**Manufacturing Guidelines for Product Design**

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**Lecture-12**
**Design for X (DFX)**

Namaskar friends, welcome to the session 12 of our course on manufacturing guidelines for product design, we are currently in the 3rd week of our discussion and in the first 2 weeks our target was to understand the basic concepts of manufacturing, we have seen the various manufacturing processes, the classification of manufacturing processes, we have then seen the process capabilities for some of the selected processes.

Because there is a big family of manufacturing processes, so it is not possible to discuss the process versatility or the process capability of each and every process, but still we were able sorry to cover our some of the processes. Then we have seen that what is the criteria that must be kept in mind when we select manufacturing process for any product. In week 2 our discussion was primarily aimed at engineering material.

We have seen the classification of engineering materials, we have seen the properties such as physical, chemical, mechanical as well as the manufacturing related to the various engineering materials, we have seen the selection of engineering materials and finally we have seen what are the broad application areas for the various families of engineering material.

So with that we concluded the first 2 weeks of our course on manufacturing guidelines for product design and in week 3 our target is to slightly discuss or to briefly discuss the soft issued related with the product design process and there are full fledged may be 20 hours, 30 hours courses on these topics already which are under the MOOC's scheme that is design for manufacturing and assembly design for manufacturing.

So the complete details are given there but as this is related to our course also, because we are also trying to understand that what are the manufacturing guidelines when we design a product or for product design. So here also we must know that what are the basic concept that must be kept in mind, our target is to identify to list to discuss what are the manufacturing

guidelines for the various manufacturing processes that can be used for making the products or for making the day today products.

So these process are not any new processes these are the old processes that we have been studying, that we have been learning. So we will try to see that what are the juice or what is the summary of these processes and how these guidelines must be known to each designer went a product design is being made and for that reason only we want to understand the basic concept of design for manufacturing design for assembly.

Design for manufacturing and assembly, so within this week that is 2 and half hours of discussion we will try to understand the basic concepts. Already in the first session of week 3 that was session number 11 we have covered robust design. Now we know that we have to ensure a degree of robustness in our product design that can be achieved through the system level or functional design, parameter design and tolerance design which was covered in the last session.

Today our target is to learn about design for x so x may stand for a variable or it can be called as excellence though design for excellence. So when we are designing the product we must design it for excellence, what is the relevance of manufacturing here, now x can take the word manufacturing or x can take the word m or the alphabet m. So it becomes design for m that is m stands for manufacturing.

So DFM we can have design for assembly, we can have design for liability, we can have design for safety, we can have design for production, so x can change to any alphabet, but the basic philosophy remains same that we have to ensure whatever alphabets or whatever words we have just taken m, a, s, r, q, manufacturing, assembly, safety, reliability, quality, cost. So all these parameters must be taken into account when are designing our product. Because once we design the product it is difficult to change it after the prototype is already ready.

So it is always better to do whatever changes, whatever maximum changes you want to do in the product design during the design stage itself once the product has been passed to the next stage it becomes difficult to incorporate the changes. So it is better that you do all tinkering, all kinds of modification, all kinds of trial and error during the design stage only. So therefore DFX becomes very very important.

And design for manufacturing is also very very important and in design for manufacturing as a bigger umbrella we are discussing the manufacturing guidelines which must be taken into account during the product design stage and what are these manufacturing guidelines we will try to understand them with process to process basis, if you have seen the course curriculum we will see that our target is to understand the design guidelines in context of various manufacturing processes.

Such as casting, welding, machining, grinding, injection moulding, or different moulding processes for plastic parts. So we will try to understand this from the perspective of manufacturing, but design for manufacturing is a well-established concept, number of lecturers are already available so the learners who are not aware may find today's session may be very very very important.

Those who know maybe just a revision on the concept of design for manufacturing as well as design for assembly. So these are the 2 important things that are related to our course because our course is on establishing the manufacturing guidelines. So courses is on focused on manufacturing, so therefore we will take into account manufacturing and assembly which fall under the broader umbrella of manufacturing.

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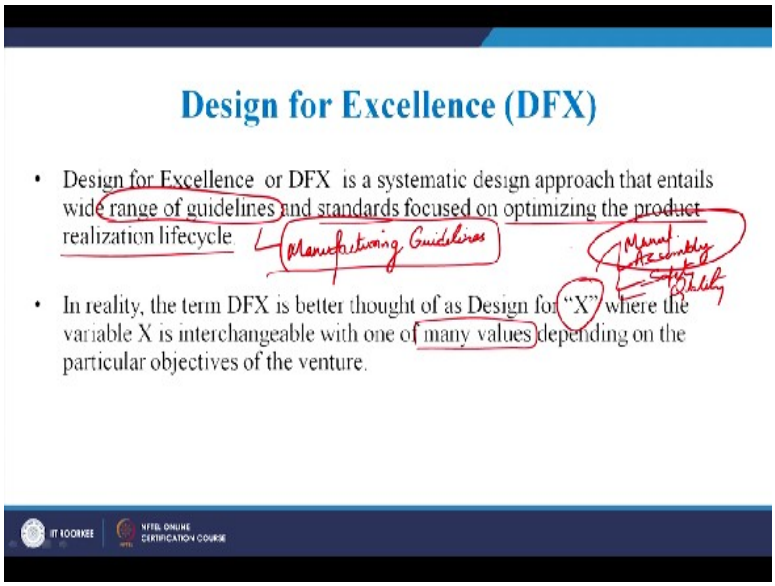


So let us see now design for x, now design for x or design for excellence is a systematic design approach that entails wide range of guidelines and our target is to establish the manufacturing guidelines. So therefore our course also falls under the broad umbrella of

design for x, our focus is on establishing or understanding or discussing the manufacturing guidelines and standards.

Focused on optimising the product realisation lifecycle. So we have to focus on optimising the product realisation lifecycle. So we try to ensure that the product realisation life cycle is as short as possible as efficient as possible, as effective as possible, as productive as possible. So the product realisation life cycle is the overall objective and optimising that is our main focus area. So if we account for the manufacturing guidelines during the product design process only we will be able to optimise our product realisation life cycle.

And for that reason only we must have a basic idea about the manufacturing guidelines which must be taken care of when we are designing the product. So our focus primarily is on understanding the guidelines for the processes because one question may be creeping-up in your minds again and again that what is the difference between design for manufacturing and our course.

When design for manufacturing we will have a broader coverage, we will have many industrial engineering aspects also, the cost aspects will also come into picture but our focus is primarily on the processes, we are going to focus on the hard core processes such as casting, welding, machining, molding, in case of plastics and sometimes we grinding in terms of finishing.

So our focus on processes only we are not going to focus on the industrial engineering aspect or design for manufacturing. So our focus is on manufacturing processes, so that is very very important to understand difference between what we are trying to discuss and what is the overall concept of designing for manufacturing. So in reality the DFX is better thought of us design for x where the variable x is interchangeable as I have already told.

With one of the many values depending on the particular objective of the venture, so many values it can take as I have already told and in the next slide we will also see that x can take a large number of values or it can be in our case our primary focus is on manufacturing, it can take assembly, x can be design for assembly, then it can be safety, it can be even quality. So we are not focused on the other aspects.

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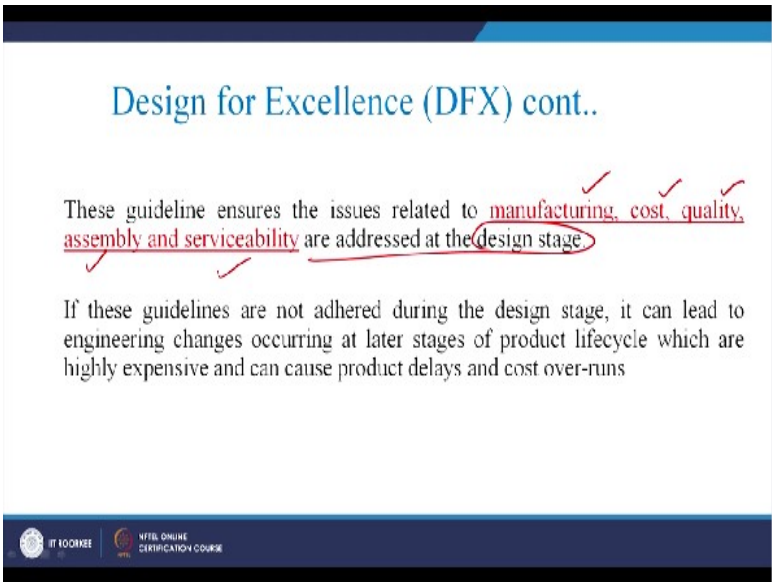


Our primary focus is to keep in account the manufacturing guidelines which broadly will be manufacturing and assembly guidelines. So let us now quickly see, now when we take care of these guidelines during the product design stage these guidelines ensures the issues related to manufacturing, cost, quality, assembly, serviceability are address at the design stage only. So no modifications are required at a later stage.

So if these guidelines are suppose if we do that we address all these issues, but if we do not do them if you do not adhere during the design stage to these guidelines it can lead to engineering changes occurring at later stages which I have already highlighted if you do not focus on these guidelines in the very beginning of the product design process, then engineering changes will be required at the later stages of the product realisation lifecycle or the product lifestyle which are highly expensive.

So later on we need to do the changes which will lead to lot of cost and those will be expensive also and can cause product dealers and cost overruns, many times in many projects we see that it started with the cost estimation of x crores or x million of rupees, but when it was finished it costed the x checker x+delta x or x+4 times delta x. So why that 4 times delta x or delta x must be added to x only because of the engineering changes or the design changes at the later stage of the product development cycle.

So once we are not able to freeze our design in the very beginning we are not able to take into account all the various issues in context of cost, in context of quality, in context of materials, in context of manufacturing, in context of assembly. So if we are not able to take into account

all these parameter at the design it will warrant changes at later stages which will be costly, expensive and will also lead to delays.

Many a times may also lead to penalty also if the penalty clauses invoked in so therefore it is very very important to take into account all possible aspects related to the product design process during the design stage only I think the learners must have been able to emphasize the importance of the product design stage in the development of new products and therefore our course also gains much relevance that when the product has to be manufactured using the standard manufacturing processes.

We must be able to understand and use as well as may be exercise the knowledge of manufacturing during the design stage only. So that the product that we push for manufacturing after prototyping for commercialization must be able to be manufactured in the best possible manner again we come to the same terms efficient manner, effective manner, cost-effective manner.

Technical it must be possible to manufacture the product because we have already taken care of the specifications of manufacturing during the product design stage only. So therefore the importance of the course again has been emphasized from this slide that we must ensure that all possible aspects are taken into account during the product design stage only. Now what are the values x can take.

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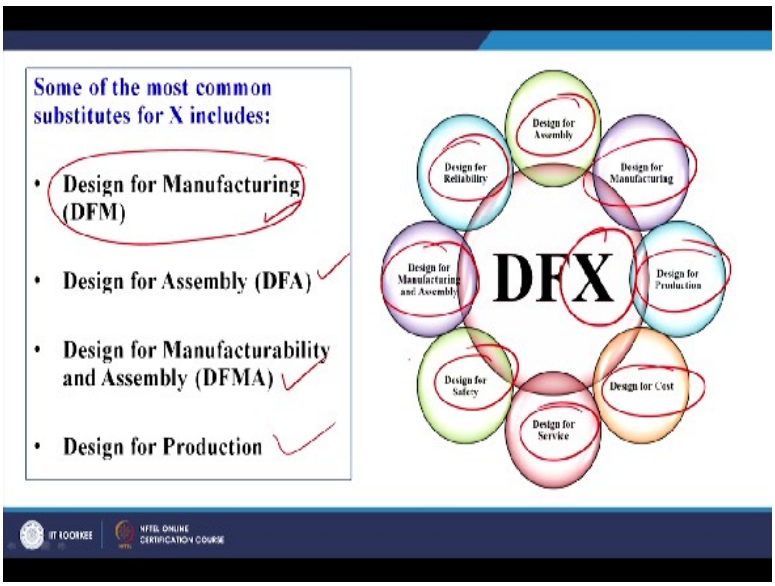

Let us quickly see design for assembly, reliability, design for manufacturing and assembly, we will try to cover basics of this design for safety, design for service, design for cost, design for production, design for manufacturing. So DFX x can take any of these values so some of the most common substitutes for x includes design for manufacturing most commonly used and our course is also subset of this.

Design for assembly, design for manufacturability and assembly, design for production, so we can see the importance of manufacturing, production, assembly, and all these things must be known to the designer when he is designing a product, he must know whether the product is to be made by a plastic material or a product is to be made by a metal or if in case of metals which alloy must be chosen for making the product.

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So all these things must be taken into account during the product design stage only. Now let us quickly try to understand design for manufacturing, DFM is the methods of design for ease of manufacturing we have to ensure that we are able to easily manufacture the product of a collection of parts that will form the product after assembly. So we have to ensure that ease of manufacturing of the individual parts.

For example there are 3 parts that have to be assembled together to make a product. So we have to ensure that ease of manufacturing of each of these parts ease of manufacturing of the collection of parts. So there are 3 parts here, so ease of manufacturing means that we have to ensure that all these 3 parts are manufactured easily and then they will be assembled together

to make the final product. So optimization of the manufacturing process is the overall objective of design for manufacturing.

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Now design for manufacturing is a development practice emphasizing manufacturing issues throughout the product development process. So we have to emphasize the manufacturing issues throughout the product development process, many a times the designers may be sitting in a different city. They have their own way of designing a product, when they design the product the product is pushed to the manufacturing facility which may be in another country.

So when the designs reach the manufacturing facility there are issues, they say that this type of surface finish may not be achieved, this type of profile cannot be created with the existing infrastructure. So the product design is sent back to the design team for little modifications, tweaking or fine tuning of the design. So this type of iterations can be avoided with the concept of design for manufacturing.

How it can be done, there can be integrated team of people from design, there can be people from manufacturing who specialise in manufacturing, then there can be other experts also from marketing, there can be experts from legal cell also there can be experts from intellectual property rights. So there can be a team of people a project team or a product development team which is responsible for launching the product in the market.

So this team will work hard, they will take into account all the aspects the legal aspects to the IPR issues, the copy right issues, the legal issues. All these things are taken into account as well as our courses the manufacturing issues are also taken care during the product design stage only. So throughout the product development process the expertise of the manufacturing personal who are employed with the company is utilised.

And therefore the iteration of the design being sent back from the shop floor to the design call can easily be avoided. Now successful DFM results in lower production cost without sacrificing the products quality. So we must ensure the successful DFM implementation because it will lead to good product quality.

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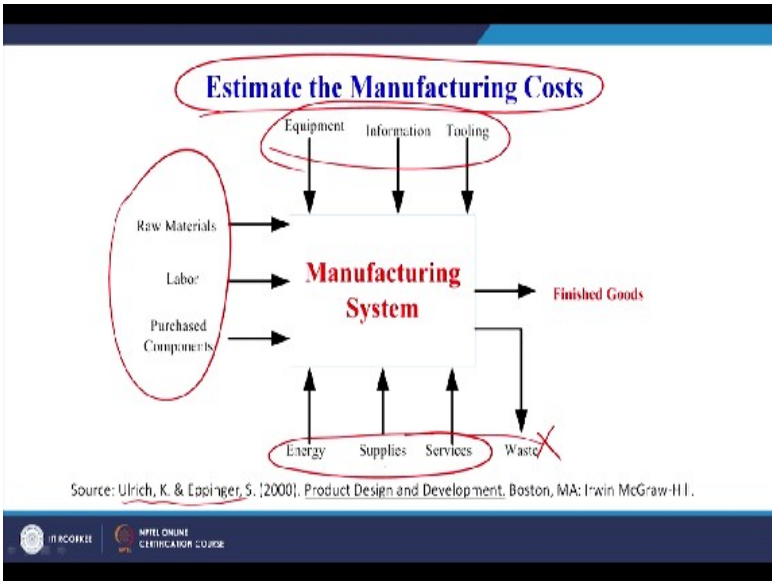


This is the estimation of the manufacturing cost as I have already told our target is not to go into the soft issues related to the DFM process. So the calculation of the cost is given the sources, given the very good book Ulrich and Eppinger product design and development, this topic is given there. So we can very easily estimate the manufacturing cost for the product and using the various input where the various inputs are given here.

These are the inputs, this is the waste which we have to avoid raw material, labour, purchased components, equipment, information, tooling, energy supply services, as these are inputs, all these add up to give us the total cost of the product or estimate the manufacturing cost.

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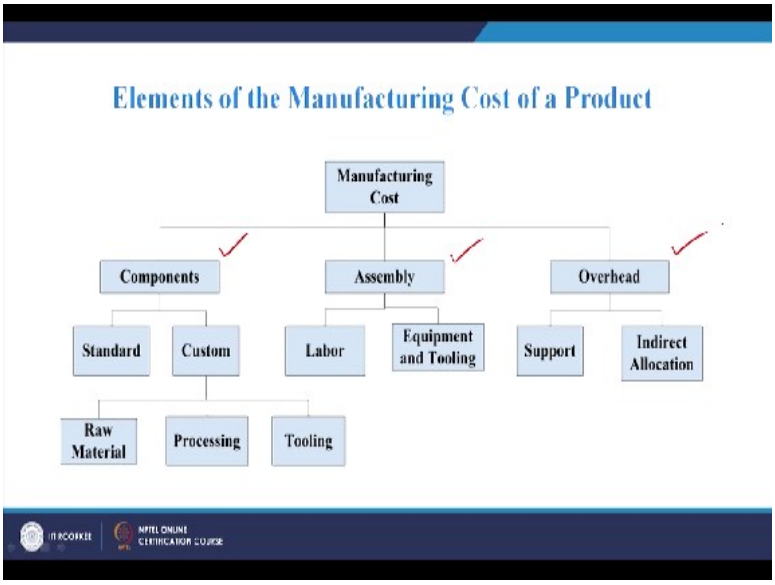


Now what is the elements of the manufacturing cost of a product, now for any calculating the manufacturing cost, cost of components, cost of assembly, cost of overheads has to be taken into account, why we are going into the cost aspect.

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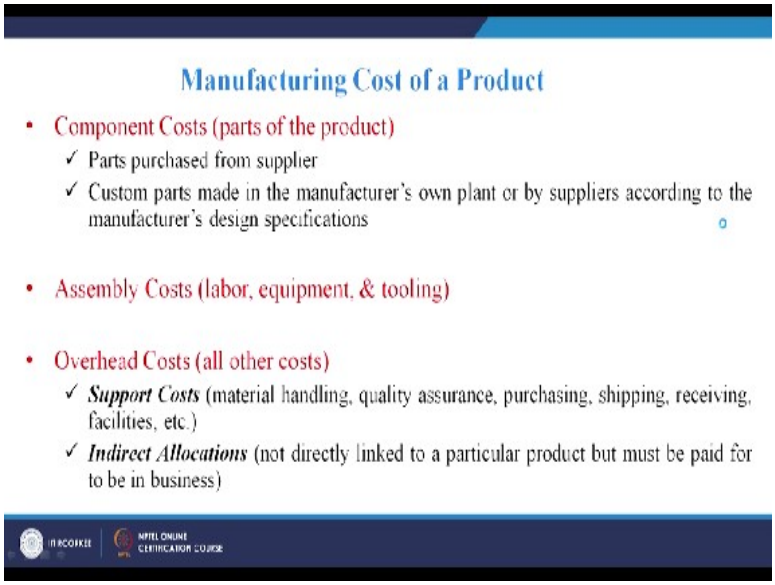


Because the manufacturing cost of a product will define it will define the steps that we are going to take using the DFM guidelines for ensuring ease of manufacturing for the product that we are going to make. So I am skipping may be the cost part, I am directly now coming to the DFM method.

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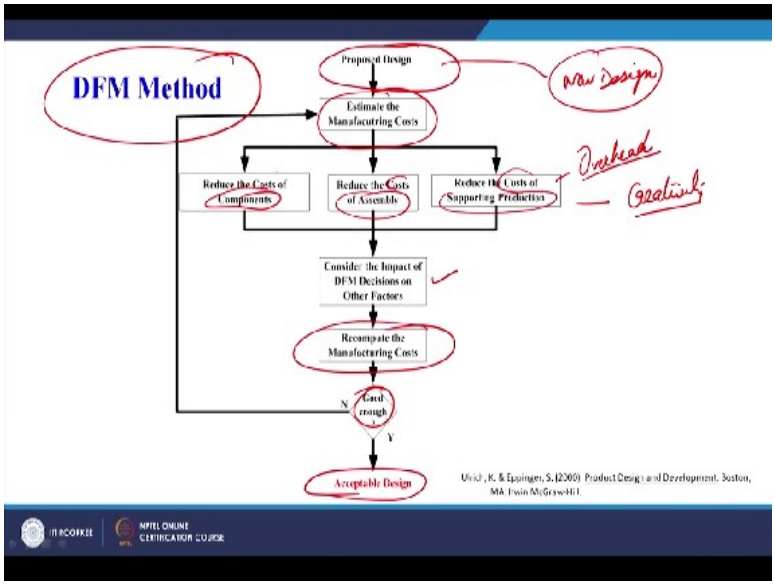


The previous 2 slides are very very simple, we can very easily calculate the manufacturing cost of a product and there are very good lectures available on this aspect also, lecture in economics, lectures in design for manufacturing which gives us an idea how the product cost can be calculated. But our focus is on manufacturing guidelines related to product design, so let us now see that we have a proposed design.

And for that design we can estimate the manufacturing cost using the standard approach which we have seen that there is a manufacturing system, there are so many inputs, so we can add the cost per unit for each of these inputs and and thereafter we will get the cost of the product. So we estimate the manufacturing cost we have 1 design, now we need to redesign it why.

We need to redesign it to optimise our manufacturing cost to optimise our design in such a way that the overall cost is saved, how we can do that if you remember we have seen 3 important cost elements are there, the cost of the components, the cost of assembly, and the cost of supporting production which in the previous slide it was written as may be the overhead cost.

So when we know there is one design of the product there is some cost associated with that we can try to change our design for how we can change it by using number of guiding principles, but it must lead to the reduced in the cost of the component, reduce the cost of assembly and reduce the cost of overheads or the supporting production. Now once we have been able to redesign our part in such a way that not all.

But some of the costs have come down we will consider the impact of DFM decisions on other factors. So we are applied our creativity and we have change the proposed design to may be a new design and the new design has led to reduce in the cost of important because now the part is easier to manufacture as compared to the previous or the proposed design. So the new design is are in 3 parts only. So it reduces the cost of assembly also, it reduces the cost of manufacturing the various part.

As well as it reduces the overall overhead cost also, so we will consider the impact of DFM decisions on other factor, then we recomputed the manufacturing cost and if we feel that the new design is better than the old design the cost is also less, it is easier to manufacture the parts which are going to be assembled for making the final product, definitely we will say it is good enough and we will take it as an acceptable design.

If we say no further modifications can be done and still there is the scope for improvement we can go back and calculate the estimate the manufacturing cost for the new design or our design changes and then the cycle can continue until and unless we are satisfied with the design that we want to manufacture based on the design for manufacturing guidelines. Now DFM guidelines will certainly help us to simplify our parts or components.

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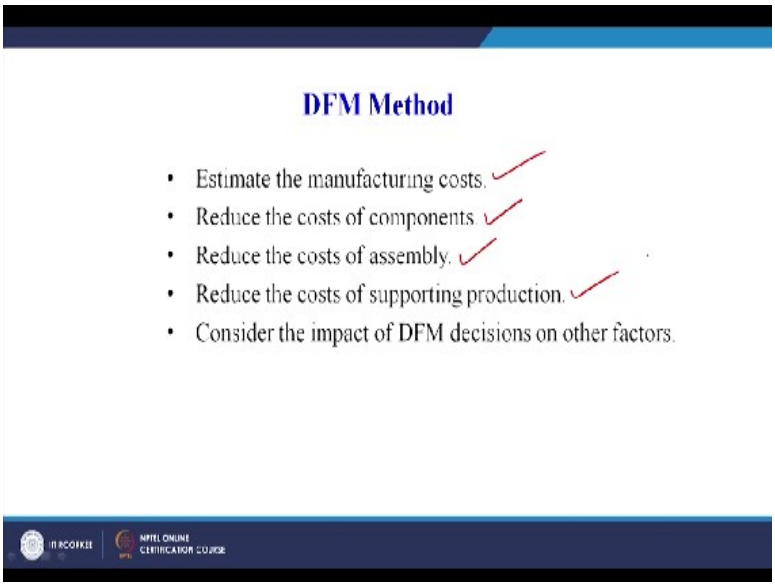


In such a way that they will be easy to manufacture as well as they will be cost effective to manufacture. Now the DFM method as we have already seen estimate the manufacturing cost, reduce the cost of component, cost of assembly, reduce the cost of supporting,

production and consider the impact of DFM decisions on the other factors which we have already seen. Now let us take an example here.

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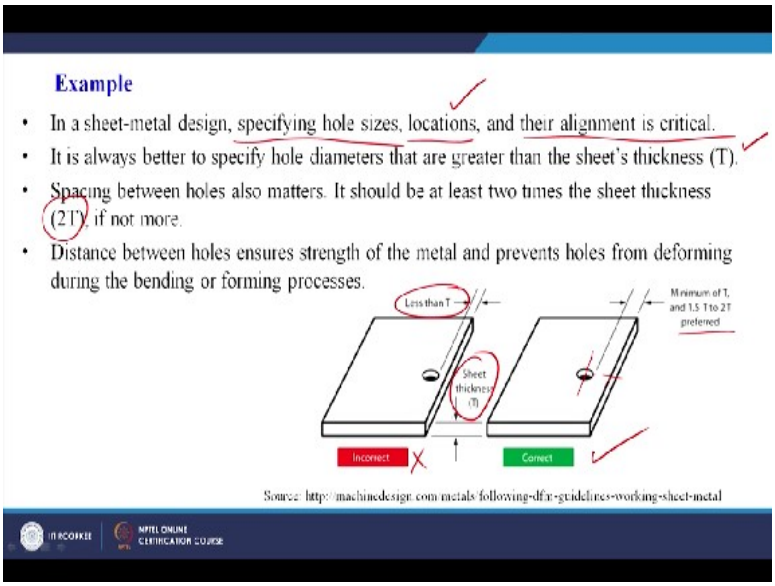


In a sheet metal design specifying hole sizes, locations and their alignment is critical. So these are the sheet metal it is shown here, we have to specify the hole size, where the hole has to be made, and must be their alignment, it is always better to specify hole diameters that are greater than the sheets thickness T, one guideline related to sheet metal fabrication, spacing between holes also matters.

That is their location also matters, which is already pointed out , the spacing between the holes must be at least 2 times the sheet thickness 2T, T is the thickness of the sheet that is the least it must be the spacing between the holes, distance between the holes ensure strength of the metal and prevents holes from deforming during the bending or the forming process. So these are some of the guidelines when we are going to make a holes in the sheet metal.

So here we can see it must be less than T which is incorrect, so here it is minimum of T 0.1.5 to 2.5T is preferred, so this gap distance between centre of the hole may be to the edge of the sheet. So this is correct T is the sheet thickness which is already known to us when we want to make a product with sheet metal. So such type of guidelines when we take into account the iterations that have to be done later on in the product design are minimized as well as the cost of manufacturing is also minimized.

So this is basically we can say the basic concept of design for manufacturing and with this we conclude the today's session, we will carry forward our discussion on the basic aspects of the product design process and tools and techniques that are usually used for product design, we have already covered 2 things.

First thing was the robust design, today we have tried to cover DFX with focus on manufacturing because our title of the course is manufacturing guidelines for product design. Next session we will try to see the other important tools that have to be taken into account during the product stage only in order to avoid the problems or issues later on.
Thank you.