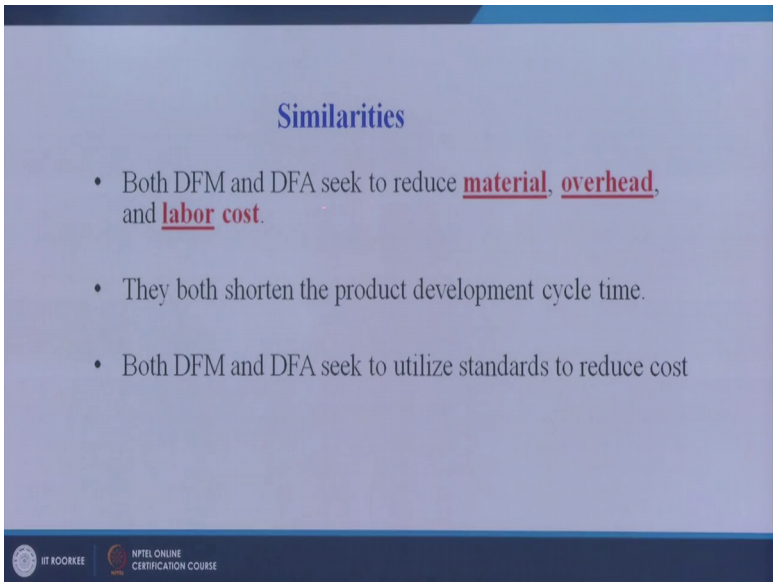

Now, what are the similarities if you remember the DFM and DFA examples they help us to design the product in such a way that it is easy to manufacture as well as it is easy to assemble.

Now, let us see both DFM and DFA seek to reduce material overhead and the labour cost. So, the cost is reduced, the product is designed in such a way or I should say that if there is already existing product and it is going to manufacturing DFM and DFA guidelines may sometimes help us to redesign the product in such a way so that the overall savings or net savings happen for the company or net savings are recorded for the company. So, we will see that the material usage is optimised overhead costs are optimised as well as a labour cost is reduced.

So, if you remember we have seen for ease of assembly we have done a comparative analysis in one example in which we have seen when you redesign that product keeping in mind the ease of assembly or design for assembly guidelines there was huge savings

not only in terms of the number of part count, but it was in terms of weight reduction also, it was in terms of the labour cost also, it was in terms of the you can say the overall product weight also. So, maybe the savings are in different forms.

So, first thing is both the design for manufacturing and design for assembly seeks to reduce all these things yes that is true both shorten the product development cycle time. So, I have discussed in detail in DFM and DFA lecture that how both these techniques help us to reduce the product development time. Both DFM and DFA seek to utilize standards to reduce the cost.

So, we have already discussed today also we will see in our discussion that wherever standard equipment standard tools standard accessories are available we should always we propose the use of such standards as product designers because it helps us to optimize our design. Now these are the similarities in design for manufacturing and design for assembly. But what we need to understand more importantly is that what are the differences between the two and that we will try to address in our next slide.

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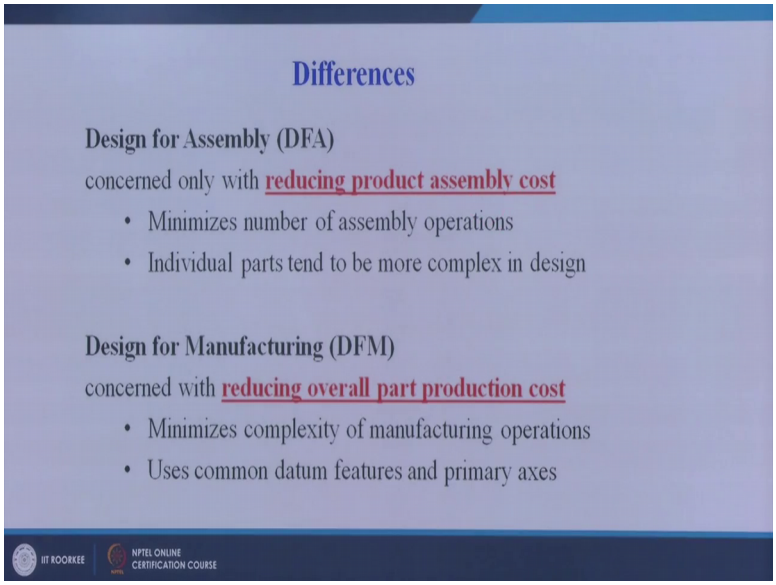

What are the differences? Now let us see them individually, design for assembly is concerned only with reducing the product assembly cost. So, suppose there are 8 parts going into a single product they are assembled together to make up products. So, if we are using the design for assembly guidelines we will say reduce the part count that is from 8 to you try to redesign the product in such a way that it can be all the functions of

the product can be accomplished only by a 4 parts. So, you are reducing the number of parts your assembly operations will reduce and subsequently your assembly cost will reduce. So, that is the basic concept of design for assembly.

If may be suppose 6 fasteners are used to assemble these 8 parts together we will say that from 8 we are bringing the part count to 4. So, we will require maybe instead of 6 fasteners you may require three fasteners only. So, we are reducing the number of fasteners also which is also leading to reducing the product assembly cost.

So, from design for assembly point of view what we are achieving is we are achieving the savings in terms of cost. So, it minimise the number of assembly operations as the part count reduces number of a assembly operations will automatically reduce individual parts tend to be more complex in design. So, that is the problem. So, if we are 8 individual parts assembled together to make a product parts maybe simple not much complex easy to manufacture, but if these 8 parts are now reduced to 4 parts only these 4 parts maybe more complex more intricate as compared to the simpler number of 8 parts. So, that is the limitation individual parts tend to be more complex in design.

In design for manufacturing reducing the overall part production cost. So, if you remember in our lecture in week 3 on DFM and DFA we have seen the overall cost breakdown of a product that what are the various types of costs that are used to calculate the manufacturing cost of the product. So, design for manufacturing guidelines helps us to reduce that manufacturing cost, it minimises the complexity of manufacturing operations and it proposes the use of common datum features and primary axis.

So, it tries to ensure that the individual parts are easy to manufacture, but here we see if we reduce the number of parts in design of assembly the individual parts tend to be more complex. So, there always is little bit of conflict between design for assembly and design for manufacturing objectives whereas, in similarities we have seen that the both tend to reduce the overall manufacturing cost, but sometimes there is a trade of between the two the design for assembly will focus on reducing the number of parts and design for manufacturing will focus on simply find the ease of manufacturing or simply find the procedures or operations which will help us to manufacture that part. So, little bit of conflict can be there here and there, so you have to do a trade off and that trade off can

be in terms of a common guidelines which are called the DFMA guidelines that is design for manufacturing and assembly guidelines.

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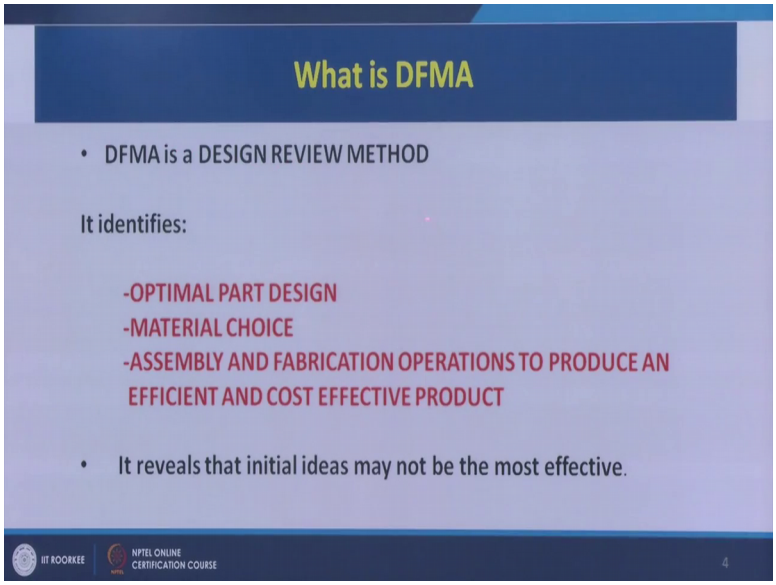

Now, what is DFMA? DFMA is a design review method, yes there can be done design now that design has to be reviewed from the DFMA guidelines perspective. Now perspective we can have a standard set of guidelines and we can check our designs based on these guidelines that whether this design is satisfying these guidelines or not. If it is satisfying we can send the design for prototyping, but if certain modifications can be done in the product design based on the DFMA guideline there and then we will redesign it so that at a later stage it is easy to not only easy to manufacture, but it is also easy to assemble the various parts together. Now, we will try to understand; what are the most fundamental DFMA guidelines which every product designer should keep in mind while he is designing a product.

Now, DFMA will help us to review over product design it will identify the optimal part design. So, for individual part we will see that what are the guidelines and how the part design should be there, what should be the choice for material. It will also identify assembly and fabrication or manufacturing operations to produce an efficient and cost effective product. So, it will focus on assembly also, it will focus on the manufacturing operations also with an objective to make a efficient and cost effective product. So, efficient can be in terms of time also that we are able to produce more number of

products in a less time interval. So, it can be efficient. It can be efficient use of materials also it can be efficient use of the manpower also and a product if you use your man power your material your infrastructure judiciously and efficiently automatically the product will become cost effective. So, the major focus is on assembly and manufacturing operations. So, that we are able to launch a competitive product in the market So, overall DFMA will try to review the design in light of the guidelines so that you can have an optimal part design which is not only easy to manufacture, but also easy to assemble.

So, we will see it will reveal that the initial ideas may not be the most effective ideas. So, it means that whatever detailed design we have produced may be little bit of offbeat and with these guidelines we can bring it to the best possible design in that particular segment. So, the point is that whatever design we are making can be subject to a questioning technique using the DFMA guidelines that whether these guidelines are helpful for that product or in or if all these guidelines have already been taken into account then there is no need to change in the designs can be sent to the next stage of the product development cycle. But as a product designer we should know that what are these guidelines and that is our target or that is our objective or that is our aim for today's discussion. We will take some examples and see what are these DFMA guidelines.

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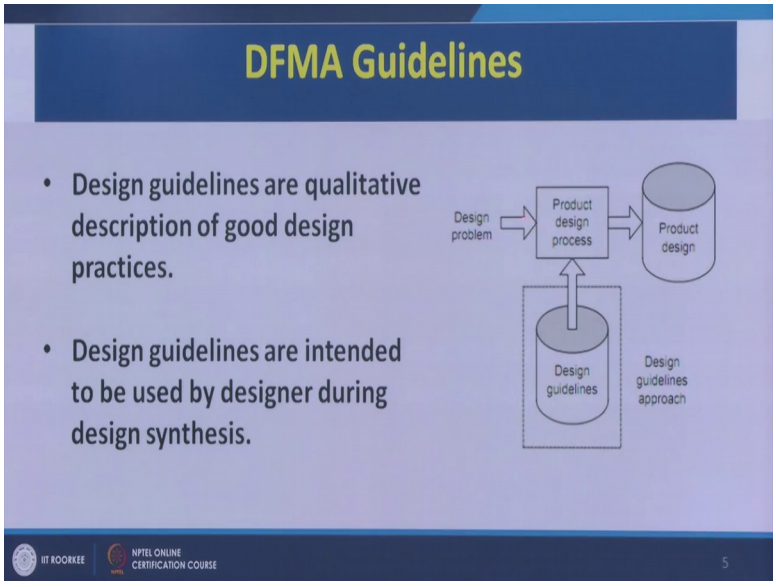

Very good diagram, you have a design problem for which you will propose a product design or it will undergo a product development cycle or a product design process various stages will come here and these are the guidelines design guidelines.

Now, when we are designing the product we will follow these guidelines now these design guidelines can be DFM guidelines that is design for manufacturing guidelines this can be design for assembly guidelines, this can be design for manufacturing and assembly guidelines, this can be design for x guidelines that is design for excellence where x can be reliability, quality, performance whatever. So, all these guidelines are input to the product design process and therefore, we are learning these guidelines so that during our design process we should not falter and the design should be such that it takes into account all these guidelines.

And finally, we get a product design. So, all these this rectangle represents the product design process in totality and the input is always coming from these guidelines and these are the guidelines these are qualitative description of good design practices. So, maybe in our subsequent sessions we will see that if the product has to be made by a casting operation or casting process what can be the product design guidelines or the part design guidelines which should be taken into account.

For example one I can share with you we should avoid sharp corners is a product has to be made by sand casting operation. So, that can be one good design practice for a part that which will be made by sand casting operation. So, these are the set of good design practices which help the product designer to come up with a design which is easily compatible to manufacturing and assembly operations.

Design guidelines are intended to be used by designer during the design synthesis, this is the design synthesis process and design guidelines should be an input to this process so that you come up with the product design which is not only robust in nature, but is easily manufacturable as well as easy to assemble.

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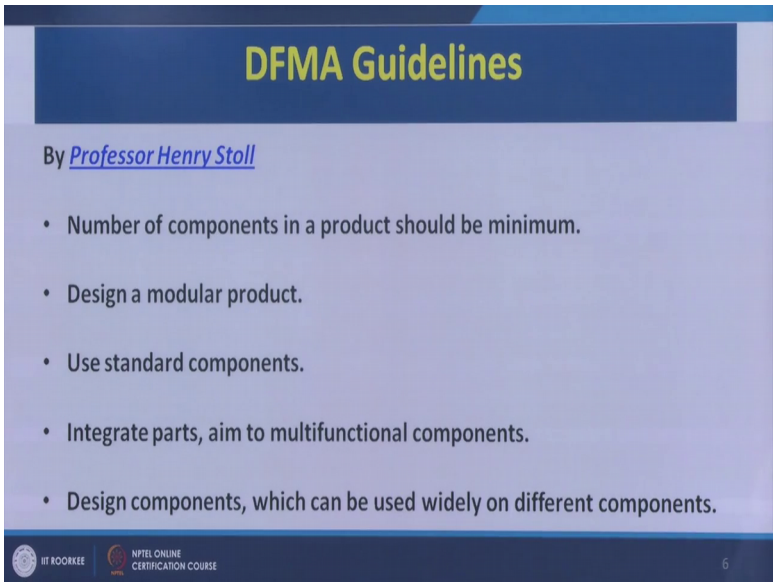

Now, we will see some guidelines and then we will go to some examples of the DFMA guidelines, try to understand them with the help of certain diagrams. So, DFMA guidelines I will read this for you these are very standard specific guidelines we should be known to each and every engineer or product engineer specifically.

For any product number of components in a product should be minimum, so that is one important guidelines that when you are designing the product it should not be exploded into 50 or 100 different parts try to minimise the number of parts that go into the final assembly of the product. So, first guideline number of components in the product should be minimum if you ensure this design will automatically become a modular product. So, we should try to design a modular product. This point number 3 we have discussed earlier also wherever standards exist we should follow those standards, so use standard components maybe there is a internationally acceptable standard for the diameters of the screws or the thread of the screws. So, whatever are the standard components available while designing our product we should take into account those standard equipment tools products components whatever standards are available.

Integrate parts with an aim to multi functional components. So, we have need to integrate the different parts together wherever the function is achieved by 3 different parts we should try that we should bring these 3 parts to 2 parts and a same function should be satisfied with these 2 parts only. So, we should focus on multi functional component that

a single component may give you multifunctions, for example, simple example can be a multi plug that we use in the socket. So, it can give you 2 or 3 connections. So, can be simple multifunctional component.

Similarly the design components which can be used easily on different components, so we should design the parts or components in such a way that they are universally usable so it is not that they are customised to one particular product only we should design our components in such a way that they are they can be used for a wide variety of products and can be used for a wide variety of application. So, design components which can be used widely on different products.

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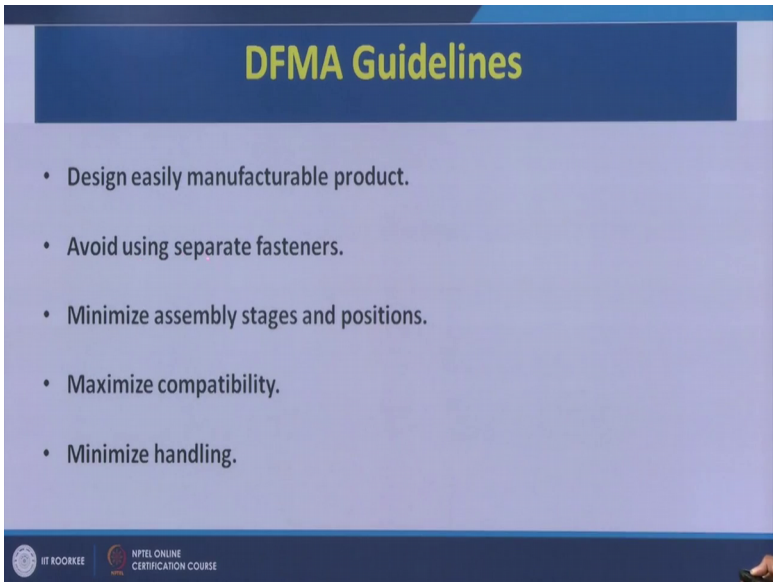

What are the other guidelines? These are general guidelines DFMA guidelines given by Professor Henry stall. Design easily manufacturable product, very simple sentence design easily manufacturable product, but it encompasses the complete discussion on design for manufacturing. So, DFMA guide sorry DFM guidelines are most important for this point to ensure that our product is easily manufacturable.

We have taken only one example of design for manufacturing there can be hundreds of examples and number of guidelines which are which fall under the category of DFM guidelines and should be used while designing our products because of the time constraint we have to finish our discussion in 10 hours. I have taken one example of DFM, but this is just an initiation if you are interested the learners are interested you can

have a different sources through which you can find out the DFM guidelines, there may be books available on design for manufacturing and we will see that how as a designer you should use these guidelines during your design process.

Avoid using separate fasteners this is DFA guideline, design for assembly guidelines that for some single product we should not use different types of fasteners similar type of fastener should be used. Minimise assembly stages and positions, again a DFA related guideline that assembly stages should be less it there should not be number of stages in assembly single stage or double stage assembly is always preferable. And positions we should not change the assembly positions to often because that is not advisable we will see try to understand it with the help of a diagram and an example that the position assembly we should not change again and again.

Maximize compatibility single word to this is inter changeability. So, compatibility means we should try to ensure that our product is compatible to different types of other products also. For example when we are designing a product and it has to be charged we should ensure that maybe 5 different type of chargers can be used to charge our product so that we ensure maximum compatibility of our product. For example we are designing a socket or shoe and socket type of arrangement we should ensure that in any part of India if we are travelling that should be usable to that is the concept of compatibility ensuring the maximum compatibility. Then minimise the handling, so during the assembly operations we should ensure that minimum handling of the parts of the assembly takes place.

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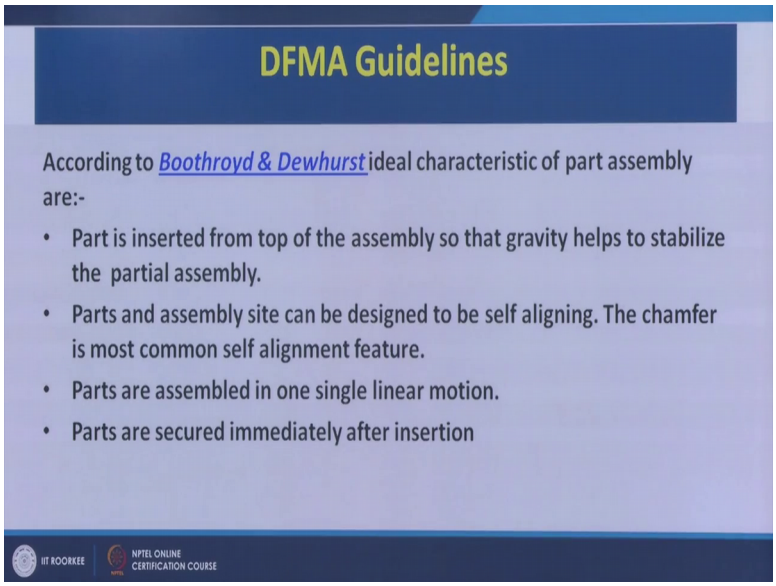

Now, these are again DFMA guidelines, but by different authors some of these maybe same, but these are majorly focused on the part assembly. So, we will see that when we are ensuring a part assembly different parts are assembled together what are the guidelines to be taken into account this is why Boothroyd and Dewhurst.

So, let us see part is inserted from top of the assembly. So, that gravity helps to stabilize the partial assembly. So, whenever the assembly we will also try to understand this with the help of an example that we should always try to do our assembly from top down approach we have seen in DFA guidelines also. So, from top the part which is to be assembled should come and should get a sample to the datum part or the base part.

Parts and assembly site can be designed to be self aligning. The chamfer is most common self alignment feature. So, parts and assembly site can be designed to be self aligning. For example, here you can see I will like to give this example, when you insert your sim card inside your mobile phone there is a chamfer or a cut on one side of the sim card so that is maybe just to ensure that in which direction you have to insert, so that this chamfered portion directly goes there and sits there. So, that is an example of point number two the chamfer is most common self aligning feature. So, you know that it will be aligned there that is you can say part parts and assembly site. Then parts are assembled in one single linear motion. So, that is also to be ensure that sequence of operations are taken into account one single linear motion is there.

Parts may be it should not be may be haphazard motion single linear motion is always advisable. Parts are secured immediately after insertion, so maybe there is a bottom part and a top part. So, if your assembling this part here we should ensure that once you insert this part inside automatically it should get secured there and then you can screw this part for the assembly operation. So, parts are secured immediately after insertion.

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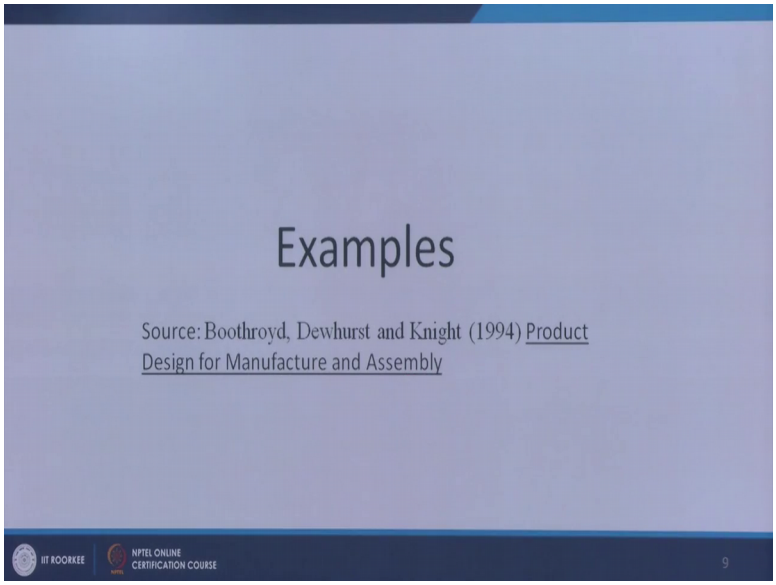

So, now let us take very quickly maybe next 7 to 8 minutes, we will try to take the examples and these examples have been taken from this book Boothroyd and Dewhurst, product design for manufacture and assembly.

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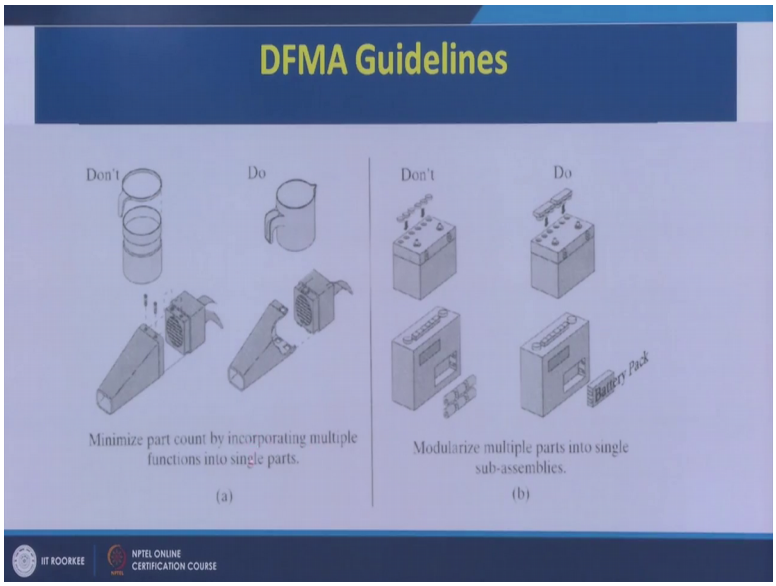

Here you see we I will read it for you maybe some of the text may not be that legible directory taken from the book, minimise part count by incorporating multiple functions into single parts. So, here we see design of a cup maybe 2 or 3 different parts are going together here which is the strict no no or do not, but do is that you can have a one single or a two part assembly for a cup.

Here also we can see similar thing number of parts number of fasteners going into the product. So, here self fastening fashioning approach has been used so that the fasteners can be eliminated. Here we are eliminating the parts, here we are eliminate in the fasteners, but the overall objective is minimise the part count by incorporating multiple functions into single part. Here this is second modularize multiple parts into single subassembly. So, here you see that individual heads are getting assembled on this box, but here you see there are two sub assemblies which have been which are carrying 3 parts each easy to assemble. So, here 6 times you have to ensure their assembly with this base part, but here only 2 operations are required. So, you are reducing by modularizing the parts. So, you are reducing your effort as well as time for the assembly operation.

Here you see a battery pack can be designed which can have the individual cells here, but here when you have the individual cells 2 times maybe you have to do the operation, here a single operation can be used to insert this battery back battery pack inside the your component. So, modularise multiple parts into single sub assemblies.

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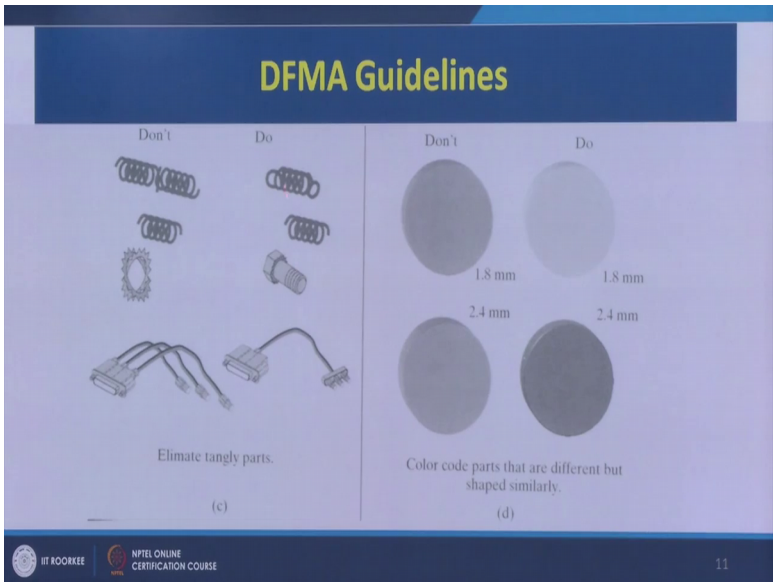

Here you see there are parts which can tangle to one another. So, we should ensure that tangle part should be avoided. So, this type of part should be avoided.

Then here you see three wires coming into this socket. So, we can club these three wires together into a single wire so that untangling can be avoided and we can ensure this type of a design. So, that untangling is awarded, so eliminate the tangling parts. Forth guideline colour code parts that are different, but shaped similarly. So, these are two disks both of 2.4 millimetres, but they are different parts shaped shape is similar. So, we can colour code them one can be green another can be read to easily distinguish these parts.

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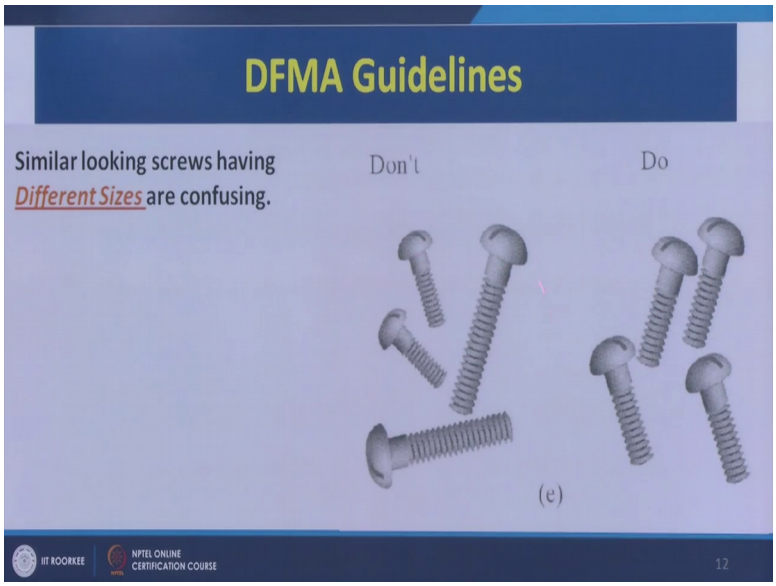

Similar looking schools having different sizes are confusing now you see, they are looking similar, but the sizes are different. So, we should avoid if possible if the design permits we should use standard size screws only and this will reduce the confusion arising out of the different sizes of the screws.

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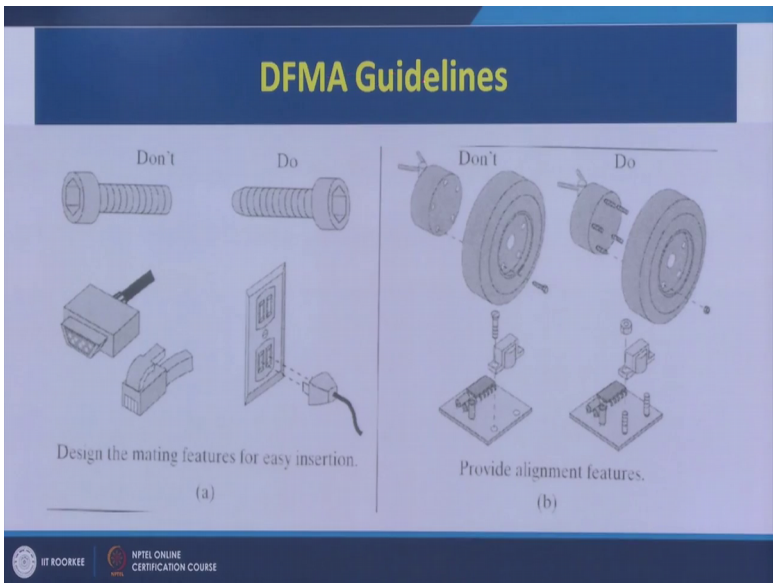

Then they DFMA guidelines related to design the mating features for easy insertion now where we can see this is easy insertion here we see the flat and here and here we have a chamfered and for easy insertion, so we can design it in such a way. Then here also we

can see the head is complicated part may be difficult to insert, but we can design the part in such a way that it easy to insert only 2 slots here 2 pins here easy to insert. So, that is also we can say we can wherever mating features have to be taken into account we should ensure they are easy to insert. These are simple guidelines chamfering and here and 2 pin 2 socket point.

Similarly we should ensure alignment features also here if we want to align this with this if we have this type of alignment pins here it is very easy to align this part with this part. So, here it is difficult to align we are using a screw from this side we have to hold this properly then ensure the you can say assembly, but here if we have this part here already existing in the design. It is very easy to fit this part in this and then we can use this nut to fasten this easier is same design, but with little modification and easy to assemble.

Here also we can see alignment features can be there, these are the two alignment features you can bring this component directly place this here it will get self aligned then and then we can use it to fasten. So, here we are saying we have to first place it and then use the screw difficult approach. Here fixing it on this screw easier approach. So, maybe we can see alignment features will help us to reduce our assembly efforts not only for the worker, but also it will be time saving and cost saving.

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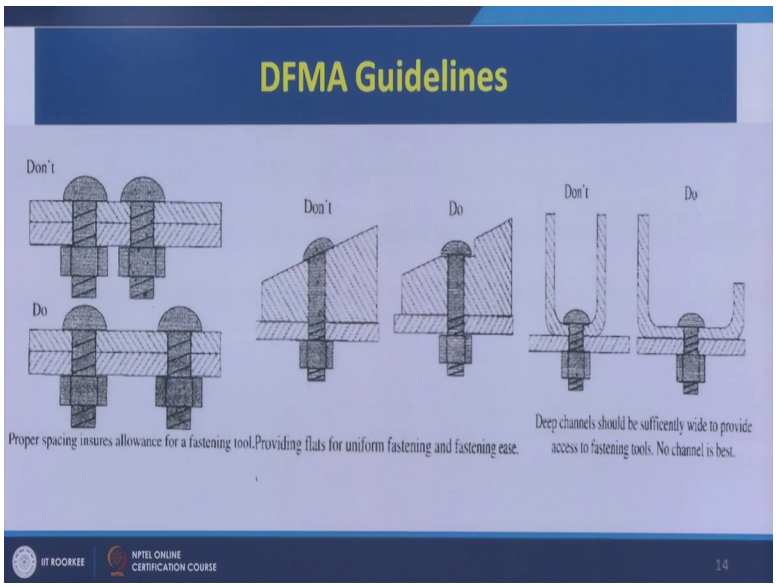

Now, here we can see difficult to screw, this two parts together because there is no space in between for the fastening process, but here if we provide adequate space in between it

will be easy to fasten these two nut and bolt combinations. So, when there is aligned surface we should provide a seat for the head of the screw that is maybe another good design practice.

Here it is difficult to fasten this screw because of the space constraint. So, we should design our product in such a way that it is easy to screw and we have a ample space for screwing that nut and bolt kind of assembly. So, deep channel should be sufficient wide to provide access to the fastening tools. So, may be no channel is always the best.

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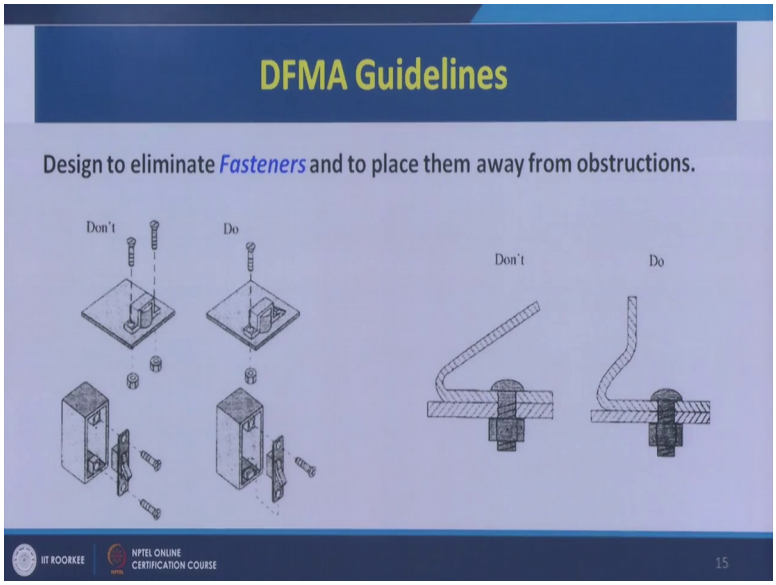

So, here also we can see design to eliminate the fasteners and to place them away from the obstructions. So, this is not a good practice, but this is always a good practice because easy excess we have for the fastening process. Eliminate the fasteners and to place them away from the obstruction. So, here also we can see we can design our component in such a way this is do not we should not use this type of assembly operation, but maybe self fastening plus may be easy to assemble.

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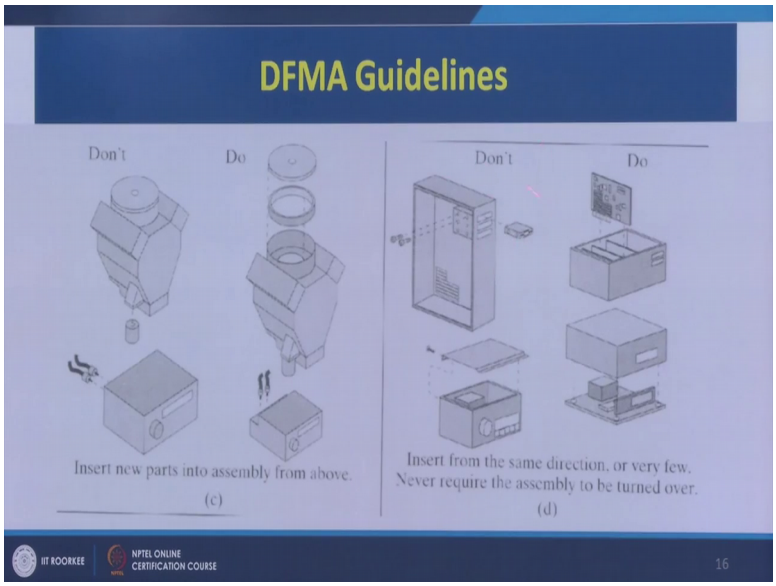

Then this is another guideline where we can see this is Don't, we should not use this insert new parts into the assembly from above this was one of the DFA guidelines if you DFMA guideline. Also the DFA plus the DFM both guidelines we have seen always from top we should ensure the assembly. So, insert new parts into the assembly from above. So, here also the parts are coming from above here also the parts are coming from above. So, that is a good practice.

Then here also insert from same direction or from very few directions never require the assembly to be turned over. So, two examples are given. So, here this is a strict objection of this guideline we are assembling, we are inserting from this direction also and this direction also. So, insert from the same direction. So, here we can see the all this is getting inserted from one direction only two parts assembled from one direction and here also we should never invert our assembly. So, never require the assembly to be turned over. So, here we are turning it over which is not required. So, we should fix everything and then just place this box over it without turning the bottom part may be that way that is not advisable and not a good DFMA guideline.

So, this is we have taken very few examples and tried to understand that; what are the DFMA guidelines. I think from the, if you go through this lecture again stop this lecture look at the diagrams. Again you will try to you may be able to appreciate that these guidelines will help us to design our product in such a way so that the product is easy to

manufacture as well as it is easy to assemble. Then in future may be in our next session we will discuss on the design of a product which has to be assembled together and what are the guidelines that need to be taken into account if the product has to be assembled manually and what are the problems and the challenges there off.

And then we will discuss in our third session the other guidelines related to the products which have to be manufactured by casting products which have to be manufactured by forging that what are the product design guidelines or part guidelines that should be taken into account.

And finally, we will discuss once our designs is ready design synthesis process is done all these guidelines have been taken care of value engineering study has been done on the project finally, how to make the prototype in the most time efficient manner using the concept of rapid prototyping.

So, this week is also equally important as we are going to learn different tools and techniques which are going to help us in the overall product development cycle.

Thank you.