Design for Quality, Manufacturing and Assembly
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Lecture - 27
Introduction to Design Process

So, welcome back to this session on design for assembly. Earlier part of this course I taught you design for quality, where we discussed concepts basic concepts on statistics, the mean and the standard deviation. How they can be used to quantify robustness which in turn can be used to find quality. We introduced Taguchi's concept of quality and how you can use a design of experiment called orthogonal array to design your experimental study, get the responses; how to account for the variation in the responses and hence enable a robust design.

So, the agenda for today is we will start talking about design for assembly. This is going to be the outline of the next couple of lectures. First, I will try to give you a generic overview on what is design for assembly. Why it is required? What it is capable of doing under design for assembly, we will as usual we will talk about why someone needs design for assembly. In that we will talk about part handling because, an assembly means two parts coming together is what an assemblies. So, we will talk about handling those parts.

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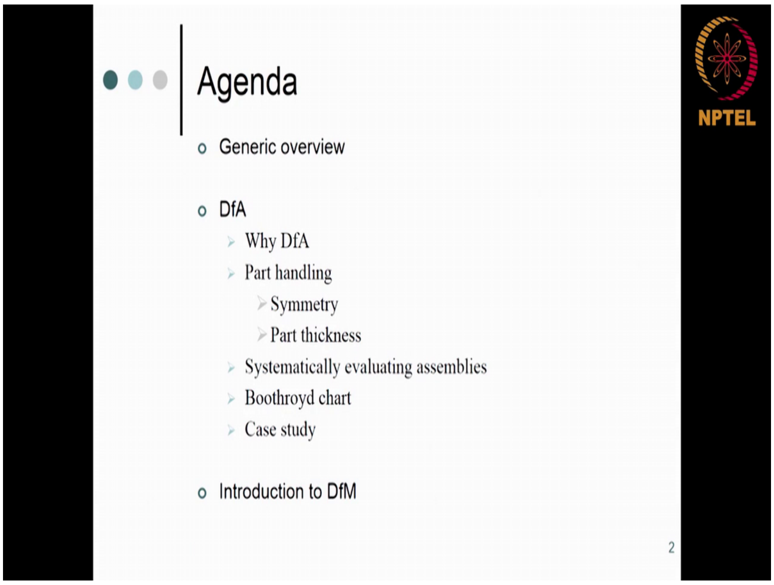

Then how do you systematically evaluate assemblies. There are the couple of techniques; we will talk about one thing call the boat ride which is a very famous approach, boat ride diverse approach. We will also look at a couple of case studies. This is a generic overview on why such an approaches required.

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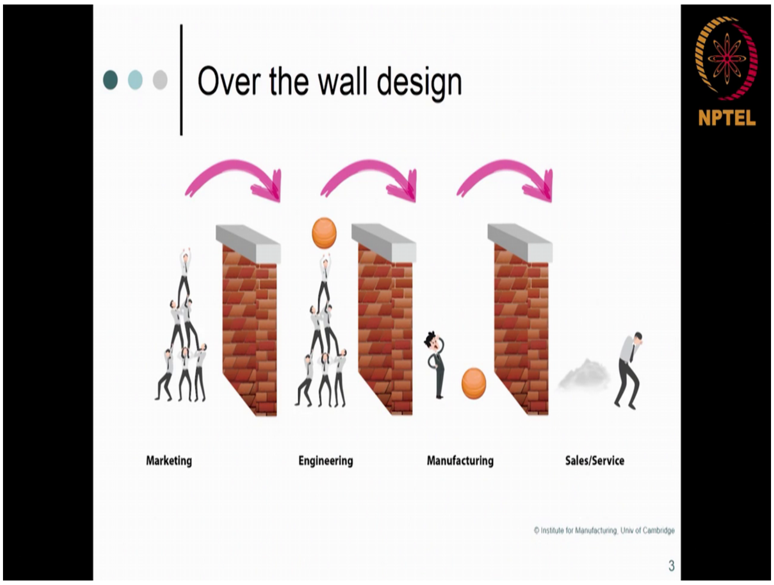

Classically, if you see in the design industry people have practiced something called over the wall design. Today we use the word silos, especially when you talk about the optimization people talk about single discipline optimization. If you take an aircraft they talk about structural optimization. They talk about aerodynamic optimization; aerodynamic is basically fluids structure is basically the structural finite element kind of approaches ok. However, you have to think from a system perspective and that is when multi-disciplinary optimization comes into picture.

So, the word that is used current is call the silos; each one is working in their silos and unless they are going to interact you cannot look at a system level optimization. The same idea is applicable for this slide as well, but predominantly from a process perspective when you are engaged in the process of product design what are the different phases. So, you can start from scratch, concept design, detail design, but this is a little bit more than that; it is not only design it is process product design going to launch it on the market it is going to reach my customers. So, who are all the different people who are involved or what are the different department set are involved.

This is not a comprehensive picture here, but these are 4 major players. For instance the marketing team is something that requires that looks into the need analysis. They look into the market and then, they see they do they conduct a survey, they conduct a study to understand what is the need, where is the gap and they suggest a particular product needs to be developed. It could be an existing product, but what they will look for instance if you look at a car. Someone who is been doing a hatchback and sedan. These marketing guys will look and try to study conduct a survey and understand how much people are expecting a looking forward for an SUV.

Then there is a likely market for an SUV and you need to come up with an SUV. And these are the different configuration or the specification that people might be interested; because, an SUV somewhere in the West is not necessarily going to be successful in a country like India. So, within India where all people might use the SUV and what are the specifications or what should be the characteristics of such an SUV. So, this is what the marketing team does that is the first one that we are talking about ok.

Then the marketing team gives out a concept, says you need to look at a SUV and it give your raw information about what a potential buyer would expect from the new product. Then these potential criteria need to be converted into engineering criteria by the engineers slash designers. So, that is the second one that you are looking at. So, this is basically passing the ball, the ball is nothing with the concept the idea ok. But, what is happening in or rather what happened in earlier days is; there is no interaction between the marketing team and engineering team.

The marketing team just did the study, there were no clarity on under what conditions, who are the set of people, how did they conduct the survey all those things, but the end product was given to the engineers or the designers. And, the designers are supposed to come up or realize that particular idea into a product. Upon that it goes to the manufacturer ok, as you can see here with respect to the designer in could be a beautiful design; very nice optimal design in all the disciplines that you can imagine, very nice design; mathematically very strong design. But probably there is no technique in the universe that can manufacturer such a design.

Today, 3D printing or additive manufacturing or rapid prototyping has opened up lot of avenues, but still it is not clear, what are the failure criteria; that are associated with components that are manufactured out of 3D printing. Though 3D printing has opened up avenues in manufacturing, still there are a lot of limitations with respect to applying it in real life performing parts ok. There is one showpiece you can always do, you can you can make a pistol, you can make an artificial heart valve all those things are fine. But, in a performance perspective in real life performance they have not been able to break through yet.

So, what is happening is when engineer designs he should also keep in mind that the product should be manufacturable. So, as a designer one need to have a perspective, should have an insight on what are the different manufacturing techniques. When you draw something on the computer, when you make 2D or a 3D model you should be at the same the engineer should be able to think through to see how was someone going to come up with this in a manufacturing setup. Should I be doing casting or should I be doing milling? Can this particular hole be drilled? Is it possible with the existing set up?

One is in a very generic sense, is it doable? Number 2 is if you are aligned with a particular company, you need to know; what are the facilities that are available for the company to manufacture. Or, if you going to sub contract it, you should know; what are the limitations in terms of manufacturing of your subcontractor. So, that needs to be taken upfront otherwise, what happens is after your design cycle it goes to the manufacturing and then you figure this cannot be done, it has to come back and you will have to retrace this entire design cycle ok. So, hence it is very important for a designer to appreciate see the engineer need not go and manufacturer ok.

But should have an insight, should know; what are the capabilities in terms of manufacturing, use that knowledge during the design stage. So, is the case with assembly also because, an assembly is one job where this significant amount of cost comes into picture. That is when robotic assembly came into picture, but something that can be manually assembled is necessarily is not possible to be assembled in a robotic assembly line and vice versa ok. Hence so, once the engineering module or the engineering department or the design department gives their final gives their final design the manufacturer looks at it.

And, hopefully it is manufacturable otherwise you will have to come back and retrace your design cycle then finally, it goes to the sales and service. So, the deal is interestingly the sales and service guy ok, does not or at least in the past did not have any interaction with the engineers and the marketing ok. It only comes directly from the manufacturer and their perspective of looking at the product could be entirely different ok. So, maybe there is some very interesting engineering innovation in that particular product that might not that the sales guy might not know ok.

So, hence it is very important for each of these silos or each of these departments to interact with each other. Off-late there are even some ISO criteria that requires in a conceptual stage like a materials person, a manufacturer, a designer all of them need to operate at the same location ok. You cannot say that we have Skype and internet these days so, it does not matter where you sit. They have specifically given this condition that they should sit personally, physically at the same location at the concept level design. So, before we go into the details a little bit off, the design for assembly just to motivate here is an example.

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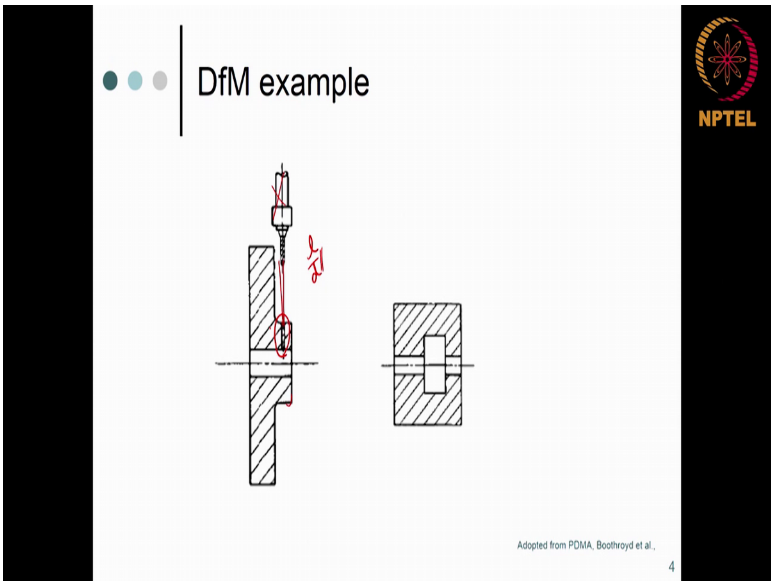

Just look at this particular design ok. Currently it is a design; it is a drawing on paper. The drawing is perfectly fine. Please observe my words that drawing is perfectly fine, then why would I show? There is some issue beyond the drawing per say, if you do this on computer I will say good work good job , but there is some limitation in being able to use this. What is that?

Student: Drilling component.

Sorry.

Student: Drill.

The drill ye, what is the problem?

Student: Drill the hole.

Sorry drill the hole, which hole? This hole.

Student: Do not, the best support.

The perpendicular, the vertical hole; what is the problem?

Student: Bring a bring drill try to drilling.

Hm.

Student: So, this dia set up all this the drilling machine will.

Hm.

Student: Stuck in the (Refer Time: 12:18).

So, this guy will hit this one that is what you are saying.

Student: Yes.

That could be a problem, but what if we reduce the drill head. The width of the drill head, let us say it is reducible whose adjust this adjust by casting you can do if you want. It is advisable to have something like this I agree, but this is double. There are a lot of right angle corner set we get to see, let us assume that I can reduce this guy to this pic. So, that it will not hit this then it is fixed there is no issue. So, let us say that even with this head I mean still be able to drill this with the long drill bit correct. So, is there really a problem?

Student: Thickness limitation.

Sorry.

Student: Thickness limitation, material thickness.

Whose thickness?

Student: Material thickness.

This material.

Student: Yes, sir.

You mean this material.

Student: Yes, sir beside the hole

No I just drew it so, that you are able to see. What I meant is it is, what I meant is this drill bit need not be limited there, it can come all the way here; that is what I meant. It can be a longer drill bit, then this particular drill head me not come here. Being there itself you can still drill it. Fine, what he told is right. Number 1, in the current setup there is a problem because this drill head will hit the component corner, the edge it will hit there is the problem. That is one thing, if you try to fix that by using a longer drill bit there is something called an l by d ratio.

So, what you are trying to do is this you are trying to fix it here and in one sense you are trying to fix it there also. So, this might lead to bending and eventually buckling of the drill bit because, the drill is expected to drill actually ok. So, you are applying forces at both ends and it is it tends so; there is an l by d ratio that you need to maintain. There is the minimum ratio that you need to maintain ok, that will be violated if you try to use a very long slender drill bit ok.

So, if you look at this particular design it is perfectly fine from a design perspective, but there is a limitation when you want to manufacturer it; especially, when you want to make this hole by drilling. However, if I did not give you this picture and I showed this only this particular component here, it might still be fine because I can always caste it. I can do a casting and I can make this. So, it does not matter where your hole is, how your hole is. So, this one example whereas, but you need to know what sort of a material it is. Because, all materials are not readily available for casting and what is the cost that is associated.

This is similar example number 2, similarly the drawing is perfectly fine there is nothing wrong with the drawing. But, from an implementation or from a performance perspective there could be a problem. What is that?

Student: (Refer Time: 16:37) It is rod.

Sorry.

Student: The second design it is a rod (Refer Time: 16:41).

It is an engineering drawing question man, what is this?

Student: This is rod.

That is not a rod (Refer Time: 16:48). That is a dashed line in between which says that is an axis.

Student: (Refer Time: 16:51).

This guy right. It is a hole so, hole or cavity hole whatever you would call it. I will say simple question actually. Someone know answer this is very simple, no answers. How can you make this hole? If you were to machine the component, take a block of material you can get this particular hole, the small hole you can get. How can you get this hole? You cannot get it, you need to have a tool to go and make this cutout this material right, cannot do that ok.

Hence, this is the problem with respect to engineering drawing this could be a perfectly fine figure. But, from a manufacturing perspective this particular thing is not manufacturable unless you are going to cluster injection mold this part ok; from a machining perspective this is not. So, this is the limitation. So, let us say that you work for a company which has predominantly machining apparatus, then this particular design is not possible.

Let us say this is an important component that connects to your engine and if you want to change this design, the shaft that goes into the engine changes which means the performance of the engine could change, the efficiency or the engine could change. So, you are in a deep chaos. So, it is very important for the designer to appreciate. Even today you cannot just say oh there is 3D printing and it will print, that is not true. So, whether you are going to mass manufacture or you are going to build legacy products, if you going to build only 10 of them fine you can do a thing. But, 1 day you are going to make 100,000 stuffs, then at least as of today 3D printing is not the way to go. It still not adopted for mass manufacturing, it might be in the future but currently not.

So, it is very important for a designer meaning like you do not need to go to the lathe, you need to go to the workshop and play the drill and play with the lathes to do the, to realize the components. But you should have an idea on, what are the limitations? What are the advantages of certain methods over the others and how a particular design can be realize to a real life product. So, these are a couple of examples from the manufacturing perspective.

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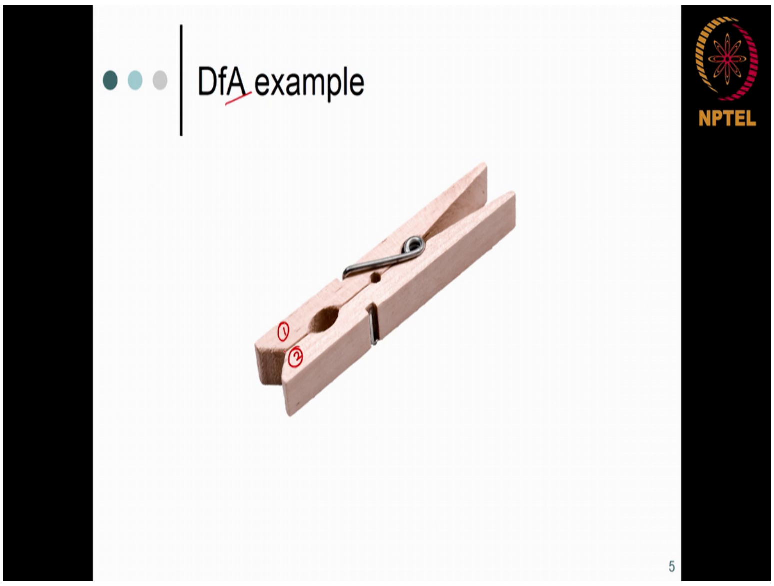

But, I guess for the design for assembly example simple example that are usually used in my class. You know what this is, right? What is this?

Student: (Refer Time: 20:25).

It is a cloth line or a club. So, there is something nice about this design from the a assembly perspective, what is that?

Student: (Refer Time: 20:41).

Sorry.

Student: (Refer Time: 20:43).

You mean to say if this is component 1 and this is component 2, they are symmetric ok. So, what is the problem? I mean sorry, what is the advantage of being symmetric? You are right, they both are symmetric so.

Student: (Refer Time: 20:58) symmetric we are in that hole (Refer Time: 21:08).

Hm.

Student: (Refer Time: 21:11) symmetric you need (Refer Time: 21:14).

Oh, you mean to say this particular hole.

Student: Yes.

Ok.

Student: So, its special (Refer Time: 21:27) many kind of (Refer Time: 21:28).

Ok.

Student: (Refer Time: 21:35).

Fine, but what is I mean what is your point with respect to assembly because, I said specifically with respect to assembly. I am I am not I am not asking for an opinion on the product itself. I am saying there is something good or bad about this product from an assembly perspective. There could always be a better clip in the market or glossy clip in the market; we are not talking about that. We are taking a clip and most of those clips if not all would share that property; so, that since I am very sure.

Student: (Refer Time: 22:18).

That is a nice point that I have not thought about ye. So, they do not have ye so, that easens the assembly process let us say, but there is also thing that what Imran pointed out. This is specific type of a spring that you need do ok, but it is a specific product so, you have a specific kind of a spring that (Refer Time: 22:46) both the.

Student: Manually assumption.

Maybe in this case yes, but need not be in all the clips that we carried on ok. So, coming back to the one is one of the answers that he pointed out 1 and 2 ok, these two are symmetric. So, if you imagine like what he said in a manual assembly or does not matter in a robotic also; before that let me ask you a question like. Let us say that there is a clip manufacturer, what is your assumption that how many how many such clips they would make on a particular day?

Student: 1 million.

Sorry.

Student: 1 million.

1 million, 1 millions 1 million is too much ha 1000's.

Student: 1000.

Easily it taken depends on the number of employees and all that ok. So, even if you put 1 guy 1 person, let us say women or men does not matter; 1 person would do at least I do not know 400 to 500 clips per day easily, I guess. So, wit that what is happening is if you look at it there are 3 major components in this clips. The 1 and 2 that I have mentioned and the third-one is just the spring that is all.

So, what is your assembly process in this? Take the left element, take the right element keep them together and put the spring. The process need not be the same maybe, you take the left element you put the spring and then you insert that that is that does not matter. So, there are 3 steps somehow, you will have to handle part 1 and you will have to handle part 2 and you will have to assemble them using a spring that is all. So, the 1 2 3 could be 1 3 2 whichever way does not matter ok, but these are the 3 steps that are involved in right.

Now, in this particular case element 1 and 2 are identical. So, the advantages I do not need to have a separate left side element and the right side element. I can put all of them into a bag and I just take any one of them whatever, comes in my left hand is the left element and whichever comes to my right hand is the right element that is all; it is as simple as it is. So, the way in which this is designed is there was nothing particular ok, like there is no a symmetric in this it is symmetric. So, you can use whichever way you want. Let us say that you have to have a different left alignment and different right element. What could be the limitations?

Student: (Refer Time: 25:27).

You have to manufacture them separately, that is an important part. In this is just a wooden clip, even in a wooden clip it is easier to make 20 such compare to 10 with the different design and the another 10 with the different design ok. In such, a sense or if you are imagining a metal clip ok; that you are going to machine or you are going to bend it and all that. Imagine making 20 clips or 10 with a particular design and 10 with a particular design you require a different kind of a die, you might require a different type of tool. In this the basic needs are the same and you are going to manufacture the same one ok.

Especially in large deigns this will have a huge implication, huge implication fine. And, you can see this in any kind of an application you know like if you take a car for instance ok. It does not matter your for instance your rear view, your side mirrors ok; they all are the same it only matters which side is your the fixture is that is all ok. So, it goes this way or it goes that way that is why your mirror is inside the cabinet. So, the mirror is the same, only the cabinet it is going to differ and many for instance, they have something called the crash cans which tries to protect the occupant from a crash situation ok. It goes like this; like a C and then it is symmetric it is not matter which way you do it.

So, here a lot of symmetric many of the designs if you look at it they take advantage of the symmetric. So, that is one particular case that we have discussed here ye. So, while designing you might actually always come up with the design, let us say weight was weight or a particular grip was an important factor in this ok. So, you might have ended up reducing the weight or increase the grip by coming up with an unsymmetric design.

But, if you look at the cost that you are incurred to build the respective dies might actually overshoot the advantage of your grip or the weight reduction. So, it is interest is important for the designer to appreciate that and have these ideas built at the design state that is important not after you build and test it.