Rapid Manufacturing

Prof. J. Ramkumar
Prof. Dr. Amandeep Singh Oberoi
Department of Mechanical Engineering & Design Program
Department of Mechanical Engineering
Indian Institute of Technology, Kanpur

Lecture - 10
Design for Modularity (Part 4 of 4)

Welcome to the next lecture on Design for Modularity.

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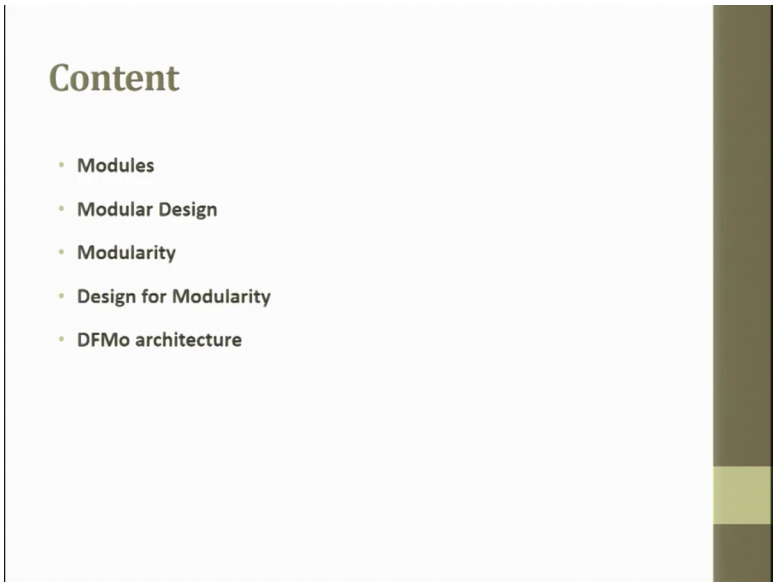

In this lecture we will try to cover what is module or modules? Then modular design, then modularity, design for modularity and design for modularity architecture.

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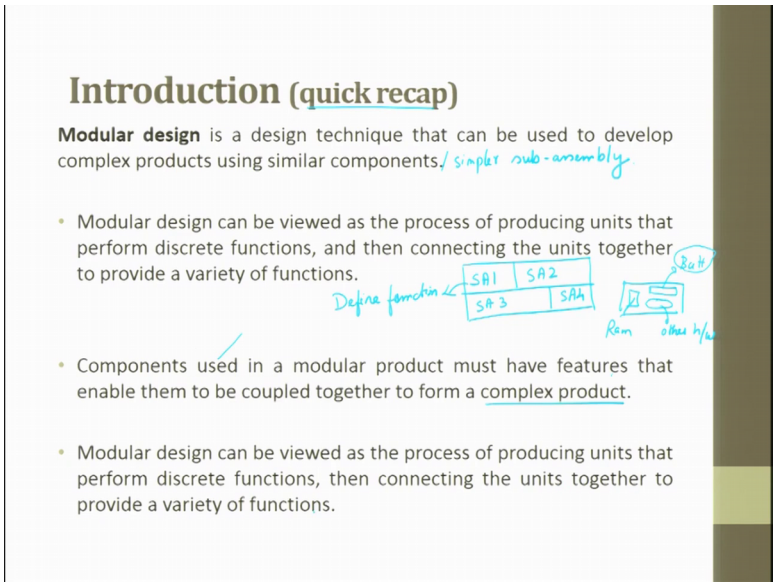

So, modular design a quick recap which we have already seen in the previous lecture. So, modular design is a design technique that can be used to develop complex products using similar components ok or we can also write it as simpler subassembly. It is a design technique that can be used to develop complex products using similar components slash simpler subassembly. Modular design can be viewed as the process of producing units that perform discrete function and then connecting the units together to provide a variety of function.

So, for example, we take a complete product we divide the product into several small subassemblies sub assembly 1 sub assembly 2 assembly 3 and assembly 4. So, each sub assembly has a predefined function. So, what is the advantage? The advantage is going to be if one particular function fails then replace this alone rest of the old parts can be retain for their application. So, performing discrete functions and then connecting the units together to provide a variety of functions.

Components used in the modular products must have features that enable them to be coupled together to form a complex product. So, first a complex product is taken that is why even in concurrent engineering stage a design engineer place a very important role because when the functional prototype is getting developed itself it can be distinguishly be classified this can be one assembly; this can be one assembly; this can be one assembly ok. Those of who are finding it difficult to visualise use you take a laptop in

your laptop, you have a ram separately you have battery separately, you have other hardware separately.

So, if the battery cons of you can replace only the battery. So, this is ram and let us make this as other hardware. So, you can change whatever is required to meet out your requirements. And second thing is you can also upgrade only the particular element what you want and still that laptop can function as is. So, that is what they say modular products must have features that enable them to be coupled together to form a complex product. Modular design can be viewed as a process of producing units that perform discrete functions. Then connecting the units together to provide a variety of functions.

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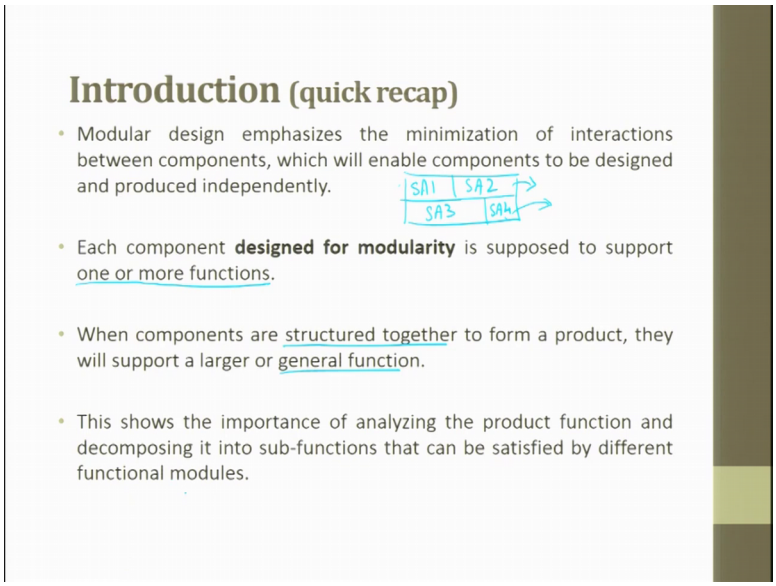

Mod modular design emphasis the minimization of interaction between the components which will enable components to be designed and produced independently. So, I will go back to the same example now what is happening in since it is established as standards SA1 SA2 SA3 and SA4. These are four parts, four different parts where it is discretise based on functional use.

So, now, what is happening is this part alone so you can manufacture it separately and you can put it in a public domain and say if any industry is interested to produce only this part can complete. So, because of this what is happening the performance of this assembly gets enhanced very fast and the cost also slash down. And when they do that

they also makes where which enables components to be designed and produced independently.

Each component design for modularity is supposed to support one or more function ok. It is not only one function you can also choose one or more functions when components are structured together to form a product they will support a large or a general function are structured together general function. This shows the importance of analysing the product function and decomposing it into sub functions that can be satisfied by different functional modules.

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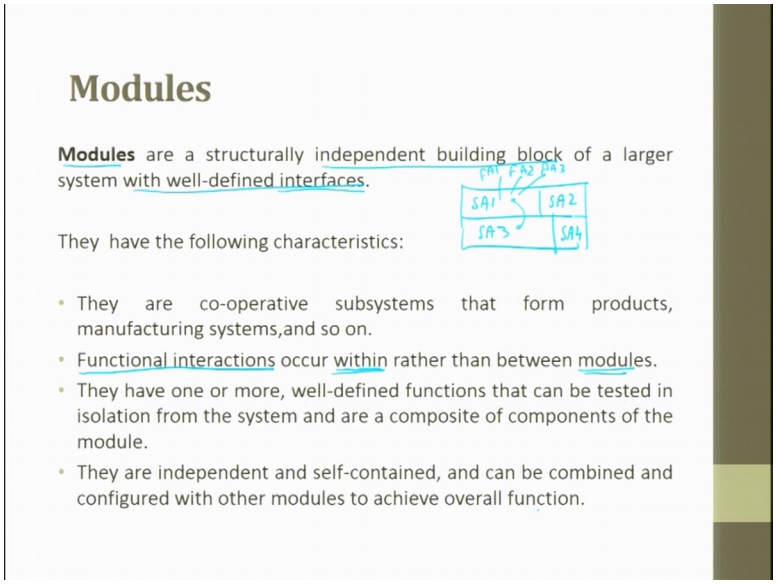

Modules are structurally independent building block for a large system with well defined interfaces. See if I go back to the same example SA1, SA2, SA3 and SA4 you can see here each will have individual functions. And you if you start making individual functions you will again have lot of components.

So, now they are also trying to tell you please integrate with multiple functions as much as possible. The last one is try to have a proper interface; that means, to say when I dismantle and when I fix it up it should not involve very complex things. And whenever I try to interface join it should give me the best output very fast they have the fallowing characteristics module ok.

They are cooperative subsystem that forms product manufacturing system and so on. Functional interactions occurs within rather than between modules functional interaction occurs within very important between modulus rather than between module. So, one function should not be linked here and then here you can have multiple functions FA1, FA2, FA3 whatever it is. But all these things should happen and should get interfaced or integrated inside one subassembly.

They have one or more well defined functions that can be tested in isolation from the system and are a composite of components of the module. That means, to say when I buy from the market SA2 or SA3 when I test it should have his own specification and I should be able to test its specification and the functionality. They are independent and self contained and can be combined and configured with other modules to achieve the overall function.

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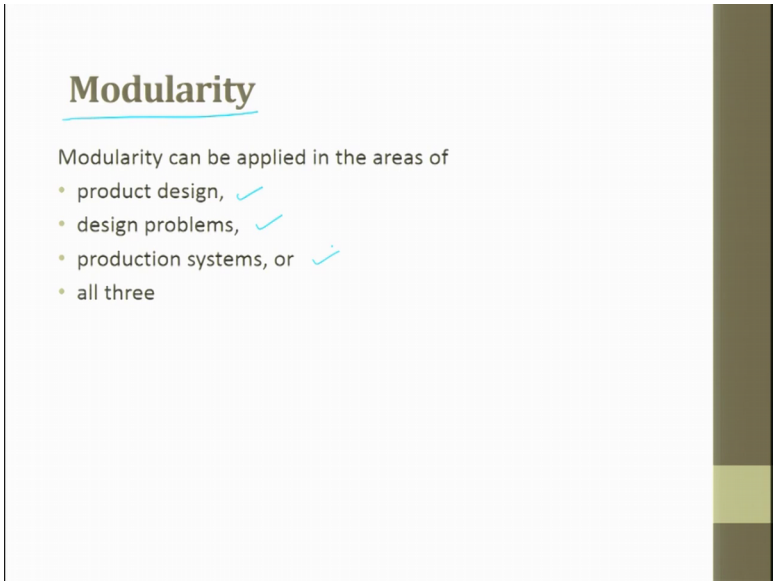

Modularity can be applied in the areas of product design, design problems, production systems or in all the three.

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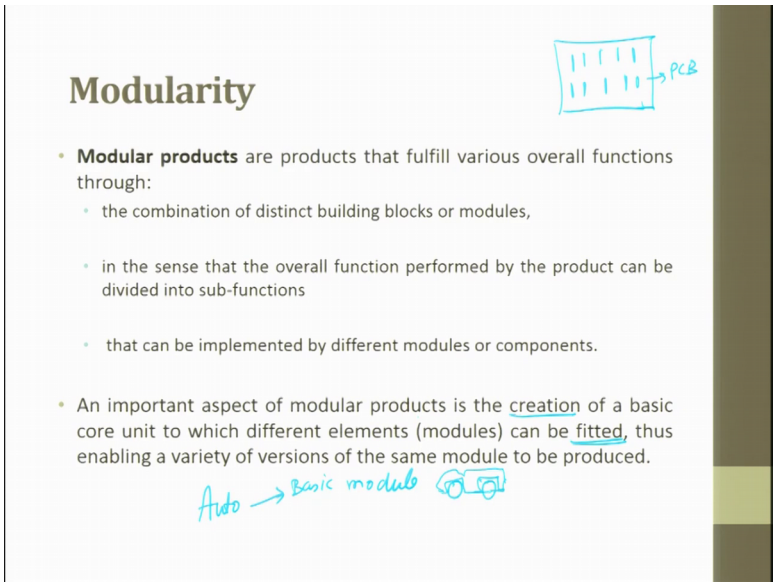

Modular products are products that fulfill various overall functions through the combination of distinct building blocks or modules. In the sense that the overall function performed by the product can be divided into sub functions that can be implemented by different modules or components.

An important aspect of modular product is the creation of a basic core unit to which different elements can be fitted. For example, if you take a PCB you can have transistor, you can have resistor, you can have diode all these things, you can have that is what they say. Modular product is a creation of a basic core unit to which different elements all these things are different elements which can be fastened or which can be attached to a PCB. You get a complete PCB in the market as a separate module and can be fitted.

Thus enabling a variety of versions of the same module to be produced that is why you see the car companies auto companies they always say this is my basic module ok. Basic module will have tyre will have all the other engine everything it will have and then it will say that the rest all things whatever we do will be an add on to it.

For example, AC will be an add on unit, speakers will be an on unit power steering will be an add on unit and power window adjusting will be an add on unit, air bags will be an ad on unit right so this is what it is. So, thus enabling a variety of versions of the same module to be produced. So, the car you can produce in it several higher ends whatever you want.

So, all those car companies auto companies consumer product companies software they follow modular concept smartphone they follow modular concept, apps they follow modular concepts. Software search engines follow modular concepts they divided into two things one is called as it is open to all. So, where and which they try to induce the anxiety amongst the users to use their software. And they say if you want to use a slightly higher version then it becomes paid. So, they are able to clearly distinguish modular and increase the versions.

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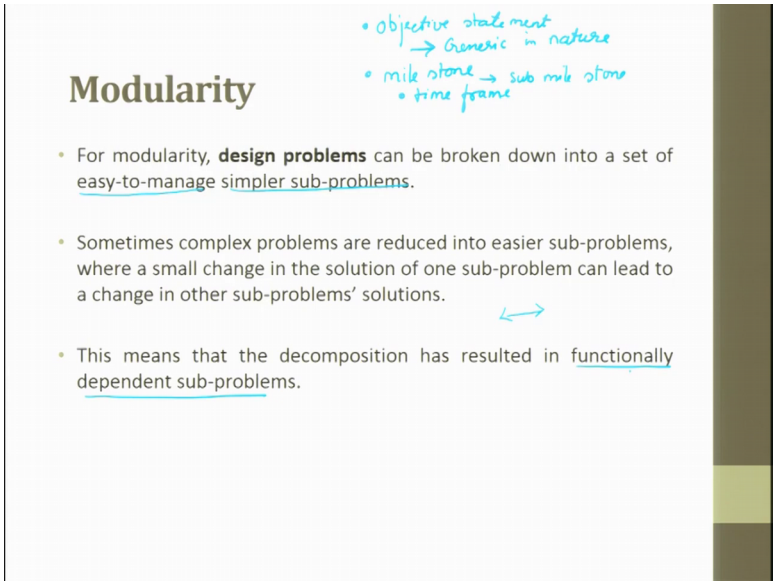

For modularity design problems can be broken into a set of easy to manage simpler sub problems so that is what it is. So, whenever we make a product or when we make a project we write a objective statement. And this objective statement will be generic in nature which captures all the key points or the key features of the project. Next what we do if we divided into several small milestones; several small milestones. And these milestones will be attached with time frame.

So, you can have milestone and then you can have sub milestone. So, what happens is just now you have split the entire project into several small sub milestones along with timeframes so that now you can try to solve the problem very easily. Suppose if you have not met out one you milestone then immediately you know what is the mistake which goes around. So, for modularity it is also follows the same concept it is broken down into a set of easy to manage simpler sub problems.

Sometimes complex problems are reduced into easier sub problems where a small change in the solution of one sub problem can lead to a change in other sub problem solution ok. For example, if I try to change the wheel the tire, the width of the tire then the entire performance of the vehicle goes higher or lower. If I take a flatter tire with a tire which has a larger contact area naturally the mileage is going to go low.

So, that is what it is, sometimes a complex problem can be reduced into easier sub problems. When a small change in the solution of one sub problem can lead to a change in other sub problem solution so be careful. This means that the decomposition has resulted in functionally dependence sub problems. We should note down this point functionally dependent sub problems ok. So, functionally dependent was the car tyre example with respect to engine performance I give.

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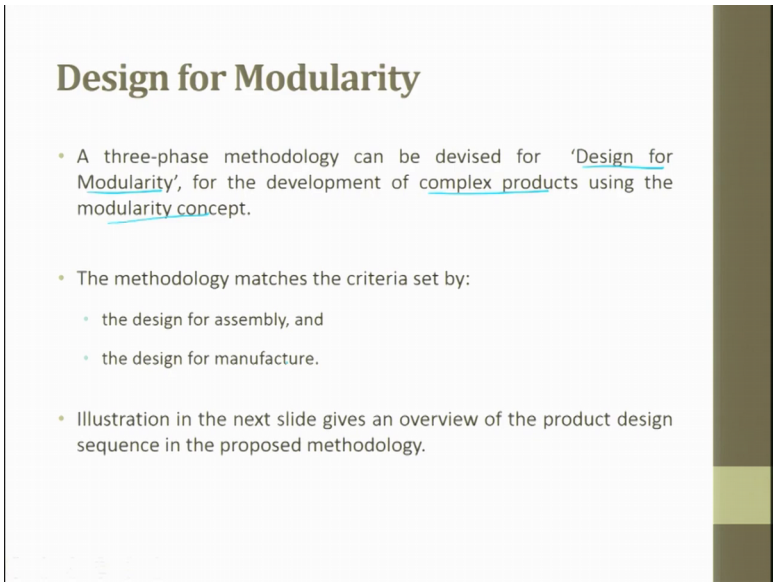

A three phase methodology can be devised for design for modularity, for the development of complex products using modularity concepts. The methodology matches the criteria set by design for assembly and design for manufacturing.

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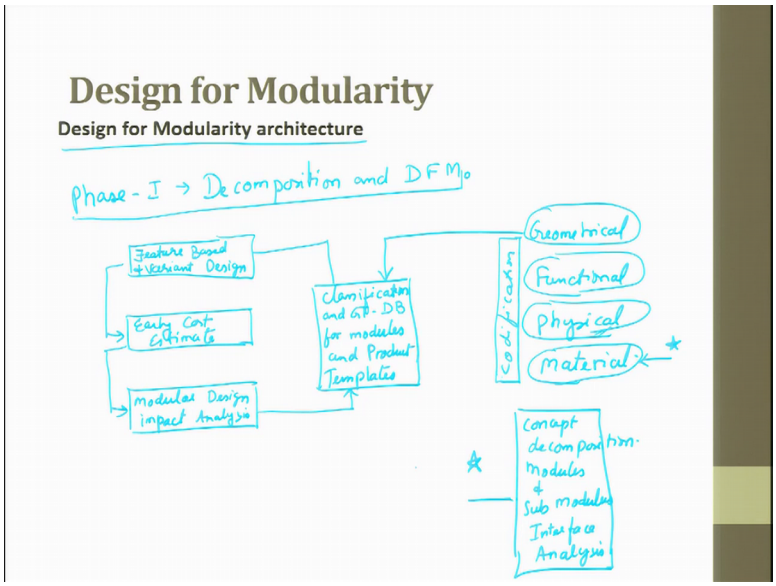

So, here we will see the design for modularity architecture. So, the phase I is going to be decomposition and design for modularity. So, here in which we will have feature based and variant design variant design. So, for example, where multiple colours which are available in a car for example, you take a car where and which you the company produces red colour, blue colour, green colour, they are called as variance.

Or you can say a standard model then you have a model which is attached with AC which is attached with a audio system variance ok. Feature based is in the entire car you are dividing it feature base for example, for cooling we have an air conditioner for music we have a music system. So, it is a feature, you can change the feature for example, from x company you can go to y company from x watch you can go to y watch ok.

So, here audio system is a feature, variants are some small changes. So then it will be early cost estimate of estimate it is not going to be perfect estimate. And then you have modular design impact analysis so all these things are interconnected. And this feature design is interned attached with a classification and GT Data Base DB for modules and product templates.

This attached with geometry functional physical and material ok. These are the classifications which is done based on geometric on functional physical and material. Because material place a very important role in the final product ok. Then it is a physical

form then functional then geometry. So, all these things are now coded this is done coding codification they do a codification on this and then they get to this output ok.

So, here I will have to you have to pardon and me. So, I will put a star here and then I will continue. So, it will go like this and you have furthermore in the block diagram it is concept decomposition then you have modules and sub modules interface analysis. So, this continuous here. So, all these things put together is phase I ok. So, from modular impact there is a connect to the classification and coding also this is phase I.

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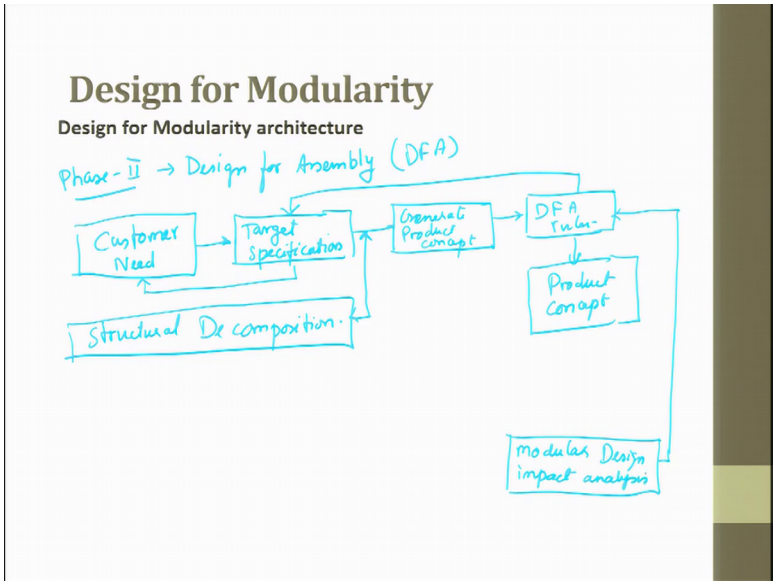

Let us try to adopt phase II is design for assembly. So, in this design for assembly we have customer feedback or customer need then we will have target specification. And then we have generate product concept and then we have design for assembly rules, this is called as DFA ok. So, we have structural decomposition so customer needs so, from target there is a link to DFA ok.

And from here we get into product concept and then from here we gets connected to here. So, generate product concept so customer need to target we go back and forth ok. So, and then from design for rules it is attached to the previous phase I whatever we saw to the modular design if you go to the previous slide you saw modular design. So, it is this one is attached DFA rules are attached to modular design impact analysis.

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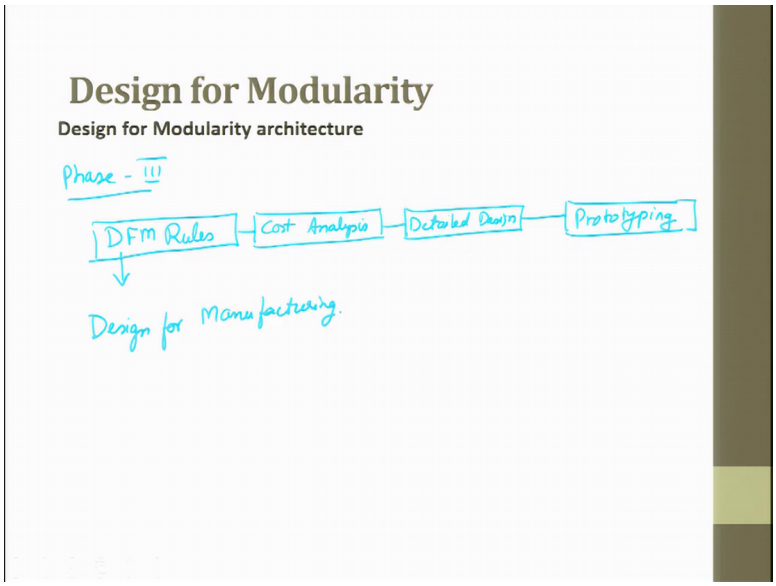

So now let us see phase III you have DFM Design For Manufacturing rules which is in turn linked with cost analysis and this in turn is attached with detailed design and this in turn is attached with prototyping. So, this is this is nothing, but design for manufacturing. So, the design for modularity is divided into three zones or three phases phase I phase II and phase III.

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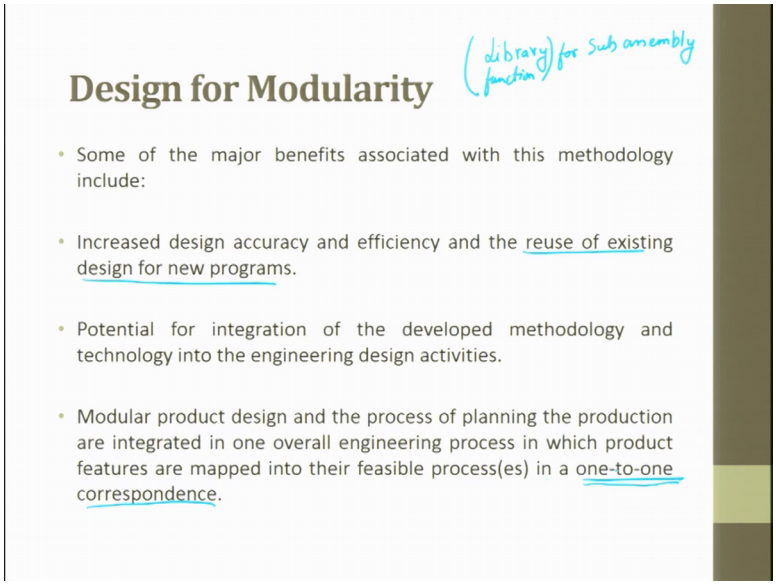

So, some of the major benefits associated with the methodology include increased design accuracy and efficiency and their reuse of the existing design for the new programs. So,

that is what I was trying to explain previously library functions for sub assemblies will be made in the cad itself library function. So, for example, in a cad model if you see people will talk about tyre separately, nut separately, bolt separately. So, all you have to do is call that nut call that bolt.

So, then the library function is already prefixed for a particular subassembly. So, subassembly intern to a function so when you follow modularity it is easy to call those already existing library functions. So, your product life cycle time goes very fast or it is reduced to a large extents or rapid manufacturing can happen. So, the reuse of existing designed for new programs can be done. Potential for integration of the developed methodology and technology into the engineering design activities is one of the another big benefit.

Modular product design and the process of planning the production and are integrated in one over all engineering process in which the product features are mapped into their feasible processors in a one to one correspondence this is very very important. The overall engineering process in which product features are mapped into their feasible processes in a one to one correspondence is a another big benefit of modularity.

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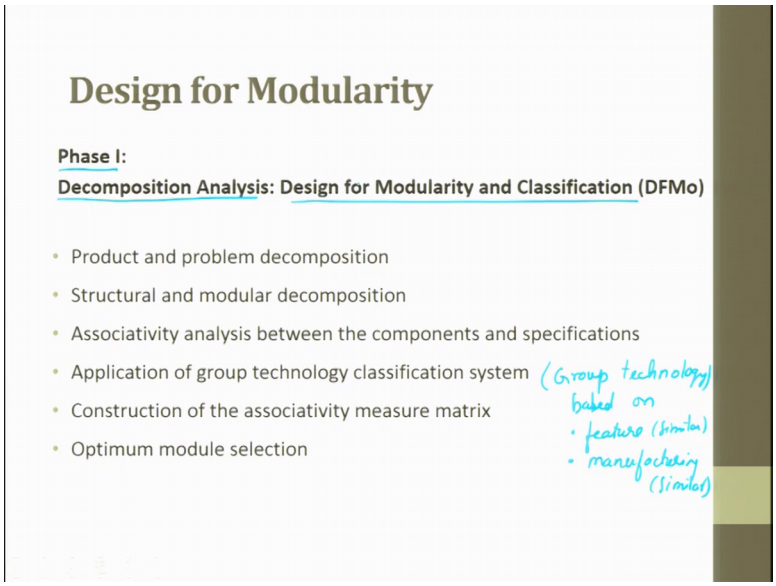

In phase I design for modularity and classification we do product and problem decomposition structural and modular decomposition associative analysis between the component and the specifications application of group technology classification

technique. So, group technology, group technology is done majorly from the manufacturing point of view or from the design point of view where grouping is done based on features or manufacturing which is similarity similar features and similar manufacturing.

So, that is what is the application of group technology classification systems which is part of modularity construction of the associate to measure matrix associate to measure matrix. What is the relationship between the first and the next what and between one sub assembly and the next subassembly. So, that is what is associative measure matrix then optimum module selection. So, these are all part of decomposition analysis which is done when we implement design for modularity or classification.

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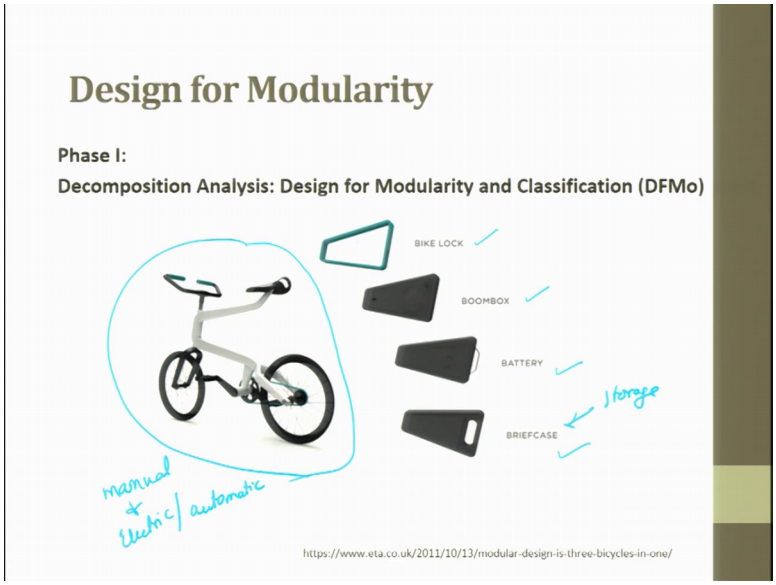

When we try to take a bicycle I always used to give an automobile or now I give you an example of a bicycle it can be divided into four or five subassemblies. One is bike lock, the other one is boom box, the other one is battery, the other one is briefcase. So, these are all models which can be attached to a bicycle and they can do independent functions. Bike lock can and only lock and it has only one functions so it can lock and the safety is taken care. Boom box is placed there battery converts it from manual to electric today slowly electric bicycles are coming into existence manual.

And electric that means to say automatic battery operated bicycles are there. Then briefcase is a place where it is for storage. So, these are all independent modules which

are very similar in shape and size. If you want you can keep this battery box if you do not want you can replace this battery box with a briefcase where in which it is use it is going to give you a storage space.

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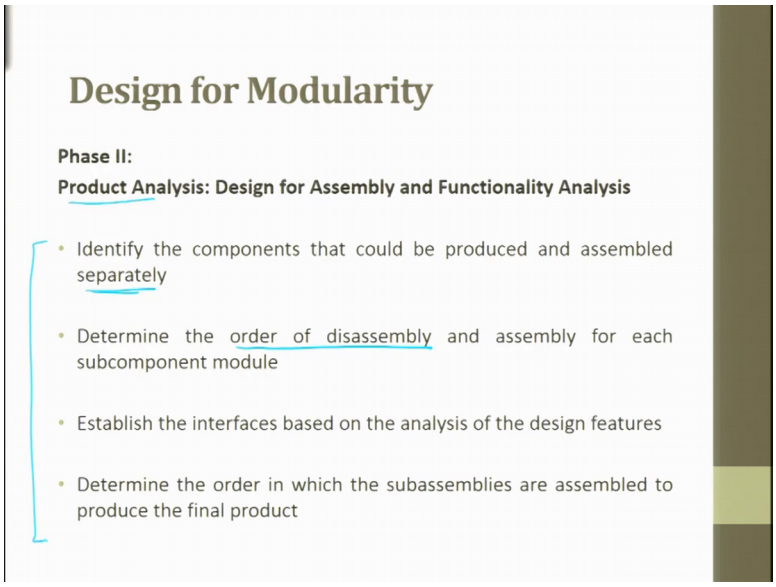

Product analysis design for assembly and functional analysis identify the component that could be produced and assemble separately. Next determine the order of disassembly and assembly for each sub component module order of disassembly sequence.

Then establish the interfaces based on the analysis of the design feature. Determine the order in which the sub assemblies are assembled to produce a final part. So, these things will be done in phase II which we saw the schematic diagram.

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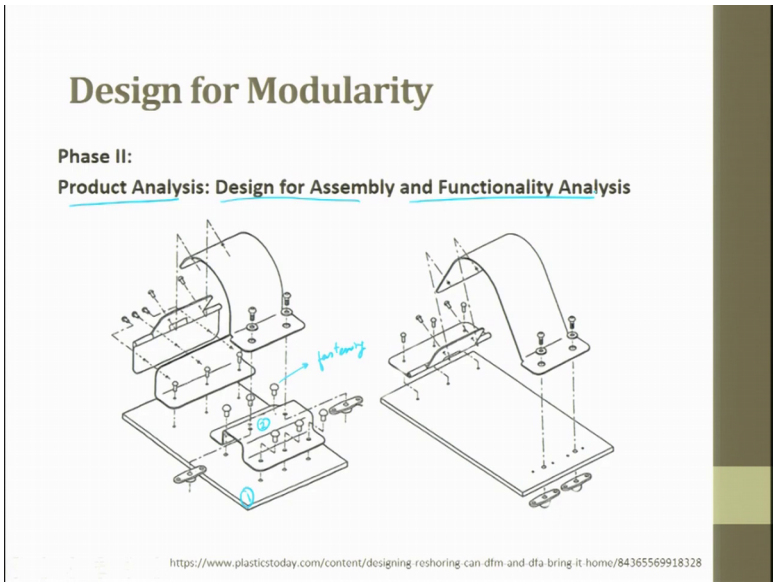

So, if you look at it so this is your product analysis where and which design for assembly and functionality analysis is done. So, you had a flat plate then you have so many clips to fasten. Then you had washers and other holders then you had all this fastening agents. So, it is supposed to lock some shaft or something like that so this is what is the previous component which is made. Once we use the concept for design for assembly you can see how much parts have reduced and how the design has become more fool proof.

So, you have one side locking and you see number of parts a number of parts which were here are now integrated into a single part. The single part has multiple features and this can be mounted by using this fastness and this is the clip which is there which can be fastened. So, the design for assembly and functionality analysis is taken care.

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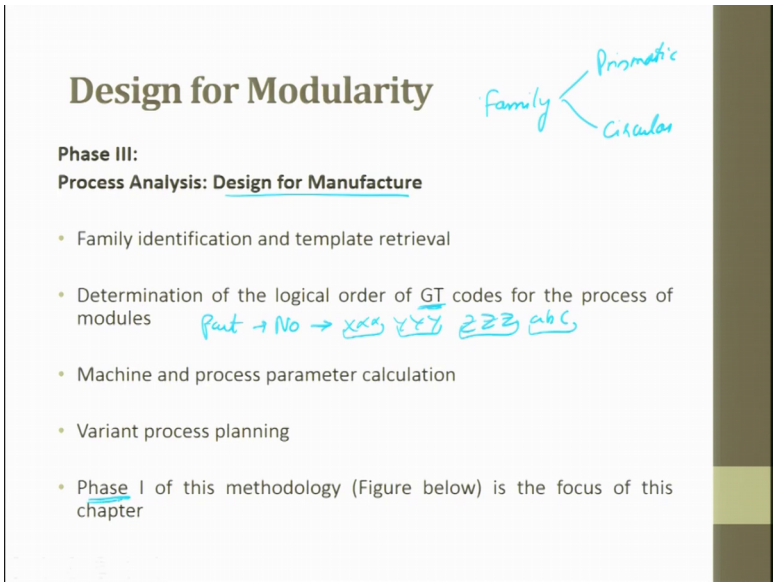

The IIIrd phase is the design for manufacture family identification and template retrieval; family identification and template retrieval is one of the advantage of the doing process analysis. So, family means you try to see whether it is the family can be whether it is prismatic or it is circular or you can have some other family.

For example, fasting family, locking family something like that you can have. So, then what the family identification is done because in your library function you already have this module there. So, identification family identification template retrieval so, whatever is there you retrieve it. So, that is part of process analysis determination of logical order of group technology quotes for the process of module. So, basically in group technology for every part if you see there is a part number.

So, this part number maybe x x x, y y y, z z z and you can have a b c it follows a system where in which by looking at the digit part number itself you can quickly find out which group technology family it goes to. Then machine and process calculations can be done variant process planning is also part of design for manufacturing. And phase I of this methodology is the focus of this chapter. So, phase I what is phase I? We saw decomposition analysis that is phase I that will be covered in full length in this discussion.

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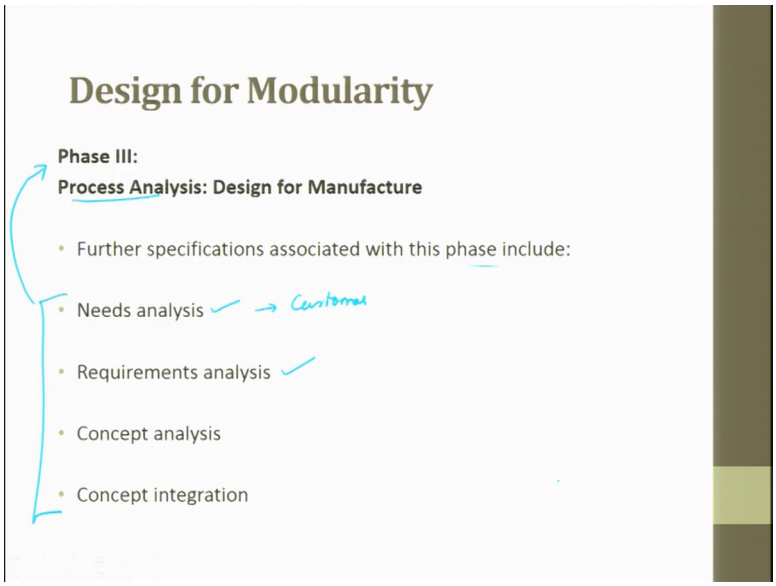

So, phase III is going to be process analysis we are going to do the specification associated with the phase includes; need analysis, requirement analysis. Need analysis is going to be the customer, then requirement analysis, then you have concept analysis and you have concept integration. So, these four things are part of phase III. So, need analysis, then requirement analysis, concept analysis and concept integration.

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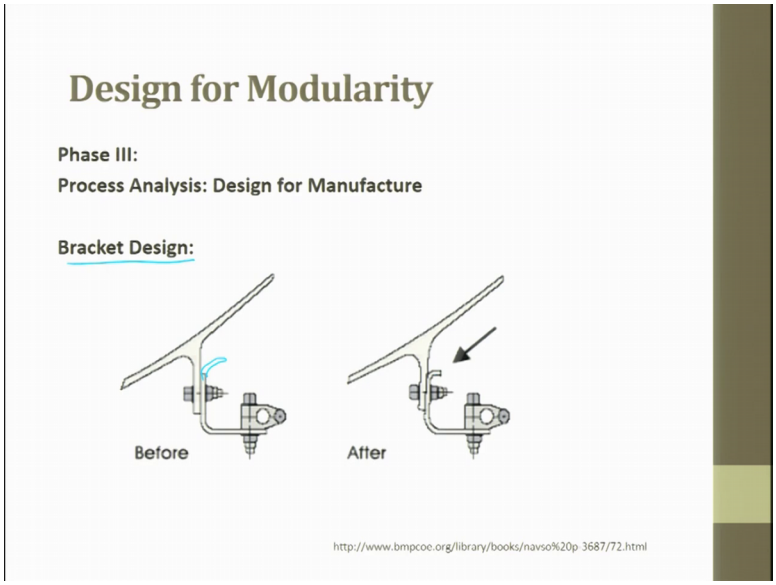

So, this you can see a bracket design which was done before. And now you can see how it is done after ok. So, you see that there is a change in the design; there is a change in the design so, you can see the bracket design is changed such that it helps in fastening.

Earlier it was very difficult because we could not hold the part. And now because of this flap which is given we can hold the part and do the assembly very fast ok. So, this is done based on phase III analysis which is part of design for modularity.

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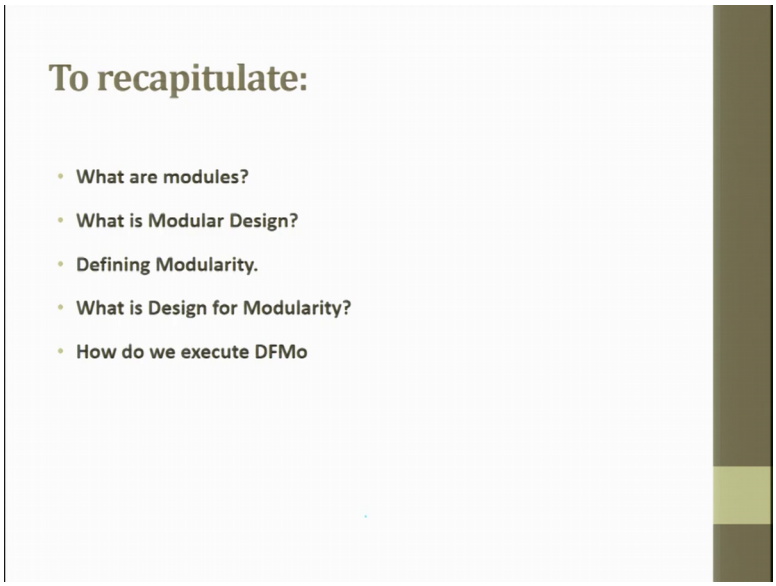

To recapitulate what we saw in this particular lecture is; What are models? What is modular design? Then defining modularity? What is the design for modularity? How do we execute design for modularity?

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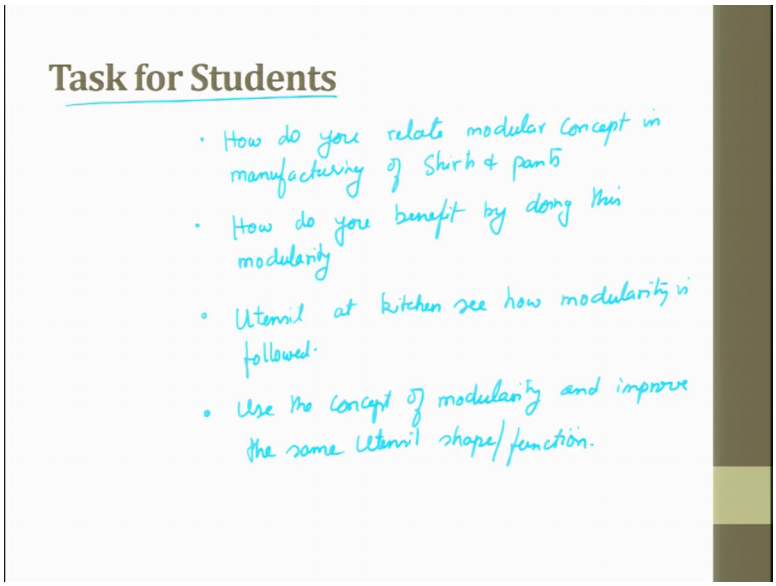

So, these were the topics which were covered at then I would like to give a task to students the task is; how do you relate modular concept in manufacturing of shirts and pants. So, what are the different modules which are there when you try to manufacture a shirt and pant ok. And then how do you benefit by doing this modularity. That means, to say if you do not follow modularity what is the time going to be there.

What is the performance going to be there and what is the cost going to be there and if you do it how is it going to be done. When you try to look at a utensil any utensil at kitchen see how modularity is followed? Use the concept of modularity and improve the same utensil shape slash function. Try to do this exercise for yourself. Then you can try to see how this modularity concept benefits in manufacturing.

Thank you very much.