Manufacturing Guidelines for Product Design

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Lecture 13
Product Design for Manual Assembly

Namaskar friends, welcome to session 13 of our course on manufacturing guidelines for product design. So, in the 3rd week of our discussion our focus is to primarily learn the tools and techniques that we must take care of while designing our products. We must also keep this guidelines in mind when we are designing the product and these guidelines are specifically related to the manufacturing aspects of the product design.

So, once we are designing a product how it will be manufactured, how the different parts will be assembled how to design the parts or the sub part of the product which have to be joined together, assembled together for making the final product. We must take care or we must give due attention to the design of the sub parts also, so that when the final product is assembled it is assembled in the most cost efficient and time efficient manner.

And in this regard in week number 3 our focus is primarily to understand the basic tools and techniques, the basic guidelines, the basic standard procedures which have already been established for designing the various parts or the guidelines which have been established that must be taken care during the designing of the parts, just to have a review of the 3rd week we have discussed.

In the very 1st session we discussed about the robust design and in robust design we have seen that we have to select the materials, we have to select the processes, we have to select the process parameters. In such a way that the product which is manufactured using the materials and the processes is in sensitive to the variation in the noise factors. The noise factors can be different environmental conditions such as temperature or humidity.

We have taken examples that what are the examples of the robust designs of product and what are the examples of not robust designs. So, with those examples we were able to find out that the materials as well as the manufacturing play a important role in deciding the robustness of a product design and prior to that in week number 1 and week number 2 our

focus was primarily to understand the basics of manufacturing as well as the basics of engineering materials.

So, week 1 was manufacturing, week 2 was on materials, week 3 is focused on the design aspects that must be taken into account and those that influence the product design or the success of the product design. So robust design has already being discussed in the second session we focused on the design for X means excellence or X is a variable which can have take different alphabets, for example design for manufacturing, design for assembly, design for reliability, design for cost, design for quality, design for reliability.

So, different it can take different changes to the variable X, so DFX X can take any alphabet or can be replaced by any alphabets. But that must be related to the design of the product and since our course is on manufacturing guidelines for product design we focused on only one aspect of X that is M, so design for manufacturing and towards the end we have take an example that what are maybe standard guidelines for the location of holes in a sheet metal part.

When it has to be used for the product design or the sheet has to be used or assembled with another part for completing the product. So therefore our focus today is primarily on the assembly, so if we assume that the product that we are going to develop is going to be made up in different parts. So, when the product is made up in different parts finally it has to be assembled together.

For example the camera which is recording this lecture is a complex product. There are number of sub parts there are number of we can say sub components which are assembled together to make the complete camera assembly. Now this camera cannot be directly made in a single process or by a single process. So, the different parts maybe some parts are metallic, some parts are plastic, some parts may even be ceramic.

So, it is a multi-material aspect of the design of a camera, so different materials manufactured by the different processes have to be finally assembled to make this product. And when the final assembly has to be made we have to ensure that the assembly is easier. Assembly is fool proof, assembly is efficient, assembly is productive, it is time as well as cost efficient. So all these things we have to ensure, all these criteria has to be met.

So, we have to ensure that the each and the every part that is being developed is made in such a way that it is easy to assemble. It is easy to build on top of one part and the other and finally we are able to get our product. So there are few design guidelines which we are going to study today which are related to design of products which have to be assembled together and how this topic is related to our course.

Our course is on manufacturing guidelines for product design, so assembly guidelines also fall under the manufacturing guidelines. So let us now see that when we have to assemble the part what are the design guidelines that have to be kept in mind while we are designing the individual parts or the components. The source for this lecture is product design for manufacture and assembly a very very good informative and exhaustive book on product design written by Geoffrey Boothroyd and Peter Dewhurst and Winston Knight.

So, this is an important book if you can buy this book it would be helpful not only for this topic but host of other topics related to product design or related to design for manufacturing and assembly. So, let us see the topic for today the processes for manual assembly, now suppose we have to as I have take an example of the camera. Now suppose we have to assemble this camera.

We will have a large number of parts, let us take a most of you may not have seen this complicated camera. But all of us have seen a car or an automobile we see that a car is made up of so many different materials we have rubber also, we have plastics also or we have polymer. There are metallic parts also there, there are ceramic materials also there. There are alloys so they it is a multi-material product.

So, different materials are made by the ancillary units or the sister concerns of the automotive manufacturer. And then these are brought together and assembled together to get the final car or a automobiles. So, when we have to combine these 2 together there are 2 things that have to be kept in mind. The first is how to handle, handle means if you remember our course on work system design which is going to be in the next semester.

We have given a complete detail about the different therbligs or the micro motions. So, handling means we have to handle the part, how to handle like I am using this pointer come

slide changer So, this is the way I am handling it I am holding it like this then I am a handling this stylus through which I am making or marking the screen. So, therefore handling means acquiring I am acquiring this orienting it in my hand to make some marks on the screen then moving the parts.

So this has to be moved in order to make a part, so sometime this if I assume as a part I am acquiring it I am orienting it, I am handling it in the way that I am moving it on the screen. So, that is basically the handling, the second one is insertion and fastening, so what I do maybe if I have to make assembly of nut and a bolt. So, what I will do first I will acquire the nut and the bolt and then I will fix them together. So, that is what insertion and fastening mating a part to another part or a group of parts.

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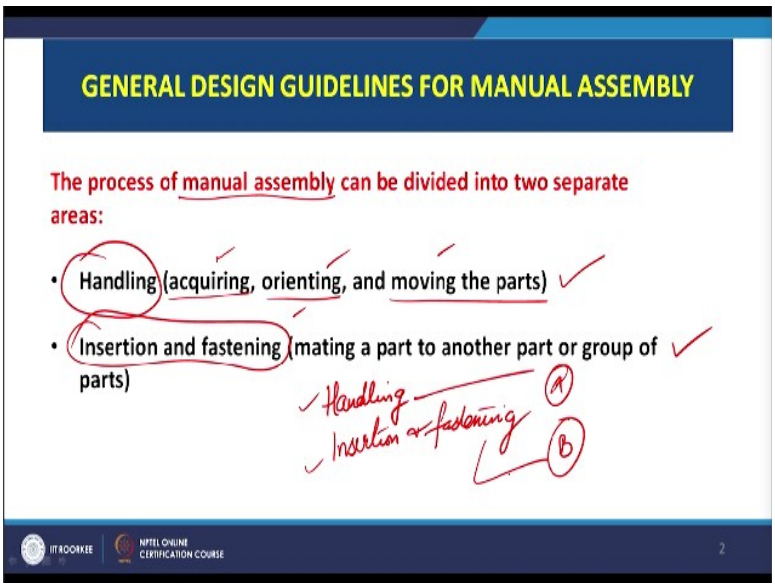

So, this is the manual assembly basically we can see the manual assembly can broadly be divided into 2 categories one is handling which is acquiring, orienting and moving the parts. There can be other acquiring functions also or other acquiring sub-functions also. The second one first one is handling which has this movements, then the second one is insertion and fastening where we combined or we mate the 2 parts together mating a parts to another part or a group of parts.

So these are the 2 things that we need to understand and when we are designing a product which has to be made by different parts. And this parts have to assemble together we must take care of the guidelines which will help us to do a cost effective and time efficient

assembly operations. Now let us try to see we will try to divide the guidelines in these 2 broader categories.

So the first category will be the design guidelines for handling the parts like what are the guidelines which are already established which must be taken care when we are designing sub parts which have to be assembled together. So, first one is handling and second one as is written on the screen that is insertion and as well as the fastening. So the design guidelines will be in 2 parts, first one is for handling, second one is for insertion and fastening.

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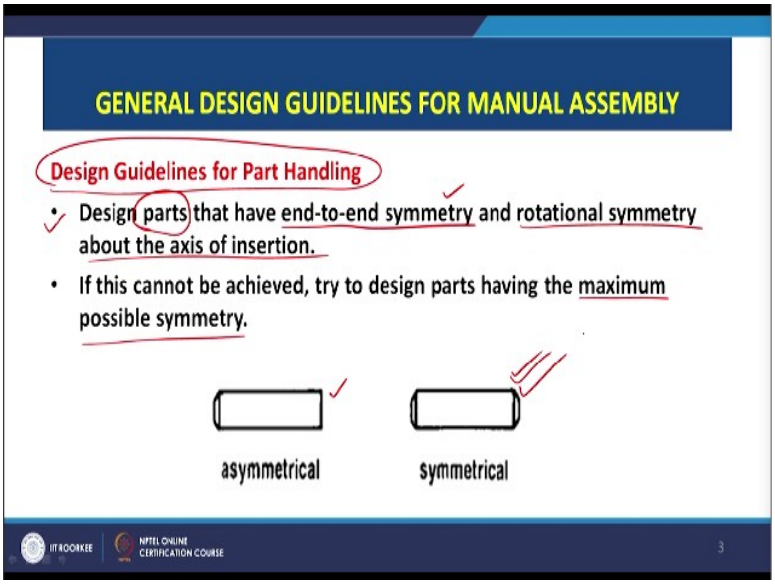

And now let us try to see first one are the design guidelines for part handling, let us see now what are the design guideline we have to handle the part. So, we have to if you remember in the previous slide we have seen handling has another sub function which is acquiring. So, when we have to acquire the part it must be easy to acquire many time there will be for doing the manual assembly the assembly will be a continuous operation, 1 assembly is over then the another assembly has to be done.

So, it is continuous process, so it must be easier for the worker to select the part to acquire the part easily. If we has to search for the part it will take lot of time, so the first thing design parts that have end to end symmetry and rotational symmetry about the axis of insertion. This is the first guideline, we must design the parts that have end to end symmetry we must ensure that end to end symmetry.

And rotational symmetry about the axis of insertion, so if we have to insert the part it must be symmetric about the axis of insertion. If this cannot be achieved try to design parts having the maximum possible symmetry, so that is another important design guideline. First one is we have to ensure it is symmetrical about the axis of insertion, if that is not possible then try to ensure that it has maximum possible symmetry.

So this is asymmetrical and this is symmetrical, so we must focus on the symmetrical parts. So, that is 1 design guideline, the second one is given on your screen.

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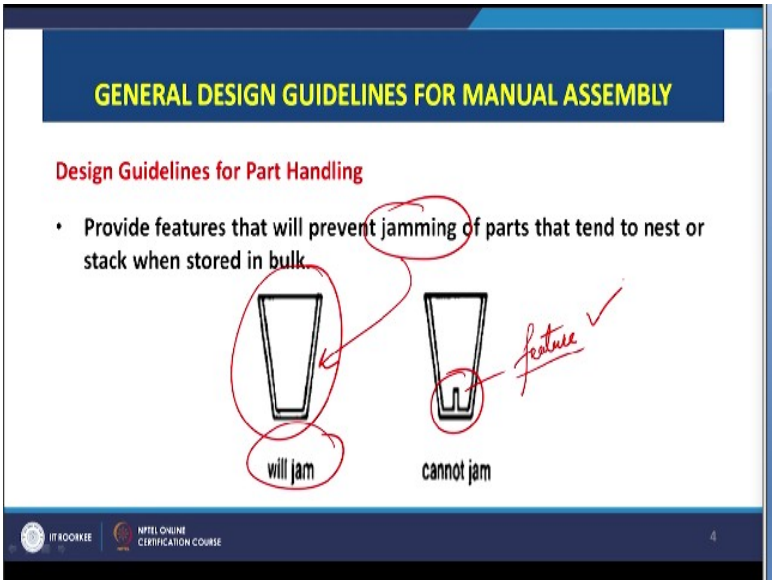

Provide features that will prevent the jamming of parts, so jamming is a important problem and these type of parts we can take the example of glasses at our home or the steel glasses at home. They have this tendency of jamming, now in industry suppose we have to do this part has to be taken and then it has to be assembled to some other part. There are chances that we may get jamming of such type and then we have to first remove them from each other or detach them from each other and then use it for assembly.

It will take lot of productive time of the worker, so we can ensure that such type of jamming does not take place. So, we can add this type of a feature or a geometrical feature which can avoid the problem of jamming. So this type of part will not jam, we can add this feature only if it does not affect the functional as well as the in-service performance of the product. We cannot add a feature only to avoid jamming but on the contrary it is affecting the performance of the part or it is affecting the assembly of the part to the another part.

That we have to ensure that if all other conditions are satisfied we can provide such type of feature which can easily avoid the jamming of parts. So, this is another design guideline when we are designing a part which has to be assembled, we must take care that there must not be jamming of parts.

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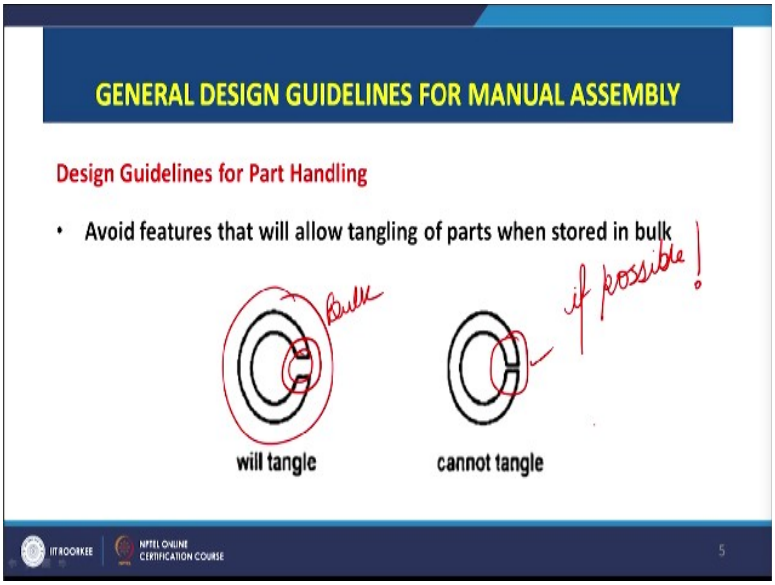

The third guideline on your screen, you can see design guide this is again design guidelines for part handling, currently as I have already told we are going to discuss the design guidelines for the parts which have to be assembled together from 2 different perspective. The first one is the handling of the parts, the second one is the insertion and fastening currently we are discussing the handling in handling we have already seen that first thing was that we have to ensure that the parts does not tangle to each other they sorry.

They do not jam with each other and the first again I will go to that first part this is very very important that we have to ensure the rotational symmetry about the axis of insertion. So 2 different guidelines we have seen, the third guideline here you can see on your screen avoid features that will allow tangling of parts when stored in bulk. Now if this part is stored in bulk, there is a tendency that through this opening they may get entangled to each other.

And when you have to handle this part you have to acquire this part and then you have to fix it to the another part the you have to first entangle it you may have to use both your hands to first take out or acquire the part and then you have to use the another maybe release your right hand and then select the other part and then do the assembly operation, so it is a time consuming process.

So, it is always better that once you use your left hand to acquire this part it must directly come out as a single part only not as a bulk as 4 or 5 different parts out of which you have to first sort out a single part and then do the assembly. So, if possible you can change the design and I have already told and it must be kept in mind if possible, many times it may not be possible because this type of opening is really required.

And on those cases you can think of other methods creatively, you have to use your creativity to find another method of storing these parts, what can be that method you can have a rod and you can keep these parts on the rod and one by one you can take it. There also you need not do the entangling on the rod you have put a large number of parts and different rods for 1 rod you have used you can put the another rod maybe it will avoid the entangling of the parts.

So, that is what you have to use your creativity for storing the parts in such a way that they do not entangle to each other. So, I have given you 2 options if you use your creative juices use your mental faculties you can even come with other solutions which can be even cost effective. Then the 2 solutions provided here, the first one is reduce this opening and the second one is stored the part on a rod maybe one above the other.

And then you take one at a time, so these have the 2 solutions to avoid entangling of parts, then there are simple guidelines like avoid parts.

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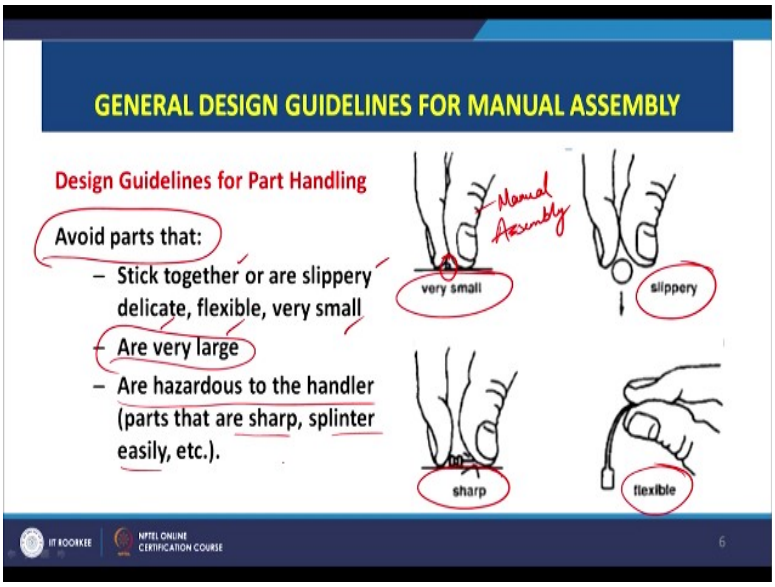

That stick together or are slippery delicate flexible or very small. So, this is also very very important we must avoid the parts which are very small it is given here. Because we are discussing about the design guidelines for parts which have to be assembled by manual assembly operation. So, when you are doing manual assembly with this very small parts become difficult to handle.

So, it is very very important that we must put design the part in such a way that it is sufficiently large to handle. But some of you may question that if the design requirement the design specification is such that you cannot have a maybe larger size for the part. In that case what can be done, in that case you have to design the equipment, you have to provide the assistive devices to the manual operator or to the worker who is doing the assembly operation.

So, that he is able to handle these very small parts, so if possible then increase the size of the part which is very very small, try to increase it to a reasonable proportion. So, that manually you can handle it and if that is not possible because of the design constraints then provide the assistive devices which can help the operator to handle that part.

Similarly we must avoid the slippery parts also, so that also it has to be avoided during our design of the parts which have to be manually handled and then assembled together. Sharp parts must be avoided that is another thing that must be taken care of and if there are sharp parts in the product assembly then we must try to use assistive device to handle those sharp parts.

Similarly the flexible parts also sometimes are difficult to handle when you are doing the assembly operation. One example of the flexible part can be when you see when you have to put the thread in the needle. So, the needle is quite rigid it is solid but the thread is quite flexible, so you find maybe you may take some time to put the thread in the needle. So, those type of flexible parts, those type of assembly operations must be redesigned.

In such a way that the parts must be redesigned or some assistive tools and equipment maybe provided to ensure that you are able to perform your assembly operation in the most cost effective and efficient manner. So this is the parts that must be avoided very small, slippery,

sharp corners or the flexible parts we must take care of designing our parts when we are designing the product.

All these parts these type of situations can be avoided because they will create a problem when finally we are assembling the product made up of all these parts. So, these guidelines must be taken care of, so avoid parts that stick together we have already seen entangling of parts as well as jamming of parts or are slippery we have already seen delicate, flexible or very small.

Also we must avoid parts which are very large and difficult to orient, difficult to handle by a manual hand or by a human hand, we must also avoid parts that are hazardous to the handler parts that are sharp splinter easily etc. So, all these type of part, the part which splinter easily which are very sharp and we are doing the manual assembly operation, so for manual assembly sharp parts must b avoided from the safety point of view.

So, when we are designing our product and we are designing the sub parts of the constituents of the components of the product we must take care of all these guidelines because then the part has to be these small parts to be assembled together to get the complete product. So, this is related to handling, so these are the guidelines which we must take care when which may create a problem during the handling of the parts.

Now coming onto the second I have already told the for manual assembly the guidelines are broadly divided into 2 categories, first one is acquiring or maybe handling the parts. The second one is the fastening and insertion**,** the first thing you have taken care that you have designed the part in such a way that is easier to handle. Now the second thing you can easily handle it but then how to insert and fasten it there are guidelines. So, first part already taken care by following the guidelines which we have already seen, the second one is related to insertion and fastening.

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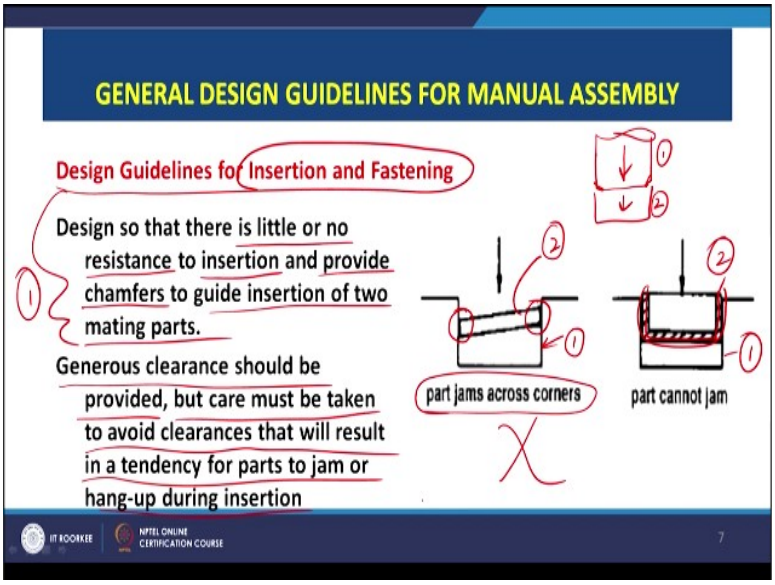

Now let us quickly see the design guidelines for insertion and fastening which is very very important. So, first thing is design so that there is little or no resistance to insertion and provide chamfers to guide the insertion of 2 mating parts, this is a first guideline, the example is also given here. Design the parts, so that there is little or no resistance to insertion and provide chamfers to guide insertion of 2 mating parts.

Now 2 different parts are there, this is part number 1, this is part number 2, so we have to assemble them, we have to insert part number 2 into part number 1. So here there maybe problem, so it may not go down into the part or settle down into the part as required. So, what we can do is the parts jam across the corners, this is a problem which we do not want, now what we want we want that this part number 2 must easily fit into part number 1.

So what we have done we have redesigned the part if you see it is redesigned in this way, so that easily it can be inserted into the part number 2. So these type of design modifications can be done, many times suppose we take another example we can give chamfers also here in order to ensure the entry of this part into this part. So, this is part number 2, part number 1, so part number 1 if we can provide the chambers here it can easily go into the part number 2.

It will ensure easy insertion and fastening and if you see when you have a screws and when we try to fit the screw at the bottom there is a chamfer that is provided. So, that kind of chamfers can be provided in order to easily ensure the entry of the part into the mating part. Though that is first thing, sorry second thing is generous clearance should be provided but care must be taken to avoid clearances that will result in a tendency for parts to jam or hang-

up during insertion.

So, generous clearance is must be given, so that yet easily able to insert and fasten the parts. So, we must be very very careful while selecting the clearance it must not be too tight, it must not be too narrow. So, we have to see that what maybe it must not be too wide, so we have to see that what type of clearance that must be given. So, that the 2 parts are easily assembled.

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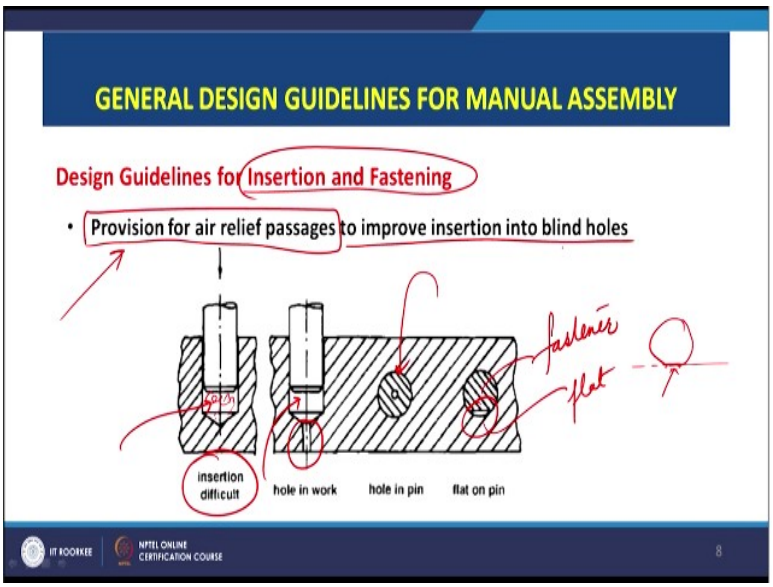

Now this is another guideline which is explained with a help of a diagram, this is again the guideline for insertion and fastening provision for air relief passages to improve insertion into blind hole. So, this sentence can be divided into 2 parts, provision of air release passages why to improve insertion into the blind holes. Now here we see this is a blind hole, this is again a blind hole and we have to ensure that the air which is somewhere trapped here must have some passage to go out.

Simple example is if you invert a glass and try to put it on water the inverted glass on water there are bubbles that is those are coming out that are coming out why. Because the glass is full of air, so the air need some passage to escape, so bubbles are basically representing the air that is gushing out of the glass which was empty but bottle is having air. Similarly we have air there in the blind hole.

So, we air must get a passage to go out and this insertion will be difficult here some of who may feel that no I can apply the pressure and air can come out from the gap ok. That is possible but the point important point is that it will increase the load that you have to apply or

the force that you have to apply or the torque that you have to apply to insert the fastener into the base or to insert the fastener in the workpiece.

And if you have to do the same job maybe 500 times a day or maybe 600 times a day it may affect your performance. So, it is always better that if the design modification is possible provide a hole for air relieves or air release in the work. So, if the work if it does not affect the performance of the product you can provide a small air release gap. So that when you are inserting from top from bottom the air can easily come out.

Or what can be done if it is possible you can provide a pin in your fastener, so for example you are using a bolt. So, in the bolt there can be central holes when the bolt is going inside the air is coming outside through the central hole in the bolt or in the fastener you can provide a flat here this is a flat, so if it is not clear here we can draw the another one like this. So, instead of being completely circular there is a flat here, so the air can come out of this passage which is there in the fastener.

So these type of guidelines will ensure easy insertion and fastening of the mating parts because the air will easily get a chance to move out. So, this is again the 2 parts when we are designing a part we must take care of we must provide the provision for air relief passages why, the air relief passages in order to improve the insertion into the blind hole. So all these are the approaches to avoid the pressure that is exerted by the worker on while inserting the fastener.

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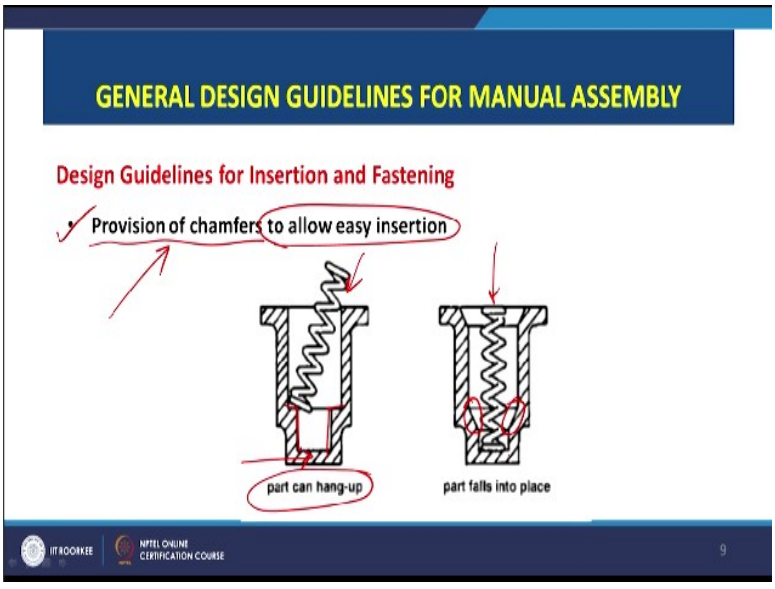

Then this is another design guideline for insertion and fastening, provision of chamfers why to allow easy insertion. So, we need to provide the chamfers in order to allow the easy insertion, so here we are seeing this spring has to be assembled here. Now the part can hang up why because there are sharp corners here. So, there are chances that the part may not go directly down, so then he has to very very careful and ensure that the part goes and fits at the base here.

But this is easily possible if we can provide the chamfer here, if this chamfers are provided this part even if we drop it down into the bottom part or the base part it will automatically be guided by the chamfers into the central positions. So, wherever possible we must provide the chamfers, so that the mating part can easily fit at its desired position.

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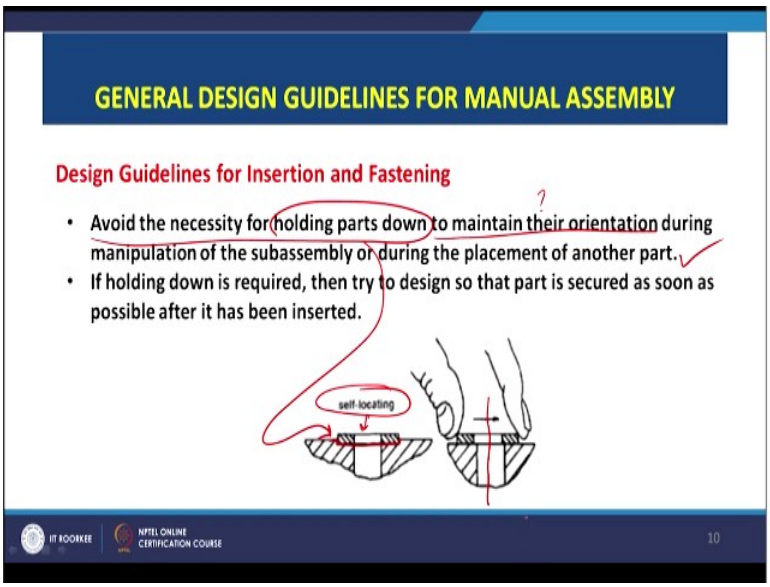

Then this is another design guideline for insertion and fastening avoid the necessity for holding parts down which is shown here. We must avoid the necessity for holding the parts down to maintain their orientation during manipulation or during the placement of another part. So, basically you can try to understand it in a very simple way that when we are seen here this part has to be placed here and then the fastener has to be placed like this.

So the top part there we have to hold it then only we can insert the fastener into this. So, avoid the necessity for holding the parts down, so that can easily be done if we can make a slot here like this. And in this slot this part can easily be first located which is based on the principle of self locating, so we will just put the top part there on top of the bottom part it will get located by on it is own and then we can easily insert the fastener.

So avoid the necessity for holding the parts down to main their orientation, so when we have to hold them why in order to maintain their orientation during manipulation of the sub assembly or during the placement of another part. It is clear with the help of example if holding down is required then try to design, so that the part is secured as soon as possible after it has been inserted, so this is secured as soon as it was inserted there. So, therefore maybe these type of guidelines we must keep in mind, then there is another design guideline.

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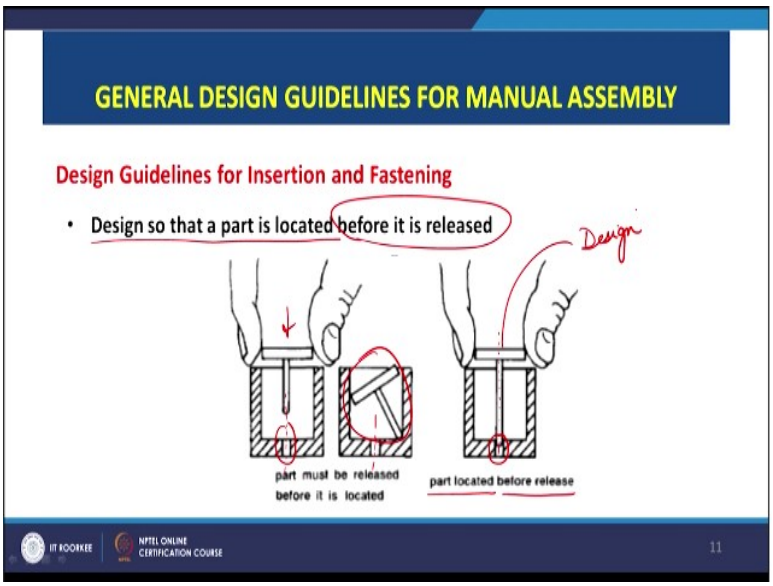

Design so that a part is located before it is released, you can see here design so that the part is located before it is released. Here you see this part you will be trying you have to fix this part here, this part has to come and it has to fix here. Now in order to fix it you cannot put your fingers inside and fix it there. So, what will be doing, we will be doing a trail and error that this pin goes and fixes here.

So, part must be released before it is located, so this part has to be released before it is located and it may not fit into the pin where it has to go and fit. So, what can be done here we must design the part in such a way that the part is located see the part is first located it is already located at the position where it has to go. And then you can release then you can release it or you can fasten it from the top.

So this is the design modification which will help us to ease out the process of assembly. So, this design modifications wherever possible in the designs we can do. So that the assembly operations become easy, so many times we will see such situations we face in our day today

life that we are not able to assemble the parts together. Because they have not been designed keeping in mind the product design guidelines for parts to be manufactured by manual assembly.

So here we have seen today that there are number of guidelines which do exist when we are designing the parts which it must be followed. So, there are guidelines which must be followed when we are designing the product. So, if we take care of all these design guidelines while designing our products and the products are made by assembly operation and the moreover the assembly operations are also the manual assembly operation.

If we take care of these guidelines the assembly of our product will be easier we will be able to produce the product with a cost efficient manner in a timely manner, in an effective manner moreover our labor productivity will also be more. The labor will be able to deliver more number of products why because the design is in such a way that the assembly operation is fool proof, it is easier, it is maybe less tiring for the person who is doing the work.

And all these objectives can be met if we take into account all these guidelines that we have seen today. So, with this we conclude the today's session, we will start our next session with discussion related to the product design guidelines and these guidelines will certainly help us during the design or for during the will help us during the design. As well as during the manufacturing of our products.
Thank you.