Manufacturing of Composites
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Lecture - 07
Continued.
Design for Manufacturing

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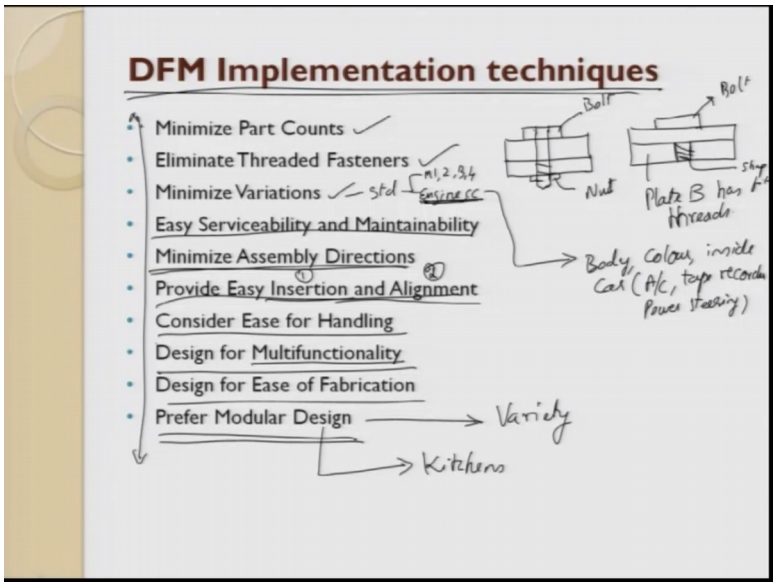

So, what are the different implementation techniques minimize the part counts that is very important as much as possible we try to remove the parts and we try to remove the part means we try to integrate these parts of the function of these parts into another part. That means, to say we are making another parts slightly complex. And then we try to make slightly complex we also make sure the proper manufacturing process is chosen such that in those processes high quality output comes. Next is as much as possible I said eliminate thread fastening that is what I gave you an example of a bicycle eliminate as much as possible thread fastening. So, how can you do it suppose you have 2 plates and then you have to assemble these 2 plates.

So, we use the nut end and this is a bolt end right bolt head bolt right. So, we use these 2 and assemble this today is replaced by one you can of course, do welding the other thing is what people have started doing is they have started using this, so the thread is done on the plate B; plate B has threads and this is a bolt. Now, what I have done I have reduced

one fastener and still I am able to get and if I do it on the plate b the possibility of this bolt coming out of the assembly is very less. So, I am trying to eliminate as much as thread fastening are possible or I can make directly something like a snap fit snap fit can be done I remove threads right elimination of part variations. So, this is why we try to have standards and we try to have m 1, m 2, m 3, m 4 whatever it is then engine also if you see engine there will be a engine cc will be almost the same, but the covering and the comfort inside a car will be different.

So, you can have thousand cc engines you can have multiple variety of looking of lucrative things or multiple things. So, engine assembly will be the same engine will be same and you will have body color of the car the inside of the car; that means, to say the ac the tape recorder the power steering all these things can be changed. So, here what happened they will have; but the engine will be the same. So, they will try to reduce minimum variation they will try to introduce mini variation very minimum to get maximum customer choice then it should have a concept called as e c serviceability and maintenance for example, 30 40 years back people gave lot of importance for aesthetic a sense. And then what happened in a in machine assembly or in a car assembly all the fasteners will be done at the bottom of the product.

So, the biggest problem is when something happens accessing those problems the bottom edge for removing becomes a big problem. So, nowadays what you see is they are trying to have snap fits. So, that you can easily lock it and then unlock it very easily or press one side you lock remove it out side. So, do a service do whatever it is then come back. The next important thing is assembly direction see what happens is if you that when you take a product it has a top end and a bottom end you can have assemblies done in both directions, but when you have an assembly in both directions the biggest problem is you have to finish all the top side. And then you have to topple you have to make the part upside down and then you start doing the assembly many a times when you have a very small cycle time doing multiple direction is always difficult.

What people generally do is they use gravity as their advantage and take only one side assembly and fix all multiple parts and when the parts are fitted properly the bottom jo the bottom side is used only for joining or world only for applying paste this I am taking an example of a p c b. So, you should have assembly directions has minimum as possible. in car assembly what happens they always try to have left side assembly right

side assembly bottom assembly will be done in the first shot it iself then they will have only 2 direction assemblies by the it the car moves in a conveyor. The operator also moves along with a conveyor and he does minimum number of assemblies and get a maximum output. So, provide ease insertion and alignment.

Whenever you try to in a automated factory we always use gravity as a major advantage when part is spread through a hopper and it is allowed to come to the required place of assembly it is moved and in such a fashion such that when the part comes out of the hopper it gets inserted aligned and inserted. So, alignment is first align or first is insert and then you will have align first is you try to do it and then you also try to have align both easily. Then ease for handling. Is very important then design for multi functionality say for example, today products are not expected to do only one customer satisfaction or one function for example, this is a pen where and which in one side I start writing the on the bottom side I use it for erasing.

So, a single pencil has become writing facility as well as erasing facility. A single product is made multi functional then ease for fabrication and prefer modular design. So, this modularity is coming up in a big way such that they give a variety. You can see today modularity is followed even in kitchens. Depending upon your choice you can choose whichever tray you want, whatever covering you want, whatever color you want, all these things are part of modular assembly. All these things all these techniques gets get implemented if DFM is implemented or if I say I am following DFM then; that means, to say I am following almost all of this points which I have discussed here.

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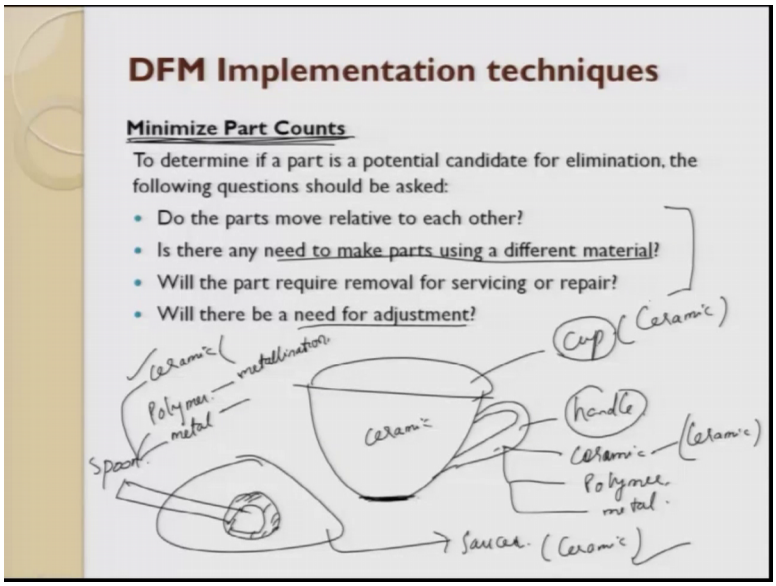

How do I minimize the part count I will not be able to cover all these points, but I will pick some few and then I will try to cover how do I minimize the number of parts. First thing is you should ask a question to determine if a part is potential candidate for elimination the following questions to be answered. How do you do? Suppose you take simple example I take I take a cup, a handle, a plate and a spoon this is spoon, this is a saucer, this is a cup, this is a handle, a simple assembly. So, what do I take this complete assembly this is a cup and saucer with the spoons this spoon is used for steering sugar and as well as it is also used for mm trying to dissipate heat and uniform distribution of heat can be done with the spoon. I am taking this assembly and I wanted to reduce this assembly. First thing is you have to this handle and the cup can be made of one material.

This can be ceramic, this can be ceramic this sometimes can be made out of polymer or it can also be made out of metal 3 options are there the spoon can be made out of polymer it can be made out of metal it can be made out of ceramic so. Now, what is this assembly I would like to reduce the number of parts? So, what do I do? So, I asked the first question do the part move relative to each other no it does not move is there any need to make part using different material. If you are very aesthetic sense person then we go for a brass or something. But if you look for true functionality then the any part need for different material no the cup can be made out of ceramic, the handle can be made out of ceramic, the spoon can also be made out of ceramic, the saucer also can be made out of ceramic. Now, will the part require the removal for servicing or repairing if you make out

of other material yes and if you make out of ceramic it is not required, but still this has lot of space in the top and bottom.

Servicing of this; that means, to say washing of this does not have any problem will there be a need for adjustment definitely no in this a cup. If at all you want that to have an adjustment you try to keep it in the saucer you wanted to know. What it is we try to give a fixture here around the cup. That what happens with this becomes exactly the bottom flat sits in that flat portion.

So, here you see now I am very clear that I do not have to make the handle different cup different, cup handle will be made out of ceramic, saucer will be made out of ceramic, spoon again if I want I can make out of ceramic glass spoons I can take or if it is heavy we can always go for a polymer or a metal spoon. Polymer today the metallization of polymer has also come. Moment this metallization comes. So, metal can be replaced by a polymer metalized spoon.

By this what have you done is you have tried to reduce the number of parts earlier the handle will be made separately, cup will be made separately, this will be made separately and spoon will be made separately now the cup and the handle are integrated and made it one shot.

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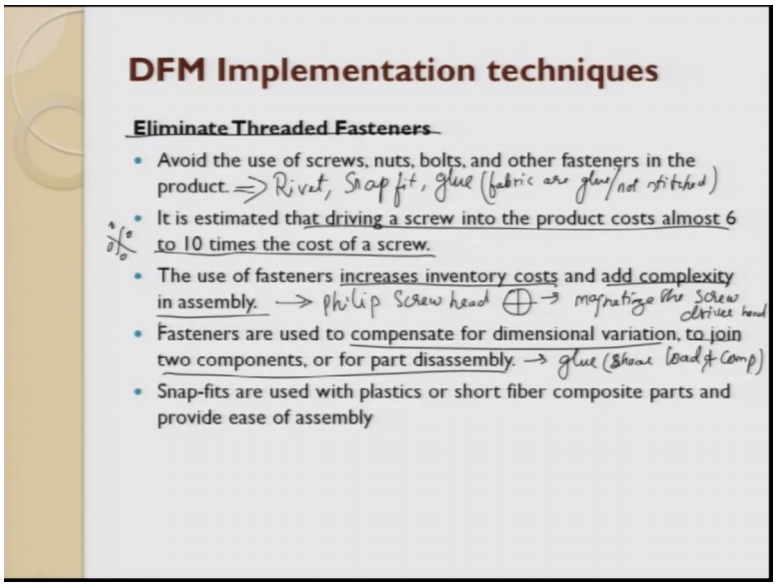

What have you done you have reduced that the number of parts by asking these questions

eliminating threaded fasteners. Avoid using screw bolt nut and other fasteners in the product for example, how do you do it sir you are room and all still what is left with me rivet is left snap fit is left. You can do it. All these things can be thought of. If we use all this things the location snap fit. So, snap right snap is nothing, but a something like a spring fit right. So, revere. Here if you use this it will definitely make sure that it is aligned it is properly held because this snap fit this spring stiffness you see and then choose it properly to eliminate is it is eliminated that driving a screw into a product cost almost 6 to 10 times the cost of the screw.

Because it involves lot of maintenance problem replacement problem please keep this in mind these are very important point though we always prefer using screws, but the cost when the full product is done it is very expensive using of fasteners using of fasteners in oh I did I forgot one more thing you can also use glue today glue I was recently fascinated to see fabrics are now glued they are not stitched not stitched today so big boon for the student community. It is glued. What has happened is the stitches have been replaced by glue and this glue is easily available in the market you do it. So, whenever there is a maintenance problem you quickly attempt to it.

This is one and then the use of fasteners increases inventory cost and also complexity in the assembly because it might look very easy, but every time you have to fastener a screw takes lot of time say for example, including in the pc assemblies personal computers desktop type if your depth which is there inside where you have to put a screw then the assembly becomes a problem that is why we use a Philips screw head it is nothing, but you have something like a plus and we also try to magnetize the screw magnetize the not the screw the screwdriver head but still I even after doing it we have accessing problem.

So, it is always easy to use for fasteners it always increases inventory and complexity the fasteners are used to compensate for dimensional variations to join 2 components or part disassemble I do understand this because you always put a spacer in between a washer in between to take the dimensional variation. But friends you try to make sure that these dimensional variations are not are not there. And if at all you have tried to use glue for fastening, because had has the glue takes care of shear load also shear and compression it can take shear load and compression load it can take snap fit are used with plastics or short fiber composite parts and provide ease for assembly minimizing variation is

another big step you try to standardize as much as possible so that there is not much of part variation the assembly is done proper handling is easy.

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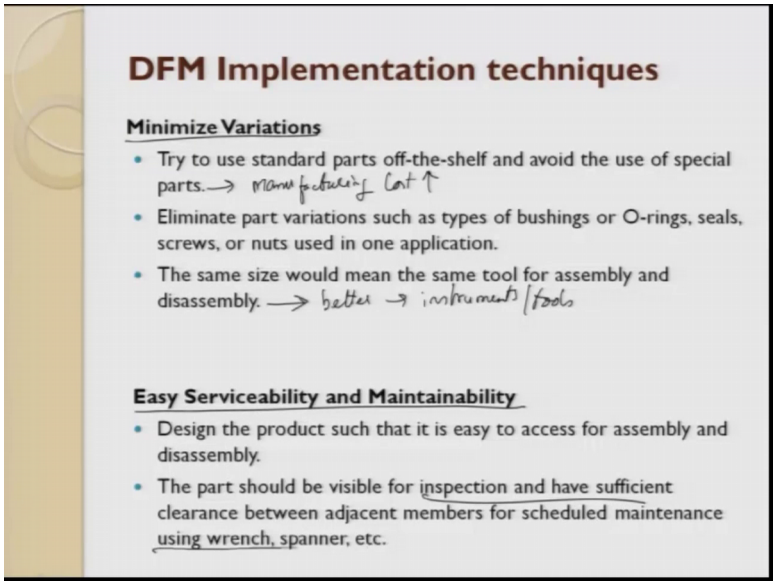

This is what we are saying in this point. Try to standardize off shelf of the shelf and avoid using special parts eliminate the if you have a special part then the manufacturing cost goes high manufacturing cost increases terribly increases right when you are trying to talk about near net shape manufacturing using polymer or polymer matrix composite this is one of the step eliminating part variations such as types of bushes, o rings, screws nuts, all these things are taken care same size a usage is always better. That means, to say you have same instruments or tools for assembly and disassembly. So, this becomes very easy for example, in a in a truck if the front tire nut and bolt at the rear end nut and bolt are different then the driver or the vehicle has to take multiple tool kits for front separately and back separately.

You standardize. So, that your assembly disassembly becomes very fast next ease for serviceability and maintenance I said I discussed people were thinking earlier more of aesthetic, but today they realized that servicing and maintenance are very important designing the product such that ease to it is easy to access the assembly and disassembly. So, the direction which is got assembled the same direction we use it for disassemble. So, this makes easy for inspection and other things which we have already dealt. So, I will not go in depth.

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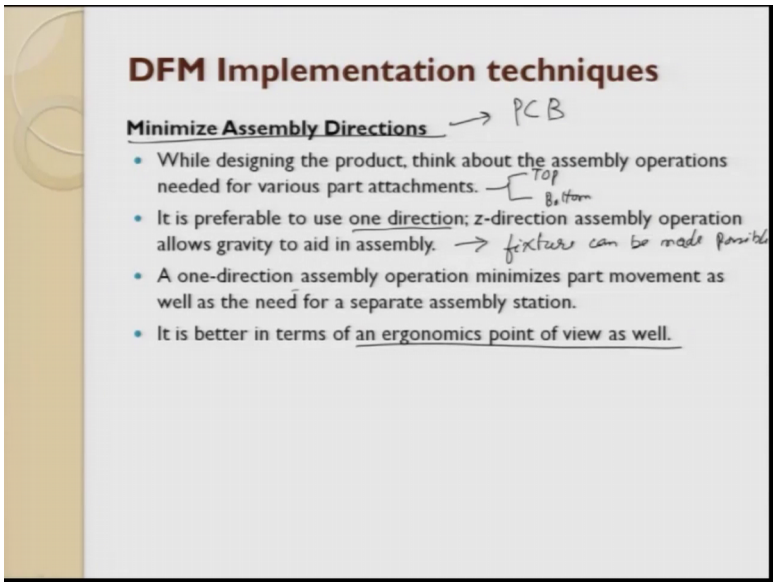

The directions the best example is PCB printed circuit board. While designing a product think about assembling operation needs from various part attachment I told you top and bottom which is top and bottom and also you can have sides and other things it is prefer to have only one direction why because the fixture can be made possible you can also see sir why not vertical.

See if you take it vertical what happens is you are you are almost half against the gravity. There is a possibility that the component can fall down a 1 direction assembly operation minimizes the part movement as well as the need for separate assembly station it is better in terms of an ergonomic point of view to have minimum assembly directions.

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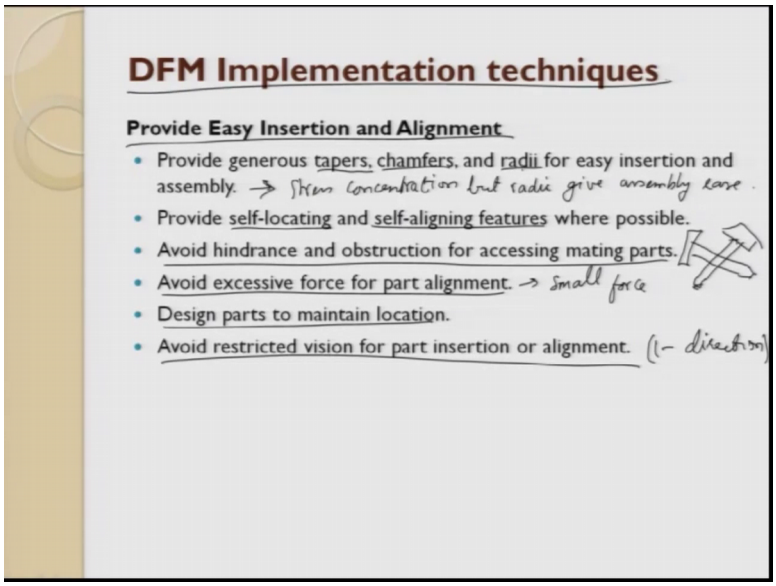

So, part is part easy insertion and alignment. Here I have told you we always try to give up tapers, chamfers or radius to the part in order to have people always talk about stress concentration that is one concentrations that is one as far as the assembly is concerned from the design perspective, but this radiusing gives radii gives assembly ease. This is what is very much talked about. And as far as possible if you can have a self locating or a self aligning feature it is very advantages today there are several products which is called as a floor cleaning robo this floor cleaning robo what it does it tries to clean the clean the place and after cleaning it when it is running out of an energy it goes back to the charging station it locates it itself and then it aligns it itself and then starts getting charged.

Avoid hindrance and obstructions for accessing mating parts. You should; once you have started a single direction in single direction also there should not be any crisscrossing of parts. So, if you have a crisscrossing of parts then what happens is it becomes very difficult to assemble these parts. Then avoid excess force for alignment. It should always be used at the very small force because when you do several assemblies it is you will get fatigue and then this force the parts can get broken.

Generally what people do is they try to have for example, the water bottle the dispersible water bottle cap. What happens is it tries to you lock it and unlock it you will have a multi thread start. So, you when you the polymer is just with minimum effort you break

the seal. So, excessive force if you do maybe it can come to such a way that the part gets mis misaligned or the bottle gets squeezed and other things. Designing parts for maintenance location and avoid restricted vision of part. That means, to say when you try to follow 1 direction then this is proper lighting can be given and this point can be taken care these are the ways where and which DFM implementation techniques happen.

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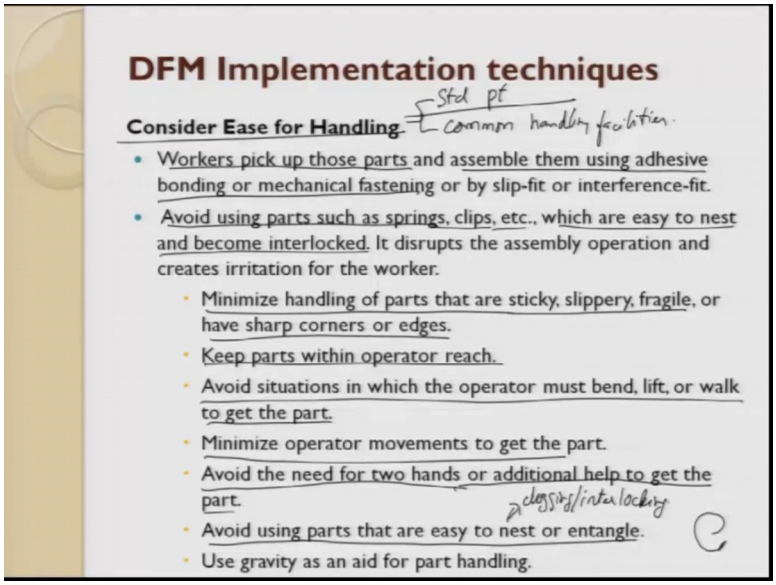

Ease for handling moment you to have a standardized part standardized part. So, then what happens you can always try to have a common handling facility common handling facility.

Initially what they do is in many companies they try to do it manual and slowly once they have they have understood the process very well then they go for automating it. Today PCB desktop assembly is then automated. Initially when it is manually the worker picks those parts and assembles them using adhesive bond or mechanical fasteners to avoid using parts such as springs, clips etcetera what has happened is today the spring whatever function has spring does the spacer also tries to do the same. And you have clips which can do the same which are easy to nest and become interlocking. These things should be avoided. Here minimize handling of parts that are sticky, slippery, fragile, and have sharp edges part of handling keep parts within operator reach right. This is talked about more from the assembly point of view.

That is why you go to many companies you can see the operator in his left hand side he

will have a series of bench in his right hand high he has a series of bin and his eyes are kept in eyes are focusing on the fixture he lays a part goes back picks and again each of these trays will be of different colors. So, each color will signify m 1 screw, m 2, screw m 3, screw m 4 whatever it is. Every time it is made sure that his left hand and rights right hand moves simultaneously brings it and then he assembles it. The sequence of placing is also very important which is also part of DFM avoids situations in which the operator must bend fit. All these things if it is done manual then for automating it becomes very easy. So, minimize operator movement and the second point is repeating avoid the need for 2 hands or additional help to get the parts.

Here I said 2 hands means 2 hands he brings it closed and on top of it you should not ask for a third hand or a fourth hand to place it. So, avoid the need for 2 hands or additional helps to get the parts avoid using parts that are easy that are ease to get nested. So, that is why you see this spring's if you watch very closely the springs the top of the spring and the bottom of the spring will be crimped. That it does not get locked or you try to look at spacers where in which there is always something like a c which has a small spacing like this or they try to avoid. So, the nesting cannot happen nesting is nesting is something like clogging, where and which in clogging or interlocking of parts.

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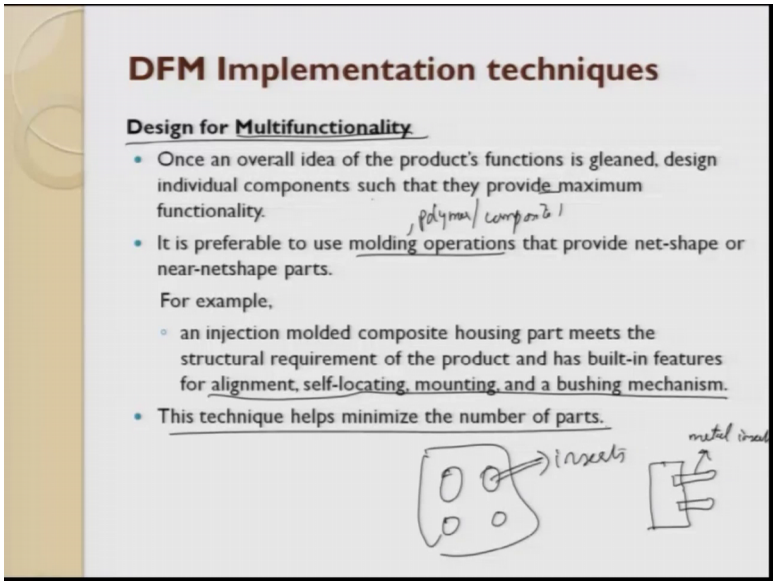

When you design for multi functional I have already told you once and overall idea of the product function is done the design individual components individual components

such that they provide maximum functionality. So, what I am trying to say is first you know the customer requirement try to satisfy all the customer require all the functions of a customer requirement in small parts and small sub assemblies moment you have understood the this all these sub assemblies. Now I can cater to all the needs of customer then I start linking the sub assemblies to make each sub assembly or a part multi functional.

So, it is preferred to use mold operations that is why polymer comes in a big way or composite comes in a big way that avoids the it is preferable to use mold operations that provides net shape or near net shape. So, in a bone mold what happens you will have a mold or a dye and you will have holes and in these holes you try to put inserts for example, the pluck point which is used have has polymer and metal. So, these are metal inserts which are placed inside a mold or a dye, so that you try to get a preferable shape.

Now, what does happened the entire product is made multi functional. So, this and this is integrated. There is no assembly at all for example, an injection molded composite housing part meets the structural requirement of the part and has built in features for alignment self locking, mounting and bushing mechanism. So, this is why the first introductory a lecture I was talking to you about construction of houses at disaster locations.

So, there they would like to ship the roofs the covering of the house the panels all these things will have ease you will have metal inserts will have slots. That they get alignment self locating, mounting and bushing mechanism can be done very easily such that they can quickly go built the house. This technique the multi functionality means I reduce the number of parts.

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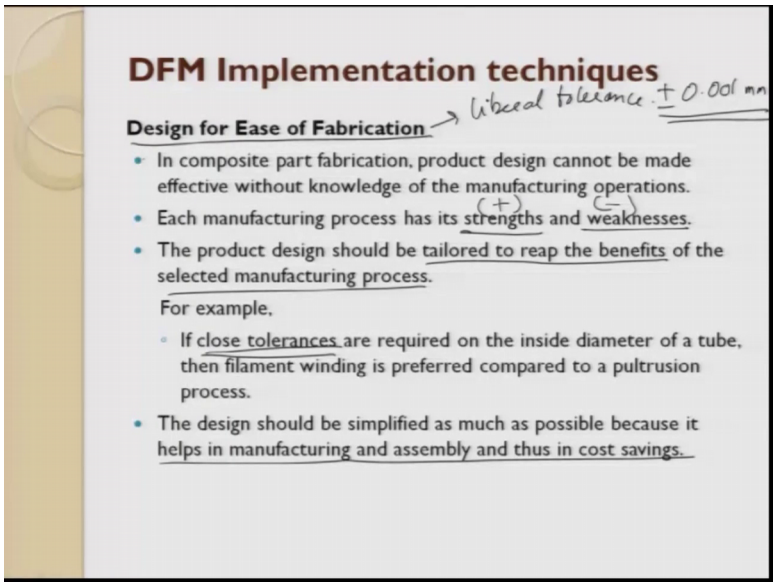

So, design for ease for fabrication is very important because you make a design and you do not even consider the manufacturability ease. What is that manufacturability ease I am talking give liberal tolerance give liberal tolerance. In composite part fabrications the product design cannot be made effective without the knowledge of manufacturing process each manufacturing process has it is strength and weakness.

There is nothing called as universal solution for producing a part it depends on the size back size it depends on the raw material and then you try to produce a part any part which is used for manufacturing has it is strength and weakness it has plus it has minus you have to judge within this two and choose the process right in the design if you make a very tight tolerance and then getting that fabricated gives you very difficult the product should be tailored to reap the benefit of the selected manufacturing process. I am talking about the close tolerance here.

So, close tolerance peoples generally without even understanding they say plus or minus 0.01 millimeter which is very difficult for a manufacturing process to do. And because when you try to insert in a composite at this tolerance level is very difficult to maintain a design should be simplified as much as possible because it helps in manufacturing and assembly and thereby saving it is cost.

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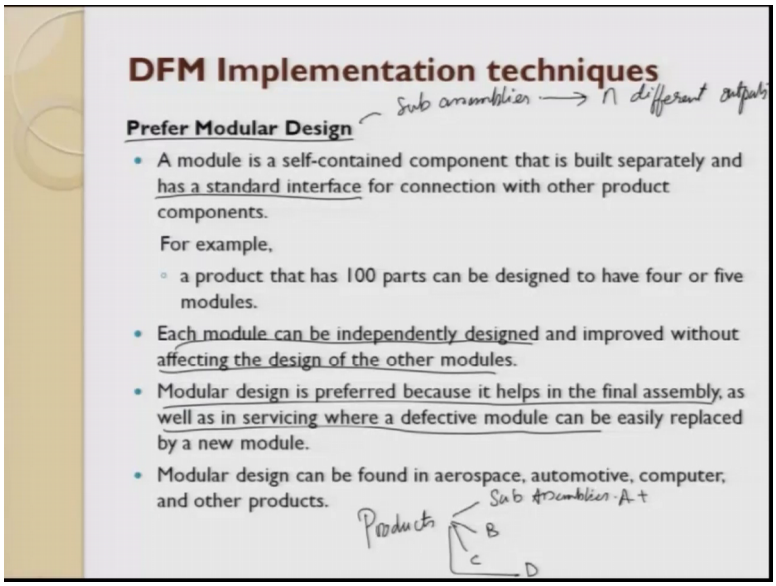

As part of design implementation technique design for ease of manufacturing is also there so, the last step is modularity. So, modularity means I make sub assemblies and these sub assemblies can get into n different outputs or customer products. So, a modular is a self contained component that is built separately. So, what happens means you have products these products will have several sub assemblies right this can be a, b, c and d you can have.

Now, what I do is I combine this or I add features to this and try to produce the required output. The modularity is self contained component that is build separately and has a standard interface. Instead of A I can go put B also. So, here the assembly point will be the same for connecting the other parts each module can be independently designed and improved without affecting the design of the other module for example, in the entire laptop you can change the battery alone.

So, the storage life of the battery can be enhanced such that the performance of the laptop enhances the customer is happy; that means, to say I do not have to frequently charge and second thing if at all my battery conks off I have there is a modularity there I just replace only the broken part whatever it is the modularity design is preferred because it helps in final assembly as well as servicing very easy modularity design is now followed in aerospace, automobile, computer, kitchen, you name at modularity is now pushed very hard there are called as mo modular furniture today for classrooms modular,

modular computer parts made, ok.

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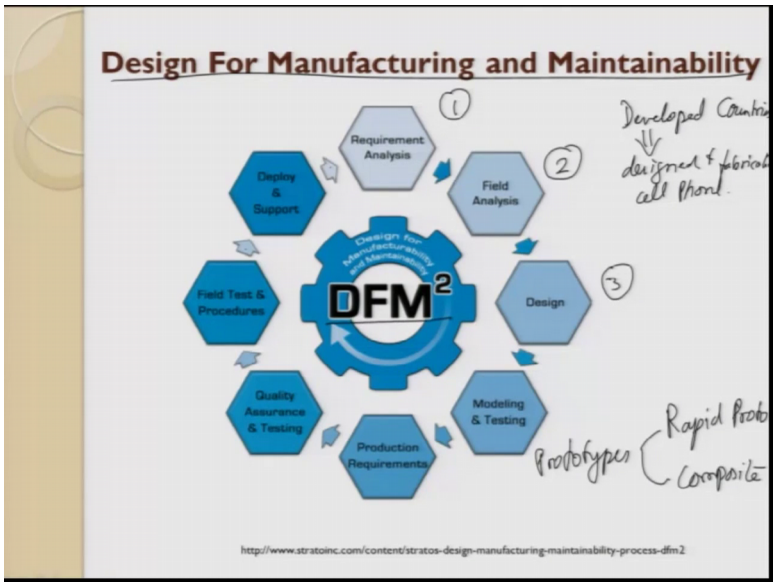

So, if you see that design for manufacturing and man maintainability first start the requirement analysis.

So, after this you are supposed to do a field analysis see I will tell you a simple example when several cell phones were developed it all got developed countries they all designed and even designed and fabricated cell phones, but when they when they when they were doing it when they were doing it they did not do a field analysis the field analysis. For example, in underdeveloped countries the requirements were very good I would like to quote a simple example here the mobile phones initially which came into the market did not have a light integrated factor, because in developed countries there is no power cut. But when these cell phones were sold in underdeveloped countries or third world countries there is a power problem. Integrating light was a big boon. Today the almost all cell phones are integrated with a lights LED light as torch light. This is a third phase design and then you try to make prototypes

Prototypes can be made by rapid prototyping machine rapid prototyping machine or it can be made out of composites a scale down model. And then you test it and then once you have test it with the customer with fields, with strength and other things then we tried to make the production requirement quality assurance and testing field test procedures are led then it is deployed and then this is a cycle which keeps on going.

Now, DFM is otherwise called as DFM square. I would like to complete this lecture.

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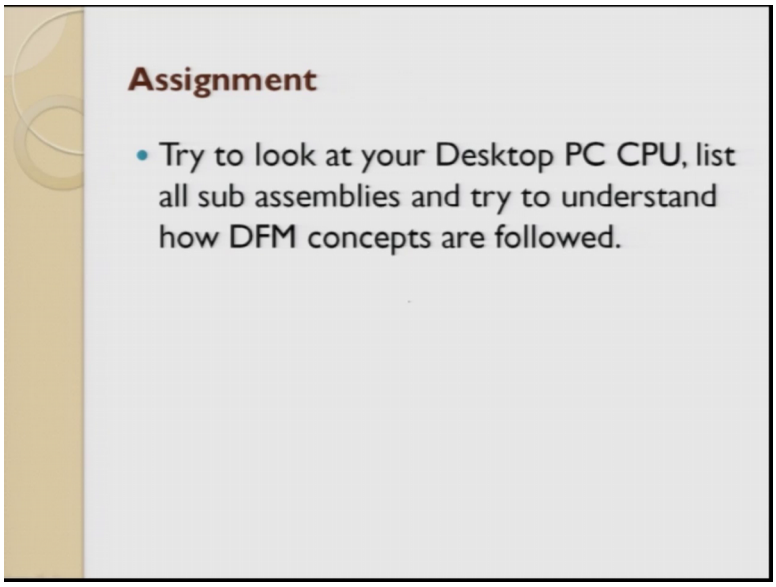

So, in this lecture we saw design for manufacturing when anything is manufactured design for manufacturing has to be followed. I close this lecture with an assignment try to look at any desktop PC CPU alone then list all the sub assemblies which you can and try to see have they followed DFM have, and then if at all they have followed what have they followed and how it will be without following a DFM how it would have been and now how is it. So, then you will be able to appreciate the DFM.

So, from the next lecture on words I will try to move towards manufacturing of polymer matrix composite.

Thank you.