Manufacturing of Composites
Prof. J. Ramkumar
Department of Mechanical Engineering
Indian Institute of Technology, Kanpur

Lecture - 07
Design for Manufacturing

Good morning. So, we will move on to the next lecture which is designed for manufacturing.

Basically, when you think of manufacturing, manufacturing means converting a raw material into a finished product with high productivity; production and productivity are 2 different com definitions. Production means trying to produce. Productivity means trying to produce with minimum material energy and minimum effort. So, in this topic we will try to cover design for manufacturing which is in a short called as DFM.

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So, design for manufacturing definition we will see, purpose for DFM, and then we will see about design flow of DFM. DFM implementation techniques design for manufacturing and maintainability.

So, these are some things which are this is a very generic discussion, this you can fit it all these discussions with respect to composites also. So, why do we need to have design for manufacturing?

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The defects or quality Problems inner product is caused by 3 things one is bad design bad material choice. That is why we had an exclusive lecture on selection of materials. So, and I also had explain to you about the weightages given for each property. And in reality there will be normally 2 or 3 different properties which are playing an important role. Towards the outcome of the product to keep the customer satisfied. The last thing is choosing of an wrong manufacturing process.

For example, if somebody comes and says I would like to make a shaft of polymer material for example. So, and they say I want a diameter of 10 millimeter. So, if the possibilities are one you can try to do it by machining; that means, to say I take 12 mm or 14 mm or 16 mm rod polymer rod I take and then I start doing machining, trying to reduce the diameter and bring it to 10 that is one possibility. The second possibility is I tried to extrude, in extrusion what happens I tried to put everything in the barrel.

And then I try to pressurize and push out through a die and get the required diameters. So, here I do not waste material the material, which is put as raw material itself I get it is as output I exactly make ten. So, through this process also you can try to make a polymer rod. So, if you t see these 2 processes, the both these processes the final outcome is achieved.

But in the first process you have lot of scrap generating, that is not accepted today when you talk about in sustainable manufacturing. The first one is commonly used for small

back size quantities, and extrusion process is always look forward for mass production. And here in mass production the die cost is very high. So, in order to take out the die cost they always try to look for mass production, the component price also comes down drastically, and it is also a very good process as for as environment is concerned.

So, here you are choosing a manufacturing process, and when you choose a wrong manufacturing process. In extrusion what happens? The load is uniformly distributed; that means, to say the grain size the defects all are taken care and what a output you get is of very high quality in terms of strength. Whereas when you do machining you will have on the surface lot of compressive stresses getting induced, but at the core you are not pretty sure what is there. So, if we make a wrong choice of manufacturing process that will also lead to a defective or a quality problem. So, defects are to be minimized in order to make a customer very happy.

So, defects or quality problems in the product is caused by 3 things bad design, that is why I kept on saying that you understand what the customer wants you decide the orientation and try to get what best you want. So, bad design bad material choice and wrong manufacturing process will always lead to defective or a quality problem induced product. Any incorrect design product will also result in a quality problem. Despite having chosen the right material and the right or the good manufacturing process. Even though I make 2 things good, and 2 things I achieved the best. But the first thing the design if I make it not correct, or I instead of a circular beam I put a square beam or instead of a, I shaft I truss I try to make something else. So, then what happens the material is chosen based upon the design the manufacturing is chosen based upon the design. So, today there is a concept called as concurrent engineering.

Where the design engineer material expert manufacturing expert all sit together look at the customer requirement, and then right from the conceptual stage they are all involved. So, that they do not make any glaring mistakes to get the product very fast today the biggest challenge, as I have told earlier also is product life cycle reduction. How quickly you can come out with the product to make the customer happy? See the occurrence of these defects is caused by several factors inherently in the design, in it not only increases the cost because of the improper design, bad material choice wrong manufacturing process. It increases the cost of the product and also it reduces the quality problems. It also decreases the product quality.

So, the cost is directly proportion to the design choice, material selection and the manufacturing process. The common design problems include loosen parts. Many a times when in the bicycle the most, most occurring problem is always from the pedal. So, in the pedal what happens? You have a screw and you have a nut and based upon the vibrations which encounters in a cycle, these nut gets uns the nut and bolt assembly try to get loosened.

So, after some period of time one of the part fails and because of the pedal failure, many a times a customer's tops using a entire bicycle, the cost of the nut and bolt assembly maybe around about 10 rupees. The other example let me take you we buy a pant which cost around about thousand rupees. The cost of the zip which is involved in a pant maybe 5 percent of the entire cost or 2 percent of the entire cost. But if there is a bad zip the entire pant fails. Because of the bad zip the company loses it is phase value. So, here what does happened? There is a problem.

So, this is a quality problem or a products quality problem whatever you say. So, here if we do not make a proper choice either in design, or in choosing material, then we will have a design failure very fast right. So, the common design problems include loosening parts which I told you a cycle example rattling. The vibration cost today we talk about smart cars smooth running cars, then parts not aligned properly. Tightened parts, missing parts, labor intensive assembly etcetera.

Labor intensive assembly is also a major problem today what we say? Is we say, that the assembly is now a part of manufacturing which has been already there, but assembly is one of the part of manufacturing generally what happens if you have more number of parts. Then your assembly has to be made very, very accurate. And if you have more number of parts and you use a labour intensive assembly, then there is a chance that there might be some failures because of bad assembly. So, this is what we say these are some of the design problems. So, all these things can be thought of during the design itself and that is why you see today you get zip lock bags.

So, zip lock bags are replacing zips a zip lock bags are coming this concept is now taken to textile also. They are trying to make a complete zip lock for your shirt. So, there is a completely different design. And then they look at the problems. And sort it out the product quality depends on how the product is designed. So, if you see basically design

is the important terminology. Design leads a bad design leads to bad material a bad material may lead to a wrong process. So, these are the pushing need which leads for design for manufacturing.

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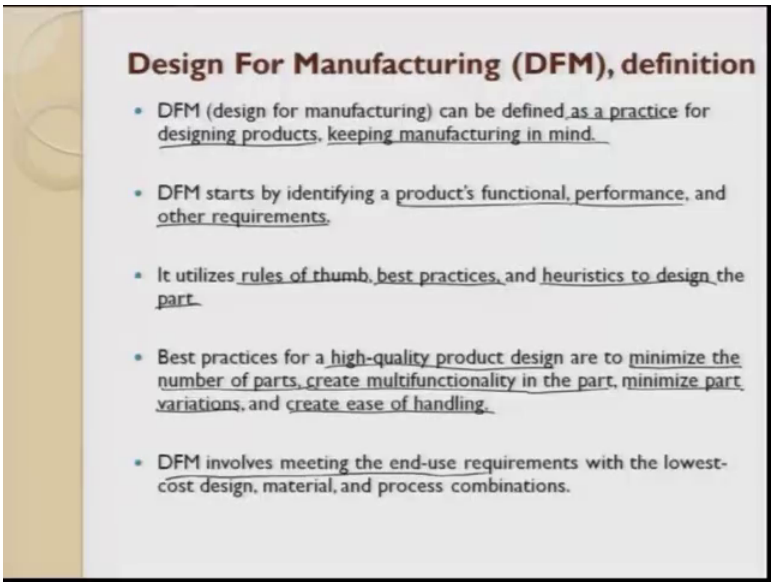

In design for manufacturing the definition if you want to see, can be defined as a practice for designing products keeping manufacturing in mind. Because just doing a design without keeping a manufacturing, then it does not lead anywhere. Whenever you design you should keep that in mind that this can be convertable into a product.

So, if you want to convert into a product we always have to manufacture the product. So, design for manufacturing is defined as a practice for designing products keeping manufacturing in mind. The DFM starts by identifying a product function performance and other requirements; that means, to say first part of DFM starts by doing a customer need analysis. It utilizes rule of thumb best practice and heuristics to design the part.

So, rule of thumb is they say if you if a mistake is identified at a very early stage. The cost of the product is reduced. If it is mistake is found at the second stage or the third stage. The rule of thumb stays it at every stage there is a multiplication factor of ten. So, the cost increases by 10 folds. Best practices are to have a proper identification either in the product, or in the fixture. And you make sure the parts are getting oriented in only one direction such that you make a proper assembly.

So, these are best practices and heuristics to design the part. The best practices of a high quality product design are to minimize the number of parts. Create monk multifunctionality parts minimize part variation and create ease of handling. So, this is some of the best practices which are followed in all the automobile industry, aerospace industry, electronic industry they follow this; so reducing the number of parts. As I told you if the parts numbers of parts are reduced then the assembly time reduces. Moment the number of part reduces the number of defects each part when you produce follows a binomial distribution.

So, within the binomial distribution if you have one side lower one part is having at the lower extreme end the other part is having at the higher extreme end. So, when you try to assemble these things it will try to lead to some defects. In order to avoid what we do is we try to reduce the number of parts. How do you reduce the number of parts? And how do you still achieve it when you reduce the number of parts basically what do you do is, you try to integrate every small, small parts function in one large part.

So that means, to say a large part or a big part will be made to do multi functional. So, you are trying to create a multi functionality in the part. So, one part is now expected to do multiple operations, for example, it can rotate and it can also give you a timer offset. For example, today earlier days we used to have a long camshaft, for injecting of the diesel. But later what happened this long as the as the part says the diesel pump size is got reduced, the lengthy camshaft has been now changed into a disc camshaft. So, here it can rotate and it can also at regular intervals of a time it has cam on a rotating disc which does injecting of the fuel. So, here the disc which was earl which was long a camshaft which was long is now reduced into small, and this small is try is expected to do multiple of functionality.

So, creating multi functionality in the part, and then minimizing a part variation. So, if you go this is very interesting many a times when we visit to pizza corner or some food chain industry they say that we have 27 products or 30 products or 40 products. But if you go and look into their manufacturing process route, you can see the starting material will be 2 base or 3 bases only. Then on each base they will try to have 4 number of different additions. Then on this 4 they will have 3 different variations of on top additions. So now, what does happened the variety has got expanded, but if you look at the base they had minimum part variation only. For example, they will have only 3

diameters diameter of 25 diameter of 50 diameter of 100. So, whatever you say your starting base in a pizza will be only these 3. From there they try to add one level of topping 2 level of topping 3 level of topping and each topping level will have 3, 3, 4, 4 variations.

Finally, you have multiple, but the starting is always the same. And each variation I said in each topping level you can have 3 or 4 different variations. If you take multiple combinations they produce lot of parts. And the other example is in automobile industry many a times if you see all through the throughout the engine they will use only m 6 screws. Or they will use only riveted bolts or something bolts and nuts. So, this is minimizing the variations such that the assembly can be done. And the when you try to minimize the variation then the other thing which comes is easy to handle. So, create ease to handling is so, moment you have lesser variation then handling you can try to automated. Once you try to automate it then human involvement is reduced and it can be the cost can go down the quality can be enhanced. DFM involves meeting the end user requirement with the lowest cost design material and process combination.

So, as I told earlier no customer wants to liberally give money. So, for every penny he gives he would like to have a quality product. So, the DFM involvement meeting the end user requirement with the lowest cost design. And material if process combinations are the text important thing which is part of DFM.

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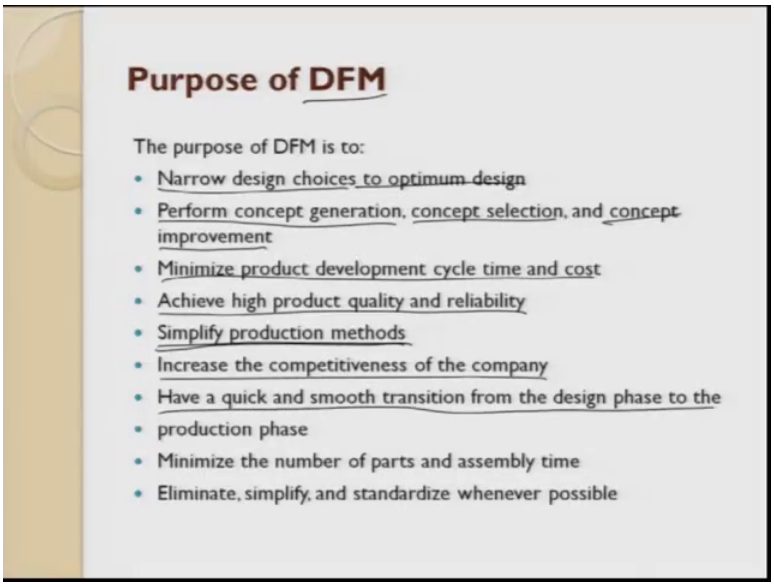

The purpose of DFM is to narrow a design choice to optimum design choice, is to narrow design choices to optimum design choices. Narrowing of design is always important because of choices is very important, because if you give a wide variety of choices we will not be able to solve the customer requirement problem. So, it is always good to narrow design choice and within the design choice you can always look for optimum design. So, narrow design choices to optimum design. So, narrowing does not mean that you have got the optimum design. Optimum design is always done to reduce the cost, or to reduce the material involved, to have maximum reliability.

So, all these things are taken from the optimum design. The performance concept generation concept selection and concept improvement are part of DFM. So, concept generation always happens at the first stage customer, you meet the customer ask them what they want come back sit with your design team manufacturing team, and then materials team sit together try to generate multiple concepts. And when you try to develop this multiple concepts and then what you do is you try to do benchmarking of these multiple development concepts, and try to have 4 or 5 different choices.

And then you try to choose the best amongst these concepts, and then you try to pick one and then try to tweak little bit such that you get a higher customer satisfaction. So, the concept which is selected can be improved. So, minimum product design less this is the very, very important concept, we try to reduce the product development cycle time. So, this is otherwise called as product life cycle management is done and the product cycle time new product coming into the market cycle time is reduced. Purpose of DFM is to achieve high quality and reliability product. I have already explained, so ill move on to the next one. Simplify the production method.

So, today what has happened when I always take I enjoy giving an example of this food chain. See in food chain like pizza CCD all these things what is happening is they have followed DFM in a very exhaustive manner. And since we go to those shops we should now look at these shops, and then see how do they manufacture and have a highest level of customer satisfaction. So, if you go to this pizza corner or CCD and all, you see that there will be lot of operators who run the shop will be part time employees. So that means to say they have very stipulated time for their work, and they come there after their studies or something. So, these people should cannot be given lot of information and cannot be told, please follow all these instructions, and do these, these assembly of

parts in these, these, these sequence and then try to give it to the customer.

So, then naturally they will try to have mistakes. So, what they have done is all these shops they have tried to standardize their production method. And these production methods what they do is they try to have an automation system or something like that. So, that has a timer, and these timers are fixed. So, all you have to do is you want the product a just put all the raw materials inside it put the timer allow it to pass set the temperature. And then you get what is it and temperature also they do not declare it as they will be giving freedom to the cust for the operator to change they always set level one level 2 level 3. So, all you have to do is set it at level 2, then set this time and wait for 2 minutes or 3 minutes what comes out is a best product. So, what they have done is they have simplified the production method, and DFM helps to do this.

So, increases the competitiveness of the company. So, whenever life cycle time product life cycle time goes down. So, you have new, new versions after product coming into the market. And when you release new, new versions you are into a competitive business. Earlier the market was always consider to happen within zones of the world. Today it has been earth has become a global village, and any product can be sold in any country right. So, the competitiveness has gone very high.

So, in order to keep in that phase you follow DFM, or DFM is followed to have this. Have a quick smooth transition from the design phase to the production phase. So that means, to say earlier point product life cycle goes down because they follow concurrent engineering, concurrent engineering. So, I have already told you minimize the number of parts, which can be to assembly time eliminate simplify and standardize this is what I said simplify.

So, simplifying the production product means, I am trying to standardize the parts. Moment I standardize the parts, then what happens is I tried to get the parts what I want in bulk. So, my transcript my shipment cost and all goes down. So, the design flows of a DFM.

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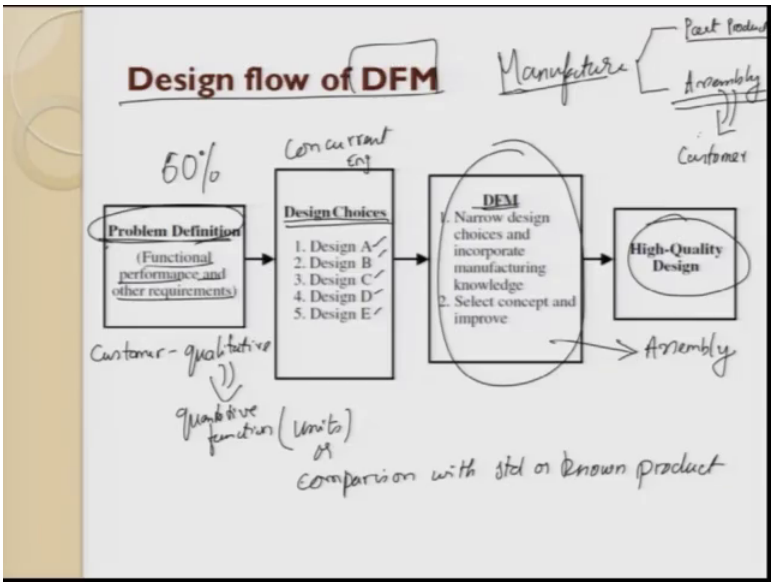

Design flow of a DFM starts from problem definition or problem identification. Many a times I find it very difficult to identify exactly what a customer wants. And if you do not identify the problem statement clearly, and you do not write the objective statement clearly, you it is very difficult for you to come up with the optimum design and has a perfect customer satisfaction. A simple example is I said to my wife that I would like to buy a towel, which is you bath towel. So, then she agreed to it. So, the problem statement was to buy a bath towel.

So, then I told my wife I need these, these, these, these parameters, I said it has to be like the length should be this much, the width should be this much, and then I said it has to absorb water very fast. It dry get very fast, then I said it should be soft very fast it should be very soft. Then I said it should also be it should also have a reliability, it should reliability, means it should I said that it should be endurance should be longer I will expect minimum a towel you come for 6 months.

So, I gave all these statements to my wife, and I say please buy a towel, but then I realized that I said the towel has to be as soft as possible. So, this softness is a parameter which is relative. For example, I go have a cup of coffee, and then I say please give me a strong coffee, strong coffee is a relative term. So now, as a customer says he needs a strong coffee alone. But now we have to quantify that strong cont the strong level or the previous example whatever I said, the softness level which is very difficult it has to be

converted into a quantifying term.

And moment I quantify then it becomes easy for my wife or for the person who prepare a coffee to give it to my expectations. That is why many a times what we do is we try to identify a shop and we try to identify a person who pro who manufactures this for example, in terms of coffee or a shop where. So, where we get a towel to our requirements we always go get go into that same shop. So, that he can understand my requirements. Problem definition is really, really tough. And people have to spend a lot of time in identifying the problem. So, here functional purpose and other requirements have to be stated.

So, here the customer will always give only qualitative, but it has to be converted into quantitative function. And then we start converting into a problem statement and then we go right, but the problem statement which I give for my wife. If I would have smartly said, saying that I would like to have a soft touch, like something I compare. Then when my wife goes to that it becomes very easy for her because she has a feel for the product with the feel for this softness of that product which she has it in her mind. So, she can quickly go identify it. So, quantifying it in always in units it is possible. Or what we do is we try to give a comparison with a known product, comparison with the standard or a known product. So, in your objective statement if you can give every parameter their function on performance and other requirements, then the first job is done properly problem definition is done properly.

Next once the problem definition is done almost 60 percent of the problem is solved. Then what do we do we try to look at various design choices, various design choices various design choices are you develop A B C D E, with each things with variation, all addressing the functional and of functional performance and the requirements placed in the problem statement you try to give multiple choice. So, this choice will be done as part of concurrent engineering. And moment you have all these choices it is like a multiple choice question. So, you have 4 choices you choose among the 4 is very easy.

So, what have you done? You have narrowed all the parameters towards 5. Narrowed all your requirements and you have developed 5 designs. Now what you do is from the chosen one you try to pick whatever you want and start applying the DFM. So, narrowed design choice and incorporate manufacturing knowledge select concepts and improve.

So, this is what is done after you generate multiple choices. So, moment you follow DFM, you have a very high quality design. Today DFM is followed to avoid to avoid assembly. And if you look at it today companies are becoming more and more smarter. So, in manufacturing we have 2 jobs, in manufacturing we have 2 major jobs. So, one is to part produce, the other one is assembly. Today what does happened is company has started giving the complete product in a part form. And this is today done at customer end; that means, to say for a simple example is you buy a pedestrial fan or a roof ceiling fan.

What we get at the customer end is only different parts and these parts will be brought to the customer end, and it will be assembled to make the end product. Nowadays as part of DFM they also try to say make your DFM very strong give the freedom to customer to assemble, and then fit it at their required place or to the required choice. So, assembly today now is reduced and the other thing is if the assembly is reduced 2 things are reduced one, the defect produced because of assembly problem is now ruled out. Second thing once the part is assembled the volume it occupies is very large. So, in order to avoid that what people do is they try to give us individual parts and it is neatly packed and given to the customer end.

So, it in the customer end on assembly it occupies a big space, when the company ships they ship it at an economical price. So, is it clear problem definition design flow of DFM happens with the problem definition, then it you try to generate several choices then there are lot of tools today available so that you can choose the best one. It is not only an expert can do or an expert system can do today then comes DFM, narrow design choice and incorporate manufacturing knowledge, select concepts and improve. And then finally, you get is a high quality design. So, I have put it in a schematic diagram concept design, and then design for assembly concept design, then you have design for assembly you have design for manufacturability, and then detailed designing. All these things are taken care at the initial stage, initial stage of product life cycle.

So, that we listen to all the experts and then try to develop. And if you look at it these arrows go back and forth, manufacturability and assembly goes back and forth. For example, when you take a computer you when you want to enhance the ram space, or if the processor is gone you want to enhance the processor. So, what we do is we buy a higher end the processor, try to bring it the slots are set in such a manner you can

assemble only in one direction. So, this is nothing but design for assembly.

So, the design flow of DFM with design for assembly which is otherwise called as DFA. So, the conceptual design, design for assembly is also thought of design for manufacture will thought of this both goes in a cyclic manner back and forth and after doing all these iterations then only we start doing a detailed design. So, detailed design is nothing but engineering design. So, where and which we talk about the tolerances the dimensions fit tolerance, all these things are talked about, is it clear?