Product Design and Development
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Lecture – 14
Design for X (DFX)

[FL] friends, so we are now in to lecture fourteen of our course on Product Design and Development. And we have divided the total discussion into four weeks and we have already completed week 1 week 2, and we have discuss the basic concepts of product design and development, we have consider the functional aspects of product design by specifically addressing the problem from the value engineering point of view, we have already seen the examples of value engineering.

In third week we are trying to learn certain important tools which help us in the product design process. In first lecture we have learned a important tool through which we take the input from the customer, and try to match that input with the technical specifications of the product and try to benchmark our product in comparison to the products of the other companies.

And try to take certain important decisions related do the product design process, that tool was discuss that was quality function deployment and we have discuss the house of quality. In second lecture once we have the voice of customers we know what customers want, we know how technically we can meet those specifications of those requirements of the customers we go for the actual design of the process and therefore, we considered important design tool that is computer aided design, in which we have seen what are the steps involved in computer aided design and we have also seen that what are the important softwares, which are used for solving or designing the problem using the help of with the help of computers.

We have also seen that today the computers are not only used for drafting the problem or for sketching or giving the geometry to the problem, softwares are also helpful in analyzing and providing solutions to the engineering problem. So, the cad as discussion helped us to I have a basic understanding about the tool and how it is helpful for the product design process. In third discussion or third lecture on week three or in week three, we have discussed the robust design procedure and how we can differentiate between the controllable parameters and uncontrollable parameters and we have concluded that it is our duty to ensure that our product is insensitive to the variations in the noise factors and therefore, only the product will be usable for the customer and it will be acceptable in the market.

So, with this background now we are slightly moving towards actualizing our product. We can conceptualize it from the customers or from the demands of the customer, we can design it on the screen using cad, we can put certain things into the product certain things means a robustness, we can put the quality into the product by appropriate selection of materials, now we have to see that when we are actually going to fabricate or manufacture the product what are the things that we have to keep in mind.

So, we have to design the product in such a way that when it is manufactured, it is easy to manufacture. We are not doing a course on manufacturing technology in which we will learn the processes like primary forming and deforming or material removal processes, we are not actually producing the product, but we are actually designing the product, but during the design stage only we have to ensure that it is easy to manufacture or fabricate or assemble the product at a later stage.

So, during design only we will ensure that all these conditions are met, and for that we have to ensure that our design is excellent and de effects is an important term that is used nowadays that is design for excellence. So, excellence not in terms of performance or quality or reliability or durability, but excellence in terms of manufacturing also in terms of cost also in terms of assembly also. So, we have to ensure that the product design is excellent in nature.

Now, from where the term x come into picture let us quickly go to that.

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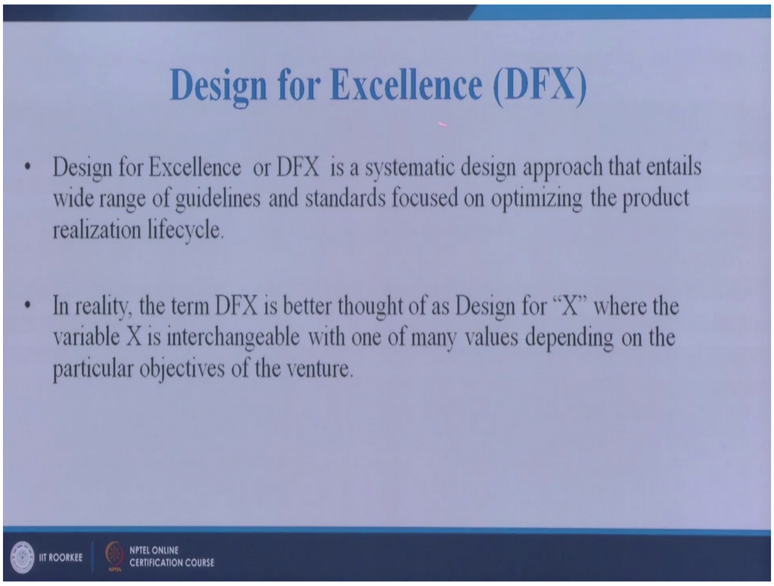

Now design for excellence generally it is called as DFX, design for excellence or DFX is a systematic design approach that entails wide range of guidelines and standards. So, first thing is, it is it entails wide range of guidelines and standards we will see examples of one or two such guidelines today with a specific example or a specific application. So, it entails wide range of guidelines or standards. So, we can also say that DFX is a set of guidelines and standards which we should follow during our design process. These are focused on optimizing the product realization life cycle.

So, these guidelines are helpful to us to make our product successfully in order to make our product economically as well as help us to actualize the life cycle of the product or to some extent we can say to minimize the life cycle of the product. In reality the term DFX is better thought of as design for x, where there variable x is interchangeable with one of many values depending one or many values depending on the particular objectives of the venture. So, we can say it is DFX, x can take any value. So, x can be it can be manufacturing it can be assembly it can be quality it can be reliability. So, DFX then becomes design for manufacturing depending upon what is our area of focus if we are focusing on the design which we want that it should be manufactured easily we will say design for manufacturing. If we have a designer hand which we need to assemble easily we will say it is DFA.

So, x can take any value, but in general DFX means design for excellence. Now here in this particular point I have emphasized on one thing that these are set of guidelines, which helps us to actualize our product also it helps us to save some time. So, this can be explained from another point of view that in previous you can say business environment usually the design center will be a certain or will be assigned the task of designing the product. The manufacturing facility will only be used to manufacture the product.

Now, there are two separate entities, the design center and the manufacturing facility. Now the design center will design the product based on the knowledge base of the designers and requirements of the customer. Now this design maybe in the form of drawing sheets we will be sent to the manufacturing facility for manufacturing the product or for manufacturing the prototype, but there may be certain guidelines or certain set of rules which have been violated by the people who are involved in the design center.

When this design reaches the manufacturing facility, the manufacturing engineers or production engineers will highlight maybe in many cases they will send the design files back to the design center with their comments; that these are we can say features or tolerance requirements which cannot be achieved by the manufacturing facilities available and then it therefore, and therefore, it has to be redesigned

Now, once this design or in the form of drawings reach back to the design center, they will see redesigned the product and again send it back to the manufacturing facility. So, this iteration maybe a single iteration, it can be double iteration three times it may happen, but it takes or eats away lot of precious time, which has to be controlled or completely eliminated.

So, in the present context there is no company in which the design center will be a compartmentalize center or will be in independence center. These days for launching a new product into the market there will be a product team in which there will be individuals from marketing, sales, finance engineering background, then production design, legal different people with different specializations will comprise the overall product team.

So, that all these problems of iterations are taken care of and the design team when it gives the product or the design of the product it is final in all its aspects and it is not sent back from the manufacturing facility to the design team, and the role of information technology cannot be ignored in achieving this thing or this particular objective. So, the DFX, DFM, DFA, DFR or this DFQ all these are concepts which want or which aims at reducing the overall cycle time for lunching or overall product design time for launching the product in to the market. So, we can see that if we use the concepts of DFX, we have a product design will be not only robust in nature, but will also save lot of time for the organization and a manufacturing cost will also be optimize.

So, we will try to see that how the concepts of DFX can help us achieve our objective. So, this is the first cons I have think I have explained it that how DFX is not only helpful in giving us a robust design, but is also help full in saving lot of money also for us as well as saving lot time for the organization.

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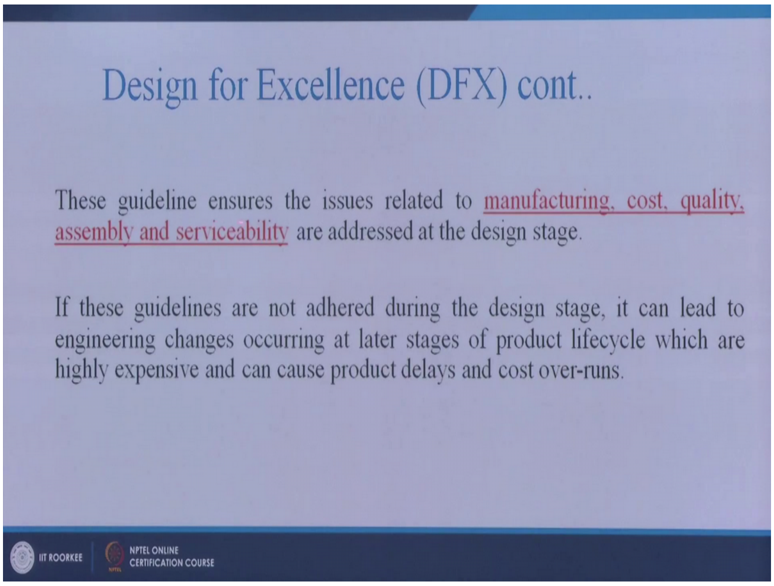

Now, these guidelines ensure the issues related to manufacturing I have already told, cost quality assembly and serviceability are addressed at the design stage only.

So, our design will be good in all these aspects. If these guidelines are not adhered during the design stage, it can lead to engineering changes occurring at later stages of product life cycle which are highly expensive and can cause project delays and cost overruns. So, I think whatever I explained in the initial discussion part for today's discussion are completely outlined or are explained in a much better manner in these sentences. That if we take care of these guidelines we achieve good manufacturing, low cost high quality, easy assembly and good serviceability if we adhered to these guidelines. If we do not adhered to these guidelines, it can lead to highly expensive product, product delays and cost overruns.

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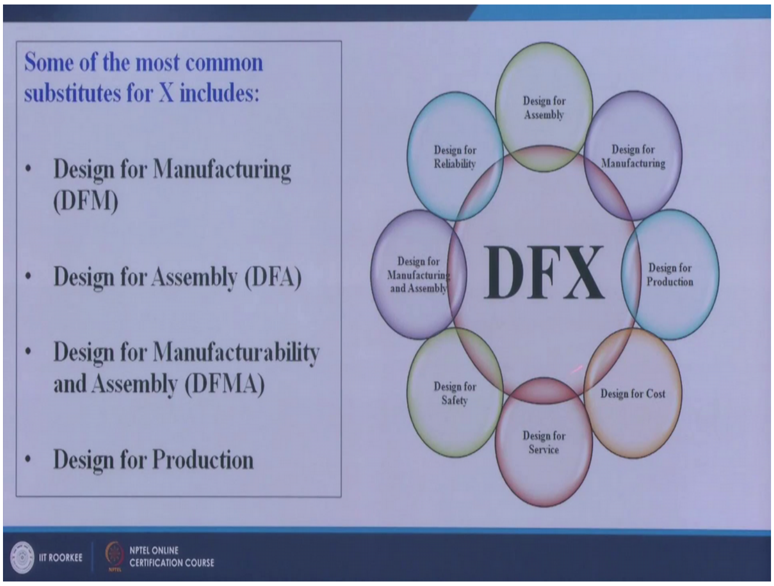

So, we are losing on all accounts if you do not follow these guidelines during the product design process. Now this is the very good diagram you can see, some of the common substitutes for xs I have told design for excellence, design for x can be substituted. So, here are few examples design for manufacturing, design for assembly, design for manufacturability and assembly design for production, and on this side you can see design for cast, design for service, design for safety, design for reliability. So, x can take any name, but the overall objective of the product designer is to ensure that the product is good quality low cost, easy to manufacture, easy to assemble; ease reliable is easy to service.

So, when you take into account all these things then it means you design for excellence. The product is robust and is insensitive to the variation in the noise factors. Now we will try to understand maybe design for manufacturing and design for a assembly in today's discussion with the help of certain examples. Now what is design for manufacturing? It is ease for manufacturing. So, DFM is a method of design for ease of manufacturing, of the collection of parts that will form the product after assembly. So, design for manufacturing means that if we have a product that we want to manufacture that design should be such that it is easy to manufacture. We will try to see that how a set of guidelines can help us to achieve this objective that the design is easy to manufacture.

So, here we are trying to optimize the manufacturing process, we are trying to design the product in such a way that it is easy to manufacture.

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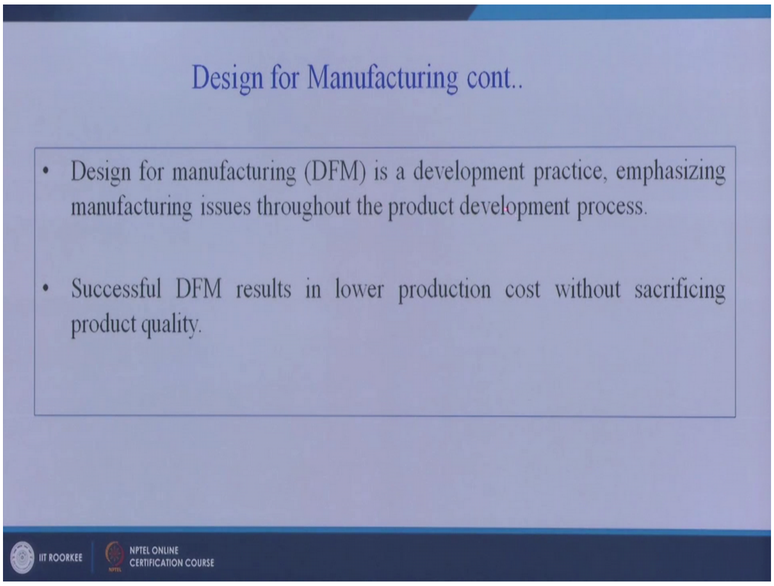

Now, design for manufacturing is a development practice, emphasizing manufacturing issues throughout the product development process. Usually this happens at the manufacturing stage only, but here you can see from this sentence emphasizing the manufacturing issues throughout the product development process, that is at the design stage also we are thinking that how this design will be manufactured when it goes to the manufacturing facility. It is not only that I am focusing on the design that it should look good it should be in this color the profile should be like this, but I am also thinking that when this product will go to the manufacturing, which machine will be used to fabricate this, which tool will be used to fabricate this, which tool will be used to finish this.

So, I am thinking of the manufacturability of the product also during the design stage only that is the beauty of this concept. Successful DFM results in lower production costs cost without sacrificing the product quality sorry. So, if we ensure that the design is easy to manufacture, we save lot of cost and the quality is also consistent.

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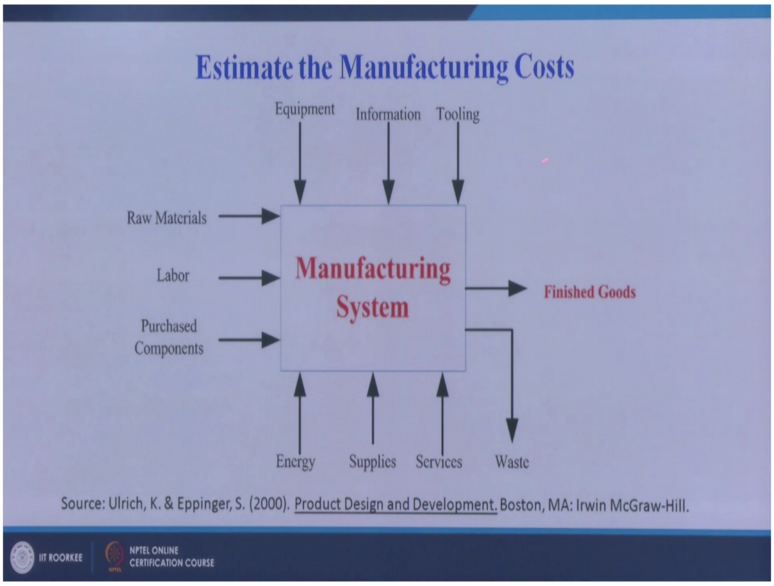

So, these guidelines should be taken into a account when we are designing a product. This is the entire manufacturing cost we can say; for any manufacturing system there are inputs there are outputs. Now input can be raw material, labour, purchased components output are is the finished good or are the finished goods. Now you have equipment going in to system, information tools, energy supplies, services, raw material, labour purchased component everything going into the system is a input and everything will entail some amount of cost.

So, this is the cost that goes into the system and it comes out in the form of the finished goods, and there will be certain waste also or discarded or rejected or discarded goods. Now what are the manufacturing costs of a product we can see?

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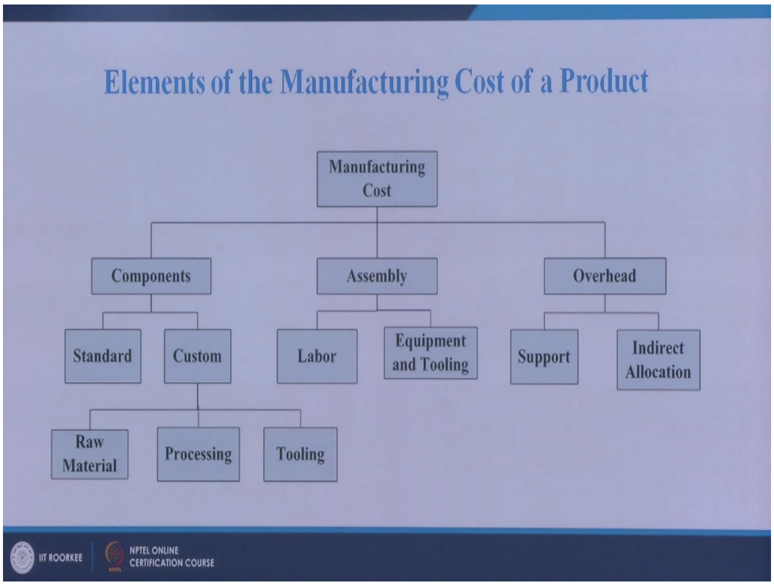

The manufacturing cost of the product can broadly the components assembly cost and overhead cost, from the previous slide only we can breakdown the manufacturing cost into its individual consistence or components. Components can be standard components, components can be customized components. So, if there are standard components they will be procured from the market if we are customized we have to manufacture them then for a customized component we need to have a raw material, there will be processing cost there will be tooling cost.

Similarly, for assembly tooling means sometime processing, can be the actual machining cost, but tooling cost can be the specific tool or a fixture or a jeep that is used which there can be difference or in many cases tooling can also be included in the overall processing cost.

In certain plastic parts the tool may have a different perspective, because is the tool is the main we can say focus of or the die is the main focus of the plastic manufacturing process. So, may be depending upon the type of manufacturing, we can bring them different or we can club them together also it hardly matters, but this as to understand that what is the manufacturing cost for a product, then the assembly cost labour cost equipment and tooling cost overheads can be support maybe consultance or the other support and the indirect allocation cost. So, this is just a general description of the manufacturing cost of the product, now we have to a certain that this cost it do not overrun and is easy to manufacture means the cost should also be minimum.

Now this is a little bit of explanation of manufacturing cost, I have already explained component cost parts purchased from the supplier custom parts made in manufactures own plant or the suppliers according to the manufactures designs specifications, the first was component cost, assembly cost, already discussed overhead cost support cost like material handling quality assurance, purchasing, shipping, receiving facilities indirect allocation not directly linked to a particular product, but it must be paid for to be in business.

So, these are the just a brief the fixed cost incurred in a predetermined amount regardless of the number of units produce, that is setting up of the factory work area or cost of an injection molding machine. Variable cost incurred in direct proportion to the number of units for example, the cost of is fixed cost variable costs or very common terms used in the breakeven analysis, whenever you draw the curve you use these curve for fixed cost remaining horizontal, then variable cost depending upon the number of products produced.

So, in general we have tried to understand that what is the cost structure of a product when we are manufacturing the product. When we are the design is not included here. So, when we are saying design for manufacturing we should know that manufacturing entails all these cost and how we should design the product so that this cost is somehow minimized and the it is also easy to manufacture that product.

So, this is just a brief summary of the overall cost structure of the product, now why we have discuss the manufacturing cost you may appreciate that. Because DFM method now we are going to see the overall flow chart of the DFM methodology, we see we have a proposed design already we have designed a particular product. Now we will estimate the manufacturing cost we know; what are the costs that are involved in manufacturing the product.

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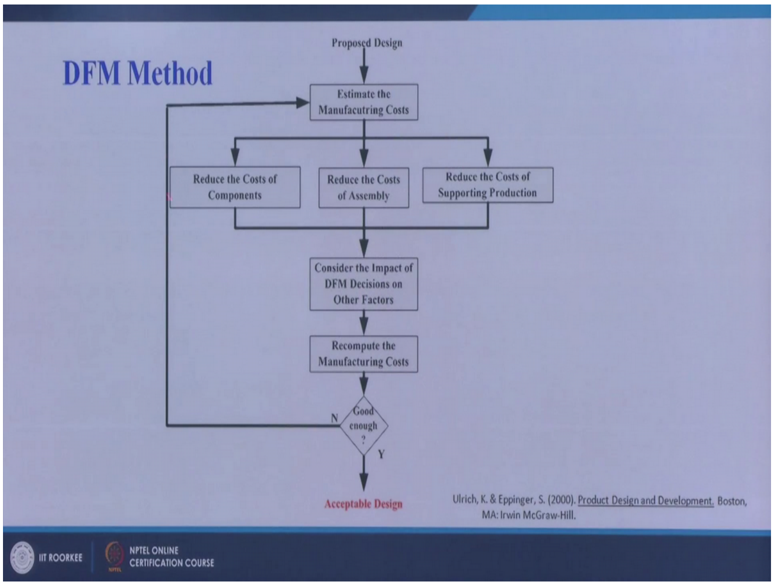

Then we will see reduce the costs of the component, we will use our creativity our innovative bent of mind and see that this component is necessary how we can redesign it, but keeping the quality, performance, reliability, durability, ease of service everything into our mind. We are not going to compromise on anything, but we will try to reduce the cost of component, we will try to reduce the cost assembly, we will try to reduce the costs of the supporting production. So, we will try to reduce the cost we are ever possible for the proposed design by coming up with the new design.

Then we will consider the impact of DFM decisions on the other factors, other factors can be as I have already told performance factors, and then re compute the manufacturing cost. If it is good enough we can say the new design is acceptable design, if it is not good enough again we will go and estimate the manufacturing cost and then again the cycle will repeat.

So, basically the overall summary of this flowchart is that for DFM to be successful we will analyze each and every product from the point of ease of manufacturing. We will try to reduce the costs wherever possible, sometimes it may so happen that initially when we are proposing a change in their design the cost may be slightly higher, but the process is faster so that it can produce more number of parts. So, the overall production cost may become lower. So, it is not always maybe when the cost is lower, we are achieving our target sometimes the cost may be higher also, but the life cycle or the overall cost of the product or the manufacturing is lower and therefore, we may propose a change in the design of the product.

So, here we can see we have a proposed design, we see how we can redesign it in order to achieve our target of ease of manufacturing inconsistency with the cost structure of the product. We will only redesign the product from manufacturing point of view, if we are gaining something out of it, if we are achieving some target. So, ease of manufacturing suppose there is a design which takes 10 minutes to produce and it requires 10 rupees for manufacturing cost.

Now, suppose we can redesign it in such a way that now it can be produced in one minute only, but the cost is rupees 12. So, we are saving 9 minutes at the cost of rupees may be the cost is initially the cost was rupees 10 minutes it is taking and the cost is rupees 10. In the second it is taking only 2 minutes cost remains 10. So, the cost remains same, 10 and 10 in both cases 10 minutes and two minutes.

So, we say two minute is better by the redesign, so that 8 minutes we are saving, 8 minutes of productive time we are saving. So, similarly we have to do a tradeoff and see that where we are gaining. We will only modified the design if we achieve something positive out of it. In this case 10 minutes 10 minutes 10 minutes and 2 minutes; so, we are saving 8 minutes cost remaining same. So, we should always go for that change in the design in many cases if we are saving money also. So, it is double benefit for us.

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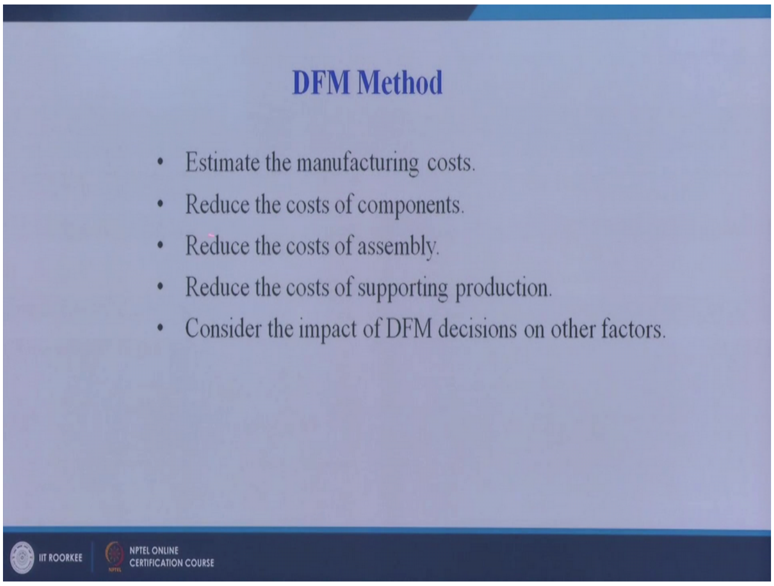

Now for the DFM I said just a brief summary estimate the manufacturing cost, reduce the cost of the component without compromising the performance. Reduce the cost of assembly without compromising the reliability durability. Reduce the cost of the supporting production whatever we are saying indirect cost and consider the impact of DFM decisions on the other factors as well.

So, that we have to see here maybe the time is not coming into pictures. So, the other factors can be the time, that if the product design is leading to less time for manufactured that can be the other factor which can taken into account. Now let us take a very simple example.

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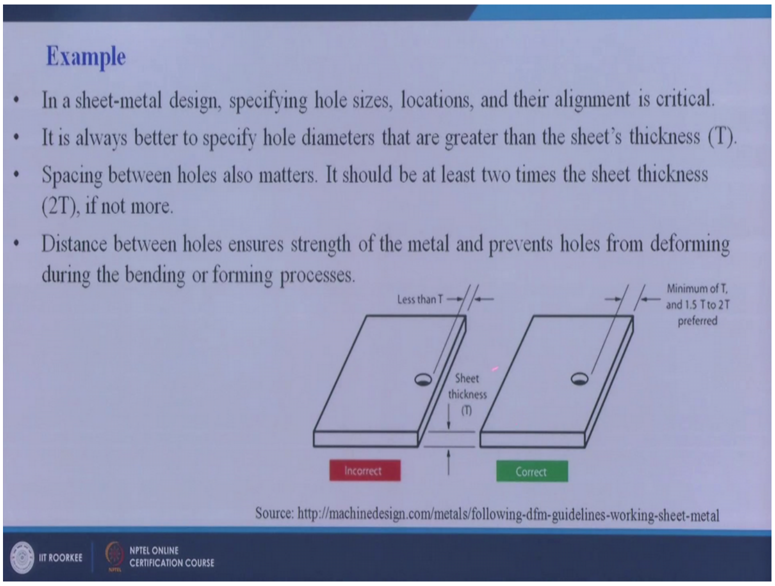

It is the sheet metal product you can see. In a sheet metal design specifying the hole sizes locations and their alignment is very very critical. So, you can see hole sizes in critical, location of the hole is also very critical because here we are this example is related to the location of the hole in the sheet metal. So, it is always better to specify hole diameters that are greater than the sheets thickness. So, this is a sheet which has got a thickness of T capital T.

So, it the diameter of the hole should be greater than the sheet thickness, it is always better to specify the hole diameter that are greater than the sheet thickness. This can be one of the DFM guidelines for manufacturing of or fabricating parts made out of sheet metal or the parts that require sheet metal operations. A mechanical engineer would be able to appreciate this point that for every process there are set of guidelines which are helpful to us, one of the guidelines given here is regarding the hole diameter in a sheet metal part. Spacing between the holes also matter, the center to center distance between the two holes is also equally important. Spacing between the holes also maters it should be at least two times the sheet thickness if not more.

So, two times the thickness of the sheet should be the center to center spacing between the two holes that are made in the sheet metal component. So, distance between holes and ensure strength of the metal and prevent holes from deforming during the bending or forming processes. For subsequent processes this distance between the two holes will play a vital role.

Now from this example we can see that only in one specific process that is a sheet metal operation we have seen at least three guidelines. So, you can yourself imagine that how many such guidelines rules of thumbs, heuristics maybe available for engineers to take into account when they are designing a product. And if you take into account these guidelines your product design would be search that it would lead to ease of manufacturing, there will be no problem during the manufacturing stage, no wastage of material will be there and the product will lead to a successful product in the market.

Here you can see red color incorrect design. You can see the central distance of this hole from the edge is less than the thickness of the sheet. Therefore, we can say green color is the correct design the distance of this hole from the edge is 1.5T to 2T which is preferred. So, this is one DFM guidelines for sheet metal components which can help us to design the product which will be easy to manufacture.

So, second part is the design for assembly. Now from design for manufacturing point of view we have seen that if we follow the guidelines our manufacturing we will become easy and our product would become may be more successful. From design for assembly point of view, DFA is the method of design of the product for ease of assembly. Design for manufacturing ease of manufacturing, design for assembly ease of assembly. So, optimization of the part or system assembly; we will try to see that how many parts we can eliminate and we can make our assembly process simpler.

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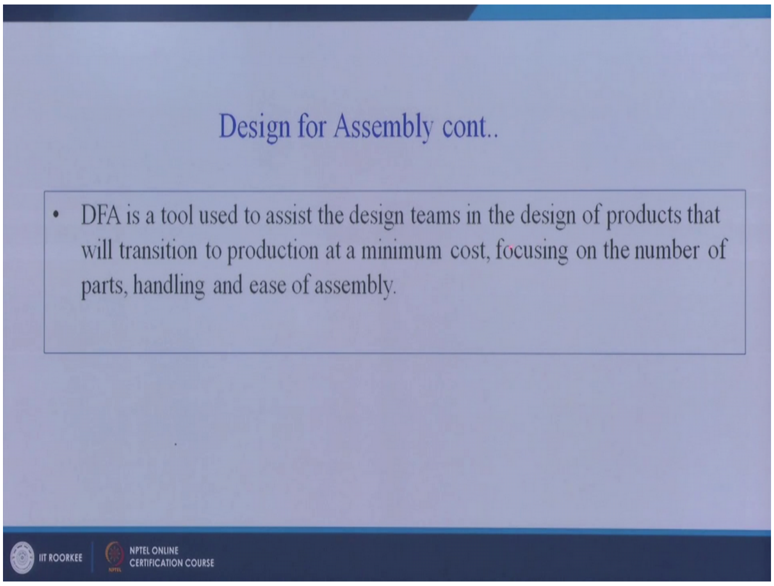

So, quickly let us see DFA is a tool used to assist in the design teams in the design of products that will transition to production at a minimum cost, focusing on the number of parts handling and ease of assembly. So, we have to see what is the number of parts going into the of product, how we should handle them that is their handling should be easier, and their assembly operations in totality should be simpler easier and cost effective. So, that is what is our target when we are designing the product from ease of assembly point of view.

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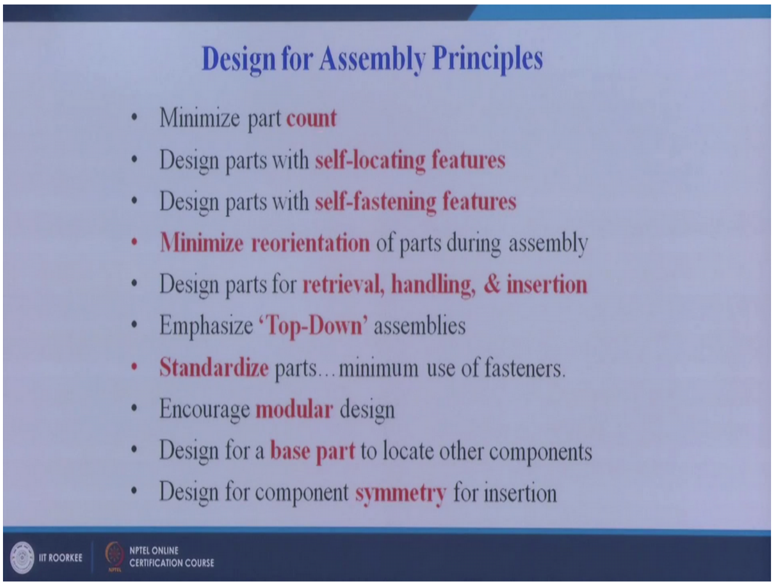

Now, design for assembly principles are given, I think quickly I will read these not much requirement to explain each point in detail minimize the part count, that is number of parts can be less or tried to be minimized design parts with self locating features. So, self locating means there should be some feature which will help it to be located at its desired position.

Design parts with self fastening features. So, if you club the two things together it should stick to each other self fastening should be there; minimize reorientation of parts during the assembly. So, once you oriented they should not get to reoriented during the assembly process. Design parts for retrieval handling and insertion emphasize top down assemblies, maybe top down means the sequence of assembly operations should be very structured maybe you can start from a bigger part than the smaller part than smaller you can build on the assembly in such a way standardized parts minimum use of fasteners.

So, standard part should be used encourage modular design maybe minimum number of parts should be there, modular means single. Design for a base part to locate other components as I have told in the top down approach sequence is very important and design for component symmetry for insertion. So, suppose a square part has to fit on a square part both parts can have a square geometry so that it is easy to fit. So, thus component symmetry also is important; if we take into account all these points or designed for assembly guidelines or principle our design would be easy to assemble.

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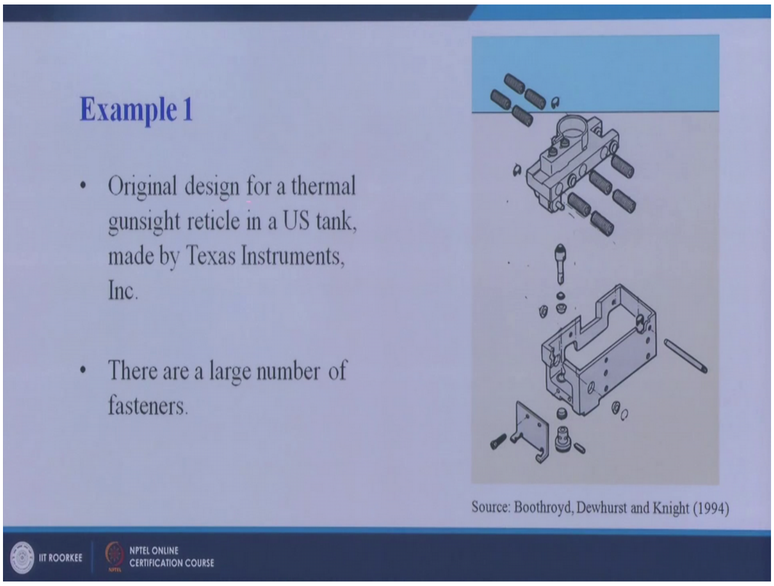

Now, here we can see one example, optimal design for a thermal gun sight reticle in a US tank made by Taxas instrument. So, this is one example has been taken from a book Boothroyd 1994 it was published. So, here you can see one design and you can see the number of fasteners going in to the product and the complexity of the design. So, there are large number of fasteners here, and as per our guidelines you can see we should design parts with self fastening features and somewhere it was written that we have to minimize the fasteners standardized parts minimum number of for minimum use of fasteners.

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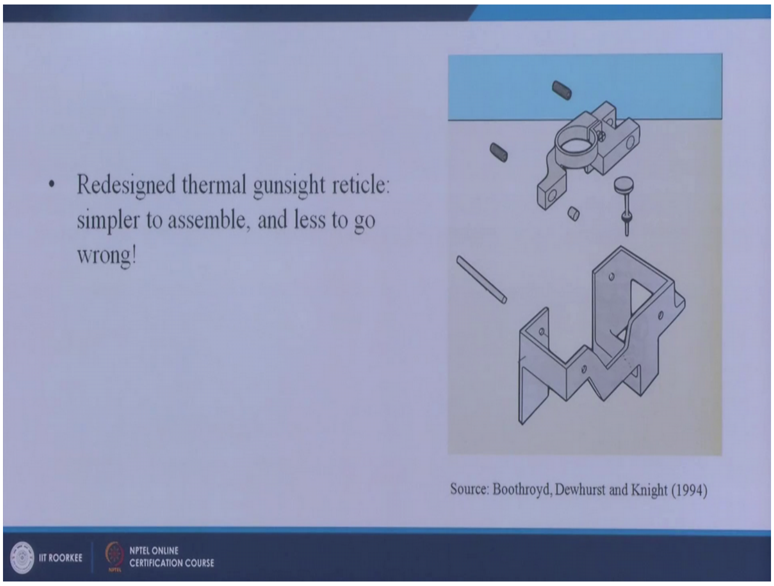

As per this guidelines if you redesign this part it you can see how simpler same objective met, same functionality, no compromise in the performance simpler part. So, redesign thermal gun sight reticle similar to simpler to assemble and less to go wrong.

So, chances to go wrong is less foolproof design easy to assemble as well as less number of fastener will definitely take less time. So, let us see what are the advantages of this new design, this is the measuring the improvement the old design and the new design. Now you can see parameters of comparison assembly time improvement by 84 percent it is less time consuming. Number of different parts 66 percent improvement, original has 84 parts sorry 24 parts number of different part redesign has only 8 parts, you can yourself see it has got less number of parts.

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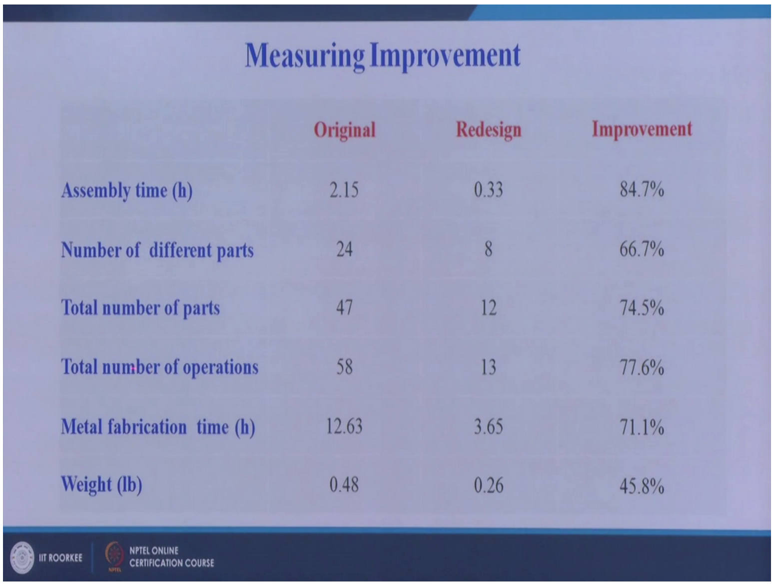

Then total number of operations in original 58 assembly operations, in the new design only 13 assembly operations, metal fabrication time also 71 percentage reduced, weight also 45 percentage reduced.

So, you can see by following a simple design guideline that is for easy to assemble product we should have minimum number of fasteners and a redesigned part with this guideline that simpler easy to assemble top down approach, minimum number of fasteners. So, if we followed DFA guidelines or design for assembly guidelines you can see for yourself what can be achieved or what is the order of improvement that we can achieve.

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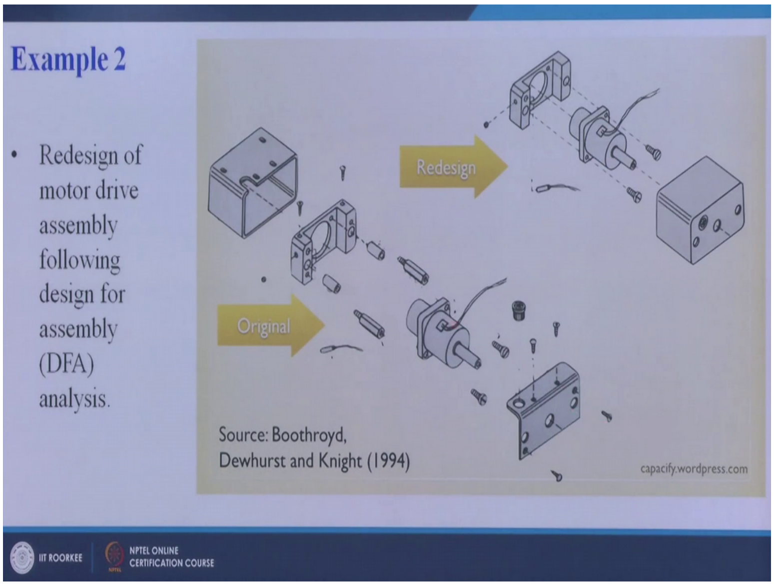

Now, this is another example, this is original part very complex, so many number of fasteners there are, so many number of parts. So, here you can see redesigned part less number of fastener easy to assemble. So, this is redesign of a motor drive assembly following design for assembly analysis or design for assembly guidelines. So, you can see different designs we can redesign based on the guidelines and the redesigned part can be much simpler, much cost effective, much better in performance as compared to the original part, which is also the basic concept of value engineering.

So, what can be the differences? This differences I will touch when we will go to the DFMA guidelines in the next we can say discussion on week 4, we will discuss DFMA guidelines in detail, and we will see what are the guidelines for manufacturing of part when it has to manufactured by casting or forging or welding.

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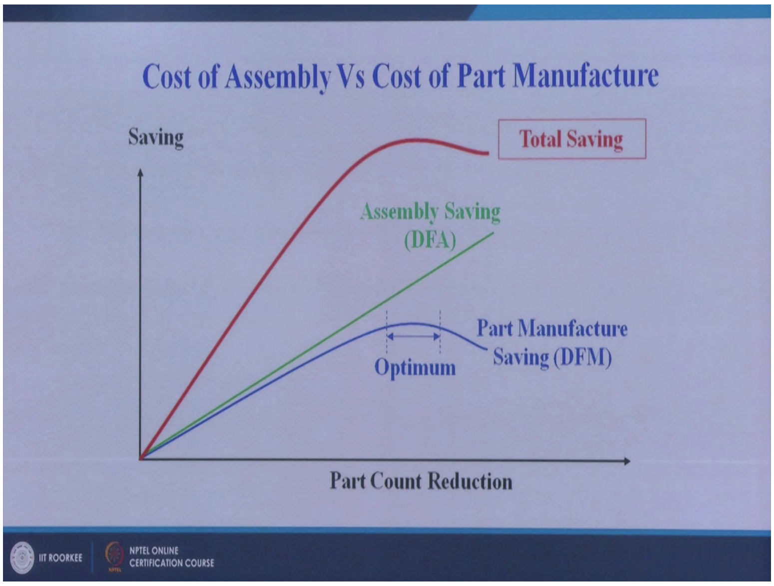

So, all those details there when we discuss I will come back again to this slide what is the difference between design for assembly, and design for manufacturing. This is the or we can say cost of assembly versus cost of part manufacture, this is important here you can see. When the part count is reduced part count reduction your green line shows your savings in the assembly operations.

So, when your part count will be reduced you will save money, because your assembly will become easier you have to assemble less number of parts. Similarly for part manufacturing saving when your parts will reduced you will also save some money, but here there is a optimum value why there is a optimum value here? After that our savings are going down. See there is a optimum value for the savings if we can draw straight line here and after this, this is going down. So, our part savings are going down why because by reducing the number of parts to a very very critical of very lower value, which means that the complexity of the product will increase to such an extent that the manufacturing will become very very difficult.

So, sometimes in order to manufacture it easily a complex part is divided it in divided into simpler part. So, that all simpler parts are easy to manufacturer, but when we want to reduce the number of parts as per the DFA or design for assembly guideline, the parts will reduced, but the individual parts may become more and more complex.

So, that has to be taken care of. So, after a optimum part reduction, if we further reduce the parts the savings potential comes down, but the overall if we follow the DFM and DFA guidelines the overall savings are positive only maybe up to a particular number of part count, beyond which the savings potential goes down. So, overall we can see that these are important concepts we have taken three examples, one in DFM and two in DFA where it has been proven that the guidelines are helpful in not only ensuring the easy manufacturing and easy assembly of the products, but also helpful in saving the other benefits also like weight is also saved, time is also saved money of course, is saved. So, it has become may be profitable for the company to adopt these guidelines to follow these guidelines in letter and spirit so that the overall cost structure of the product improves and product becomes more and more competitive in the market.

So, the market companies that follow these guidelines have a competitive advantage in the market, because their rejections are less the cost is also competitive as well as the time for manufacturing is may be saved and they are able to launch their products with the much more we can say agility as compared to their competitors.

In the next lecture we will see that what are the other tools which are helpful to us in designing the product, which will design, which will help us to design a product, which is going to be successful in the market and our focus primarily will be on the agronomic aspects of product design.

Thank you.