Product Design and Development

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Lecture - 05
Product Design Steps and Product Analysis

[FL] friends, we have already finished 4 lectures on in this topic of Product Design and Development. So, as you know the courses divided in 4 weeks. So, today we are going to end discussion for week 1 in which we are discussing the 5th lecture related to product design and development.

In week 1 our focus was on basic aspects of product design, the need of product design, the product design steps and the product analysis. So the last 4 lectures we have already covered most of the parts related to the product life cycle we have seen that what are the various stages of product design process and we have also seen the product policy of an organization.

So, in today's lecture our focus is on you can see the product design steps and the product analysis. So, we will quickly go through the steps because there are number of different books written on this topic and there are number of stages which have been outlined by various researches and engineers, but we will try to outline the standard procedure which is most common, in most of the design process or most of that design of products or most of the examples of that product design. So, let us see what are the product design steps.

So, this is something which I have shown in the last class also we have seen this, but initially you have ideas generation in which you develop idea or you generate idea then you develop that idea in the form of a conceptual design.

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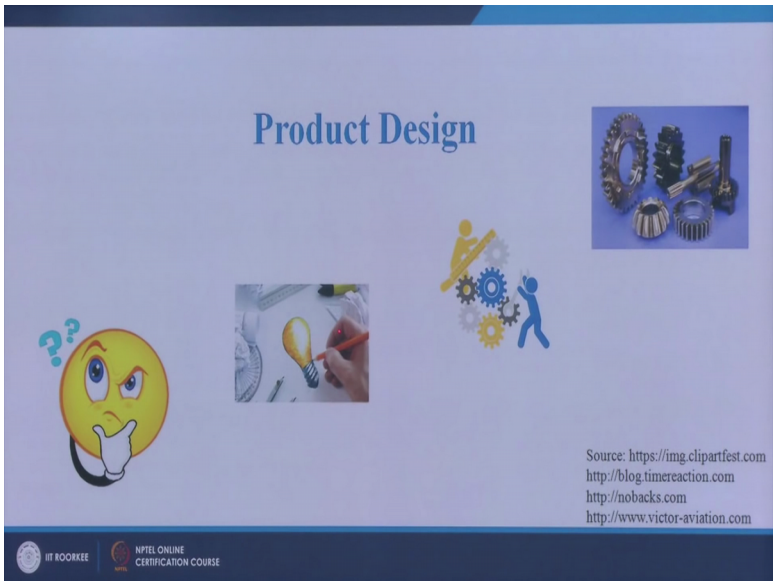

And then that conceptual design is taken to the detailed design process and from the detailed design process you come up with the product here you can see they are kind of gears or cutters which are a final product of an idea which was generating at the initial stage.

So, product design basically to revise we know that it is the culmination of ideas into the tangible product or the products in their physical form. So, you may have a idea and it may lead to a product. Similarly the products may not be tangible or may not be physical in nature sometimes you have a product which is a software a product which is a mobile app. So, different types of products can come because of the generation of the different type of ideas. So, here you can see you have idea generation and the final products. So, our today's target is to go through the various steps that are followed for converting this idea into the final product.

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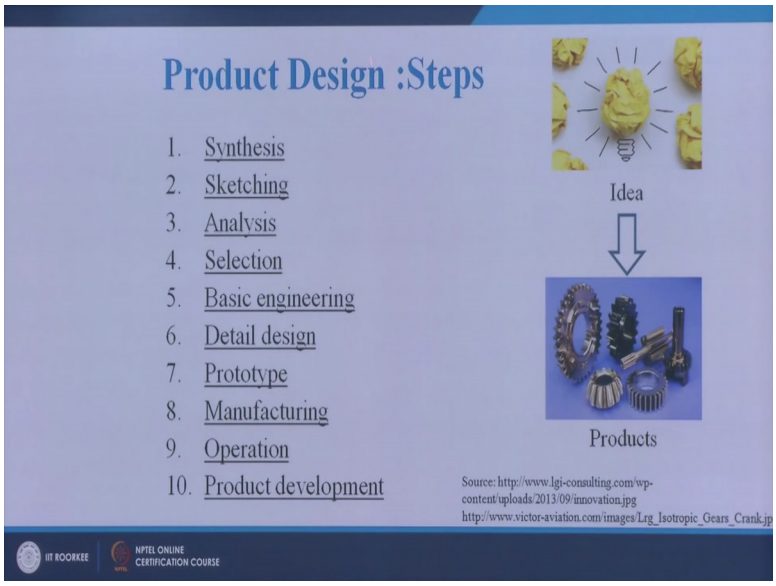

So, you can see here this is the product design various steps that are used for product design first one is synthesis, sketching as we have seen in the previous slide where there was idea generations some sketch or some conceptual design or conceptual shape was being drown by a designer. So, initially synthesis, then sketching analysis means you will do or compare the various ideas as I have told in the previous lecture that they are may be 4 ideas 5 ideas, out of those 5 ideas you will take only two ideas further.

It means there was (Refer Time: 03:28) of ideas out of which we will select the best idea. So, that is the analysis part here. May be the ideas may be compared based on the technical marred, they come be compared based on their economic visibility, they come be compared based on the safety features, they can be compared based on the environmental factors, they can be compared on the bases of legal factors. So, there can be different parameters of comparison as well as evaluation and not all ideas will reach the next stage very few ideas will reach next stage.

And I have told in one of the previous lectures the idea mortality rate suppose you generate 100 ideas only 2 or 3 ideas will reach the market means they will be converted into a physical or a tangible product. So, it the lot of I therefore, there is a need to generate lot of idea so that some of them could be converted into the final product.

So, there is analysis or evaluation of the ideas will take place at stage 3 followed by the selection of the most appropriate or most relevant idea, then you will do the basic

engineering you will make a rough design of a product using the engineering skills and some of these engineering skills we will learn during the course of this lectures not lecture, but during this particular course on product design and development. I should tell you that we are into the third hour of our discussion and we have to do 10 hours of discussion on this topic.

So, in the remaining 7 hours of discussion our focus will be more practical in nature to (Refer Time: 05:07) with the various tools that are helpful in the product design process. So, the basic engineering skill we will develop during this course on product design and development and that skill is there by used to make the design of the product. So, we will learn some of the tools here at this stage. Then the detailed design is made once the detailed design is ready as we have seen in a previous lectures. What is detailed design? You will have all specification for example, related to the dimension of the product for example, we are developing a chair.

So, in detailed design we have all the dimension the that what would be the length of the chair what would be the width of the chair what would be the foam height what would be the backrest, type of backrest, dimensions of backrest, material of backrest all those designs the type of support system below the chair whether it will castor wheels or it will be the fixed frame. So, all those design with the exact dimension as well as material will be finalized during the detailed design stage.

So, now you have a complete design it can be in the form of a engineering drawing or it can be in the form of a CAD drawing that is computer design drawing, last class we have seen that what are the tools basically used for product design in which we have seen cad cam reverse engineering concurrent engineering. So, all those are tools which are used during the process, but here in detailed design process the outcome will be a CAD file or it would be a engineering drawing file or in the engineering drawing which will mention all details, all specifications, all dimensions, all tolerances, all materials that are going to get that product or that are going to help us in manufacturing that product

Once your detail design is ready next stage is the prototyping stage in prototyping stage we will try to develop a prototype. As you may have seen the course structure towards the end of our discussion we will go to rapid prototyping and rapid prototyping is one of the most relevant most common technique which is used these days for making very

small prototypes or the prototype of a complete model that we are going to use for further testing. It can be a functional testing, it can be a non functional testing we just want to see that how the product would look like that can be made using any technique of rapid prototyping.

So, that is prototyping will be done we will learn some of the techniques of rapid prototyping such as a stereo lithographic operators we will see may be laminating object manufacturing depending upon the time we will see how much we can cover in rapid prototyping. So, once synthesis sketching analysis selection basic engineering detailed design is done next stage is prototyping I have already discussed in brief, next is the manufacturing and in manufacturing you will manufacture the product full scale in prototype you will only may few models, but in manufacturing it will be a full scale manufacturing in which the complete factory will be used and the product will be manufactured as per the design and as per the customer requirement or the demand in the market.

Then the after the manufacturing the product will undergo in service operation for example, now I am using this pointer now it is in service, it was the conceptualize, synthesized, evaluated, prototyped manufactured and now I am using it. So, in use we will say that it is now in operation, whether it is the operating successfully or it is not operating successfully that will be tested during the operational time or during the operation.

And finally, the product development, so I have already told you that product design and development that is not a process which is time we which is you can say only stagnant process it is the moving process. So, once the product is designed the designer will keep on working on in innovating in doing incremental invocations and adding features to the product, because the value of the product is directly influenced by the features of the functions that product offer, so that designers would keep on working in improving their product value by increasing the functions or sometimes eliminating the unnecessary functions in order to add value to the product. So, the product development process will keep on continuing and it is a continues process and you will, you have seen that in the product lifecycle during the maturity stage the company would defiantly love to add new features to make different types of policies so that the product remains competitive in the

market. So, product development tenth number is a continues process which will help us in further improving the value of our product to the customer.

And next week our discussion will focus on the various concepts of value engineering which relevant in product development process. So, now, let us see this product design steps one by one. We will see just a very brief outline of the various steps because we have to cover the next stage of product analysis also in today's lecture. Now synthesis I will just read quickly I have tried to explain it with the help of an example of that what is synthesis and what is evaluation, let us see one by one.

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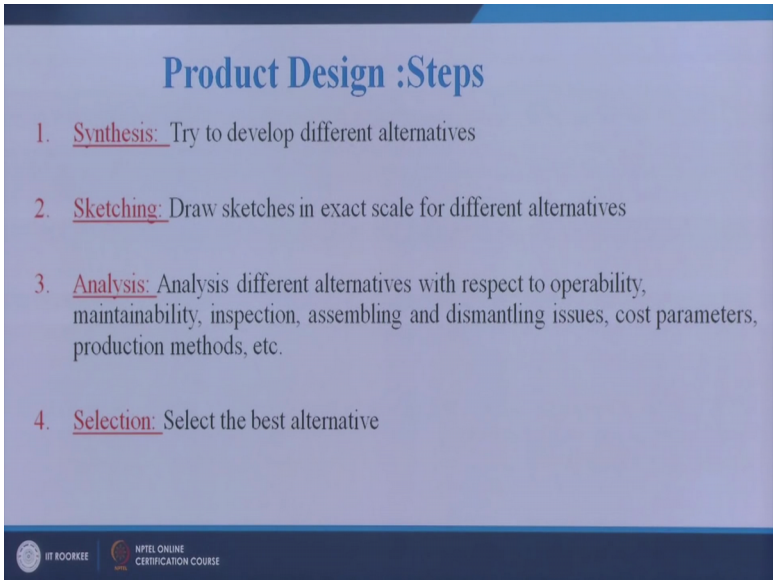

Synthesis is try to develop different alternatives, sketching is may be use different alternatives here can be the various ideas that you have related to the product.

So, first part is the different alternatives or different ideas next is draw sketches in exact scale for different alternatives. So, you now sketch the various ideas that you have conceptualized the idea. Then analysis, analysis different analyze different alternatives with respect to operability maintainability, inspection, assembling and dismantling issues cost parameters production methods. Even I can add legal methods copyright issue, IPR issues and then environmental concerns, waste disposal, recycling you can name any issue it can be covered here analysis. You have the ideas you can analyze those ideas based on number of parameters and then you will be left with a few them because some

of the ideas would get eliminated because of the criteria we have chosen for selection or analysis.

So, finally, selection we select the best alternative I should say at this stage we may not be selecting only one alternating we may selecting 4 or 5 or 6 alternatives that may be further you can say evaluated for different other criteria. May be many criterion we are covering here, but there may be some criterion that may be left for a later stage analysis, but this would lead to just short listing of the ideas. We may have may 10 ideas now we have short listed to three ideas. So, those three ideas we will take further in our discussion or in our analysis. Then the basic engineering as I have explained we will use different tools like DFM, DFA that is designed for manufacturing design for assembly we may use DFMA tools, we may use designed for quality all these tools will be used concurrent engineering, reverse engineering to come up with the design of the product.

So, basic engineering design we prepare a layout in exact scale calculates strength of the components select proper cost effective material as I have told now each and every component we will design may be for a chair we can see we will in basic engineering design we will see that what would be the foam or what would be the combination or thickness of the foam that would be there in the back support, what will be the thickness on of the foam that will be there on the seat what will be the material of the foam and what would be the back support what is a material that we are going to use for back support.

So, for a design of chair we will do complete analysis of the strength of the component as well as we will select the material in the basic engineering design.

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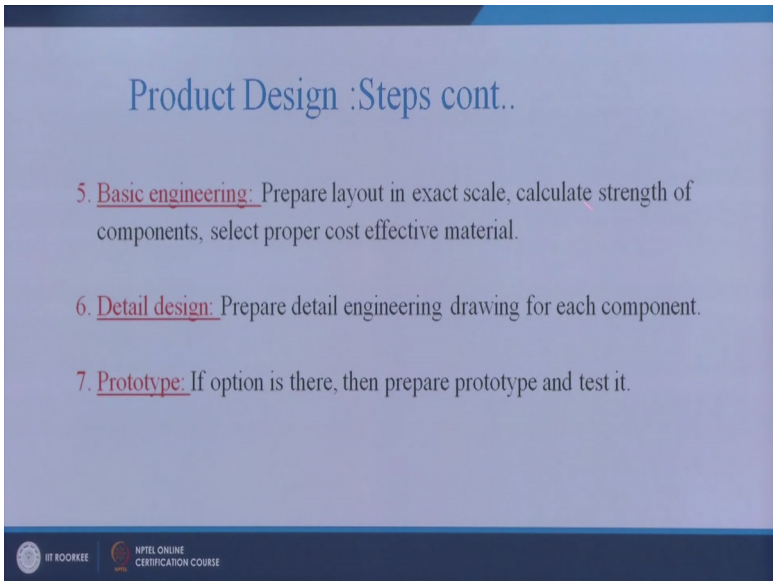

Then coming on to the detailed design in detailed design we will prepare detailed engineering drawing of each components. So, as all of you have studied or may have studied the engineering drawing or engineering graphics or computer aided design course there is a complete different views are plotted may be in first angel or third angel depending upon the requirement. So, we will have different views of the object or the product even the bill of materials is also there, the number of screws and bolts and other things are also finalized the material that is going to be used to fabricate that job is also finalized and fixed and frizzed.

So, in detailed design your design is now ready for manufacture you have found out or you have designed the product as per the customer requirement and as per the technical feasibility as per the engineering basics, may be as per the engineering you can say application we have designed the product completely. I have taken the example of a chair you can take any other example and see the complete design and there will be input from various engineering sections for the detailed design of the product. And sometime it can be a multi disciplinary design in which the engineers may be required from civil engineering, from mechanical engineering sometime from chemical engineering also for example, a paint factory a paint factory would require engineers from mechanical civil and may be chemical engineering.

So, the overall product may require the inputs or skills of various sets or for various engineers. So, therefore, it is important we focus our attention on detailed design so that we come up with the design which is visible which is technical as well as economically feasible and which is profitable for the organization. And here number of tools will be used that we will cover on the subsequent discussion. Then the prototypes is made if the option is there then prepare a prototype and test it and for prototyping these days, as I have already told rapid prototyping is a in thing and there are number of techniques will for techniques which fall under the brought umbrella of rapid prototyping. Then the manufacturing of the product if the prototype is not made then follow manufacturing steps and solve manufacturing problems and assembly problems if any.

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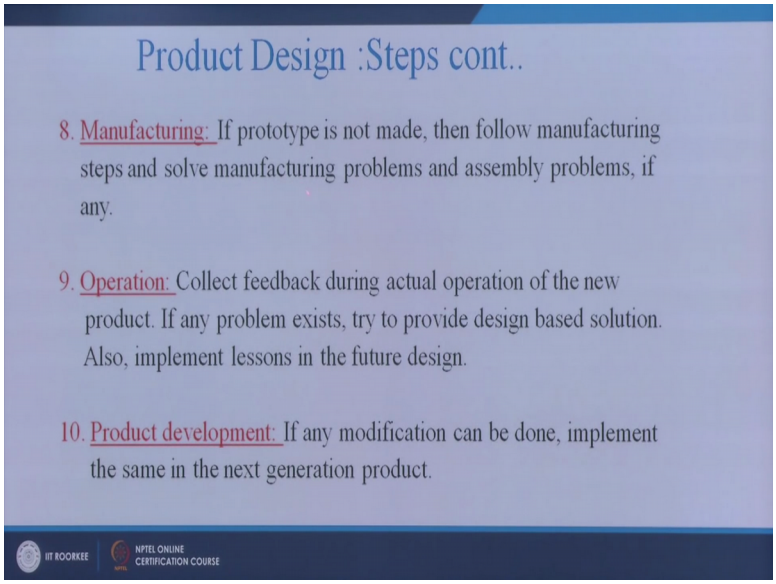

So, manufacturing problem and assembly problems will arise only if we have not taken care of the DFM or DFA or DFMA that is designed for manufacturing designed for assembly and designed for manufacturing and assembly principles at the first instance. May be when we if we take care of all these thing during the detailed design point of that, detailed design point or detailed design step all these problem will never occur during the manufacturing stage. So, this is the standard process therefore, we will try to iron out or smooth out or solve all the manufacturing problem assembly problem during the manufacturing stage, but these things can be eliminated or reduced if we make use of the product design tools at the very basic design stage of the product design process.

Then the operation once the manufacturing is done, product is launched in the market user start to use the product after that there is a operation collect feedback during a actual operation of the new product if any problem exit try to a provide design based solution also implement lessons in the future design.

So, continues feedback from the customers may a time you may have seen in that the automobile companies they take their vehicles back and do some retrofitting change of a component why because the component is faulty and that design is not as per the requirement and it is creating problem for the customer. So, they call the thing back and then the replace it that is what is highlighted here if any problem persist try to provide design based solution also implement the lessons in the future design. And finally, the product development if any modification can be done implement the same in the next generation product. So, product development process is a continues process and it will continue with passage of time.

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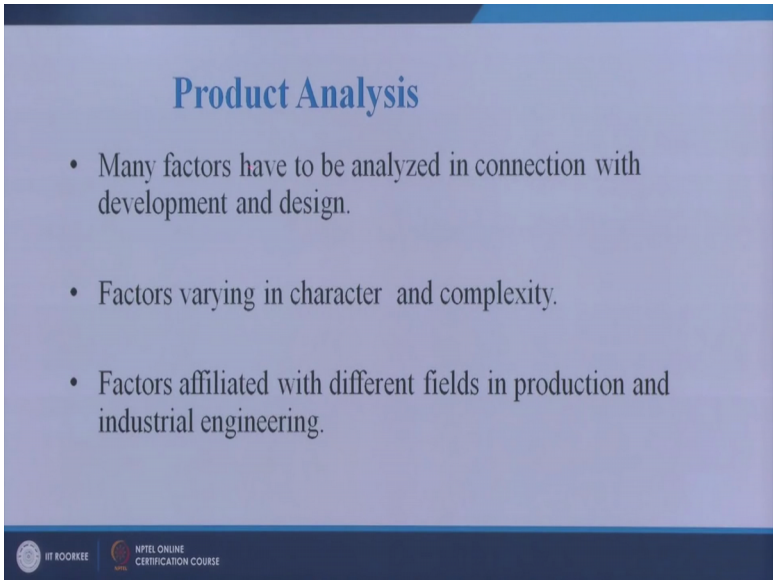

Now, the last part of our week one is product analysis quickly we will try to go through the product analysis process. Now many factor have to be analyzed in connection with the development and design factors varying in character and complexity. So, different types of factors are parameter are there we have we will see one by one and the factors affiliated with different fields in production and industrial engineering. So, these factors

may be related to the manufacturing or production or sometime from the management point of view that we usually call as the industrial engineering point of view.

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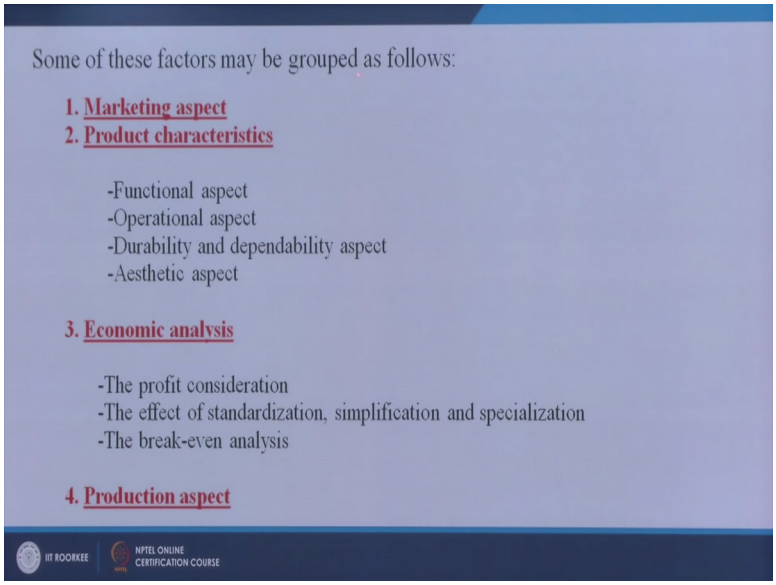

So, this is the brief summary this has be taken from a very common book or very most red book on production planning and control by the author Samuel Eilon.

So, this discussion is taken from that particular book and as per Samuel Eilon some of this factor may be grouped as follows. So, when we analyze a product we can at first have the marketing aspects then the product characteristics like in product characteristics we will see functional aspects, operational, durability and dependability and aesthetic aspects. In economical analysis we will see the profit consideration the effect of standardization simplification and specialization the breakeven analysis and the production aspects. So, majorly the red colour points give the 4 major aspects that need to be studied related to the product analysis. Again I have reading marketing aspects product characteristics, economic analysis and the production aspects.

So, in a on a broader scale when you are analyzing a product we have to keep in mind all these 4 parameters. So, we will try to go to the one by one. Now in marketing aspect once the product is selected then it is very important to know the marketability of the product that is whether it is a there exists the demand for that product in the market or it is just may be the fancy of the promoters of the company that they want to come up with the product. So, marketability is important all further steps are dependent upon the

demand of the proposed product and customer acceptability of the product. So, the customer today the customer driven business environment. So, if customers are accepting that product then we should further go ahead and design the product accordingly.

If there is no potential market then it is wasteful exercise to design and manufacture the product. So, all the points can be summed up in one line only that as per the customer demand we should design and develop the product. Now if it give the answer of the following question what will give the answer the marketing aspects or the marketing analysis.

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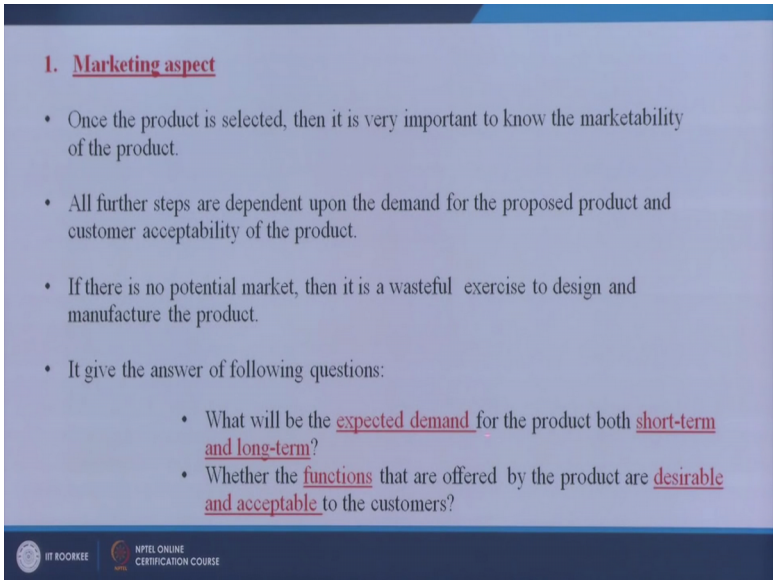

What will be the expected demand for the product both the short term and the long term demand? Whether the functions that are offered by the product desirable and acceptable to the customer. This should be the output of our marketing analysis or the analysis of the market that what is the demand and what are the functions which are expectable to the customer. And from the customer point of view also we can do a further analysis what is the age of the customer whether he is a urban or a rural customer or what is the education slandered of the customer.

So, from customer point of what is the demographic region from where we are taking the sample. So, from customer point of view also we can do further analysis in the marketing aspects. So, what was second aspect that is most important? That is the product characteristics. So, from product characteristics point of view first are the functional

aspects of the product that is when the marketing possibilities have been explored, the functional scope of the product has to be carefully analyzed and properly defined.

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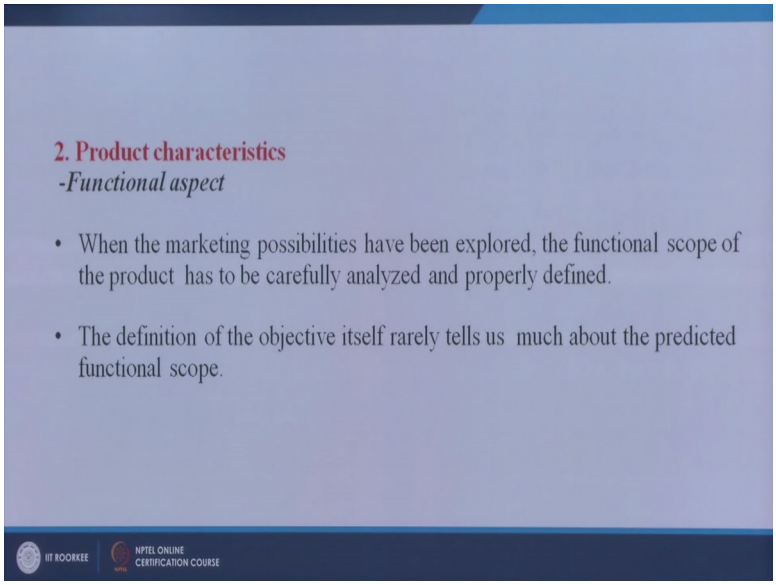

So, I am not going to delve too much in to the functional aspects why because we have one complete week on value engineering and in that value engineering part we will focus majorly on the functional aspects of the product design. So, the definition of the objective itself rarely tells us much about the predicted functional scope.

So, if we want if we say that we want we are going to take an example of a washing machine. So, if we say that washing machine the job is to wash the cloths it is one broad functional scope of washing machine, but it may further have sub functions also which we are going to see now. Now let us take the example this example is again from Samuel Eilon's book this is a functional aspect a washing machine for example, has a clearly defined objective to wash cloths which is the functional scope of the machine this does not state; however, how the washing should be carried out.

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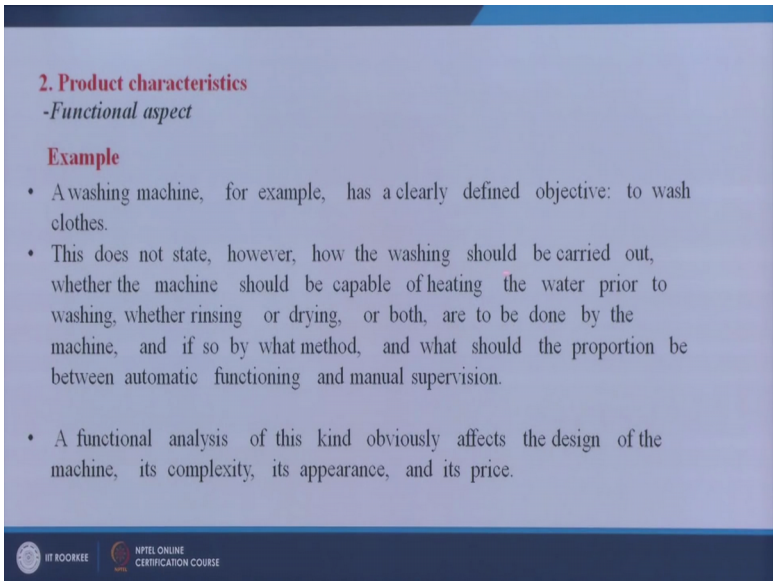

Whether the machine should be capable of heating the water prior to washing whether rinsing or drying is possible or both are possible or they are to be done by the machine and if. So, by what method and what should be the proportion; what should be the proportion be automatic functioning and manual supervision.

So, what we do we need to understand and here is the broad functional definition of a washing machine is wash cloths, but how to wash cloths whether using a hot water or a cold water or combination of both whether automatic, semi automatic. So, functional definition of a product is very very important because it will lead to the design of the product in the subsequent stages why because we have to use our engineering skills to map these functional requirements of the customer. Customer may give a 10 functional requirements we have to use the skills to map our engineering design with the functional requirements of the customer. So, functional require characteristics of any product therefore, become very very very very very very important.

So, the functional analysis of this kind; obviously, affects the design of the machine its complexity, its appearance as well as its price. So, when we satisfy the functional requirements of the customer we have to satisfy them with constrains on the complexity it should not become too complex the machine or the equipment or the part of the product, appearance should be good as well as the price should be competitive. So,

therefore, it is not easy to satisfy the functional requirements with all these constraint and therefore, we need to study the functional analysis of the product in much more detail.

Now let us see the operational aspects once the functions are satisfied the next stage is to make the product easy to operate for example, I am using this pointer. There are only three buttons here one is to be used for the pointer this red part moving on this screen. The other two arrows give the movement of the slider flipping of the slide most easy to operate a foolproof design easy to operate. So, whenever we are designing a product it should its operational aspects should also the taken into account for example, when you are driving a car on the gear liver your gears position of the gear is clearly marked. Suppose it was not marked then it will become a difficult proposition for any driver to operate the gear liver properly. So, the operational aspects of the product are very very important.

For example, the mixture grinder in mixture grander if the things are not properly mapped or not properly marked or not properly explained to the user the operation may become risky also because if you are putting your jar on the mixture grinder there has to be indication or the mixture grinder will only start when we have fixed it properly if the jar is not fixed properly on the machine the operation of start should not be possible. So, that is operational aspect that it should be easy to operate as well as it should be safe to operate.

So, in operational aspects when we are designing a product we have to keep these things in mind that is the product should be safe to operate as well as easy to operate.

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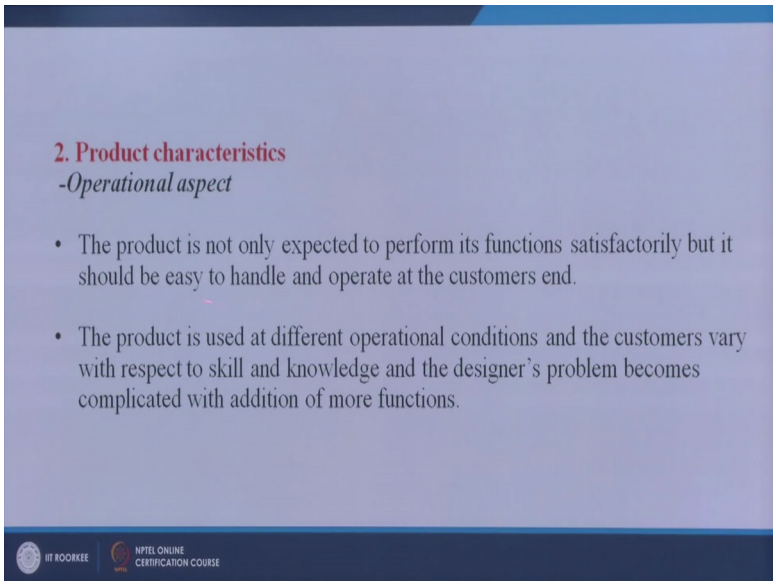

So, let us see now the operational aspects. The product is not only a expected to perform its functions which we have already ensured during the functional analysis stage it should not only perform its function satisfactorily, but it should be easy to handle and operate at the customers and it should foolproof design. If you take me a for granted the mobile phones if you buy nobody uses the manual that is given along set the mobile phone we start we take the phone and learn it just by a operating it. So, the operational aspects means that it should be foolproof design that person with a lower I q level also should be able to use that design and even a fool if he is operating the power should operated in the best possible man otherwise the product may fail.

So, foolproof design the Layman's definition I have tried to give you just to give you an idea that as a designer what are the factors are what should be a target that the product should not be misused even if the person is not aware of how to use a product. Many a time if you go to a hotel and stay there, there will be number of equipment may be a hair dryer or hot water cattle or they can be other products that are placed there.

Now, as a customer if I am going there I may not have used that product before, but the product design is such the handling is such that if we use your common sense you are able to operate that equipment or a machine. Many times I have seen I have heard a experienced all to also if you go to a hotel it becomes very difficult to find out that which that tap is for hot water and which tap is for closed water, but when this product has been

designed it is very easy to write c and h on the tap. So, that if the c can be indicative of cold water and h can be indicative of hot water. So, this is one basic principle of product design that when you are designing the product you should keep these thing in mind that it should be easy to operate as well as safe to operate.

So, second point on your slide you can see the product is used at different operational conditions and the customer vary with respect to skill and knowledge and the designer's problem becomes complicated with addition of more and more function. So, one point only combines 3 or 4 points together that is depending upon the customer skill and knowledge we have to design the product and if you keep on adding more and more and more functions to the product the operation may become slightly complicated and that has to be taken care by the designer during the design process.

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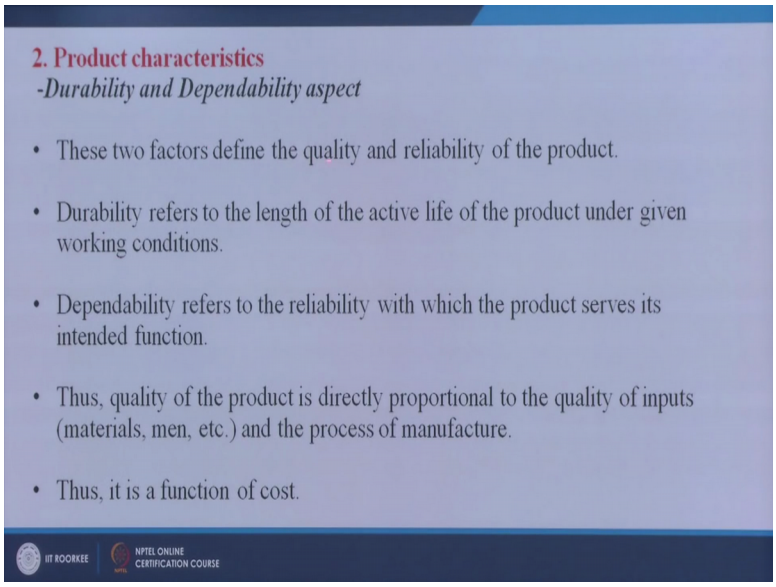

The durability and dependability, durability is in respect of time these two factor define the quality and reliability of the product. Durability refers to the length of the active life of the product under given working conditions. So, it is in respect of time suppose we are buying a jacket. So, we would expect it to function may be for 3 or 4 your duration. So, that it becomes the durability of that jacket similarly dependability refers to the reliability with which the product serves its intended function.

For example, we take a match box if all 50 sticks are able to light up we will say yes this is the dependable organization or dependable company which is manufacturing this

match box because all 50 match sticks have lighted up. On the other hand suppose only 20 match sticks light up for that match box we will say not a very dependable product because only 40 percent or only 20 out of 50 match sticks have been able to light up. So, that is a basic definition of dependability.

So, you have durability you have dependability. So, if the product is both durable and dependable we will say yes it is the product of quality and good reliability. Thus the quality of the product is directly proportion of the quality of the inputs and the process to manufacture.

So, here these two points also influence the type of material that is being used or that is going in to the manufacturing of the product. Thus function, thus it is the function of cost. So, durability dependability is a function of cost. So, a product may be more and more and more durable that the cost will also increase simultaneously. So, we have seen that first we have to addressed the functional scope of the product then we have to ensure that it is easy to use it is safe to use and then we have to ensure that it is durable as well as it is dependable and finally, we have to see that aesthetically it is placing to i.

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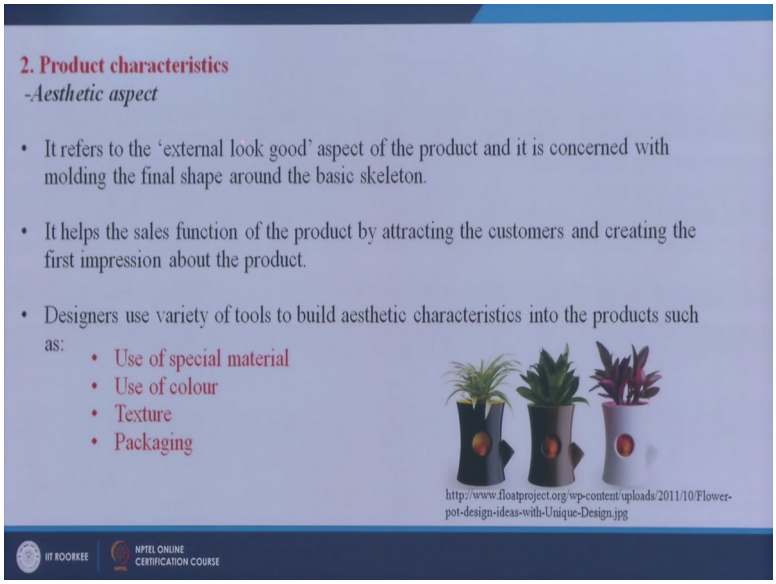

So, aesthetically means it refers to the external look good aspects, externally look good aspect of the product and it is concerned with molding and final shape around the basic skeleton.

Most of the time we will see that our bridges are standard run of the main functional scope only satisfy a bridge just to cross the river, but in many western country now in India also we will see some of the bridges are very beautiful designs. So, the basic functional scope is to provide a passage to cross the river, but sometime the design is such that it looks pleasing to the eye. So, that basically is the aesthetic aspects of the product design. So, it is a external look good or it should look pleasing to the eye it helps to the sales function of the product by attracting the customers and creating the first imprecation about the product.

So, aesthetic aspects are also equally important in product design. So, product will function properly as well as it should not look good also and the designer use variety of tools to build the aesthetic characteristics into the product. Such as now I will design for example, this plus this particular product again I am taking this example may have been white in colour, but in order to give it a executive look black pigment may have been added to this polymer to make this product. So, you add colours some time you provide a particular type of surface finish in order to make it look pleasing to the eyes and if it is if it is pleasing to the eyes a customer may be attracted to by the product. So, sometime the designers use spatial material they use colour, colour, colour combination texture may be given to the surface and some time the packaging is done in such a way that aesthetically the product looks appealing.

So, it is not only the functional scope or the operational scope or the durability and dependability, but it is also the packaging that matters. So, that is you can say the product characteristics related to aesthetic aspects.

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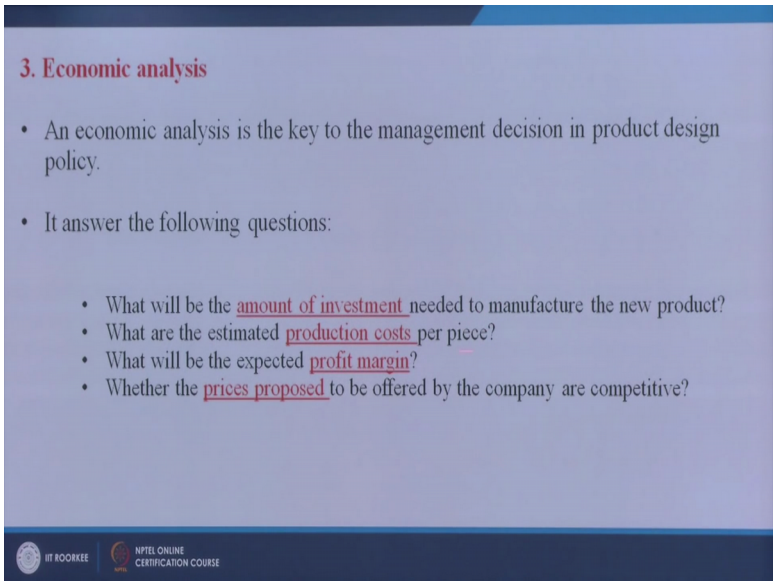

Then the economic analysis you can see, during this analysis we need to address these answers what will be the amount of investment needed to not only manufacture, but to design and manufacture the new product, what are the estimated production cost per piece we need to calculate, profit how much we will get and whether the prices proposed are competitive in the market or not.

So, all these things have to be done had by economic analysis stage. As I have told you that there are four major stage is first are the marketing aspects, second are the product characteristics, third is the economic analysis and fourth are the production aspects that we have to take into account. And currently we are focusing on the third one, one is marketing we have already seen product characteristics we have already seen third one are the economic aspects that need to a answer all these questions during the economic analysis that is what will be the amount of investment production, cost per piece, what would be the predicted profit margin and what are the prices proposed and how they are competitive with the prices of the other products or the competitive products.

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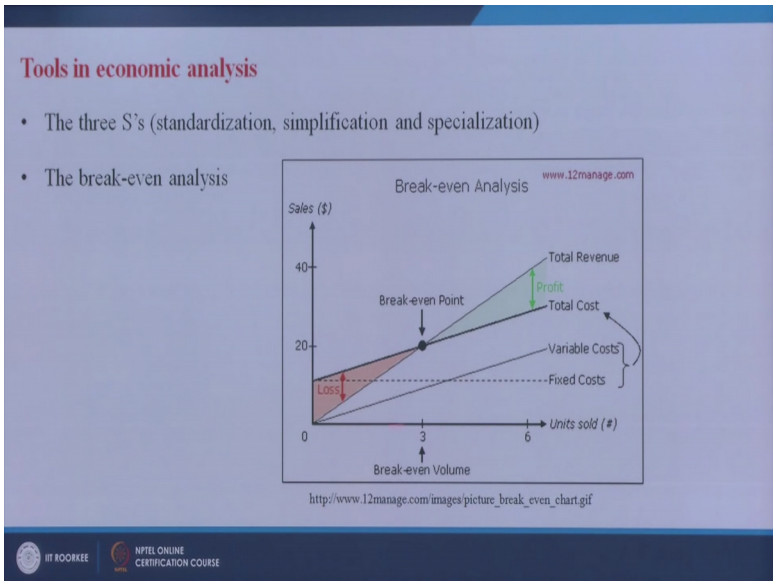

Now this is the tools in economic analysis many times we use the break even analysis as a engineering tool it is start in various engineering economic versus in all across our engineering curriculum or engineering discipline. Most common tool breakeven point, during economic analysis we can even do the break analysis we can have a total cost curve here you can see I am just revising there is a fixed cost line which remains fixed infrastructure cost and other cost, then there are variable costs then there is a total cost curve total revenue curve and where the total cost curve cross is the total revenue curve that point in is called as the breakeven point or no profit or no loss point.

So, usually the company do the analysis do the all calculation, they have the data related to the fixed cost, they have the data related to the variable cost and then based on the total cost and the variable cost they draw these to total cost line the sales volume multiplied by the profit per product will give you the total revenue if it is not profit it can be you can see the total revenue can be the number of product sold multiplied by the cost of the product so that we will give you the total revenue. So, you have a total revenue line you have a total cost line and a breakeven point and y axis are the sales and z axis is the volume.

So, we want to find out at what volume we will reach a situation where we will start making profit because here you can see that below the breakeven point or less this direction when the unit sold is less than the break even units you are under loss because

the total revenue line is less than the total cost line, but after the breakeven point you can see the total revenue line is above the total cost line that is you have a profit area here.

This is a standard method standard technique which is taught to all engineers across all discipline in all engineering issues. So, we are not going to delve much into this, but the only point to explain here is, during the economic analysis or for preparing a business plan for a particular product or idea we need to calculate this breakeven point that after how many number of units sometimes we can say after how many years of manufacturing we will be able to start making profit. So, one of the important tools of economic analysis.

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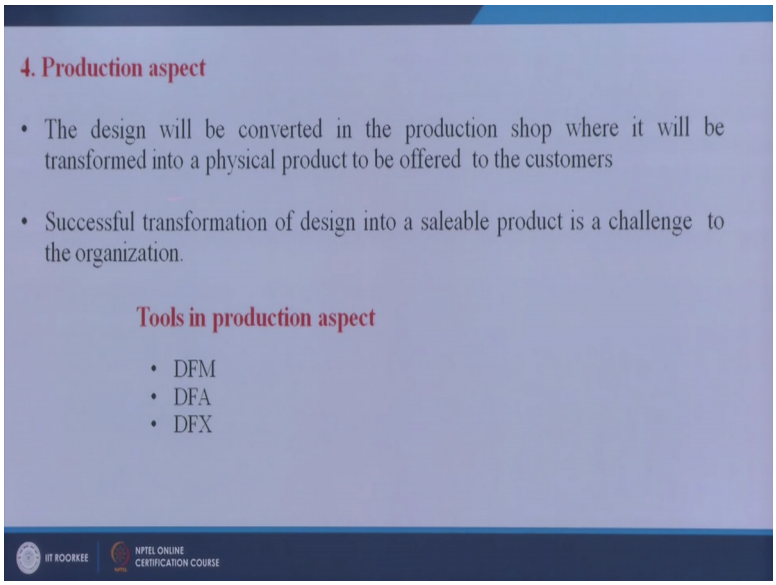

So, then the last part are the product aspects we have seen the first three that is marketing aspects, product characteristics and the economic aspects, the last are the production aspects the design will be converted in the production shop where it will be transformed in to a physical product to be offered to the customer. So, idea now can be converted into the product using standard manufacturing processes sometime advanced manufacturing processes also.

The successful transformation of the design into a saleable product is a challenge for the organization. Even we take into account all the factors that we have covered in the last two and half hours still sometimes it may become impossible for a company to lunch a successful product, but certainly if we take into account all these factors our decision will

be a informed decision, it will be a logical decision and it will help the company to at least reach its target of being breakeven that they may not be making lot of profit, but at least they will be able to recover the cost that they have invented in the whole process or product design and development.

So, at production stage there are few engineering tools that we will cover during our next lectures those will be designed for manufacturing, designed for a sampling and designed for x. So, we will see all these tools in the subsequent classes. In week 3 we will see the basic details of these tools with some examples that how these tools have been helpful in lunching a successful product in the market or the how they have been helpful in you can say simplifying the process of design

So, with this I thing we have come to the end of week 1 in which we have taken 5 lecture or we have discussed 5 different aspects of product design starting from the need of the product design to the product life cycle to the product policy of an organization to the product design process and finally, the factors or the characteristics or you can say the objectives to be taken in to account when you are designing a product. In today's class we have seen that what are the various steps or product design process and what are the various factors or you can say characteristics that we need to take into account in contest of the product design.

So, with this we come to the end of week 1. In week 2 our focus will be on value engineering aspects and I will try to introduce the various case studies or application areas of value engineering and that would be a important week for all of you why because whatever we have discussed in week one is mostly covered as a curriculum course in many of the engineering institutes in India, but value engineering is not covered at under graduate level. So, those two and half hours of discussion we will be very very very very relevant and important for all of you. So, maybe we will meet again next time and start our discussion on value engineering.

Thank you.