**Industrial Engineering**
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**Module - 4**
**Lecture - 14**
**Product Design & Development**

A very warm welcome to all of you in this lecture on product design and development. Product design and development is one of the most important activities of any business organization. Business organizations or manufacturing plants or factories are only surviving because of the products that they are manufacturing. Every now and then a company has to relook into its business environment it has to see that how the products that it is manufacturing is faring in the market or how much market share has been captured by their products.

We see every now and then in the advertisements that most of the companies are coming up with new and new products or the enhanced versions of their old products or a modified versions of their old product. So, all the time new and new products are coming modified products are coming. So, the science and engineering which involves the design and development of these products is called product design and development.

So, we will see, in today's lecture a lot many different aspects which are directly or indirectly related to product design and development we will see that what are the factors we have to cover when we do a complete product analysis? Then we will see that when the design is ready we have to select a material which would be used to fabricate or manufacture or in our language we can say develop that design.

So, what are the factors required in selection of material that we will also see then we will see that a material has been selected we have to select a manufacturing process in order to make that product into reality or the design into reality will be done by the manufacturing process. There we will see that what are the factors to be considered in the design? In the selection of the manufacturing process thereafter we will see that there are certain tools and techniques for rapidly making the prototypes. So, we will see 1 particular process for rapid prototyping also.

So, let us see we have, so many things to cover. So, I may not be a explaining all the points in too much of detail, but whatever I will say would be very clear and you will be able to understand it very easily. Now let us first talk about the introduction I will read it for you.

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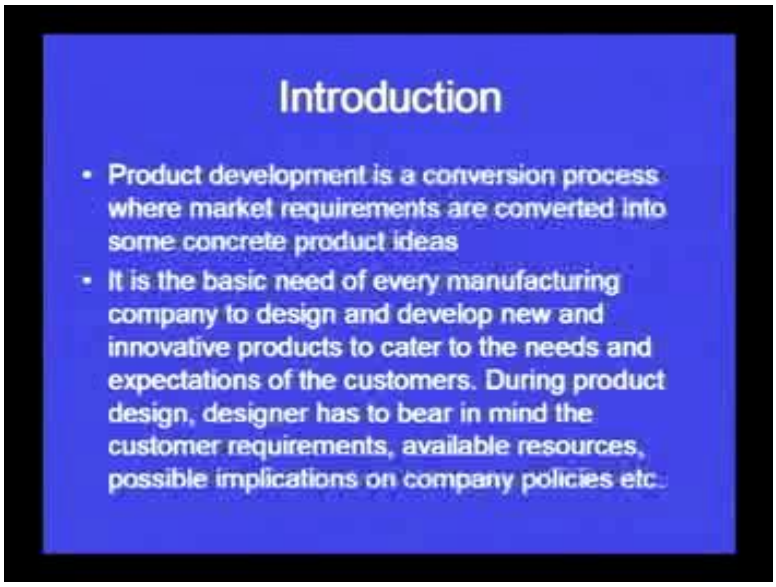


Product development is a conversion process where market requirements are converted into some concrete product ideas. So, there is a market requirement for a particular type of product and in product development that need or demand is converted into the product idea. It is the basic need of every manufacturing company to design and develop new and innovative products to cater to the needs and expectations of the customers.

So, whatever I am reading is very clear for all of you. During product, during product design, designer has to bear in mind the customer requirements, available resources, possible implications on company policies etcetera. So, basically keeping in mind the customer's demands or customer's expectations the company takes a decision to launch or to modify a particular product. So, basically this type of development activity is taking place on the basis of the demand and the expectations of the customer. Now this diagram very well explains what we have seen in the very first slide?

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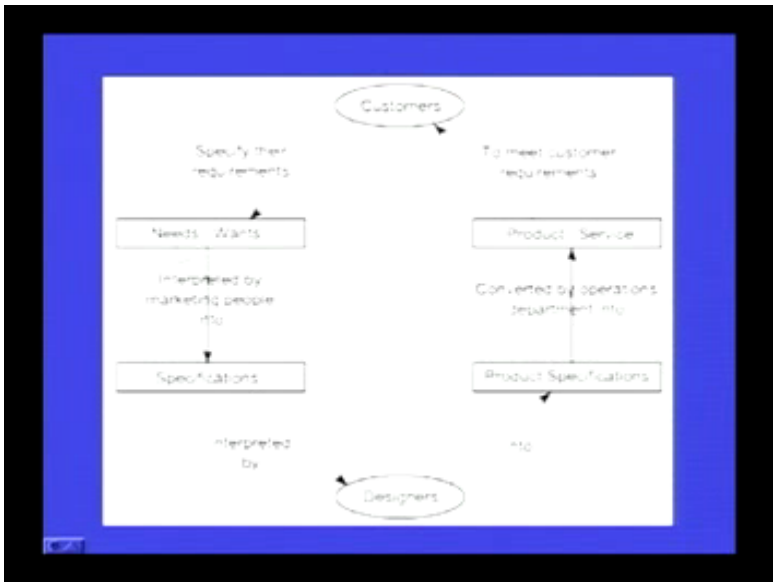


The customer is specifying their requirements. So, customer says I need this product of this color, of this size and in this much quantity then specification is set by the customer what he requires and then needs and wants are studied by the company personnel or the marketing personnel of the organization or of the industry. Then these needs and wants of the customer are interpreted by the marketing people which already I have said and these are converted into the specifications. Now these specifications are interpreted by the designer.

So, where the designers are getting the feedback, so this diagram very clearly explains the feedback to the designers is given directly by the customers through the marketing personnel. So, the customers they need a product they specify their requirements their needs and wants are studied by the marketing personnel and then they are converted into the specifications which are given to the designer or which are interpreted by the designers.

Now, whatever information the designers have whatever, knowledge they have developed they transform those specifications set by the customer into the product specifications. And these product specifications or the design which is ready is converted by operational department or operations department into the product or the service and this is finally, used by the customer. So, this product service is, so designed and developed to meet the customer requirements.

So, you can see with the help of a very simple diagram we have been able to completely understand the basic process of product design and development. So, what basically is happening customer is specifying some requirements the designer is keeping those requirements in mind and he is designing the product and when he is designing the product he is specifying certain specifications for that product. And then that product according to those specifications is manufactured by the manufacturing people or the at the manufacturing plant of the organization and this product is then finally being used by the customer. But this seems to be very simple, but this is a very risky business why this is risky business that we are going to see in next slide.

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So, on your screen you can see that this product design and development is a risky business, why this is a risky business? We will see. Most of the product ideas which go to the product development stage never reach the market. So, product ideas are there, but most of the cases they may not be able to reach to the market why? Due to non availability of money, technology, manpower or due to change in the demand, so these 4 factors may lead to the death of many product ideas. What are those factors?

That is non availability of money, money is not there to develop that idea into a tangible product. Technology is not existing the need is there the design is there, but there is no technology to manufacture that product. Manpower or skilled manpower is not there or there is a change in the demand. Initially there was a customer specification or needs and

wants of the customer dictated the development of the new product, but somehow the demand changed the customer specification changed.

Then this product idea or the design that has been made cannot be finally, developed into the product. So, most of the product ideas which go to the product development stage never reach to the market due to non availability of money technology manpower or due to change in demand. So, we have developed idea the design is ready development may take place, but it is not reaching the market what is going to be the implication of this.

The company has invested a huge amount of money; in all this process and finally, when the returns have to come the returns are not finally, coming. So, this becomes a very risky business. Then the second point is many products that do reach the market are not successful mainly due to inferior quality, high product, cost poor, functionality poor, marketing skills or change in demand. Then even if the product is able to reach the market still it is not certain that it would be making profit still there may be a failure why that failure may take place? That is already there on your screen.

So, you can see it may fail due to inferior quality or the cost may be high or the functionality is not that good the competitor product are more functional as compared to our product poor marketing skills it has not been advertised properly or again the change in demand. So, the demand is not there for the product in the market again it is a risky business. Then successful product stand to have a shorter life due to change in demand stiff competition or rapid technological changes.

Now, even if the product becomes successful still it may have a shorter life why? Because the demand of the customers always keep on changing moreover, there may be stiff competition from the competitors who are also manufacturing the similar type of products or there is a technological breakthrough and a advanced version of the product is already there in the market.

So, even a successful product may become obsolete. So, product design and development is not a very easy process we have to take into account a large number of factors in order to be successful in this type of activity. Now, what are the good product ideas where should we focus our attention.

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So, the good product ideas basically are the product with a gap between demand and a supply can be considered as a potential product idea. So, basically this point specifies or it tells that wherever, there is a gap between the demand and the supply. So, demand is there, but the supply of that particular equipment item product or service is not there. In such cases we may think of that product as a tangible product we can think that this is a feasible product in which we should put some efforts.

So, the demand for that product is there, but the supply of that product is not their there exists a gap then we may decide that yes this is a good product idea, we should always think of developing designing and developing this type of a product. Then if, some of the ideal resources of the plant can be used to manufacture a product, it can be considered a potential product idea. So, within the organization there may be some facilities which are not being used.

So, if we can use those facilities in order to design and develop a product may be designing can be done by the design team and those facilities can be used for developing that product or manufacturing that product. We may say yes it is a fairly good idea because otherwise, also those facilities are not giving us anything. So, if we can use those facilities to make a product which can have certain amount of market share we can say yes it would add to the revenue of the organization, then if a product can reduce company's dependence on a select customer base.

Now, it may. So, happen that the company is having a selected customer base and if that customer base switches their loyalties to some other product then the company is left with no other alternative, but to shutdown. So, if an idea or a product can be there which can make the company independent of that customer base that selective customer base that can be a good product idea it can be selected as a potential product idea.

So, if a product can reduce company's dependence on a selected customer base, it can be selected as a potential product idea. Then sometime good product ideas may come from our environment like friends, co-workers, etcetera. So, this is highly unlikely that only the product ideas are going to come to a few individual. If you are open to conversation open to discussion, so many new product ideas may come to our mind or come to the company or come to the organization which can be pursued for carrying out the further business activity on those ideas.

Now, once we have identified that we have got a idea that this product has to be developed then we have to think of the complete analysis of that product. So, we have seen that always there is a risk involved in product design and development then we have seen that yes there are certain circumstances, where some good product ideas may come. Then when we identify that yes we have certain good product ideas available with us then we have to go for a complete product analysis.

Now, in product analysis we have. So, many different points that have to be taken into account. These points are basically very important and summarized points there may be some other points which may have to be considered in product analysis. So, we will consider 1 by 1 that; how these points have to be taken into account?

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So, the very first point is the market potential. So, here I would like to address the word potential we have to see, that the product that we are designing or that we are thinking to design does it has substantial potential in the market will it go into the market and capture certain amount of market share. Have we done sales forecasting? What are the forecast? What is going to be the demand for this product in the market, in different demographical zones? What is going to be the demand or the sales of this product.

So, market potential is very important. It may, so happen that we design a product we develop a product we launch it into a market and it is not being sold in the market the company may run into losses. So, first important point is that whatever, we are manufacturing it should be consumed in the market. So, market potential is one of the most important points that has to take into account. Then the second is the product life cycle. Some products may have a shorter life cycle, some products may have a longer life cycle. So, in this point the important thing is to first understand that what do we mean by a product life cycle.

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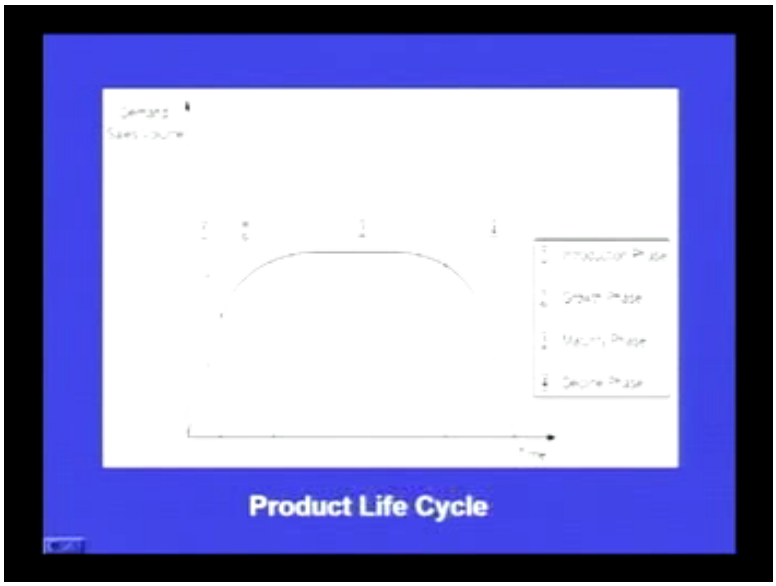


Now, on your screen you can see this is a product life cycle. Which shows that the demand or the sales volume varies with time on x axis we have time; on y axis we have the demand or the sales volume. So, demand and sales volume is varying with time in this particular fashion. We have different phases first phase is the introduction phase, second phase is the growth phase, third phase is the maturity phase and fourth phase is the declined phase.

Now, when the product is lunched into the market or introduced into the market there is a sudden increase in the demand then in the growth phase also the demand or the sales volume increases. Then comes the maturity phase in which the demand becomes more or a less stagnant or the saturation point is reached. This saturation point may reach may be reached because of stiff competition by the competitors or by the launch of certain new technologically higher level products by the competitors.

So, we will reach to a level of maturity. And finally, the decline phase where the demand decreases or declines with the passage of time or we can say this is the death of the product. So, here we have the introduction of the product in the market here we have the death of the product. So, each and every company would like to keep most of its products, if it is producing a variety of products in the introduction or the growth phase only because here the demand is increasing.

As soon as a company has all its products at this particular time or this particular time scale it has to seriously think of redesigning or launching new products into the market because its products are at that stage of their product life cycles where they are going to die or their demand is going to decrease. So, we can see that the product life cycle is very important we have to take into account the product life cycle of the product. That whenever, this product would be designed and developed what is going to be the product life cycle of this particular product? Whether it would be a shorter product life or it would be a longer product life cycle and according to that we have to do the analysis.

Then the third important point is the competition. Here we have to take into account that the product that we are developing how it fares or it competes with the products which are already there in the market. What is the functionality of those products? What is the cost of those products? What is the quality of those products? And then we will compare the design that we have made that we are going to launch into the market with the competitors products.

And if, we feel that our product is better than the product of the competitors then only we should carry forward our product design and development activity. Then the fourth point is the customer needs. A, company always have to take a decision that according to the customer need it may have to produce a large variety of products, because every customer for a same product would have different specifications. Somebody would like certain sizes certain colors or certain shapes some other customer may have his own specifications.

So, a company always have to adopt a policy that whether they are going to satisfy each and every demand or each and every want of the customer or they are going to focus on certain standardized items or products. And then with aggressive marketing they are going to tell the customer that this is what we have got for you? And this is the best product for you. So, customer's needs also have to be taken into account whenever we are thinking of a new product or a modified product design and development.

If we say that we are going to take into account the customer's need in a detailed manner each and every customer's need would be taken into account. The variety of the products that the company has to make would be very high or it may reach to a infinite value, and then the production activity would become very complex. So, a company policy is very

important taking into account the customer need that whether they are going to provide the customer with what he wants? Or whether they are going to tell the customer that what is good for him?

Similarly, the operational aspect of the product should also be taken into account. Sometime it, so happens that the actual operation time, is considerably less than the setup time and the cleaning time. So, we have to design and develop the product in such a manner. So, that the operational time is a substantial amount of the total cycle time. So, the operation should also be very simple full proof operation should be there. So, this aspect also has to be taken into account while we do the product analysis.

Similarly, the durability and dependability aspects also, have to take into account in product analysis. Now, durability and dependability are very simple words. Now, durable means that product should be able to perform satisfactorily for the period for which it has been designed and dependability in very simple terms it means: that a product should be able to perform its function whenever, it is called upon to do so. So, these aspects of product should also be taken into account that it should be a durable product it should be a dependable product, but the most important analysis that has to be done related to the product is the functionality analysis.

So, from functionality analysis point of view always the focus is to improve the functionality of the product, but the cost should not increase or we want to keep the functions of the product constant, but we want to reduce the cost. So, very important term in case of doing the functional analysis of the product is value engineering. So, we are going to briefly discuss that what is the meaning of value engineering? And how it fits into the product design and development?

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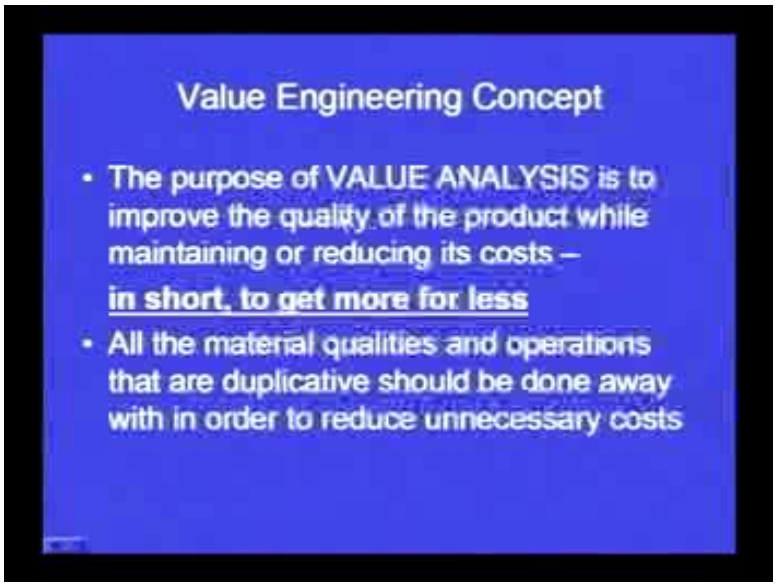


Now, what is the concept of value engineering? The purpose of value analysis or value engineering is to improve the quality of the product while maintaining or reducing its cost. So, from quality we can say functionality is also one of the aspects of quality. So, improve the functionality of the product while maintaining or reducing its cost. So, in short to get more for less.

So, we want more functionality more value of the product, but at a considerably lesser price. So, all the material qualities and operations that are duplicated should be done away with in order to reduce the unnecessary cost. So, how we are going to do? Value engineering to a product. We would focus on the areas or operations or materials where we are unnecessarily spending the money and we would try to address those particular areas and would like to minimize our investment in those areas. Now, value engineering concept we have already seen what do we mean by value engineering to get more for less.

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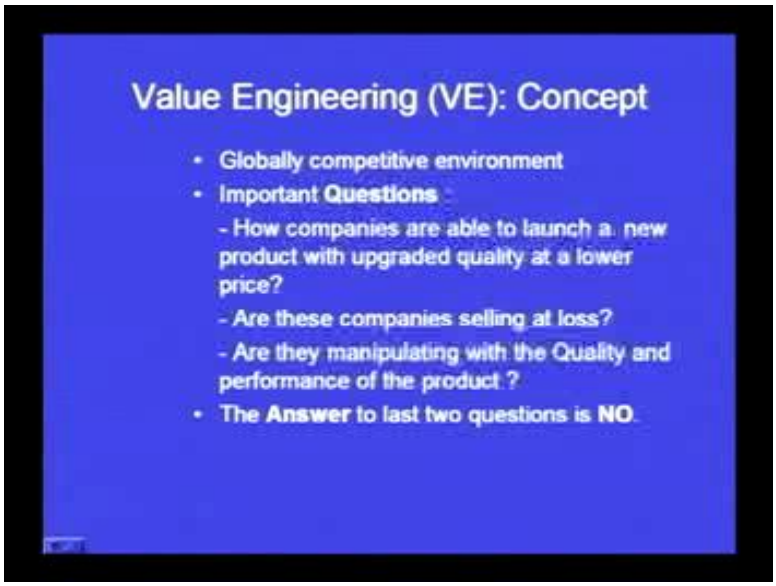


So, usually in globally competitive market what are the important questions? How companies are able to launch a new product with upgraded quality at a lower price. So, we have been seen, we have being seeing this thing. If we take an example of a mobile phone the costs usually reduce or the price usually reduces we have seen that a product is launched in the market after 6 months its price falls. Why that is this is happening how companies are able to launch a new product with upgraded quality, but at a lower price are these companies selling at loss.

So, no company would be selling at loss each every company would like to make as much profit as possible. Or are they manipulating with the quality and performance of the product no the answer to the last question is no or the last 2 question is no. So, what are the last 2 questions? Are the companies selling at loss? No, No company is selling at loss similarly they are also not manipulating with the quality and performance of the product.

So, what is happening is? That the companies are launching new products in the market, but the rate is reducing. How the rate is reducing that we that we will see when we understand value engineering. So, they are not selling at loss, they are not manipulating the quality, they are not sacrificing the performance of the product, but using certain standard techniques we can certainly think of reducing the total costs involved in

manufacturing the product and thereby we can reduce the selling price of the product. What is value engineering basically? Is it cost reduction? Is it item elimination.

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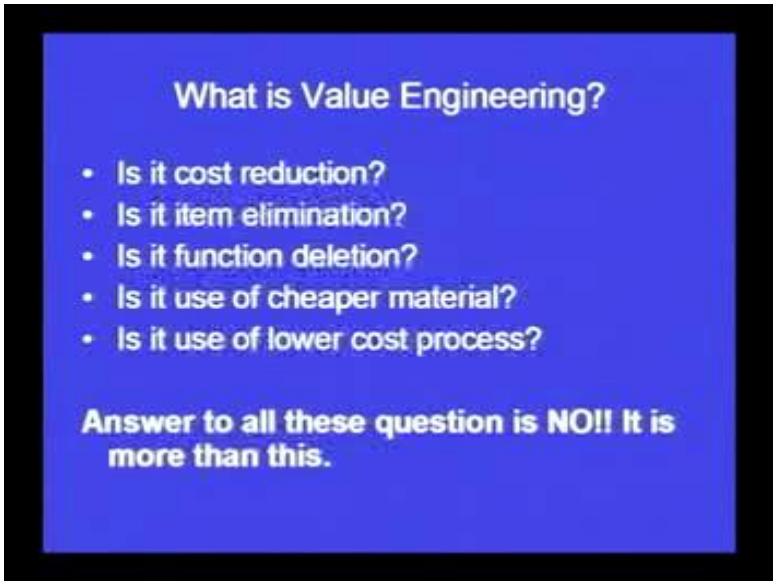


So, is the value engineering cost reduction? So, there is a difference between value engineering and cost reduction which we may not be covering in this particular lecture, but if as specified lecture is taken on value engineering or a detailed discussion is required on value engineering we will see that what are the salient differences between value engineering and cost reduction.

So, value engineering basically is not cost reduction is it item elimination is it function depletion or function deletion is it use of cheaper materials? Is it use of lower cost process? So, sometimes it may, so happen that some people may argue that you reduce the type of or the quality of the material being used or you reduce the money that we are investing in the manufacturing process or you use a lower cost process to reduce the overall cost of the product or the overall selling price of the product. Answer to all these questions is no it is more than this. So, value engineering is not cost reduction, it is not item elimination, it is not function deletion, it is no use of cheaper materials, it is no use of lower cost process, but it is something more than that.

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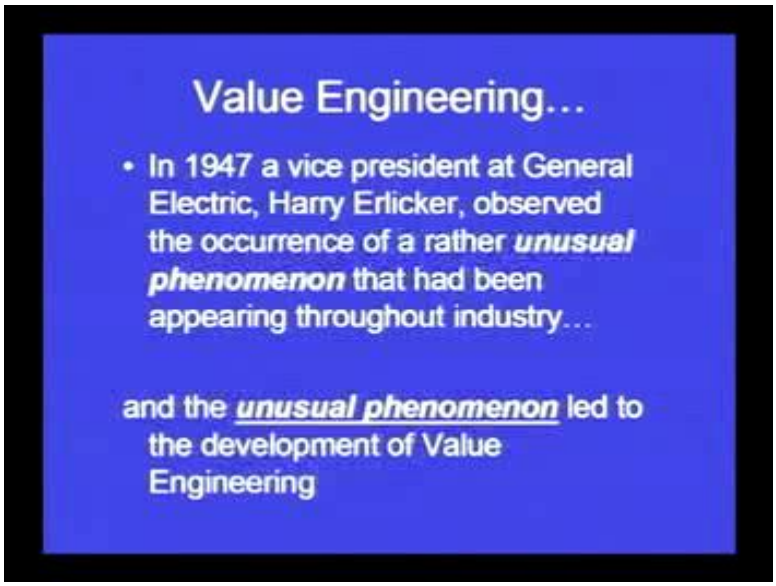


So, value engineering how it developed? In 1947 a vice president at general electric, Harry Erlicker, observed the occurrence of a rather unusual phenomenon that had been appearing throughout industry and this unusual phenomenon lead to the development of value engineering. Now, what was this unusual phenomenon. The unusual phenomenon was that after the world war it was observed that most of the equipment has been damaged or most of the machines have been damaged or most of the warplanes or the fighter tanks have been damaged also the design guidelines were lost.

So, these particular equipment, machines or warplanes were redesigned with certain additional specifications with certain additional type of materials, but the performance and the quality level was kept the same. The materials were changed the processes were changed and then these were developed again. It was observed that in order to achieve the same quality, same performance, same reliability the new designs are much better than the older designs.

So, it was found out that if this can be done in this hour of need why this cannot be developed into a full blown branch of engineering, which would lead into money making or profit making for the different organizations. So, the basic idea was that design and development was done in a different manner using different materials and different processes and it was done at a considerably lesser costs.

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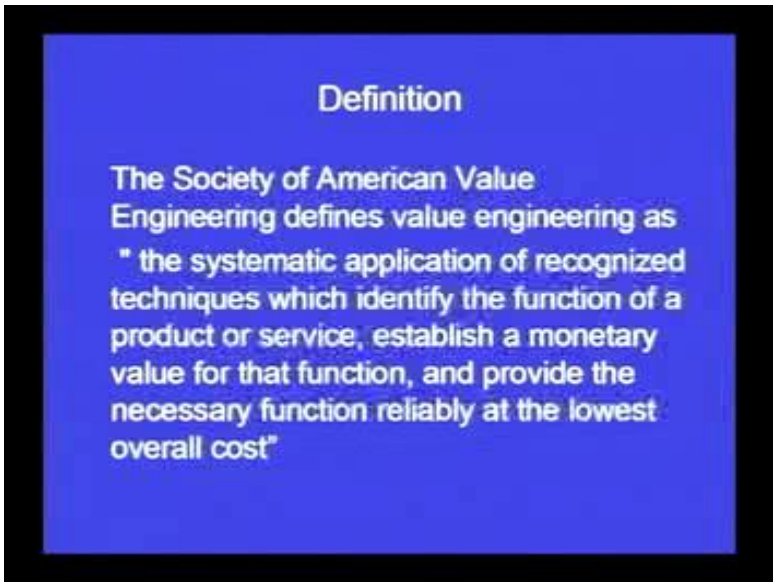


Now, let us see the definition of value engineering. The Society of American value engineering defines value engineering as: the systematic application of recognized techniques. So, it is a systematic application of the recognized techniques. So, techniques already have been identified there are certain standardized techniques of value engineering which are usually followed.

So, a systematic application of recognized techniques which identify the function of a product or service establishes a monetary value for that function and provide the necessary function reliably at the lowest overall cost. So, basically a function is identified a monetary value is associated and then that function is provided or necessary function is reliably provided at the lowest overall cost.

So, basically a function has to be achieved and how it can be achieved in the minimal possible cost that has to be ascertained in value engineering. Also it has to be seen that the function is achieved reliably or the function is provided reliably. So, once again I would read this definition for you. The systematic application of recognized techniques which identify the function of a product or service establish a monetary value for that function and provide the necessary function reliably at the lowest overall cost.

So, we are not compromising with the reliability, we are not compromising with the quality, we are not compromising with the performance, but still we are trying to achieve the function at the minimal possible cost. So, this gives us the very basic definition of

value engineering. Now, we come on to an important aspect that we call as the selection of materials. So, we have already completed the product analysis. In product analysis we have seen that we have to take into account, so many different factors what were those factors? Just to summarize we have seen the market potential customer needs dependability and durability, functionality and there were some other factors that we have considered.

So, we have done a complete analysis of the product and now we know that yes this product has to be manufactured. Whenever a design is being completed we have to specify the materials which would be used to make that design or to produce that design or to develop that design. So, whenever we have to select a particular material we have to consider a large number of factors. Now what are those factors that are considered in the optimal selection of materials that we are going to cover now, an ever increasing variety of materials.

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So, variety you can see has been highlighted, large number of type of materials or large number of material are available out of which we can choose the most optimal material for our product. So, an ever increasing variety of materials are now available, large number of materials are available even new and new inventions and discoveries are taking place in the field of material science and engineering.

So, a large or ever increasing variety of materials are now available each having its own characteristics, each and every material will have its own characteristics, it will have its application areas advantages and limitations. Now, so many different materials are available out of which we can develop our product, each and every material will have its own characteristics, advantages, limitations and application areas. So, we have to make a judicious selection that which material we have to use in our product or in the development of our product.

So, the challenge is to select the optimal material according to the requirement now the, product is being developed for a particular requirement. Suppose, a product is being developed for underwater applications then the material would be selected accordingly. If a product is being developed for aerospace applications then the material would be selected accordingly. So, each and every material will have its own characteristics, advantages, limitations and application areas. So, what are the different types of materials out of which we can choose a specific material for our product that we are going to see now.

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So, the variety of materials, are we may choose from ferrous materials or ferrous metals we may have nonferrous metals like: aluminum, magnesium, copper, nickel, titanium. We may choose from plastics we may go for thermoplastics we may go for thermosets as well we may go for ceramics and diamond, also we can choose composite materials

which are being widely used these days or we can go for nano materials or shape memory alloys. Also there are many other type of materials which are not there in this particular list which are being used widely in 1 or the other application areas.

So, we can see that the list is very long we have a variety of materials at hand. Now we have to see the product that we are designing and that we are planning to launch into the market what are the specific requirements of that particular product? Now, according to the specific requirements we will choose the most optimal material for that particular product, but there are certain factors which would help us in this judicious selection. So, let us see which are those factors, which are going to guide us or which are going to help us in making our selection?

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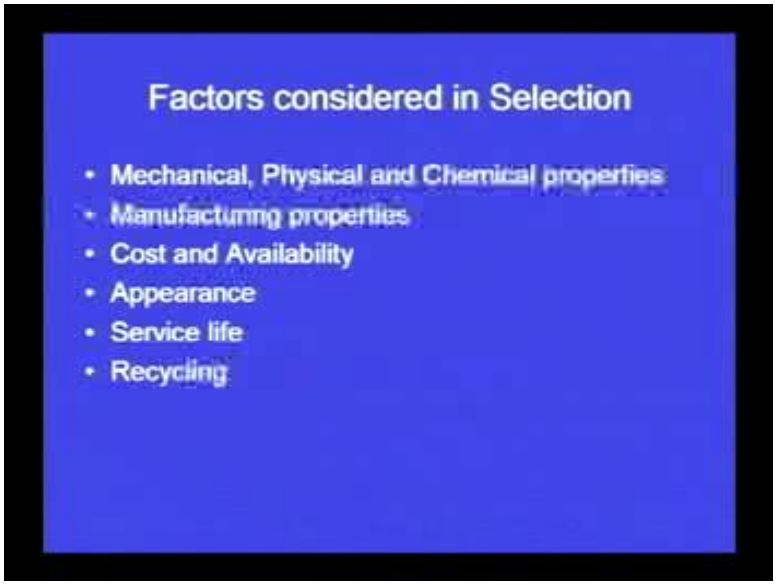


Now, the factors that are considered in selection of a appropriate or optimal material for the product are: mechanical, physical and chemical properties each and every material would have certain distinctive mechanical, physical and chemical properties. So, all these properties have to be considered in detail or exhaustive examination of these properties have to be done whenever a particular material is being used for the product for each and every material these properties would be varying.

Now, we have to see what are the requirements? Which are the properties that are matching to that requirement? And then we would be selecting that particular material. Then we come on to the next point that is the manufacturing properties. These properties

also have to been seen that if we are specifying a particular material, for a particular product then are or is the manufacturing of that material easy or it is difficult or we can also go to the extent of saying that whether it is possible or not.

So, the manufacturing properties of the materials also have to be ascertained. Then we have seen that mechanical, physical and chemical properties guide us in a right direction for selecting a material. Manufacturing properties of the material also help us to guide help us or guide us in the right direction of the optimal selection of the material. Then cost and availability issues also have to be looked into. Sometimes the designers may be specifying a material which is not available in our country then what is going to happen? We are not having material availability; we may not be able to launch the product well in time.

Similarly, the appearance is also very important how the material would appear in the final product. So, the final appearance of the material is also very important in the selection process of the material. Then the service life that what is going to be the service life? Now for example, a company always has to decide that the product that it is manufacturing or it is putting into the market should have a long life or a shorter life.

Now, let us take an example of a tooth brush, if a company makes a tooth brush and the bristles are having infinite life then nobody s going to go again and buy a brush. A brush once you have bought or a tooth brush once you have bought its life can be more than your life. So, no company would like to use such type of materials whose life is, so long why? Because, it is not, creating business opportunities for the company.

So, we have to see what is the service life of the product? So, the service life of the materials which are going to make that product has to been seen. That, if the life is more the product would be in the market for a longer time if the life is short, after certain amount of time the product would be reused or the product would be re-required by the person who is using that product. So, service life is also equally important Then the recycling aspects of the material are also gaining a lot of importance these days.

So, we have to take into account the, recycling aspects of the materials also. So, we have seen that so many factors have to be considered while selecting the most optimal material for our product. So, what are these factors? Just to summarize we will just read it out mechanical, physical and chemical properties of the material manufacturing

properties of the material cost and availability appearance of the material service life of the material out of, which we are going to make the product and the recycling of the material of which, the product is going to be made up of... Now, what is the criteria for selecting, so many different materials would be satisfying these requirements. So, what is the criteria for selecting the most optimal material?

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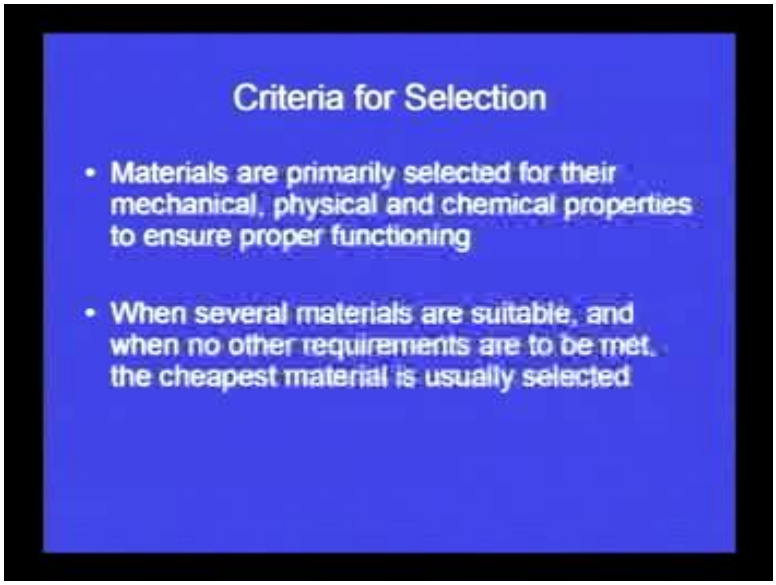


Now, the criteria for selection is that the materials are primarily selected for their mechanical, physical and chemical properties to ensure proper functioning So, the first criteria is that's the material should satisfy the mechanical physical and chemical properties or it should require, it should satisfy these type of requirements, so that the product, which is made out of that material functions properly.

So, first criteria or the foremost criteria is the mechanical, physical and chemical properties of the material. When several materials are suitable which I have already said and when no other requirements are to be met then the cheapest material is usually selected. So, then we go for the cost of the material. If all other requirements have been met then the cost of the material is the final deciding point or the final decision variable which is going to guide us for selecting the most optimal material.

So, till now we have seen that the product analysis is very important. So, many factors have to be taken into account in order to carry forward or carry the product analysis. We have seen once the design is ready. We have to select the most optimal material, we have

seen, so many factors have to be taken into account for the judicious selection of the material for the product.

Now, we are going to see that which manufacturing process should be used for manufacturing this product or the product that we are launching into the market material is also freezed, we know this material will be used for making a product.

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Now, the selection of the manufacturing process, the manufacturing process is selected primarily based on the following factors. Material of the product, now we have already decided that this is the material which is we which would be used to make the product. Now, the material we know on the basis of that material we will see that which are the manufacturing processes, which are feasible for converting this material into the final part or the final product.

So, the material that we have selected is going to guide us towards the selection of the manufacturing process. Also the shape of the product, the product may be very complex or the shape may be very complex in nature then we have to choose a appropriate manufacturing process. If it is very simple the shape is very simple we may choose a different manufacturing process. Also the size of the product is also going to guide us in the appropriate selection of the manufacturing process.

Similarly, the volume that what is the quantity that we are going to produce, that is going to guide us in selection of the manufacturing process. So, some processes may be feasible economically justifiable for small quantity some processes may be economically justifiable for large quantity. So, the volume of the product or the amount of the product that we are going to launch in the market is going to help us in deciding that which manufacturing process should be used.

Also the quality requirements would be guiding us in the right direction what is the surface finish required? What is the dimensional accuracy that is required? What is the surface conditions that are required? So, all these things are going to guide us towards the optimal and the judicious selection of the manufacturing process. So, just to summarize these points.

Let us see what are the factors that we are going to consider in the selection of the manufacturing process. We would be considering the material of the product, also the shape of the product, relative intricacy or complexity we are going to see the size of the product, we are going to see the volume of the product, also the quality requirements from the product. So, then we will see that which process is the best manufacturing process for this product and we are going to adopt that process for manufacturing this particular product.

Now, we will see that once the design is ready we know that this design is to be fabricated or developed out of this material and finally, from the material we go to the finalization of the manufacturing process depending upon. So, many factors we go for prototyping. In the product design and development the next stage is the stage of prototyping, where we design and develop, a particular type of a prototype, which would be tested before the full blown production of the product can start.

So, a prototype would be made, which would be tested according to the requirements. So, for prototyping we have a new developed branch of science and engineering that we call as rapid prototyping. Now rapid prototyping, what is a prototype? Let us first understand the basics of the prototype.

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A preliminary and original full or small scale and usually functional version of something new design or construction that has been or will be copied or developed. So, this is something a fully functional version of what we are envisaging? What we are thinking of launching into the market? So, this is it can be of the same scale or it can be of a reduced scale for testing purposes. So, we make a model or a prototype and do our testing. So, prototype we know now what do we mean by a prototype? Now, what do we mean by rapid prototyping that we are going to see in the subsequent slide.

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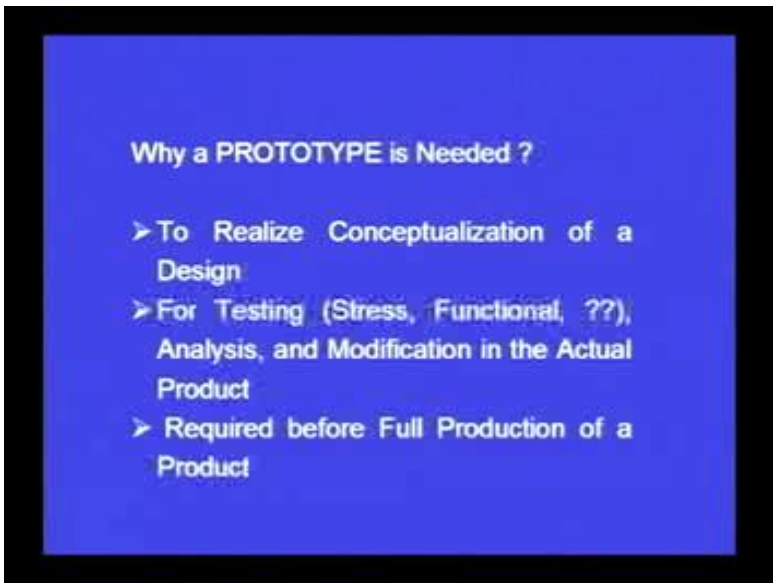

Let us first try to understand that why a prototype is needed to realize conceptualization of design. So, basically we have a particular design available with us that we want to launch into the market. Now we want to see that how exactly our design would look like. So, to realize the conceptualization of design, we need a prototype for testing which already I have told that prototypes or models are for testing purposes.

So, we would like to see that what type of stresses it can bear? Or what type of functionality it has? So, for that purposes we need a prototype. So, analysis and modifications in the actual product can be done, if the testing has been done on the prototype may be certain in certain cases it may fail under certain requirements or certain circumstances. So, we would like to redesign or redo the design in such a way. So, that it does not fail under those operating conditions or environment.

So, prototype testing is one of the most important points in the product design and development cycle. Then it could be required before full production of a product is taken care of. So, when full production of a product has to been done before that we may make a prototype and see how it looks like: how is the concept? How it? And even it can be tested also. So, basically prototyping and testing is one of the important aspects which has to be taken care of in product design and development. So, it will also take some time. We do not want to spend too much of time in this particular process. So, we go for rapid prototyping. So, what do we mean by rapid prototyping?

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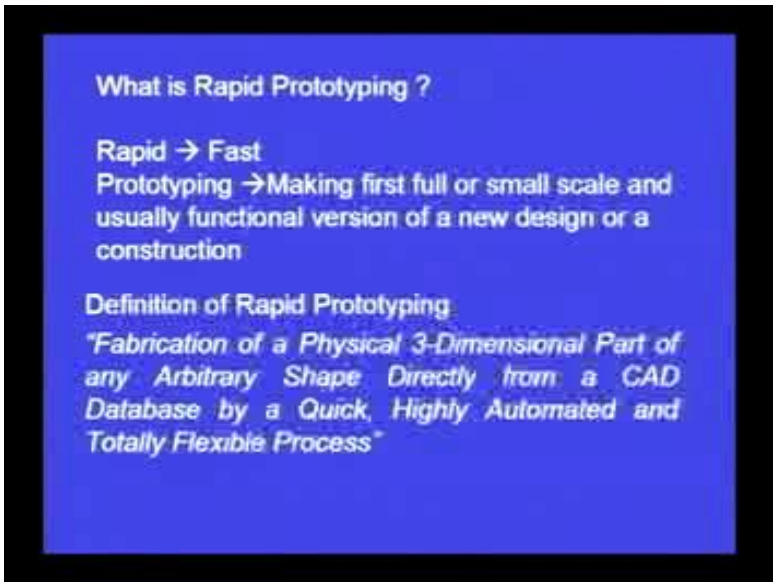

Rapid prototyping means, rapid means: fast and prototyping means: making first full or small scale and usually functional version of a new design or construction. So, prototyping already we have seen what is a prototype? So, prototyping is basically making a prototype, which can be either a full scale or a small scale, it is usually functional may be, it would be a working model we can say of a new design or construction. And rapid means fast.

So, we want to develop our prototype at a very fast pace in order to reduce the overall product design and development cycle time. So, definition of rapid prototyping is there on your screen now, you can see fabrication of a physical 3 dimensional part of an of any arbitrary shape directly from a CAD database by a quick highly automated and totally flexible process. So, there are, so many things which can be discussed in detail in this particular definition, but basically I need to address on quick highly automated and totally flexible process.

So, basically we are developing a database, we are developing a model or a prototype from a database and the process of rapid prototyping is very fast, it is quick, it is highly automated and a very flexible process. So, these 3 are the salient advantages that it is quick, it is flexible and it is highly automated. So, from a CAD database which is available with us, we are transferring that particular information into a solid prototype or a model. So, we will also like to go through one process of rapid prototyping.

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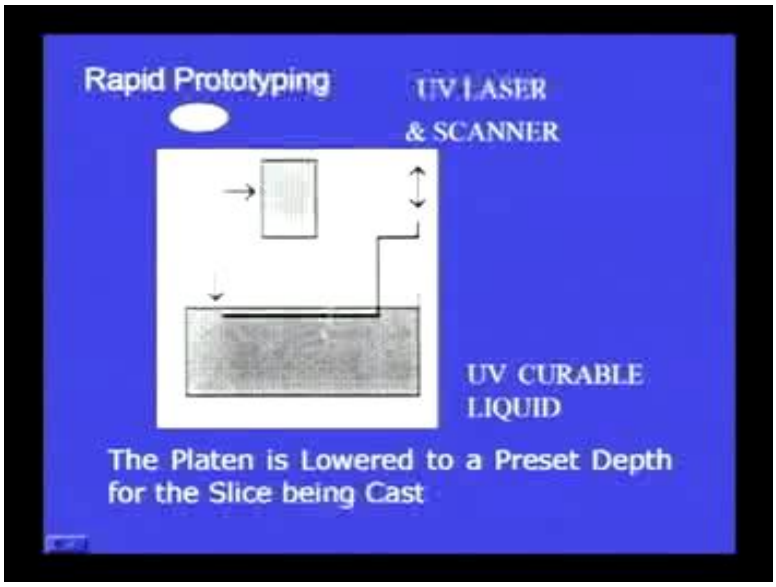

So, this is 1 process of rapid prototyping, this is step one you are seeing on your screen there is a UV laser and scanner then we have a UV curable liquid this is the liquid, UV curable liquid and the platen is lowered to a preset depth for a slice being cast. So, this platen, this platen on your screen you can see this is lowered to a preset depth. So, this is the depth. Some UV curable liquid is on top of the platen which has been lowered to a preset depth.

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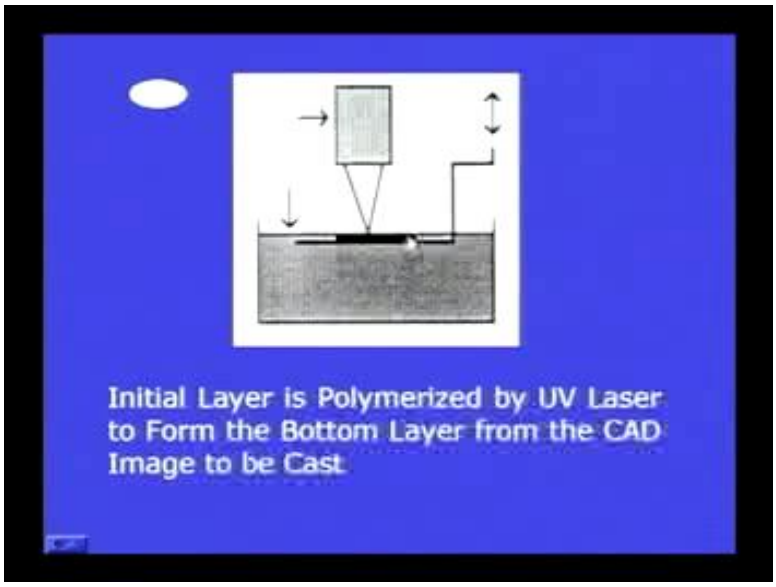


Then this is the second point initial layer is polymerized by UV laser to form the bottom layer from the CAD image to the cast. So, basically this is what where the polymerization has taken place initial layer is polymerized, this is the initial layer which has been polymerized. So, a UV layer, a UV laser is being used for polymerization process and this is the liquid which is getting polymerized. So, the platen would be lowered we can see that this platen can have a movement, movement is possible. We have at first step, we have fixed a predefined depth to this platen and now this would be moved in the subsequent steps. So, we have cured certain depth of the liquid.

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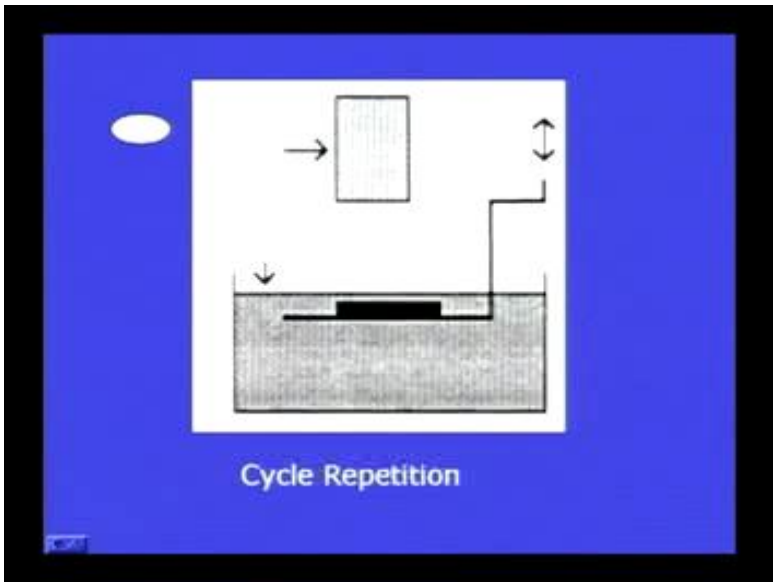


Now, this is the third step, this is the cycle repetition this would be moving down and this would again be polymerizing certain amount of liquid which is coming on top of the already polymerized liquid or already solidified liquid. So, how this is moving the movement of the UV laser would be according to the drawing that is there in the CAD database. So, the drawing of the product or the rapid prototype that we want to develop is already existing in our computer system. From there the laser is being moved in that particular direction and the material or the photo curable material that is coming beneath the laser is getting polymerized.

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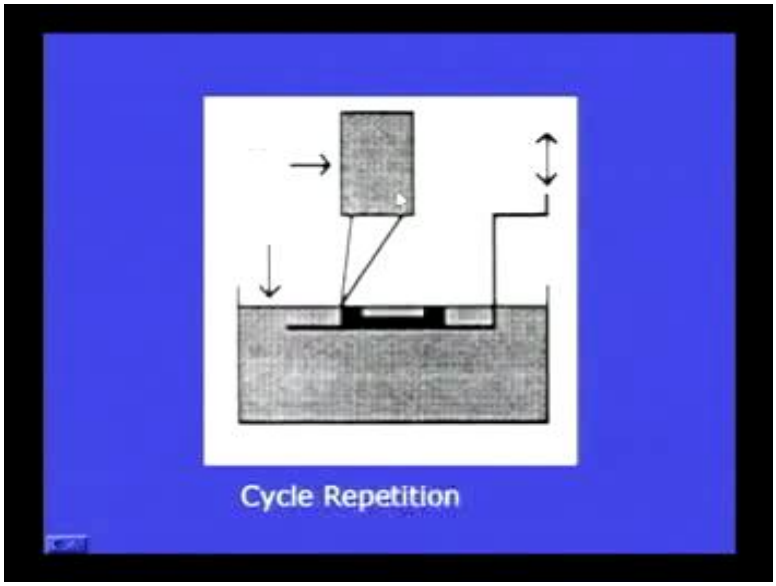

So, we can see that this is a shape that we are getting and this movement is controlled by the computer and this goes up and down at a predefined depth. So, cycle repetition is taking place.

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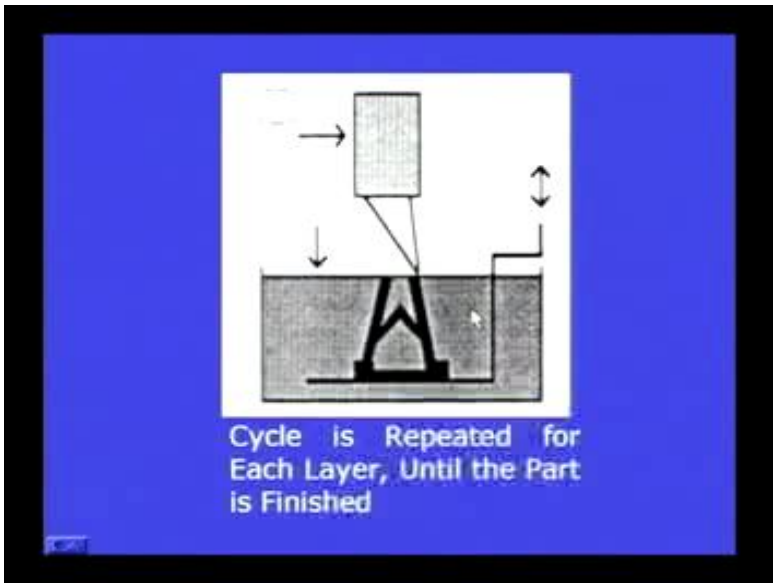


Here, we see this is the product that we are making. So, it is a 2 D image only, but we will get a 3 dimensional rapid prototype or a 3 dimensional model of the product that we want to launch in the market or that we want to develop. So, the platen is continuously moving you can see in the beginning it was here, now it has moved down as the liquid is getting polymerized the cycle is repeated for each layer until the part is finished.

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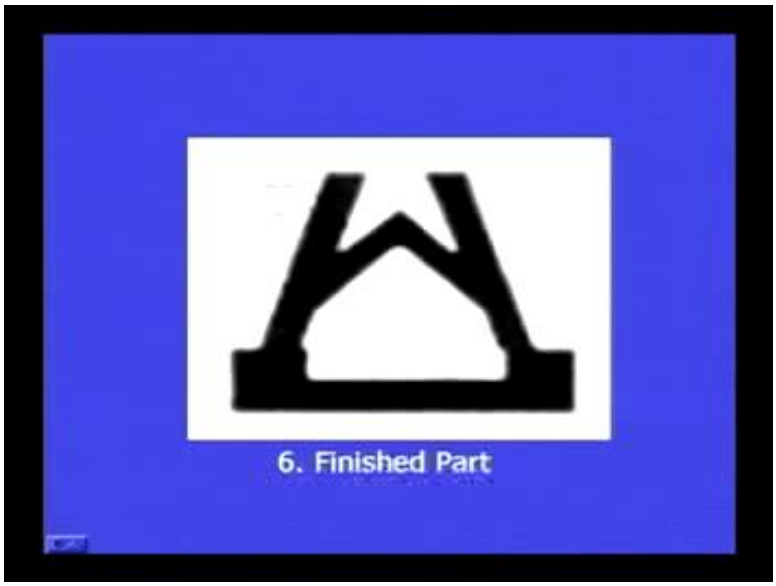


So, this is the finished part now, which we needed to produce. So, this is a prototype that we have developed which would be tested according to the requirements of the product and finally, the full scale production of the product can start. Now, we will see the procedure that we have followed in this rapid manufacturing or rapid prototyping process.

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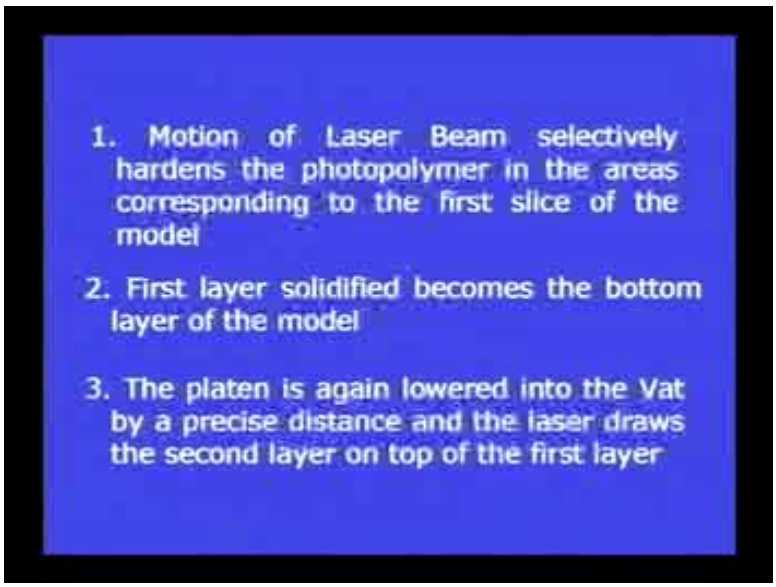


Motion of laser beam selectively hardens the photopolymer in the areas corresponding to the first slice of the model. Then the first layer that has been solidified becomes the

bottom layer of the model. So, we have a predefined depth of the platen and the liquid which is on top of the platen gets solidified or polymerized and then it becomes the bottom layer for the subsequent polymerization of the liquid.

So, first layer solidified becomes the bottom layer of the model the platen is again lowered into the vat by a precise distance and the laser draws the second layer on top of the first layer. So, first layer was deposited in the first go or we can say in the first pass and then the platen is lowered more liquid comes on top of it this is already solidified. Now, the laser moves and solidifies or polymerizes the liquid that has come on top of the first layer. So, first layer then second layer and similarly layers will keep on adding on and we would be finally getting the final product.

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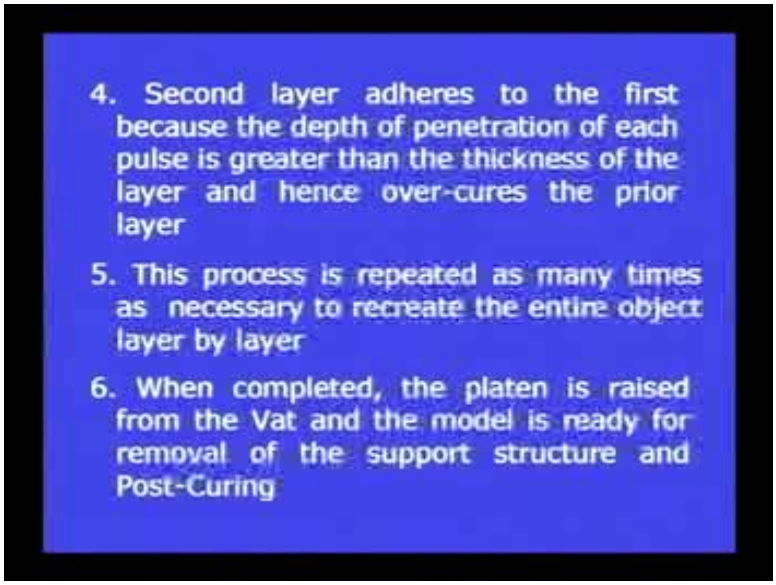


Then second layer adheres to the first because the depth of penetration of each pulse is greater than the thickness of the layer and hence over cures the prior layer. So, the bonding between the 2 layers would take place, because the depth of the penetration is more than the actual thickness of the layer. So, the bottom layer will the top portion of the bottom layer would get over cured and would bind with the second layer.

Similarly, second layer would bind with the third layer and the layers would keep on binding with 1 another because the depth of the penetration of each pulse is greater than the, thickness of the layer that we are polymerizing or that we are curing. This process is

repeated as many times as necessary to recreate the entire object layer by layer. So, layer by layer the whole object would be produced.

When completed the platen is raised from the vat and the model is ready for removal of the support structure and for post curing. So, once the structure we have got we are going to take it out for post curing. So, once the prototype is ready this prototype would be tested. And finally if the testing gives the adequate results full blown production according to the manufacturing process that has been decided would be taken.

So, in today's lecture, we have seen that product design and development is an important aspect of any business environment every now and then we see, so many different products, new products, modified products coming into the market. It is a risky business it is not very easy to design and develop the products, but we can very easily find out some good product ideas which can be translated into good business opportunities.

Many factors have to be taken into account while selecting the materials for the product, while selecting the processes, for the product or the manufacturing processes for the product. Similarly, in order to reduce the manufacturing cycle time or the product design and development time rapid prototyping is very important. We have seen that what do we mean by rapid prototyping and also we have seen one of the methods of rapid prototyping.

Thank you.