Design for Quality, Manufacturing and Assembly

Prof. Palaniappan Ramu
Department of Engineering Design
Indian Institute of Technology, Madras

Lecture-31
Systematic DFA Methodology

So, we saw bunch of guidelines basically, which I use the word best practices for instance, but how do these guidelines help. End of the day, it should help a designer, who is based out of Chennai; it should help a designer, who is designing from Michigan; it should help a designer, who is in Oakland. So, basically across the world, wherever a designer is trying to design something, they should have an insight into manufacturing or assembly, what we have discussed, now is the assembly perspective.

The designer a prairie should have an information on what might happen in the assembly situation. On the in other words, I would rather put it this way, if you have two products two assemblies, assembly 1 and assembly 2, but it is a same product, functional device both of them do the same thing, do the performance in the same time. But, there are two different assemblies; one has three components and one has five components. So, you want to evaluate, which assembly is better. How would you go about quantifying this assembly is one of the important (Refer Time: 01:35) and how would you compare them.

So, we saw certain guideline saying do not do this in an assembly situation or rather do this in an assembly situation, because there are two major activities in an assembly. What are those?

Student: Handling and insertion.

Handling and insertion. So, we saw some set of guidelines for handling, some set of guidelines for insertion, but how do we convert this into a quantifiable sense, how do we formulise this learning. Right now, it is only a set of guidelines, but we need to formalize this, so that anyone can use it let us say over a software or as a legacy document, someone should be able to use it.

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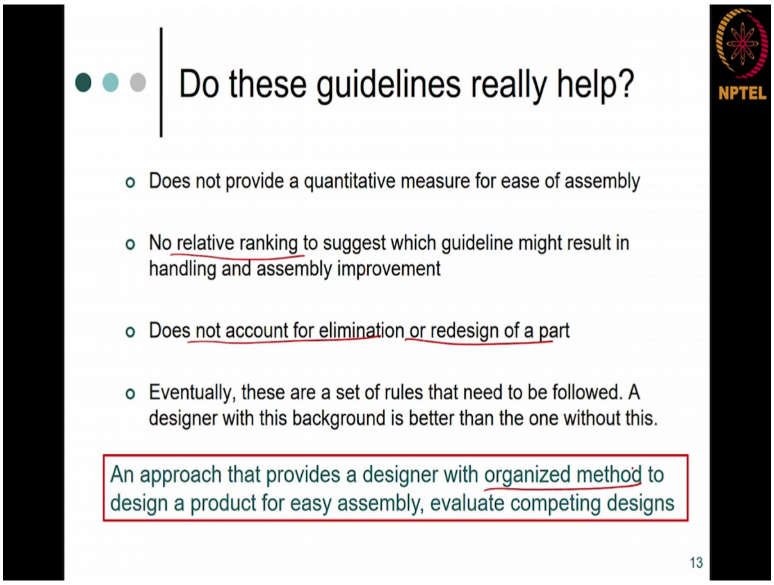

That is what this slide basically tells you, currently the guidelines they do not account for the elimination or redesign of a part, it just says ok, it is good or bad, but sometime that is not sufficient for us. How much is it bad, what else should I do to fix this error that could be one thing. And there is no relative ranking at this point, you are not able to compare two different assemblies assembly, assembly a and assembly b in a quantifiable sense, subjectively you might be able to do that is what I guess we would have said somewhere. I want to be able to quantify it not qualitatively say this is better, quantitatively someone should be able to say the assembly b was better than assembly a. So, what are the factors that goes into quantifying the fitness of an assembly is something that we are.

So, these are just a set of rules or guidelines that needs to be followed a designer with this information is any day better than a designer without this information, but how can you generalize this understanding, how can you formulise this learning is what DFMA tool is all about, yeah. So, the approach that provides a designer with an organised method. So, this is step one, this step two, this is step three, and then you get a matrix for the assembly, and then you will be able to compare these two assemblies. So, it is an organised method to design a product for easy assembly, and be able to evaluate it and compare it.

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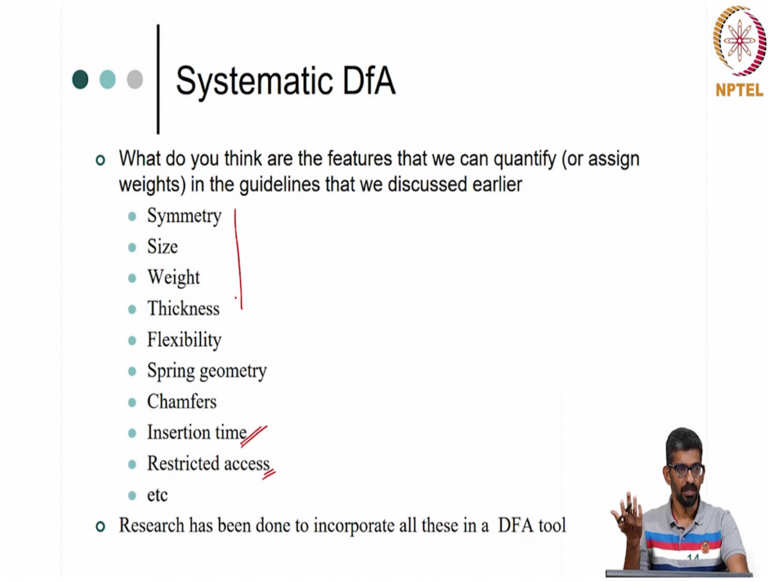

So, what do systematic design for assembly mean or what are the different steps in that. What do you think out of the few guidelines that we discussed or quantifiable from an assembly prospect. Number of parts we did not discuss as assembly criteria yet, but yes, the answer is yes, but we have not discussed that as a guideline, because you can never given guideline for number of parts, you can give a guideline for the relative number of parts, but not for the number of parts per say.

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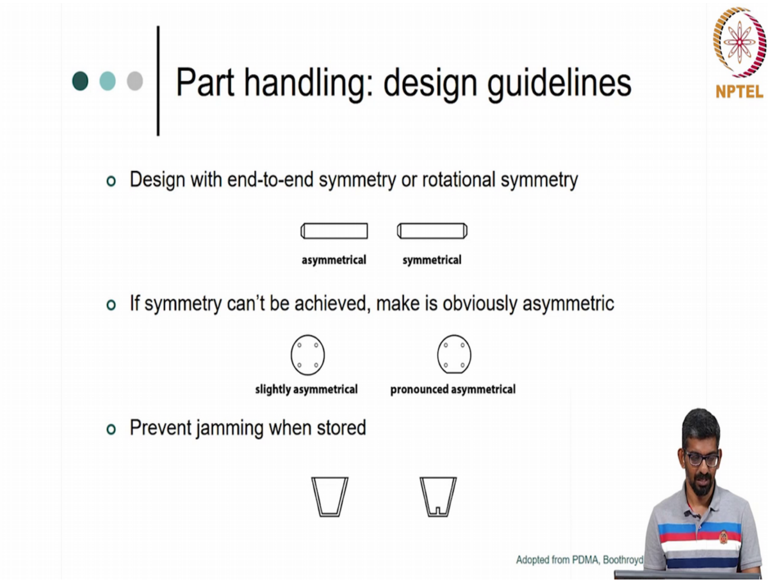

So, from a part handling perspective, these are the things that we discussed yesterday, symmetric, non-symmetric. If you cannot make it, symmetric make it pronounced extra asymmetric; and prevent jamming.

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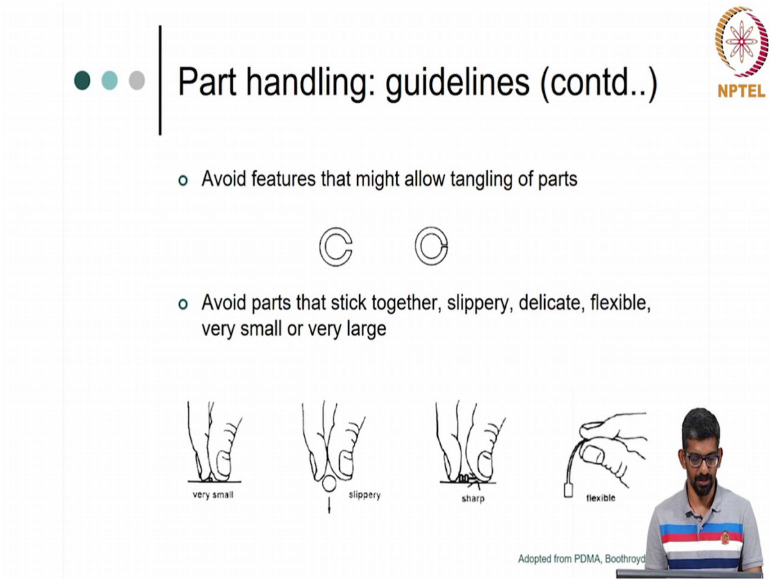

Tangling avoid tangling; avoid very small designs, flexible designs, sharp designs, slippery designs.

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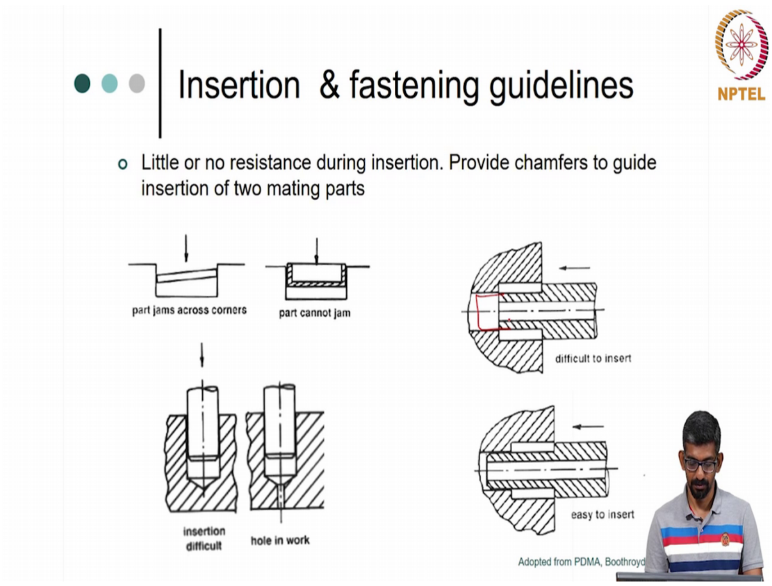

In an insertion sense, make sure that you have access to the part that you are inserting until the insertion is over. And hole in the work sometimes air might get locked that is all one that I am talking about. Difficult to insert, because this particular length matches this length that is not what you want, you might want this a little longer, then you are fine.

So, now with this, can you tell me what of these guidelines that we spoke about can be quantified or this is just a few guidelines, but you can also think of something else, number of parts could be one. But, something that we discussed yesterday itself in the pen you decompose the activity of assembly into two; one is handling, and the other one is insertion. Well practically the size, the symmetry, how symmetric it is, how anti-symmetric it is, how big it is, how small it is, what size of a shape it is and all that ok.

So, basically symmetry can be quantified or need to be quantified size, the weight, what is the thickness. Basically weight includes thickness also. What is the level of flexibility, what is the geometry or that chamfers, insertion time, this was something that was discussed yesterday, restricted access; sometimes it is very difficult ok. From a serviceability perspective, this becomes very important.

Imagine that someone put a spark plug you know where you need to go underneath, the charges of the vehicle and you need a special tool to remove it, half of the automobile market will suffer ok. So, restricted access, and there are a lot of other things as well ok. So, these are some guidelines. For instance, symmetry, size, weight, these are the stuff that we discussed in one sense, because I in the example, when I explained I told you that the pen example, the cap I was able to handle, but not always you are going to have something a part that you can handle using a single hand. Sometimes, you might want two hands sometimes you need a crane.

For instance, if you have seen these metro train construction ok, so basically it is an assembly, they do not build it ok, they have all these concrete stuff, only the pillars are built per say, and the your entire track is put together ok. So, if you see the Kathipara junction underneath that they had stored all those stuff, they are also made out of concrete anyway, and then they bring and just assemble them ok.

But, the one on the front side will be marked front or there is some numbering scheme that they have, because they are would not they are not the same ok, because the next one needs to have the holder for the next block to come and Faison into it. Whereas, on the other side, it will have a hole, so that it can go and plug with self into the preceding block ok.

So, imagine that the crane lifts it all the way up in the wrong direction, and then realises that it should actually be in the other way round, you understand what I am saying ok. So, in order so there will be some kind of a marking on that saying this is a front side, and this is a back side, it goes this way. If you see many times in your cell phones, it is very clearly mentioned which way your SIM card goes, correct. Your SIM card has a small what you call like cut ok, it is not a perfect edge right. In one edge, it has a cut, basically it is a directional notation, it says this is the way.

So, you can see many of the your the road sign boards, they are beyond language, there are that is why they are signboards ok. Someone from Germany comes, and can also ride I mean riding in Chennai traffic is a different story, but anyone coming from Germany also will understand the signboard. Similarly, when you go from here to anywhere in the world, you will understand the signboard from the sign, it will not you might not understand what is written at the bottom ok, the language might be different, so that is the basic idea, it should be universal, the idea that you come up should be universal ok. So, the reason that I gave the example of the metro train was it is large, but even there it is a same story; assembly has two things, one is handling the part, and the other one is inserting it with the other stuff to attain or to accomplish your assembly.

So, people over the past have analysed each of these and much more elements that are part of handling and assembly, and they have done some detail study, which has gone into building this DFA tool ok. Today it is a commercial software, but there are also a not open source, but for research purpose, some tools are available for free.

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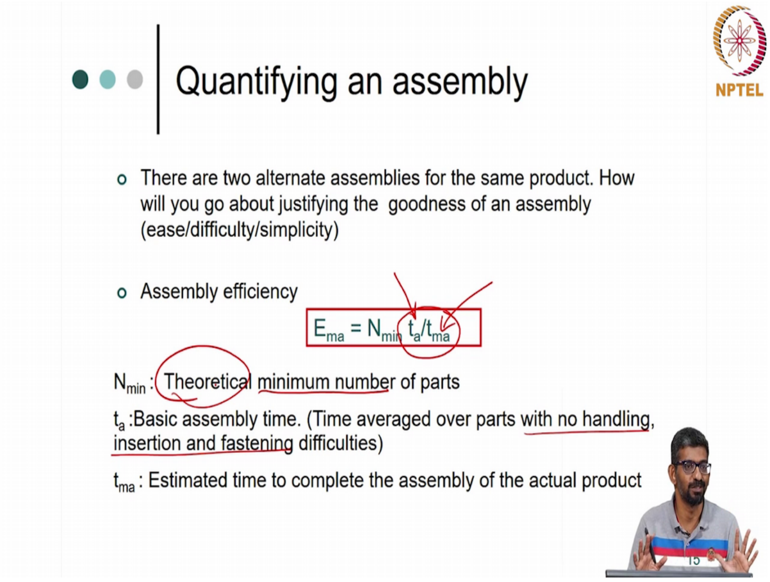

So, how do you quantify an assembly This multiple times I have told in my lecturers right now. So, let us assume that you have two alternate assemblies for the same product, and how will you go about justifying one assembly is better than the other assembly from different perspective, from the ease in which the assembly can happen or the ease in which it can be serviced or what are the difficulties. If you want to if you do not want someone to disassemble it in an easy manner ok, how will you what are the difficulty levels, which one is more difficult. So, it is not always easy, it could also be difficult.

For instance, if any of you use MAC desktop ok, you will see in the monitor, which is also integrated with the CPU. You will never see (Refer Time: 10:54). It is nice it is the aesthetic finish is awesome, the seats and] single integrated setup, it and there is no additional CPU, there are no wires is only one wire that connects the monitor to the your plug point, but it looks great.

But, once there is a problem, you cannot just open and just like that there are no force screws that you can open, you actually need a vacuum puller that you will pull on it, and then you will have to pull it. So, you need a skilled labour to do that. So, there might be a reason why MAC did that, probably that is one of the most nice fastening scheme ok, but from a removal perspective, it is difficult may be there is a reason for that also. So, it is always not ease, but also the difficulty could be as tough.

Then the assembly efficiency is something that you want to look at. So, efficiency is not a new word for you right. So, we have seen efficiency in different senses, it is basically what people say is output by input that is you give this much, and this is the output right. So, there is something called ideal ok, what would be your ideal efficiency one. So, basically I give this much input, I get the same output, but that is not possible. So, efficiency is usually less than 1 ok, there is always some loss that is what your law of momentum says right or law of conservation says.

In a similar sense what do you think could be an assembly efficiency, you can always say this assembly has an efficiency of 0.6, but what could be because assembly means it is a ratio, output by input, output over input right. So, in an assembly prospective what could be an efficiency?

Student: So, it will be giving some base to all of the components (Refer Time: 13:07) and based on these ways they could be given some marks, so.

Ok.

Student: So, it is a kind of like calculating the CGPA.

Correct, but that is just 1. In CGPA, I know the maximum you get I am just giving you an example is 10 then I say you get 8. So, the CGPA calculation is only the top the numerator, the denominator I know is 10, so then it is a ratio, you are right. The maximum CGPA that you can get is 100 percent, which is 1 primarily. In a similar fashion, what is what could be the numerator, what could be the denominator? Numerator is one sense what you are saying is right.

Student: If the marks are given are from 1 to 5. So, maybe we can take 5 as highest possible mark and use that as the denominator.

So, basically that is the ideal ok, but that is ok, it is similar in idea. But, then what we figure out is, let us not worry about this n min yet we will come back to that the one that I am talking about is this guy. So, it is going to be in terms of time.

What it says is there is a ratio t a divided by t m a; t m a is the estimated time to complete the actual assembly or the actual product that you have right now that is your denominator. And the numerator is this is kind of the ideal stuff, it is a basic assembly time, which says the time averaged over the number of parts that you are looking at without any handling or insertion difficulty, it does not account for that it just says there is a bolt and there is a nut, and then you are going to tighten it.

Someone asked so what kind of a nut it is, what kind of a bolt it is and then what are the size? Someone has made a study, and then they have given a mean value, and then they have given an deviation around it in terms of time. So, sitting on a computer, you can say if my product has two components two parts, and it is assembled using four screws without having the product feel without physically feeling the product, on computer you can tell how long will it take for this assembly to be done that is what this says.

So, what it says is this is the physical time of the actual product that you have, this is the ideal time that comes from a theoretical perspective. So, always it is likely that this number is less, because it does not account for handling insertion and fastening ok, and this guy is likely to be more ok, so that is why the ratio is always less than 1 in that sense. And n min means the theoretical minimum number of parts ok. So, we will see meaning, you have to just multiply this with the theoretical minimum number of parts.

We will see what a theoretical minimum number of parts is, because this is something that you hit upon you said that the number of parts can that be a gauge. In one sense that is what they are coming up with, they are saying at under what conditions will you say that you need to have two parts to do this, cannot you join these two parts, cannot we merge these two parts. Under certain conditions, they say you need to have two parts.

So, those that is what is called the minimum theoretical minimum number of parts. See it for a practical purposes, you might say that I do not have a vendor, who will who can merge these two designs and give me ok, these two components into a new design and give me, but there are plenty of vendors, who can give me part a and part b.

Now, I have a design, which merges part a and part b, but I do not have a vendor or the vendor is expensive, but cost wise you know it is much easier for me to make a and b separately. For practical reasons, you might have any reason for that, but that is why it is called the theoretical minimum number of parts. So, it is ideal. Theoretically, on paper this is what it is, you could have plenty of reasons from a practical perspective. So, we will see what that theoretical minimum number of part means.

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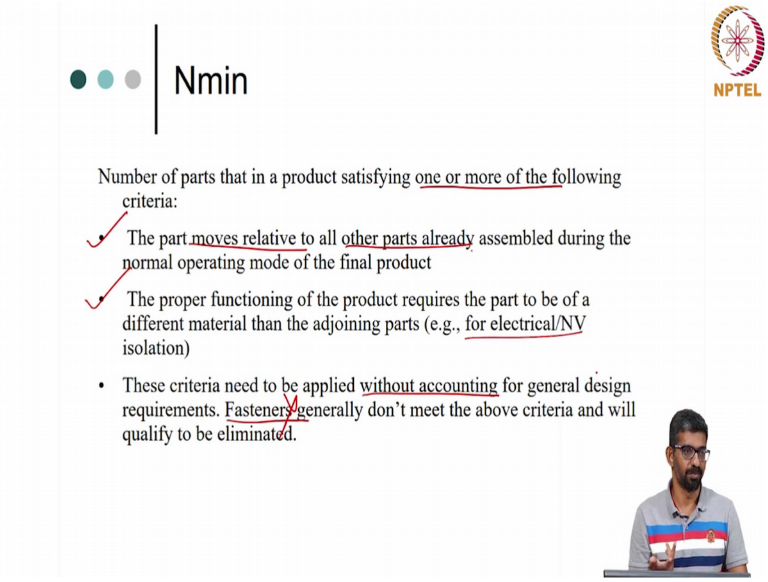

It says satisfying one or more of the following criteria ok. So, what the first one is the part moves relative to all other parts that are already assembled ok, it moves relative to all other parts already assembled, then it needs to be a separate part, correct. If a part is going to move relative to another part, then I cannot merge it.

But, the question is if you have multiple parts and this guy is rotating only with respect to one part ok, you might still be able to integrate it with another part. But, then what happens that entire part the integrated part rotates with this, and you will have to figure out whether it is fine that is why it says, it moves relative to all other parts that are already assembled, then for sure it is a it should be a separate part, the part that is rotating with a with respect to all other parts have to be a rotating part.

I have to be a separate part otherwise there is scope for integration. So, you can always say oh I can integrated, but then there is something that comes in between I will have to integrate part number 1 and part number 3, whereas part number 2 is coming in between, and it is very difficult too. Yes, there is difficulty, but theoretically, it need not be a separate part ok. However, one part is moving with respect to all the parts, then obviously it needs to be a separate part, so that is bullet one.

The bullet two is the proper functioning of the product requires the product to be of a different material, this is something that we if we spoke about yesterday. You take any strength of materials based software like finite element software in and stuff like that, they all talk only about the performance, they never spoke about you are giving me two different material models, is it possible to merge them, that is not a rule or that is not within the scope of finite element.

Finite element just ask for the property of the material and it will make sure that the loads that you apply, you know and give the stresses are the response, I said you can see whether the material has failed or not. It will never say can you assemble, is it possible to merge these two guys, it is possible to tighten these two material different materials, you know two different components made out of two different materials.

So, what this says is the proper functioning of that product requires a part to be of different material than the adjoining material. So, let us say for instance, one example that is cited is for electrical reasons, I might want to you know have it in a different material ok, either it should be conducting or non-conducting material, it should be of a different material[norse/noise] noise vibration isolation.

In order to do that, I need to have a rubber material, so that it damps ok. Ideally, you might want to you know it can be continuation of a I do not know like a steel material, but in order to isolate the noise and vibration, I put a rubber material ok. So, then it has to be made out of a different material obviously, then it can be a different part.

The third one is these criteria need to be applied without accounting for general design requirements. Fasteners generally do not meet the above criteria and will qualify to be eliminated ok. See for instance, when you look at it in the ideal assembly case, fasteners will not be counted. It will say, they do not need to be two different parts, I can always well them ok. Hence fasteners will not play a role. However, in reality, you have four screws, each of them will take half a minute, 2 minutes is there for 1 assembly. If you are making 100,000 assembly per day, it is 200,000 minutes count ok. But, that in the ideal case, it will not be accounted for that is all.

And these criteria that is what I said these criteria need to be applied without accounting for general design consideration, you cannot say oh there is a manufacturing issue, hence I am doing it, no. You will have to look at assembly as a standalone assembly, and make these comments ok, you cannot say that is why it has to be on a software per say, you cannot apply your legacy thought on it, and you cannot say this is not possible; it does not matter.

From an assembly perspective, unless this part is moving with respect to all other parts, it need not be a separate part that is all ok. So, this is what is the theoretical minimum number of parts. You can apply these criteria and you can find out how many different parts are is a must, you add them up and that will be your theoretical minimum number of parts.