Rapid Manufacturing

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Lecture - 7
Design for Modularity (Part 1 of 4; Design for Manufacturing)

Welcome to the next lecture for our discussion. In this course on Rapid Manufacturing we are now going to focus on design for modularity. As it very clearly says modularity so that means, to say design has to be thought in modular form or I have to make the parts or the design in modules. So, what is that it is something like a library function. We have predefined and these library functions are ready.

So, whenever you want looking into the requirement you pull up the material from the library function, modify little bit and then start using it for the final product. Let us take an example of modular kitchen. So, in modular kitchen what they have done is they have made the kitchen into several small compartments. And each compartment has a fixed space and a fixed dimensions. So, then what you do is you expand or contract the dimensions, but the kitchen is completely divided into compartments.

If one compartment goes bad you can replace it. You are now trying to make the space in the kitchen from 2D oriented to 3D oriented. So, with this modular kitchen you can accommodate more items and in a more systematic manner. So, that is a very simple example for modularity followed in domestic front. The same concept can be followed in reality also. Let us take the example of battery in a car.

So, there are several cars, several different manufacturers. So, the battery is made as independent entity whenever it comes off you can replace it with any other brand. So, the power supply to the entire car depends on the battery. This battery is completely made modular. Same way the battery what you use in clocks what you use in watch they follow a modular concept. And since it is modular it is standardized the cost is very economical.

So, modularity plays a very very important role as far as designing is concerned. So, can I think of it upfront? No you cannot think of upfront, what it does is as and when you start evolving the product. So, slowly slowly you can make sure that certain things we can start using standard parts, certain things we can start using which is customized to the product. So, this is more specific towards modularity.

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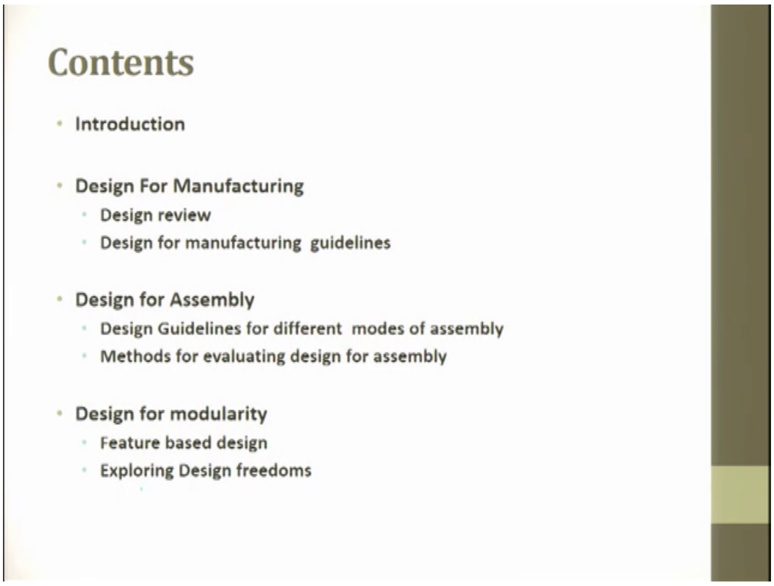

So, the content we will see a small introduction, followed by it we will see design for manufacturing. So, we will see design review there. Then design for manufacturing guidelines we will see. Then we will see design for assembly. Then design guidelines for different modes of assembly. Then methods for evaluating design for assembly. Then we will see design for modularity, feature based design and exploring design freedoms. So, these are the contents which we will go through in this lecture.

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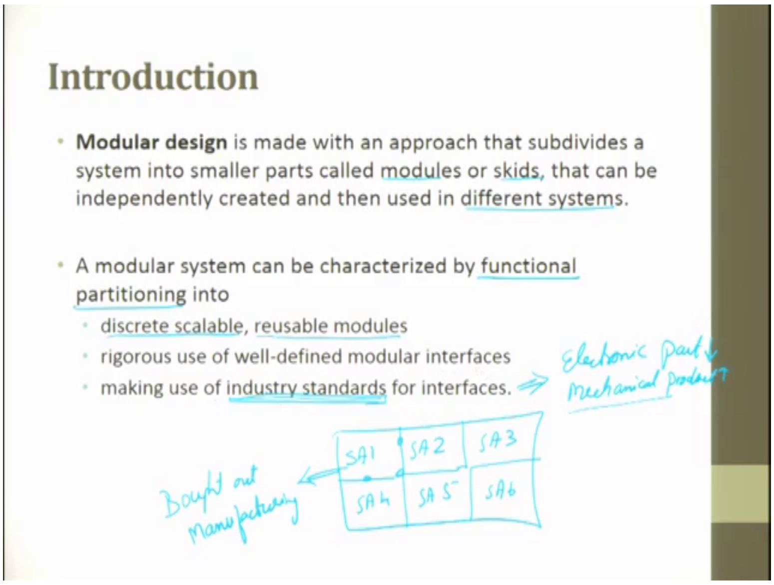

Modular design is made with an approach that subdivides a system into smaller parts called modules or skids. That can be independently created and then used in different systems. If you go back and look at the example of battery what I gave is the same, modular design is made with an approach that subdivides a system into smaller parts. So, you take a product then you divide the product into sub products or sub assembly.

So, this is sub assembly 1, sub assembly 2, sub assembly 3 so these are sub assemblies. So, now, into smaller modules that can be independently created you can make it as a bought out item or you can do manufacturing inside your factory. This is independently done and this is attached to the system for which helps in working to the expectation and then used in different systems.

A modular system can be characterized by functionally partitioning into discrete scalable reusable modules. It can be discrete, scalable and it can be in the reusable modules; rigorous use of well defined modular interface making use of industrial standards for interface. I would like to share a simple example with you this is regarding the standards are concerned. If you look at it electronic parts; electronic parts the price keeps slashing down.

Whereas, the mechanical parts mechanical parts are products if you see the price will always keep increasing as the time period goes high for example, car cars they say initially it started with 2 lakhs, 3 lakhs, 5 lakhs today it has gone to 10 lakhs. So, now, it has gone even to 25 lakhs, 1 crore. So, there are cars, but electronic parts when they came into the market they say it is 1 lakh then subsequently the computer price slashes down to 40000 and then so on and so forth.

Why is this happening only in electronic not in mechanical is because the electronic industry has established a standard which has to be followed. So, if you take a computer the computer is divided into several modules and each module has a specification and each module has a standard to fix it with the other part so that it can function. So, this standard is let open free at the beginning and lot of companies try to make their products to meet out the standard requirements.

So, this leads to heavy healthy competition, this leads to a price reduction in electronic parts. This all can happen because of the modularity concept which we follow. Modularity system can be characterized by functional partitioning. So, you divide it based on function and not on shape and size. For example, battery it does give electrical support to whole system. So discrete scalable reusable module rigorous use of well defined modular interface making use of industrial standard for interfaces.

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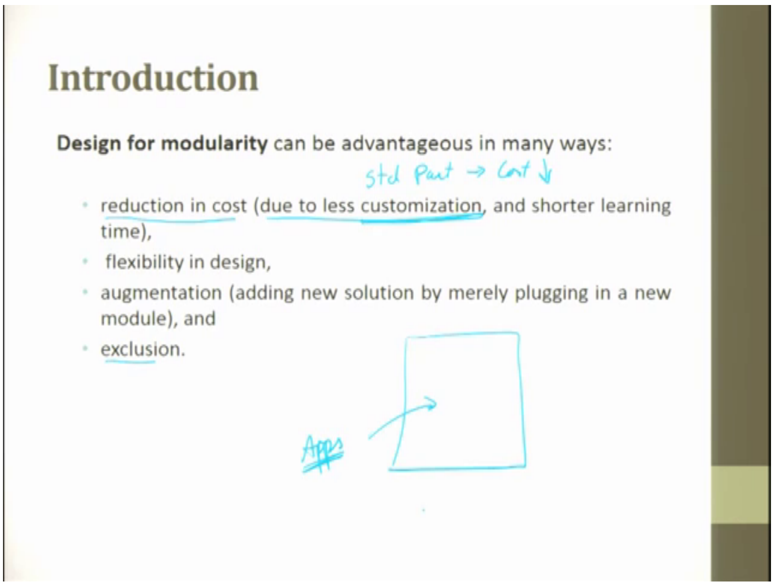

Design for modularity, can be advantageous in many ways. Reduction in cost, that is what I gave you an example of electronic parts due to less customization. Please understand whence you start producing standard parts you get it at a cost which is reduced. But the customization is the huge sacrifice you have to do ok; so, reduction in cost due to less customization and shorter learning time.

Flexibility in design right, then augmentation adding new solution by merely plugging in a in a new module and so on; for example, if you try to take your smart phone you try adding apps, each app does a particular function so you can say this as modular. So, the augmentation adding new solutions by merely plugging in a new module it is almost the Smartphone example.

But this is very much talked about in software. In hardware it is slightly difficult because there is a energy consumption and other things. So, augmentation add new solutions by merely plugging in a new module and exclusions are the benefits at or the advantages by following the design for modularity.

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For example today you see modular furniture’s. So, if this furniture is broken you replay only one. Your ground if you see is divided into several tiles, your floor is divided into several tiles. So, if there is one tile broken you have to replace only that tile and not the entire floor. So, in the same way if one feature or if one chair gets spoiled you just replace one and not the rest. So, this is what it is and all these things are joined together at a proper interface so, they do not get liberated.

So, you can see here the person is constructing a table, the table is divided into several modules. So, depending upon the requirement he attaches or detaches to get the table to the requirement. So, this is a perfect example for modularity. In furniture people follow modularity furniture design people follow modularity.

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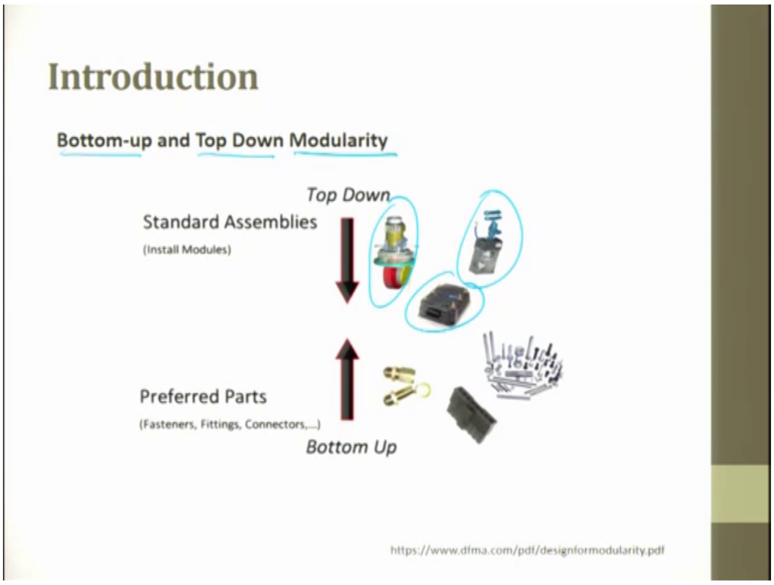

So, as far as modularity is concerned there are two types of modularity, one is called as bottom up modularity another one is called as top down modularity. When we talk about top down modularity it is standard assemblies are there from there it goes down. So, if it is bottom up it is preferred parts are chosen and these parts are put together and you start forming a module. So, you can have bottom up modularity or top down modularity. Top down modularity is sub assemblies are chosen and then the product is made. Parts are chosen and from there you go towards the assemblies.

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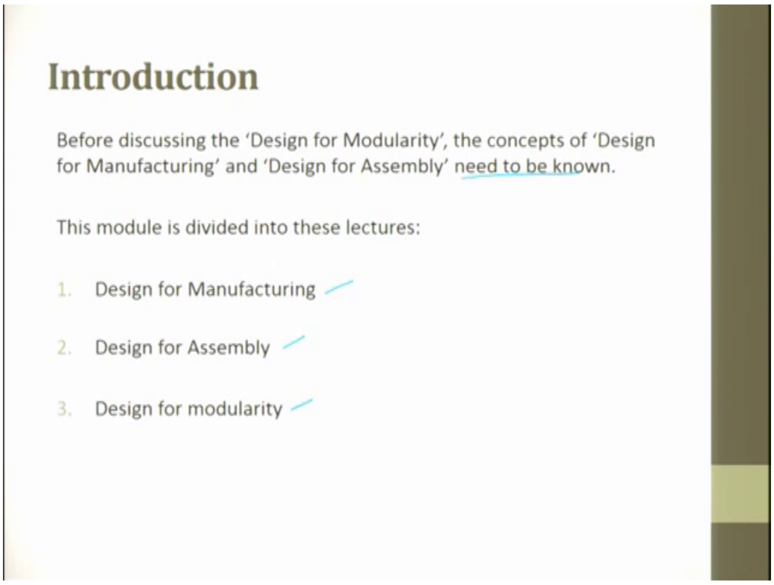

Before discussing design for modularity the concept of design for manufacturing and design for assembly has to be understood. So, this module we divide it into these three lectures. One is design for manufacturing design for assembly and design for modularity if I say modularity it is intern it has to have a subset of manufacturing and assembly.

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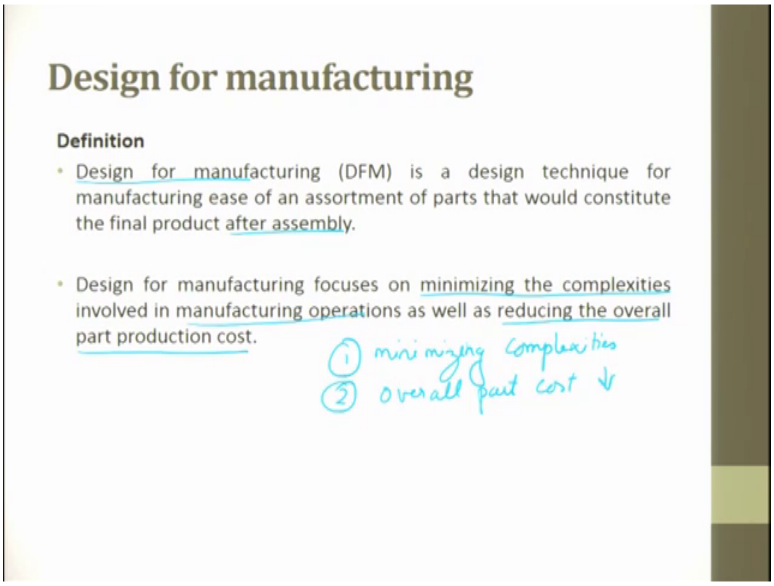

So, what is a definition for design for manufacturing is a design technique for manufacturing ease of an assortment of parts that would constitute the final product after assembly. Design for manufacturing is a design technique for manufacturing ease of an assortment of parts. That would constitute the final product after assembly. Design for manufacturing focuses on minimizing the complexity involving the manufacturing was operations as well as reducing the overall part production cost.

Manufacturing it is more focused towards minimizing complexity. If the complexity is very high then manufacturing operations also will be very high. And reducing the overall part cost reduction. So, these two are the main objectives of design for manufacturing.

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Design for manufacturing is also the process of proactively designing the products to optimize all the manufacturing functions like; fabrication, assembly, testing, procurement, shipping, delivery, service, and repair. Design for manufacturability is going to optimize all the manufacturing functions, these are all the manufacturing functions.

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Then next is going to be assure the best in cost, quality, reliability, regulatory compliance, safety, time to market and customer satisfaction. The earlier one was functions of manufacturing. Now it is assure the best cost, quality, reliability, regulatory, compliance, safety, time to market, and customer satisfaction.

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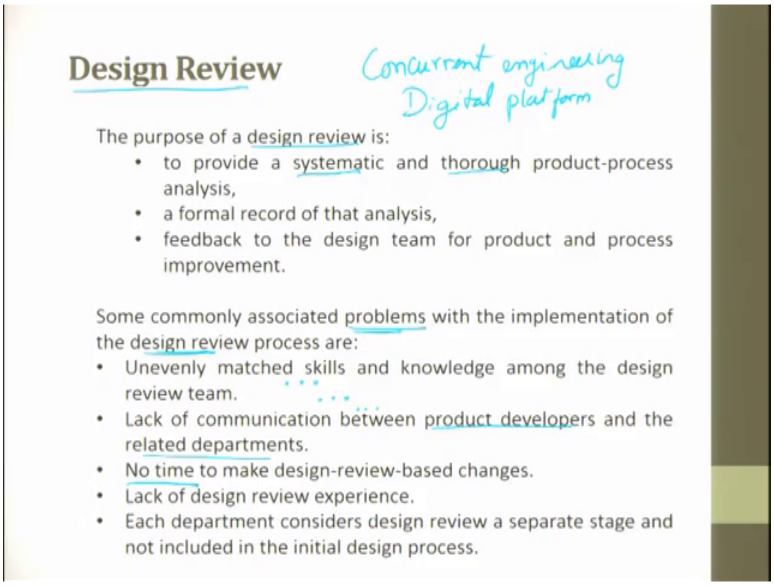

So, when we talk about design review the purpose of design review is to provide systematic and thorough product process analysis. The formal record of that analysis it is a formal record of analysis feedback to the design team for product and process improvement is also given out of this design review. So, it is systematic and thorough product process analysis is done by the design review. Some commonly associated problems with the implementation of the design review processes are; unevenly matched skills and knowledge among the design reviewer team. So, problems in associate for design review. So, unevenly matched skills and knowledge amongst the design reviewer team, may be there are few experts there are few people at the lower level, then there are few more at the lower level.

So, the team itself is quite complex. So, it is not a complimentary to each other it is only a supplementary. So, his knowledge he has a same knowledge; he has a same knowledge not much of supplementary it is just a different level there. Lack of communication between product developer and the related departments this is why we are coming to the concept of concurrent engineering. And when we use a digital media as the common platform of communicating between various departments, digital platform with various department. So, you will have there can avoid a lack of communication between them. No time to make design review based changes so this is a problem.

Lack of design review experience. See review is nothing, but design review is nothing, but validation of what customer wanted, what you are producing whether it will meet out to the customer satisfaction. That is what is design review in a crude sense. But how do you do it systematically you do it and thoroughly you do it lack of design reviewer experience each department considers design review a separate stage and not include in the initial design process. When we talked about concurrent engineering this problem is tackled and it is removed.

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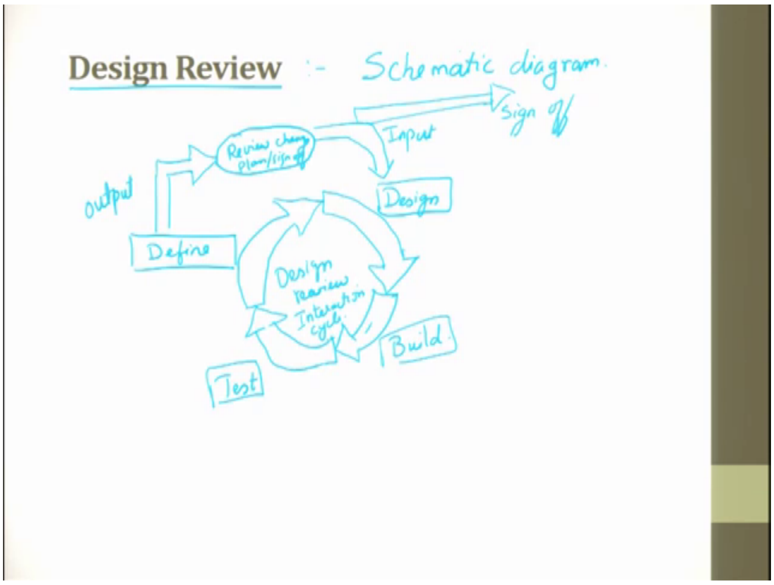

When we talk about design review the schematic diagram right; define a problem then it is design, it is test, we have this build. So, we will have output we will have review, change, plan and sign off ok. Then it comes to it is input and if you this is sign off. So this is the typical design, review, interaction, cycle ok.

This is the design interaction cycle you have four stages; define, design, build, test. this keeps on going iteratively, the define output is review changes has to be there if the reviews are all then it gets to sign off that is the design is final if it is not. So, it comes to design then it reiterates it keeps going. So, it is a continuous cycle and the design process always says there is a scope for improvement.

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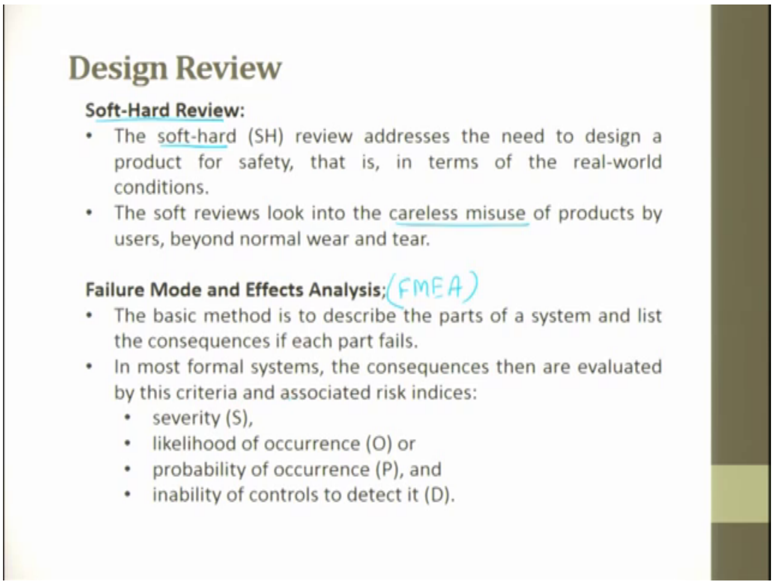

In the design review we have soft and hard reviews. Soft hard reviews addresses the need to design a product for safety that is in term of the real world condition. So, this is SH review, the soft review looks into the careless misuse of products by user beyond normal wear and tear. Suppose I have this pen over a peep over a period of time if it starts getting the plastic starts degrading and if it breaks it might have sharp edges this will try to hurt if somebody uses it after the wear and tear.

So, the soft review looks into the careless misuse of products by user beyond normal wear and tear. Failure mode effective analysis which is otherwise called as FMEA a very very powerful tool to do design review. The basic method is to describe the parts of a system and list the consequences if each part fails, is done in this failure mode effective analysis. For example, if you have a tire in a car and suppose if the tire fails what amount of impact it is going to create to the product as well as to the passenger.

So, that is done at the beginning itself, the basic method is to describe the parts of a system and list the consequences if each part fails. In most formal systems the consequences that are evaluated by this criteria and associated risk indexes are attached to it. Severity is S, likelihood of occurrence is O, probability of occurrence is P, inability of control to the defect is D.

So, now you know the weight ages you multiply the weightages. And then you can get the impact of each failure or each part in the overall performance.

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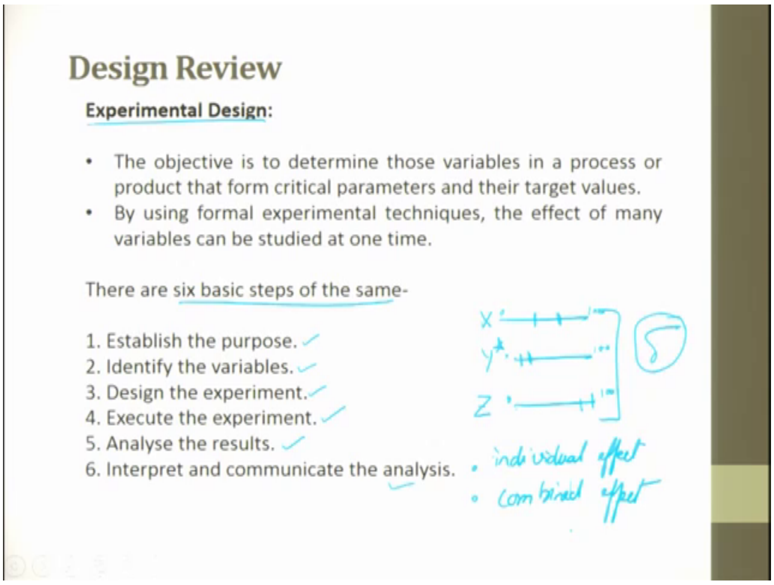

Experimental design: the objective is to determine those variables in a process or product that forms critical parameters and their target values. For example, you have X parameter, Y parameter, Z parameter to get an output; output is delta you want to get an output. So, now, the parameters X this window Y this window Z this window might be used to produce a good product such that you get this del. And also when we have three parameters you would like to know which parameter is playing a significant role on getting a good output ok.

The objective is to determine those variables in a process or product that forms critical parameter and their target values. By using formal experimental techniques the effect of many variables can be studied at one time. So, we can do experiments and we can study the effect of individual things. There are six basic steps for the same establish; the purpose, identify the variables, design the experiment, execute the experiment, analyse the experiment, and interpret and communicate the analysis.

Establish the purpose why are you doing this experiment, identify the variables X Y Z are variables which are identified design of experiments has to be done. Because in this X this is 0 this is 100 like this if you have 3 variables if you want to do experiments for all these it is going to take lot of time. So, what we do is we try to establish a window and we within that window we try to do experiments, then we follow design of experiments plan and do little experiments to talk about the process execute those experiments analyse the result.

What is the individual parameter? What is the individual effect? What is the combined effect? What is the individual effect? What is a combined effect? Many a times you will see this in your family or in school or in even college they say if this fellow is if a is alone is a good boy if b is alone is a good boy. Moment A and B joints they create so combined effect right. Individual effect, combine effect you are able to find out by analysing the results. And finally, you interpret the results and you communicate the analysis such that this is taken back to the design team they review change and then give the good output.

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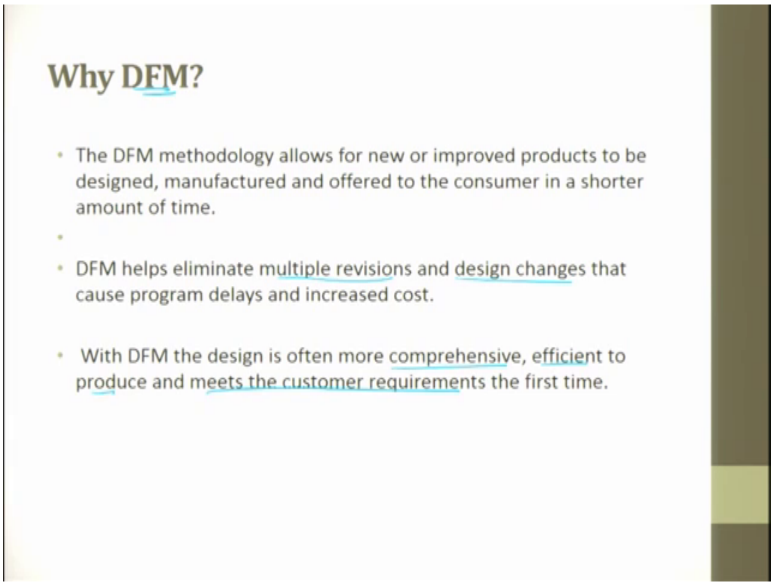

Why DFM? DFM methodology allows for new or improved products to be designed, manufactured and offered to the consumers in a short amount of time. So, time to market, time to customer, product lifecycle, reduction all these things if it has to happen we have to follow DFM. DFM helps eliminate multiple revisions and design changes that causes program delay and increasing cost. So, it reduces the revision and design changes because you have all sets of data as upfront.

So, all you have to do is use those tweak little bit of meets out the requirements with DFM the design is often more comprehensive effective to produce and meet the customer requirements the first time. Today what we talk about is go best the first time first part is not scrap. So, all these terminologies are, all these jargon words are used today. So, if you want to do that use design for manufacturing.

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How to perform design for manufacturing? Many companies today are integrating DFM and DFA practices through design and manufacturing team. The design for manufacturing and design for assembly techniques are two different classification. DFM techniques are focused on individual parts and components with a goal of reducing or eliminating expensive complex or unnecessary features which would make them difficult to manufacture.

DFA technique focuses on reduction and standardization of parts sub assemblies and assemblies. It is more towards on reduction and standardization. The goal is to reduce the assembly time and cost. This is the ultimate goal is to reduce the time and cost give a good cost with customer satisfaction.

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So, minimizing number of components or parts once you minimize the assembly cost is reduced. Final product is more reliable if you have more number of parts the wear and tear of each part has an influence on the output. So, the final product is more reliable because there are fewer connections. Disassembly for maintenance and field services is easy if the number of parts are reduced. Reduced part count usually means automation is easy and it could be easily implemented. Work in progress is reduced and there are few inventory control problems only if the number of parts are reduced.

Fewer parts need to be purchased which reduces the ordering cost also. So, these are the benefits you get if you try to minimize the number of components, use standard commercially available components designing time and effort are reduced. Design of customer engineer component is avoided. There are fewer part numbers inventory control is facilitated quantity discount may be possible. So, these are the advantages when you start using a standard commercially available component.

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Use common parts across the product line. For example, if you are producing different types of cars; car 1 2 3 4 5 6 it is excellent. But all these six cars must have a standard tire dimensions. So, you order the tire and whatever might be the car the tire size is constant so it can be easily fixed. If you buy any cycle tire to a large extent the general one the cycle tire diameter is constant the spokes are constant. So, you go to the market and buy that alone and then fix it in your cycle and keep moving.

So, it can be used for various product lines. There is an opportunity to apply group technology, implementation of manufacturing cell may be possible. We will see what is manufacturing later then quantity discounts may be possible when you use a common part for different product lines. Designed for ease of part fabrication; net shape and near net shape processes may be feasible, part geometry is simplified and unnecessary features are avoided.

When we start using design for ease for part fabrication. Unnecessary surface finish requirements should be avoided otherwise additional processing may be needed. So, net shape and near net shape. Net shape means it is almost the final product, near net shape means it is close to the final product that is a difference ok. Near net shape needs one more operation of machining or finishing before the part gets into assembly. Net shaping is you can use it directly may be feasible. So, these are the advantages you get when we try to make the part fabrication easy.

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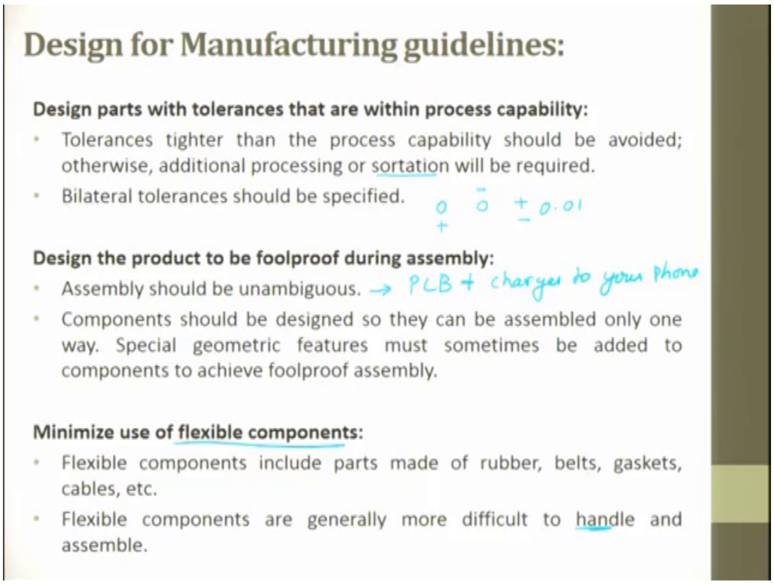

Design parts with tolerances that are within process capability. Do not try to demand your tighter tolerance. If you start demanding a very tight tolerance then these tighter tolerance will demand more processes. So, try to see what process you have and you see the process capability and try to give that as your tolerance limit. So, it does not mean that since you have a very weak machine or a very old machine you can be liberal in your tolerance.

Because when the product which is getting developed when it comes to performance it will not be up to your expectation; so, there has to be a trade off ok. There has to be a trade off in your design. So, design parts with tolerance that are within the process capability, tolerance tighter than the process capability should be avoided. Additional processing or sortation will be required bilateral tolerance should be preferred.

So, there is something called as unilateral tolerance there is something called as bilateral tolerance. So, plus and minus you try to give a value that is called as bilateral. If it is bilateral it is easy for the process to the capability, design the products to be full proof during assembly. Assembly should be unambiguous this you can see in your PCB or when you put your charger to your phone.

The side which you have to plug it in is very clear and you cannot make any mistakes. So, this is nothing, but design for assembly is taken care, the designing a product to be full proof during assembly. Component should be designed so that they can be assembled only one way. Special geometric features must sometimes be added to the component to achieve full proof assembly.

For example when you insert your ram into the slot you can do it only in one direction. If you do it in the other direction you will not be able to push the ram into the slots when you are do assembly of personal computers. Minimizing the use of flexible components: flexible components including parts made of rubber belts gasket so, this has to be reduced because this gives you a lot of flexibility and rigidity will not be there. The flexible components are generally more difficult to handle them and assemble.

Because since these rubber if you want to automate a process this rubber, rubber belt caskets holding it and taking it for assembly if the stiffness is not so, high then it becomes very difficult to automate the process. So, in if you think of automation try to have a part which is rigid and which has some stiffness to it.

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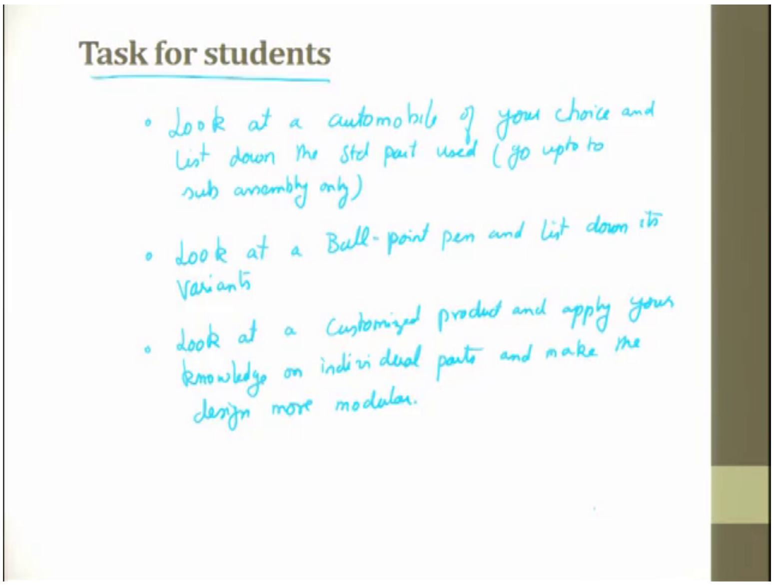

So, coming to the end of the lecture; the task for the students are try to look at a car, look at here automobile of your choice let it be scooter also automobile of your choice scooter, bike, car, bus. And list down the standard parts used, do not have to go to product level go up to subassembly level only.

Look at here ball point pen and list down it is variants. Look at a customized product and apply your knowledge on individual parts and make the design more modular. When you try to do all these three live examples you will see how beautifully designed for manufacturing, design for modularity, design for assembly is followed ok.

Thank you very much.