Product Design and Manufacturing

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Lecture - 24
Rapid Prototyping, and introduction

Good morning, welcome back to the course product design and manufacturing wherein we are trying to learn the systematic procedure to obtain a final product from the very basic thing from the idea generation only. So, till now what we have covered is we have gone through basics of manufacturing, the systematic procedure for product development and manufacturing also, value engineering quality function deployment which is a technique to translate the customer needs into the manufacturer's documents.

So, in this module I will cover Rapid Prototyping, which is a technique to quickly produce the product or maybe the model. So, what is the prototype? Prototype is an early simple or model that is used to test a concept or process or to act as a thing to be replicated or long term. This prototype can be a computer program; prototype can be a physical product. We are more concerned with physical product here, we will try to develop a physical model of the product which we have designed and we have made it to pass through various stages various analysis and finally, we are ready with the CAD model.

Now, after that we will like to have a physical product to see how does the product look like the physical product in your hands example, to produce a prototype of this product means to have physically this all these shapes contour then to have this pen in my hand so, this is Rapid Prototyping.

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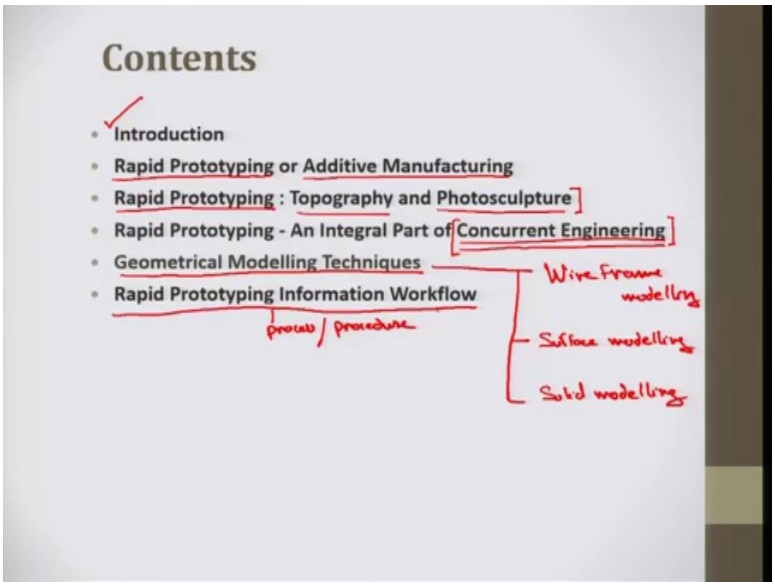

So, in this lecture I will try to give some introduction to Rapid Prototyping, then we will see what is Additive Manufacturing. Rapid Prototyping is now also known as Additive Manufacturing why it is so called? We will see Rapid Prototyping some history on this. Topography, photo sculpture was a few techniques which were used in early nineteenth century. So, we will see what are these things, then we will see that Rapid Prototyping is an integral part of Concurrent Engineering. Concurrent Engineering is thinking about the manufacturing preliminary design and the previous steps only.

Now, then we will go through the geometrical modeling techniques, these techniques are maybe wire frame modeling, then we have surface modeling and solid modeling. Then we will see how does the information flow in Rapid Prototyping, this is actually Rapid Prototyping process or better to call it a Rapid Prototyping procedure.

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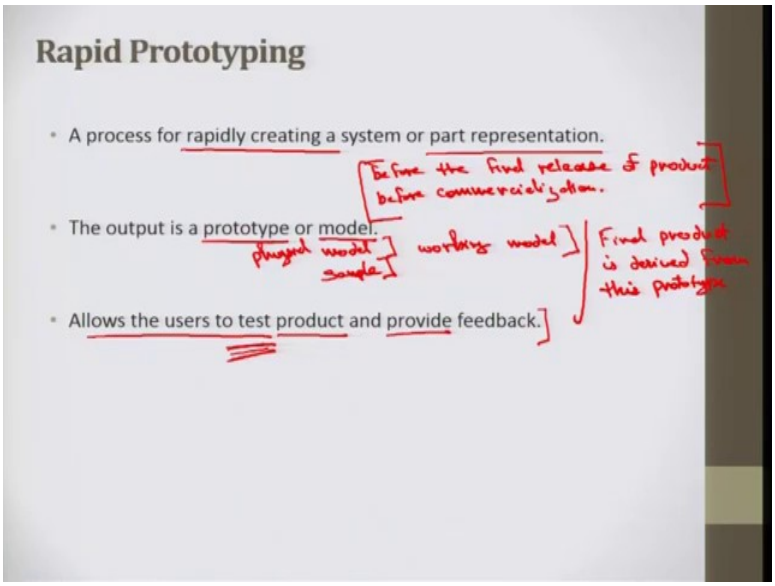

So, what is a Rapid Prototyping? The process of rapidly creating a system or part representation this is known as Rapid Prototyping. Rapid Prototyping is used in a variety of industries to describe a process for rapidly creating a system or part before the final release. This is before the final release of product or before commercialization.

So, what manufacturing concerns are interested in, they wanted to they always would need to test their product before making it to go to final user, they would like to check that what is the feedback. They are first manufacture a few initial products, few early samples they like to give it to some internal customers.

For example, I have been in hero cycles for what they do? They first produce the bicycles the initial models and make the internal customers. The customers who are within their factory they use the cycle for few days and they give the feedback and that is why this Rapid Prototyping is also required. Though the cycles are not bicycles are not produced by Rapid Prototyping, but here a Rapid Prototyping is required because, we need to produce the product very quickly. It is said in manufacturing industry if you snooze, you lose.

So, there needs to be some agile way some fast ways to produce a product to have the physical form that is even sometimes workable. So, though output of this Rapid Prototyping is a prototype or a model in our case, we are not talking about any software prototype, but a physical model here physical model or a sample. This model is

sometimes a working model as well, for instance if I say the physical model of a pen, the pen model the body can be something working in which the filler can be put in.

So, in case of in certain models for example, the physical model of a car carburetor, car carburetor needed needs to be the material has to be one that in material has to be aluminum. So, this model can be working model or maybe if it is not working at least we can have the field of the shape and contours of the thing.

In some cases, the working model can also be a working model if it can take a loads for example, in case of this pen this pen outer body can be a working model because the inner components can be put in. But, when we this is actually a stylus, if I talk about the pen this inner refill the refill the ink cannot be created here the outer body can be a physical prototype here. That is that is working in which this refill can be put in.

So, this prototype or model the more emphasis here is on creating something quickly and the output is a prototype from which the further models are eventually final product to be derived. The final product is derived from here is derived from this prototype.

In a product develop and contacts the term Rapid Prototyping was used widely to describe technologies which created physical prototypes directly from digital data. So, this allows users to test the product and provide feedback as well; Users of Rapid Prototyping technology has come to realize that this term is inadequate.

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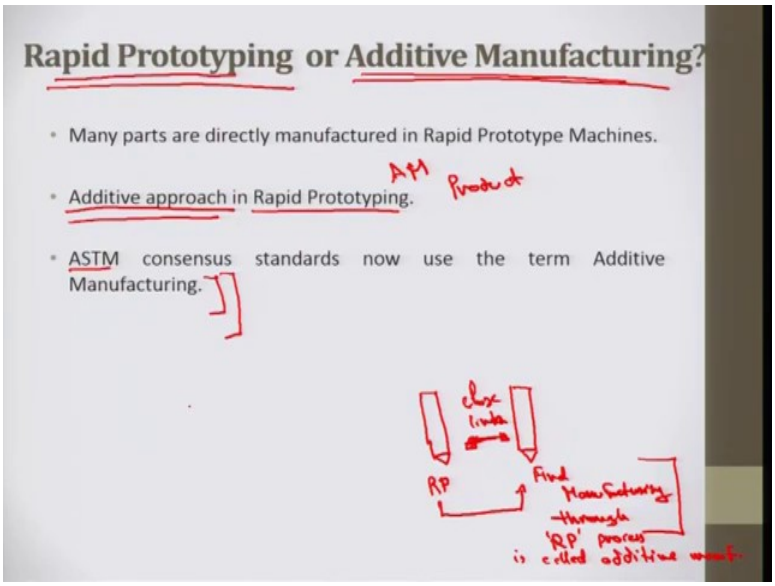

So, I will come with some other thing Additive Manufacturing. So, why do they think that this term rapid proto time typing term is not very adequate we will see.

So, the most recent applications of technology that is the improvement in the quality of the output from the Rapid Prototyping machines has meant that there is no there is a much closer link to final product. For example, if I have my Rapid Prototyping product and this is my final pen. So, it has a very close link right.

So, the users or the manufactures here think of why not to use this technique for final manufacturing. As you know, the prototype is something that is the early product or the initial product. The final manufacturing when is done through initially called Rapid Prototyping process is called as Additive Manufacturing. As the additive approach is used in Rapid Prototyping something some material is being added being deposited here so, this is known as Additive Manufacturing here.

So, many parts are in fact, now directly manufacture in these machines so, it is not possible for us to label the term as prototype. So, it is better to call it a product that is Additive Manufacturing product. Now, these American society consensus standards now use the term Additive Manufacturing. However, there still a conflict to use this term, but it is widely accepted and even some of the journals Rapid Prototyping journal is now known as Additive Manufacturing journal, the journal names are also renamed. The recently formed technical committee has named this thing.

Now, next I will like to discuss how quick is Additive Manufacturing. Additively manufacturing, the basic principle of this technology is that a model that is initially generated using 3-dimensional computer aided design.

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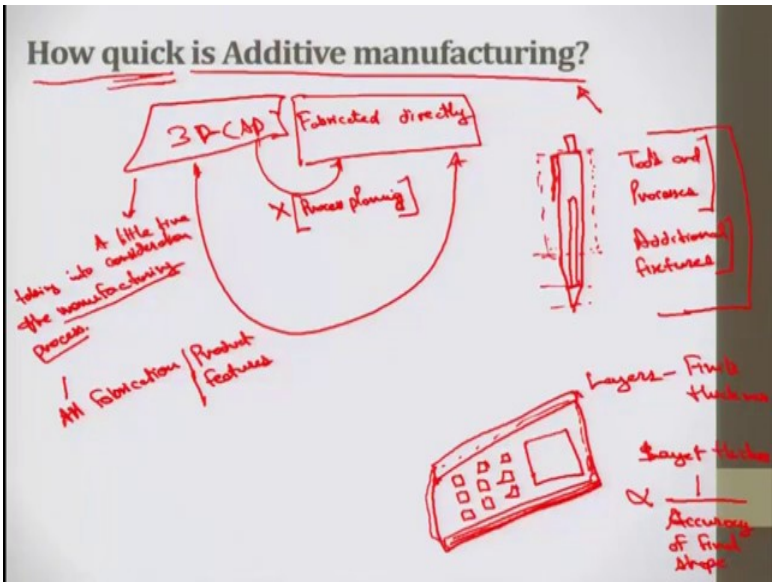

We call it 3D CAD model. This can be fabricated directly fabricated directly from the CAD model. This is the principle of Additive Manufacturing without any needs need of process planning, there is no need of process planning here.

So, it looks like that because this time-consuming thing is missing so, this should be a quick process. So, although this is not that simple, in it is first as it sounds here. The Additive Manufacturing technology certainly significantly simplifies the process of producing complex 3D objects directly from CAD data, but other manufacturing processes require a careful, detailed analysis of the part geometry to determine things like the order in which the features can be fabricated.

The features of a product for example: if I take the example of the pen only, pen has various components here. It has a clip, it has a click button, it has a refill inside not the part has various features see the contour is changing here; the contour is very much same through this. So, this is one part, this is second part, this is third part, then the clip has to be there, work material would it be, it has; it to be a metallic pen. In case of Additive Manufacturing we only can have the materials for which powders or for which the liquid material is (Refer Time: 12:27) raw material is available.

So, to decide these features is also a little complex thing. So, what tools and processes must be required tools and processes for this one? And what are additional fixtures that

are required additional fixtures to complete the part? So, this is a little bit fall of Additive Manufacturing.

So, it is not that quick as it looked like that it would go directly from 3D CAD model to fabricate directly; however, in 3D CAD model only it takes a little time, little time taking into consideration the manufacturing process. If this manufacturing process is traditional then CAD model can be the time could be less, if this CAD manufacturing processes additive then did in this, within this CAD model only these things are getting into consideration the features.

AM: Additive Manufacturing fabrication, that is the product, features. So, additive manufacturing needs some basic dimensional details and a small amount of understanding on how the Additive Manufacturing machine would work and the materials that are used.

So, the key to how Additive Manufacturing works is that the parts are made by adding material in layers. So, when example this mobile body I take an example of a mobile body, this mobile body is to be manufactured using the Additive Manufacturing process.

So, in this case Additive Manufacturing is always done in layers and layer for layer the thickness is finite. That layer thickness would be very finite, we have layers here, we have a hollow space here for the screen. I am talking about the all model of the mobile not the Smartphone's here, but this is just the outer cover of the mobile.

So, this is made in layers so, this layer has finite thickness and the thinner the layer is the closer is the final product to the original. That is, I will say layer thickness layer thickness is inversely proportional to the accuracy I would say accuracy of final. Most of the additive commercial Additive Manufacturing machines used a layer-based approach.

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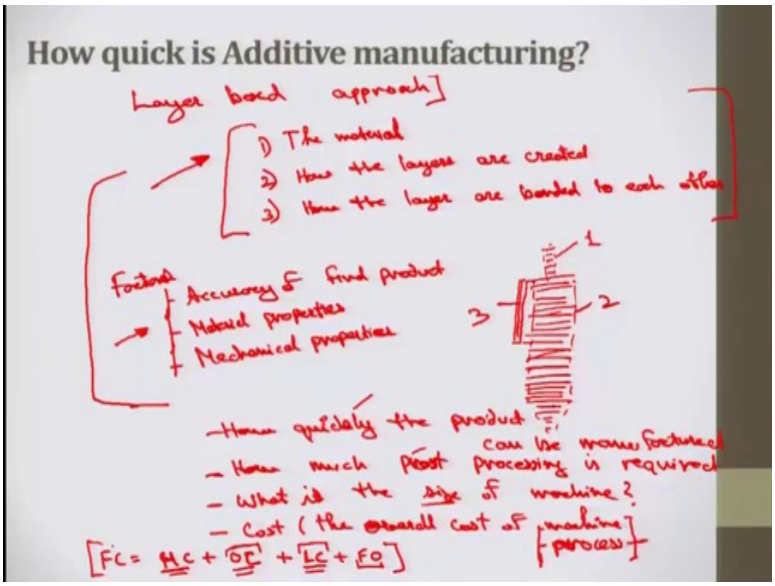

So, a layer-based approach is used. It is layer by there the product is manufactured if we talk about this pen body these layers would form my final product. This is a separate thing, clip is made in separate layers so, so this will constitute my pen body.

So, if I talking just about prototype just the pen body that is not a workable that is not a working model, then we can make it in one go. But if we think of to put a separate clip and separate click here is click button here then this has to be made in parts. So, the more comp the complex the product is the more is the number of components, more is the number of parts that you should be made in Rapid Prototyping in Additive Manufacturing better I would say here.

So, in this case this would be made separate, this is part 1, part 2 and part 3, this will be made separate and will be assembled. The major ways these machines or Rapid Prototyping processes differ is number 1; the materials that can be used, number 2 how the layers can be created, number 3 how the layers are bonded to each other. Number 1 the material, number 2; how the layers are created and number 3 how the layers are bonded to each other.

So, in the next lecture we will discuss various kinds of Additive Manufacturing or Rapid Prototyping processes which are maybe common processes Stereo Lithography, laminated process and some other processes. In this in those cases we will see that what are the specific pros and cons of the specific processes here.

So, these differences determine the factors like accuracy of the final product, now the factors that are dependent is number 1 is accuracy of final product, then maybe material properties. When we talk about material properties we can also say mechanical properties.

Now, this kind of machine effectors the parameters that defined the machine and the kind of the final product required. These for the determine the process parameters, that is how quickly the product can be manufactured or how much post processing is required. The size of the product, it determines what is the size of the machine that is required.

Cost is also one of the considerations I would say the overall cost; overall cost of machine, then process. As we have gone through the cost components, the final cost of the product is or we would say the factory cost is the cost of the material cost + operation cost + labor cost + factory overhead.

So, this material cost is important here, material cost the kind of material which we are using here. The operation cost is the cost of the process; operation cost would also maybe include the cost of the machine. Though it is an initial investment, but the final product which are made from these expensive machines are also sometimes costly likes just sold at some higher price. So, then labor cost, what is the labor required. In this case the in case of automated system the operation cost is a higher, in case of manual system the labor cost is higher, then factory overheads are also there.

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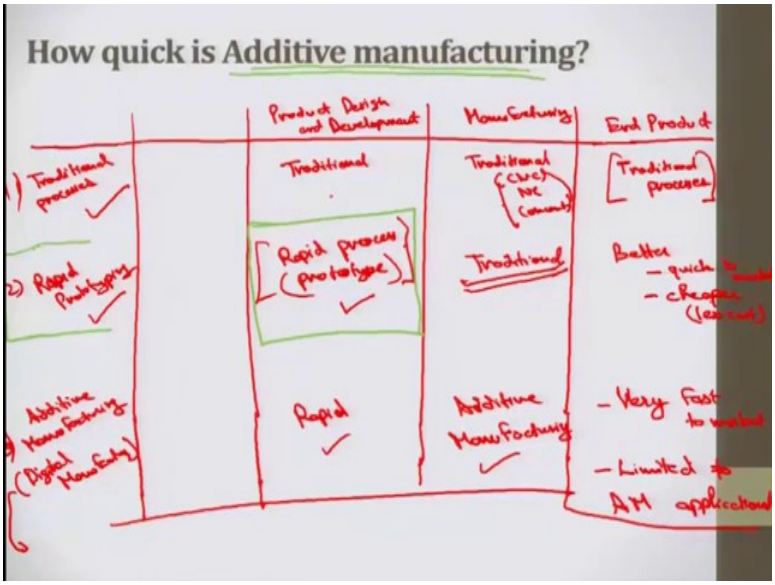

So, this would determine by cost of the final product final cost. So, let me compare Additive Manufacturing with traditional manufacturing here. So, this is one thing I would put it in this rubric here in which I will call this first step is product design and development. Then we have manufacturing here finally, we will get an end product.

Now, in case of traditional that is non Additive Manufacturing processes this design is traditional though CAD models all those things are used here, but Additive Manufacturing consideration not taken into account. So, this manufacturing is also traditional. This traditional does not mean the conventional machine, the traditional may be CNC machines, NC machines or conventional machines. Then you would have an end product that we have that we could say product that is made from traditional processes.

Now, in case of Rapid Prototyping thing; So, what do you say? In Rapid Prototyping what is product design and development? So, product design and development is a Rapid process here because, we will have a prototype in our hand that would be a faster process here.

And if I say manufacturing is traditional here, this end product here is not very much traditional, but a better one better in a way that is brought faster to market, quick to market. Then it is sometimes because the RND, that is the product design term development time is lesser here, it is sometimes or most of the time I would say it is a cheaper product. It is of not cheaper is less cost.

But, it is still limited to this traditional manufacturing processes. In case of I would say Additive Manufacturing I would also include digital manufacturing here as well. Though I was going to put this is in a 4 step, but I will try to now I put it in a the divided into 3 categories only 1, 2 and 3. In this case this one is Rapid and this one is Additive Manufacturing, that is the manufacturing product is also.

This kind of products are brought very fast to market, but only the limitation is the limitations of the Additive Manufacturing applications limitation or we would say limited to Additive Manufacturing applications. Because, not all the products can be manufactured using Additive Manufacturing.

Now, this is all we can compare, the traditional process both the things are traditional, Rapid Prototyping in which only product design and development is a rapid and the

manufacturing is the traditional and Additive Manufacturing in which both the things are Additive.

So, in the current course we are more interested towards this thing Rapid Prototyping. We only discuss how the Rapid Prototype is produced. So, I have just discussed Additive Manufacturing because you will definitely come to this term when you talk about Rapid Prototyping, people will talk to you that what is Additive Manufacturing? How does Additive Manufacturing differ from Rapid Prototyping? These things would always come into account whenever you are in the interviews, in the job interviews or you are in manufacturing these things would also come into account. That is why I have discussed this thing.

So, in the domain of this course we will just discuss the Rapid Process to produce or initial or early sample early model here.

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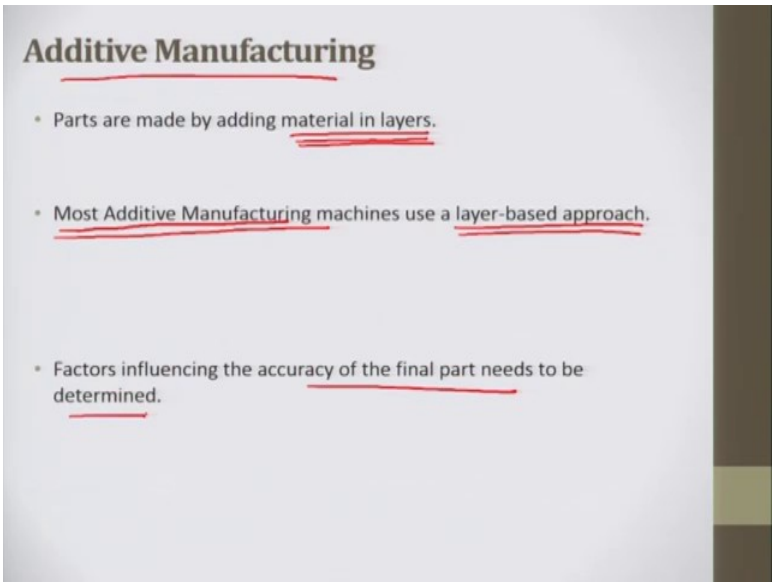

So, little more information on Additive Manufacturing because so, revitalizing again. Additive Manufacturing in this the parts are made by adding materials in layer that thinner the layer is the closer is the part to the final product that is required. The machines most of the Additive Manufacturing machines used a layer based approach. We will discuss various kind of processes in the next session. The factors that influence the accuracy of the final part that are need to be turn up determined. So, we have a listed these factors here.

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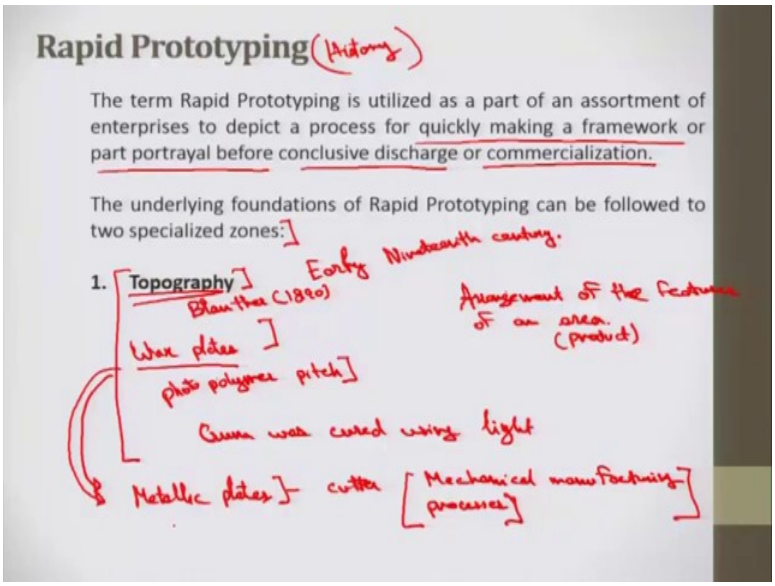

So, let us come back to the Rapid Prototyping however, I might use the term Rapid Prototyping and Additive Manufacturing hand in hand; But, when I say Addictive Manufacturing that would definitely mean that the whole manufacturing is being carried out by an Additive process.

When I say Rapid Prototyping, Rapid Prototyping here is the initial product let us put some light on the history. So, how does Rapid Prototyping evolved? So, this time Rapid Prototyping is utilized as a part of a sort an assortment of enterprises to depict a process for quickly making a framework or part portrayal before conclusive discharged or commercialization.

The underlying foundations of Rapid Prototyping can be followed by 2 specific zones typography and photo sculpture. These twos were used in early nineteenth century early nineteenth century. So, what is typography? Typography is an arrangement of the features arrangement of the features of an area; though the arrangement of the features then bringing all these raised features together to have the final product.

So, a layer technique was proposed by Blanther in 1890. So, this was the first time the Rapid Prototyping basis came into existence. So, a layered technique was proposed by Blanther as a right on time as for making molds, for geological relief maps. Both positive and negative 3D surfaces were to be gathered form a progression of wax plates and they

were cut along the geographical form lines. The wax plates they were cut through to form the geographical form lines here.

So, this strategy was additionally advanced by a certain other researcher. They portrayed a layer producing procedure to shape throwing molds. The layer of the molds was created from particles, covered with photopolymer pitch the photopolymer pitch was used. So, gum was also used here that was specifically cured used utilizing light gum was cured using light. Certain there is used, certain other researchers used the same technique using the metallic plates.

So, idea came from here, but the metallic plates were then used to have a topography structure here. So, these metallic (Refer Time: 32:34) magnetic plates a cutter was used to cut these into the shape. Then certain overlay procedures were introduced like blanking of a test press, shaping devices, forming devices. So, mechanical processes came into existence here, mechanical manufacturing processes came into existence to produce these plates.

So, this is a kind of a laminated plate, plate procedure will discuss the kinds of Rapid Prototyping processes in which we will see the powder process, laminated plate process and liquor process are the major classification of Rapid Prototyping. So, this is a kind of a base for our laminated sheets or solid material Rapid Prototyping processes which are even being used today.

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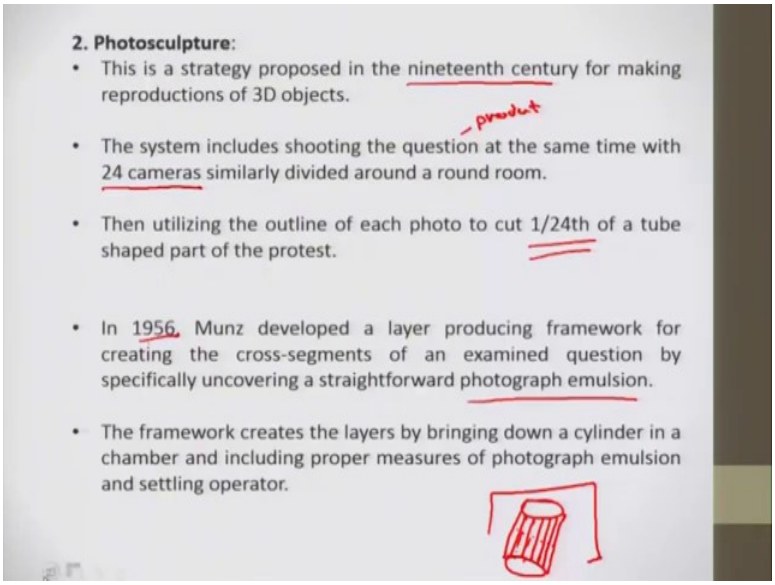

So, next was photo sculpture. So, this is a strategy that was proposed in again ninetieth century for making reproduction of 3D objects. The system includes shooting the question shooting the I would say the subject or my product at the same time with 24 cameras which was similarly divided around a room. Then these were used to utilize the outline of each photo to cut 1 by 24th of a tube-shaped part of the protest.

So, what happened this tube is there this is divided into 24 cameras was used to produce the shaped, then this is divided into 24 parts.

Then endeavors were made by different designers to enhance a strategy by mitigating the manual cutting steps here. Now, further the researchers propose the utilization of organized lighting to make shape for a protest photographically and after that utilizing these lines to cut and manufacture the form sheets.

So, in 1950's that is in the half of our twentieth century, Munz developed a layer producing framework for creating the cross segments of an examine question by specifically uncovering a straightforward photograph emulsion. The framework creates here the layers by bringing down cylinder into a chamber and including a proper measures for photograph emulsion and settling operator.

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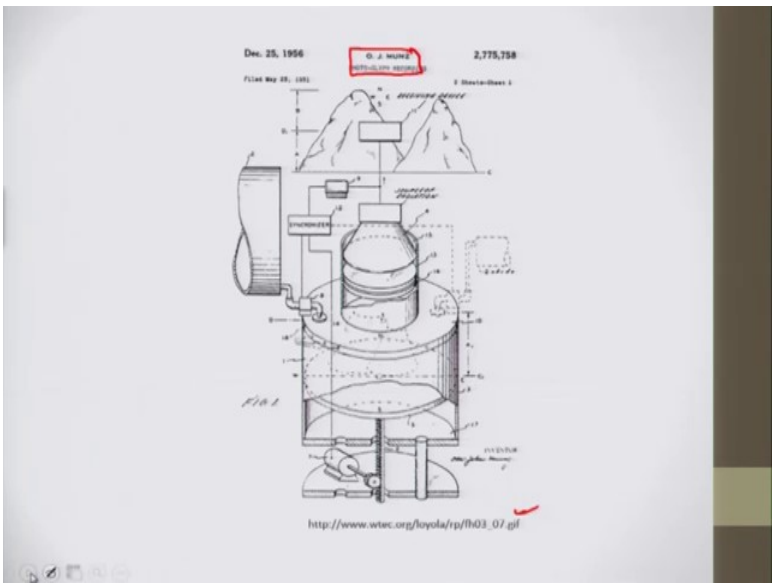

So, you can read the work by Munz to have more information on the photo sculpture or this is of a figure that is taken from the reference here. So, this is a cylinder which is put

into the chamber and the various lights technique lighting techniques were used to have this shape of this one.

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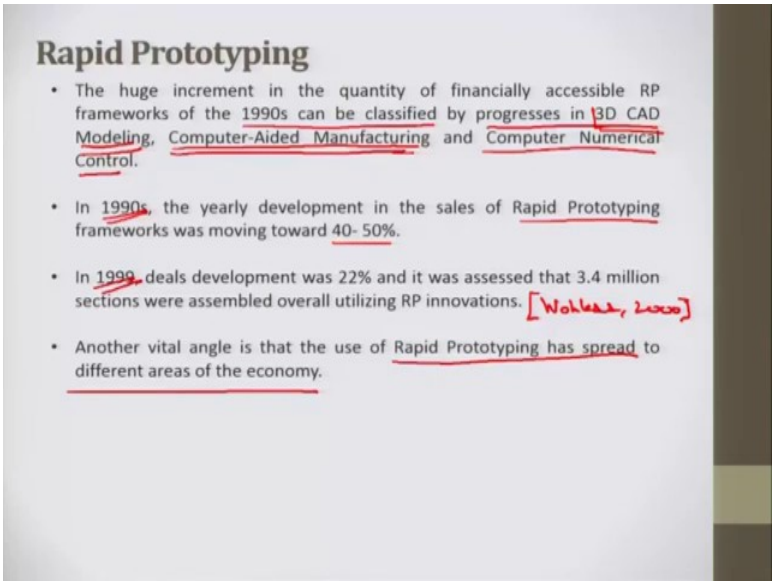

So, after 1950 here, now recent here in 1990's and I would talk about the twentieth century as well twenty first century as well here.

Now, the huge increment in the quantity of the financials accessible Rapid Prototyping frame work of the 1990's can be classified by progresses in 3D modeling, computer aided manufacturing and computer numerical control. These are the terms which we have been going through multiple times. So, this was all well been 1990's.

So, the yearly development in the sales of Rapid Prototyping process was about 40 to 50 percent and in 1999 the deals development was 22 percent and it was assessed that 3.4 million sections were assembled overall utilizing Rapid Prototyping innovations. Now this fact was brought into light by Wohlers in 2000.

So, another vital angle is that the use of Rapid Prototyping has spread to different areas of economy. This solid and predictable development in the deals and boundless utilization of the innovation show exceptionally hopeful prospects for Rapid Prototyping business and it is future here. So, we can see here.

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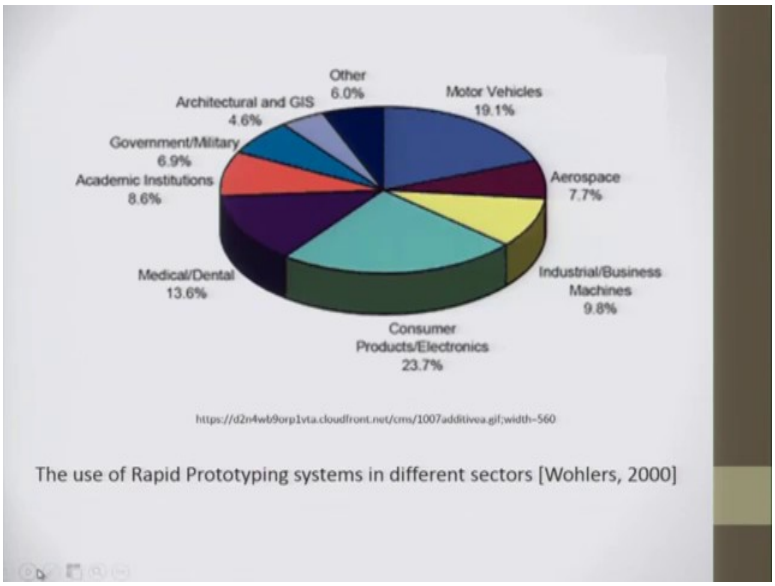

The work of this man Wohlers in 2000 he said that the Rapid Prototyping had these much of applications. So, maximum consumer products or it has maximum application in consumer products, then medical and dental products, academic institutions also used that and these were also the certain applications here.

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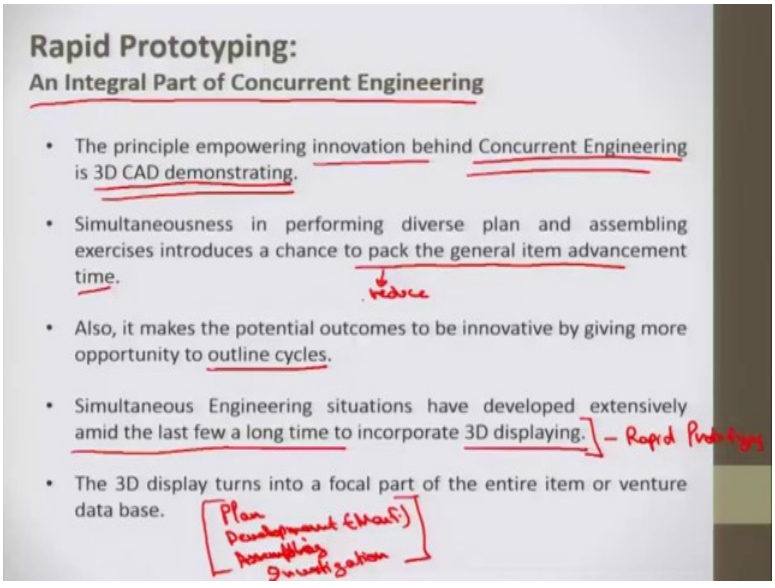

So, next I like to discuss how Rapid Prototyping is an integral part of Concurrent Engineering. We know that Concurrent Engineering is designing and development. When the various steps are working simultaneously rather than conductively step by step

procedure is not very prominent here the various steps various parts of the product development team all work together and all the processes are going simultaneously, most of the processes are even overlapping.

So, how Rapid Prototyping is an integral part of Concurrent Engineering? The principle of Concurrent Engineering is that is this innovation is behind it is 3D CAD demonstrating. The simultaneous in performing diverse plan and assembling exercises introduces a chance to pack the general item advancement time, hereby pack I means reduce. Also it makes the potential outcomes to be innovative by giving more opportunity to the outline cycles here.

Simultaneous engineering's situations have developed extensively amid the last few a long time to incorporate 3D displaying. So, 3D displaying we have a Rapid Prototyping.

Now, 3D display turns into a focal part of the entire item or venture database. Which implies that taking the all the things together. That is planning I would say plan, then development, then assembly I consider development as by manufacturing as well development and manufacturing, then assembling, then investigation. So, these all things come together.

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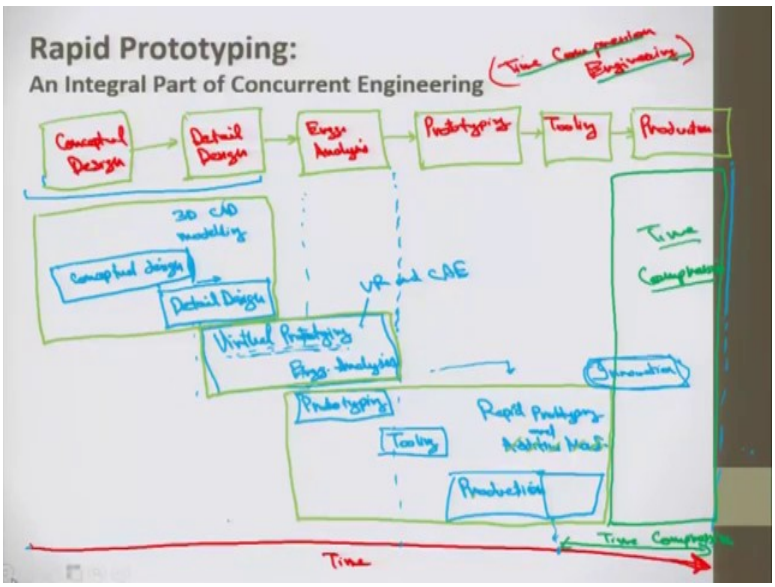

So, let me try to compare the general process with my Concurrent Engineering here. So, in general process what we have? Conceptual design. What I will try to put here is how

Concurrent Engineering is also known as time compression engineering time compression engineering that is the overall time is reduced.

So, in general we have concept design, then detail design, then engineering analysis, then prototyping, then tooling and production. So, I have time going through here, this is our time. So, these are various steps here in a noncurrent engineering way.

So, what happens in Concurrent Engineering for what do have first here is 3D CAD modeling. In 3D CAD modeling both these things conceptual design and detailed design are working. However, these 3D CAD modeling is can be used here as well.

So, when the conceptual design is there, when the conceptual design is complete then detailed design starts. There is a little overlap here is because when even the concept is there in the mind of a designer that details some detail some specifications are given and when if the concept is very clear at this point of time at this point of time there were concept is very clear the detail design takes a fast shoot and the detailed design is complete here. So, this is my 3D CAD modeling here.

Then is prototyping, then what we have here is virtual reality and finite element analysis kind of a thing. So, what do we, but we can put here is Virtual Prototyping Virtual Prototyping and Engineering Analysis; Now, Virtual Prototyping is using by CAD's software only to do Engineering Analysis and having the prototype on the screen only here. So, these things go hand in hand here. So, at this point of time we are even close to Engineering Analysis.

Next comes is Rapid Prototyping here, Rapid Prototyping. So, we can see even in Concurrent Engineering even there is an overlap of the various steps here, but till Engineering Analysis the time is almost same. But when we have Rapid Prototyping here so, this overlap this prototype exiles a started even during this Engineering Analysis only. Prototyping starts here only, right. Then after prototyping because the initial prototype is ready here, tooling decisions can be made here and if I talk about Additive Manufacturing here the production can also be started here, the time to production.

So, in this case that time to production was this much and in this case the time to production is this much. So, this difference here this difference is my Time Compression. So, that is why it is known as Time Compression Engineering.

So, I could better put here this is my Time Compression. So, to put it into maybe 2 or 3 major steps this is Concurrent Engineering 3D CAD modeling, this is Concurrent Engineering virtual reality and this is Concurrent Engineering Rapid Prototyping process.

So, even if Additive Manufacturing is not here the time to production that is to time to decide the final production that whatever manufacturing process would be there that is reduced here. So, let me take this thing like here. So, there is no duplication and no misconception in Rapid Prototyping. So, the item data here can be duplicated and may be re utilized it is promptly accessible for various downstream applications.

Gatherings can be checked for obstruction and through virtual prototyping can be practiced through scope of assignments here. The front people can be assigned job here so, obstructions can be seen here only.

Then auxiliary and warm examinations can be performed on similar models using CAE software, CAE applications computer aided applications here. I would share here this is my VR and CAE. CAE is actually computed aided engineering; these applications are also as secreting downstream producing forms.

And at last these exceptionally precise also information rich models can be taken straight forward to the Rapid Prototyping and computer aided manufacturing applications. Accelerating process arranging and now and again disposing of the requirements for illustrations; As an incentive comprehension of various geometrical portrayal methods and configurations for information trade, it is urgent for the effective usage of Rapid Prototyping innovation here innovation is induced here.

So, I will take a break here and would come with the next part of this lecture. We will discuss various geometrical modelling techniques and we will come go through the general procedure of Rapid Prototyping.

Thank you.