Product Design and Development

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Lecture – 12
Computer Aided Design (CAD)

[FL] friends, welcome to this lecture number 12 on our course on product design and development. As you are aware that we have already finished our discussion for two weeks, and the broad topics that we have covered in those two weeks were on the basic concepts of product design and development the product life cycle, the product design steps the value engineering concepts we have covered in week 2. And then we have seen the fast diagramming approach which is very well known approach for the functional analysis of a product. We have also seen the functional cost relationship, matrix and the functional cost relationship methodology to improve the design of the product.

Now, we are into the week 3 of our discussion on product design, and we are discussing the various design tools which can help us to make a good design. In our lecture 1 that is overall lecture number 11 and lecture number 1 for week 3, we have discussed one of the important aspects of product design and development that is house of quality, in which we have seen that how the voice of customers can be related to the technical requirements. And we have tried to understand it with the help of a pizza selection company or select or a selection of a pizza company, we have seen that how the voice of customers or the customer's requirements needs and responses can be mapped to the technical requirements with the help of a relationship matrix.

We have also seen that there is a importance relative importance column or room in the house of quality, which helps us to we can say differentiate or categorize the various requirements of the customer. And house of quality the output can be that we can use the information available or information derived from the house of quality, for benchmarking our performance with the performance of the other companies.

We took an example of a pizza company, there can be number of other examples where house of quality has been used and there can be slight modifications in the various rooms of the house of quality. For example, the house of quality that we have seen was not having any complaints room, there can be a complaints room also in the house of quality.

More over we did not feature much on the goals and objectives of the that company in our example, which was kept as it is only. So, there can be additions or make an we can say modifications in the various rooms of house of quality.

But some of the rooms will definitely remain the same, that is the voice of customers, the relative importance of the various we can say requirements of the customer, the technical requirements matrix, the relationship matrix between the voice of customers, and the technical requirement matrix, then the correlation matrix showing the interrelationship among the various technical requirements.

So, all these are the common rooms in any house of quality issue or problem you will see all these rooms existing and the information available is mapped using these rooms, and then the decisions are taken based on the house of quality; the overall picture of the house of quality, the overall output of the house of quality. So, with the house of quality we can maybe compare our product, we can even find out that which technical requirement has to be given more importance and which technical requirement is not much influencing the customers needs and requirement, and can be left out or can be eliminated.

So, it has got practical implications also, it is not just a theoretical tool which can be used, but it is a practical tool which can be applied scientifically for understanding about the product design process. Now let us go to the next stage of the product design, we know that what are the technical requirements that have to be met, what is the requirement of the customers what do they want. Now we have to design the product and for designing the product we have to make a model of the product.

Because usually we say graphics or engineering drawing is the language of engineers. So, we need to understand that how we can put whatever is the requirement of the product on a piece of paper, and how the product would look like what would be the various parts of the product, how these parts would interact with each other, how they will be assembled to each other. So, we have to explode the product into its individual parts and components, and then these parts have to be designed individually and then they have to be combined together to make a complete product.

Now we have to understand that whatever decisions whatever information we have taken out from the house of quality or what are the technical specifications or requirements

required to or maybe important to meet the voice of customers, now we have to work on those technical specifications or requirements in order to design the product successfully, and for that purpose in mind computer aided design is an important tool, and we will try to see that what this term means and how it will be helpful to us for designing our product, moreover we will see that what are the important software's which are useful for computer aided design process.

So, let us go one by one, and try to understand that what are the various aspects of computer aided design.

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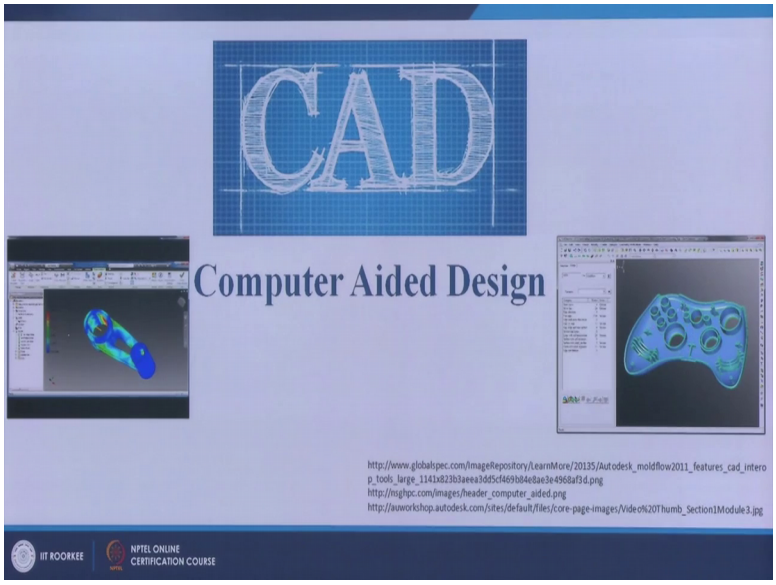

Now, here this is the first slide you can see a very rough sketch or maybe we can say one other basic or primitive ways of representing information. Here it is written CAD which is a simplest way of representing any piece of information; here you can see another component here. So, this is the way the products would be you can say designed using the CAD tool. So, in CAD it is computer aided design, but it is not only the design it starts from the drafting or may be sketching to final engineering drawing to some part of analysis and we can integrate our designs with the analysis tools also, and it can be a complete package which can provide us engineering solutions.

So, we will try to understand that what is the basic fundamental behind this term, that is computer aided design.

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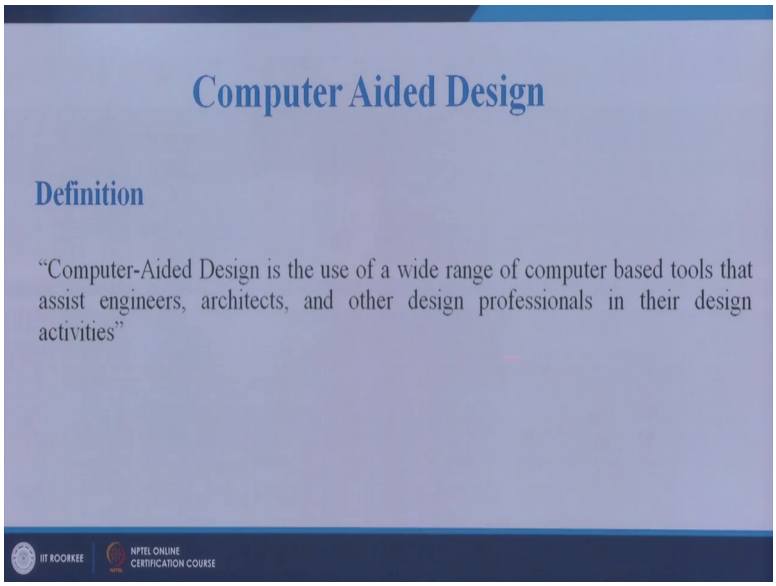

Now let us see try to understand the definition of computer aided design. So, computer aided design is a use of a wide range of computer based tools. So, I have already told in the previous slide that it is not just one tool or one software which you can use and design, it is a combination of tools depending upon our requirement, and then we will see in the subsequent slide that how these tools can be combined together to finally, make a product or could design a product. So, it is a wide range of computer based tools that assist the engineers architects and other design professionals in their design activities.

So, computer aided design is not only one software, but it is a combination of software which combined together in order to assist the engineers architects and other design professionals in their various activities of product design and development.

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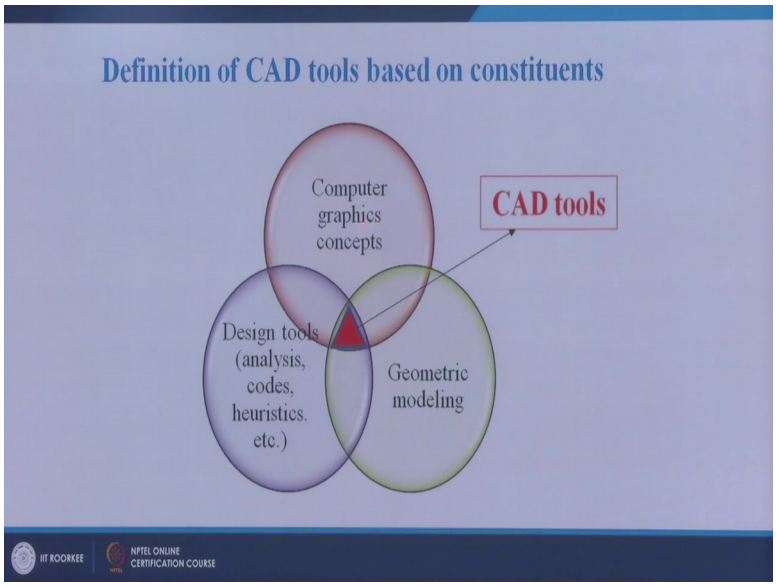

Now let us see various CAD tools where do they fit in this red triangle represents the you can say intersection of the various concepts that is the definition of CAD tools based on the constituents.

So, there may be software's which may only be good at computer graphic concepts only. May be only you can design something may be different tools are there, you can just do the sketching on the screen and then you can save it for further use, but no analysis can be done based on that sketch. So, maybe you have simple computer graphic concepts, then you can have a geometric modeling where you can do some dimensioning and a drawing can be made, and then there can be analysis tools may be you have you give the density of the material, and you give the size and shape of the material, you can compare that which material should be used in order to make a lighter product, the geometry remaining same, the dimensions remaining same only the material is changing.

Now, we have to see that we want to design a lightweight material or lightweight product. So, which material should be chosen in order to make it light or it is easy once you know the density there is no need to do the analysis, but in many cases it may be a multi material concept in which the complete product is made up of maybe 5 or 6 different materials. So, they are if you give the input of the material for each and every part of the product, and then compare the two may be concepts that in one particular product you have 6 different material, in other product you have 4 different materials and

their densities are different of the material, and you want to compare which one would be heavier which one would be lighter. So, that type of simple analysis can also be done.

So, there would be CAD tools they fit in here this triangle. So, they will have the graphics facilities also, geometric modeling facilities also as well as little bit of analysis. So, there would be standard software's which will which may not be having a very high analytical capability to in order to solve their engineering problems. Some of the software's may only be limited to drafting of the problem into an engineering drawing, but we will see that what a can be the capabilities of the various CAD software or what are the combination of tools which can be used to solve any problem using the concept of computer aided design.

So, here we this is a very good slide to explain that where CAD tools usually fit in. So, just to summarize there are three you can say edges. So, as per the edges it three important capabilities they possess. So, when can be (Refer Time: 11:40) computer graphics geometric modeling and analysis.

So, any good CAD software can be used for solving simple problems of maybe related to the weights weight reduction or maybe sometimes related to the modification based on the shape and the design or you can say the size. So, different things can be analyzed using the design tools sometimes we may also use the concept of finite element analysis, which will fit in here in the purple box here. So, we have graphics geometric modeling and analysis we will see in the subsequence slides that how CAD can help us to solve various problems.

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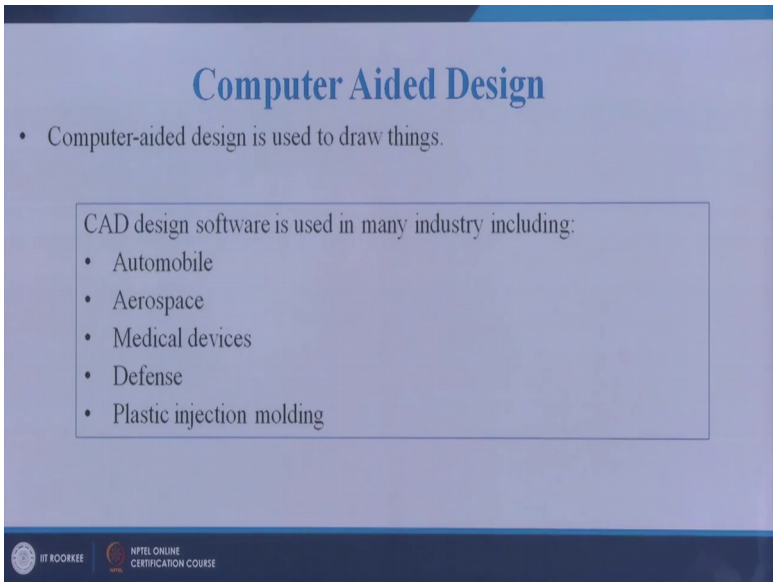

So, computer aided design is used to draw the things. So, this is the first part that is catching and the geometric modeling. So, we are not talking of the analysis right now, but we will come to analysis also that CAD can be integrated with the analysis softwares also; analysis softwares are now being in built into the CAD softwares to solve simpler problems also.

So, computer aided design is used to draw things very basic definition of CAD, CAD design software is used to many in many industries including automobile industry, aerospace industry, medical devices defense plastic injection molding, just the tip of the iceberg. CAD can be used in almost all engineering industry; this is just to the list of the major users of CAD softwares or CAD applications. So, if you wish to join automobile or aerospace company, you should know the fundamentals of CAD not only the theoretical fundamentals of CAD you should know how to use apply the concepts using the various software flat form.

So, you should know hands on training you can have or you can learn or you on your own the different software's which help you to design a particular part or at least to model a particular part using the various options available on that flat form. We will try to understand maybe the fundamentals of those also.

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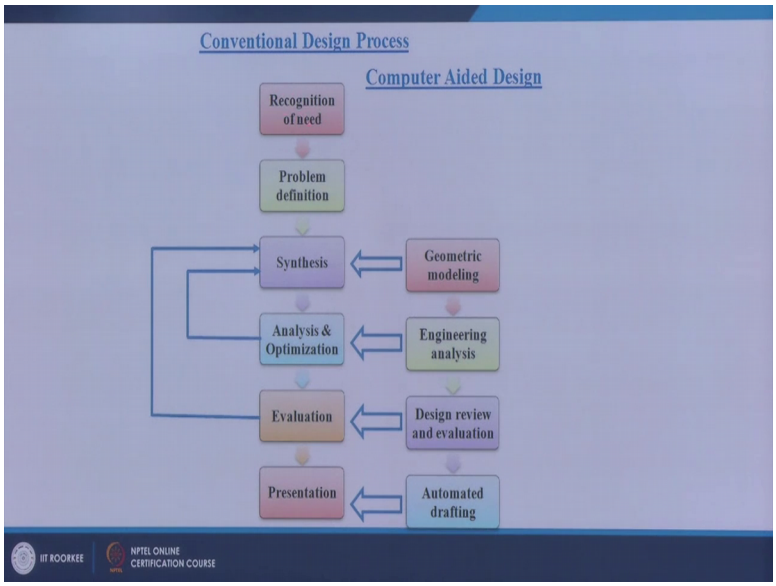

Now, we are here company the conventional design process and the computer aided design process. So, you can see in the conventional design process, what are the various steps you can see recognition of need problem definition, synthesis analysis and optimization evaluation and presentation. Standard approach already discussed in our week 1 where we have seen the product design process.

Now, in computer aided design we have geometric modeling engineering analysis, design review and evaluation an automated drafting. So, you can see the computer aided design process is slightly different from the conventional design process, and this we will try to understand each one of these steps one by one. So, once you know maybe from the house of quality you have found out that what are the technical requirements which have to be met in order to meet the customer requirements or the voice of customers, now we are working on those technical requirements and try to trying to design a product around those technical requirements, and for that we need to first model the geometry of the product.

So, this is what is outlined as the computer aided design process or what are the various steps involved in the computer aided design process. So, right here we have all the information related to what actually we want to design, and based on the design we will follow these steps and come up with the design which is now ready for prototyping and manufacturing.

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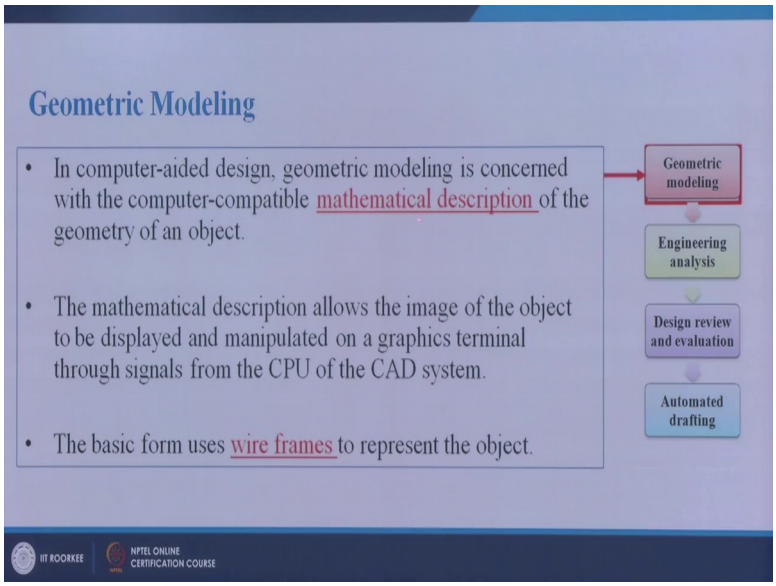

Now, first part here is the geometric modeling; when geometric modeling you can see in computer aided design geometric modeling is concerned with the computer compatible mathematical description of the geometry of an object. Now some of you may be wondering who are not from engineering background, that how data is saved on our system; usually we see a picture it is a square there can be a circle inside. So, how this square and circle is stored in the memory of the computer, there it is saved as the mathematical description of that square and the circle.

So, that cads and geometric modeling it computer compatible mathematical description of the geometry of the object is saved inside the system that is inside the computer. The mathematical description allows the image of the object to be displayed and manipulated on a graphics terminal through signals from the CPU of the CAD system. Now we can display we can manipulate, we can work on that, we can cut a section, we can make a hole inside our geometry if it a 3D geometry we can extrude hole out of it or maybe we can add certain features on the geometry. So, all that is done we see on the screen the actual geometrical translations, but in the backend or in the software these are all mathematical operators which operate or it is a there is a mathematical description to each and every shape that we produce on the screen.

So, that is the representation true representation of those things is not in the form of a square which will be saved in the memory of the computer, it will the mathematical

representation of that circle which will be saved in the memory of the computer. Maybe there may be two words only written for that circle on your screen you will see a circle, but on in the memory you may have only the central coordinates of that circle as well as a radius or the diameter of that circle. So, in your CPU you are storing two pieces of information that is this radius and the center of the circle, but on your screen you get a complete display of the circle. So, that is a relationship between how the geometry is modeled on your screen. So, you should know what is happening at the backend of the system.

So, geometric modeling is nothing, but it is the representation of your data on the screen. If you want to model a square, it may ask you that give the center and the radius and it will generate that circle on the screen, but at the backend it will be stored as a radius and the center points on the center coordinate. So, first part is geometric modeling. So, if I want to solve any problem or a structural problem, I want to see the impact strength of a table maybe the table on which we are placing our books and computer and laptop, I want to see how much impact it can take.

So, first part of the design of the table would be I have to represent it on my computer screen, it can be a 2D model or a 3D model, and once I model it I have to give what is the length, what is the width, what is thickness of that apply, what is a steel frame that we are that is used to support that table. So, all that will fall under the geometric modeling stage only. Then the next stages engineering analysis. So, first part is representing our problem on the piece of the. So, on our screen or on a piece of paper, but in computer aided design, it is paperless we will model everything on our screen.

So, first is representation of the geometry on the screen and that is called as the geometric modeling. In next stage we have the engineering analysis.

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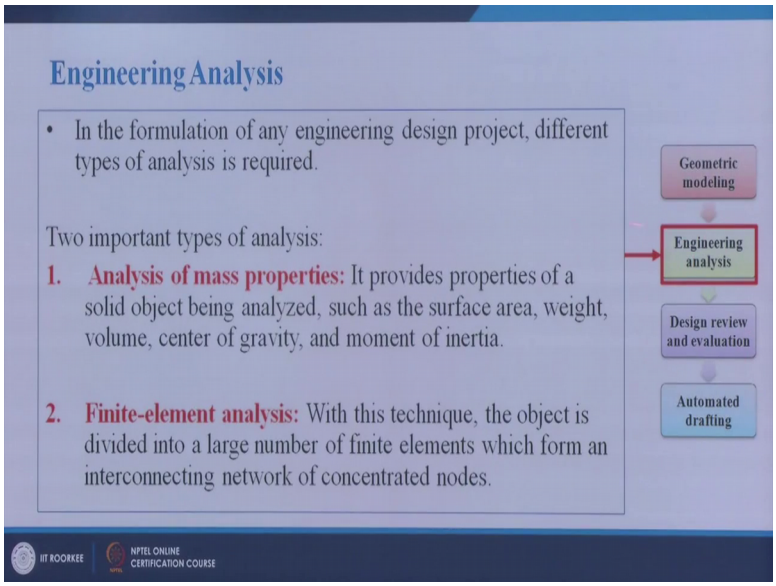

In engineering analysis in the formulation of any engineering design project different types of analysis is required. Now just two important types of analysis I am trying to explain here; first one is the analysis of the mass properties, it provides properties of a solid object being analyzed such as a surface area, weight, volume, center of gravity and moment of inertia.

Now I have told you that the software these days are not only the drafting softwares that you can make a geometry on the screen, but they have the analyzing or analytical capabilities also. So, we can analyze maybe a particular thing based on our requirement; so, maybe we can compare the weight of the various designs, we can compare the surface area of the various designs the software will give us the output that what is the surface area of this particular design.

Now, suppose we want to compare as we know that the heat transfer is a function of the surface area, and we want to design a particular surface in order to minimize the heat transfer from that surface. So, we will see we may have 4 or 5 designs, now we would should know that which design has the minimum surface area, so that the heat transfer is minimum from that product or from that object. So, the CAD software will help us to compare the surface area, that surface area is minimum for a particular design. So, we will take that design why? Because the heat transfers from that design that particular design will be less.

So, these days many CAD softwares have got the analysis capability also, and one of the analysis can be the analysis of the mass property. Another can be the finite element analysis where we will discretize the product into the very small elements, and then we can apply the boundary conditions on those elements or on that geometry and see the behaviour of that geometry, we can see what are the types of stresses being developed, what are the strange being developed, what are the displacements happening. So, all that we can do in finite element analysis. With this technique the object is divided into large number of finite element which form an interconnecting network of concentrated nodes.

So, it is only showing that we can divide the complete structure into its individual components or smaller finite element, and then apply the boundary condition. For example, we want to solve a cantilever beam problem, we can model that thing divide that beam into the individual components apply a load here and see how it will deflect what would be the maximum displacement that is happening or what are the type of stress is being developed on the application of load.

So, those types of problems can be solved using the finite element analysis, everything on your computer screen. So, CAD these days is not only related to drafting, but it can be we can say combined with the analysis procedures also, and can give us a complete design of the you can say product.

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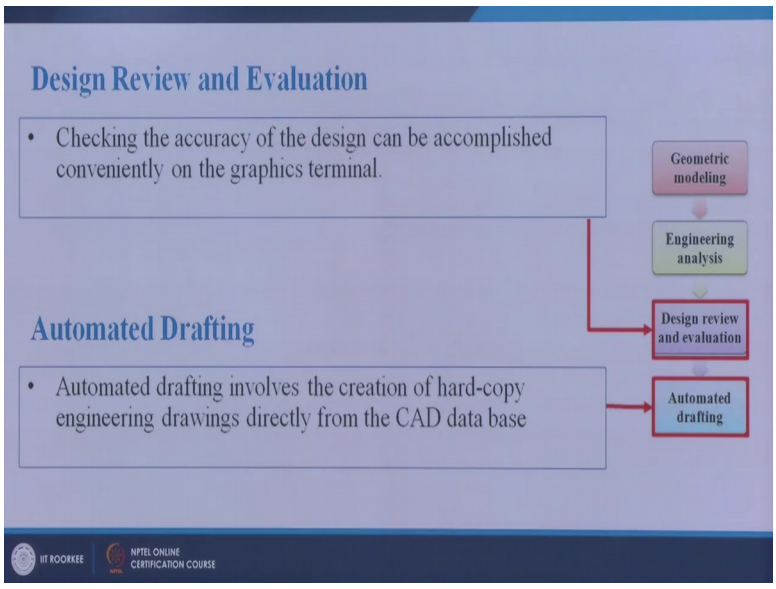

Then the third stage is the design review and evaluation, which means checking the accuracy of the design it can be accomplished conveniently on the graphics terminal. So, we can do the design evaluation. Then the automatic drafting automated drafting involves the creation of a hard copy engineering drawings directly from the CAD data base. Now whatever we have designed successfully as we can see as I have already told that maybe we may have 4 or 5 designs, and we want to select a design which has a minimum surface area.

So, we can do the execution of our program and see that which particular design is giving us the minimum surface area that design now we are selected, and we can do the drafting for that design with all dimensions and all details and we can even generate a hard copy for the on word transmission to the prototyping department, where they can start manufacturing the prototype of that product using any of the standard prototyping techniques. From our discussion point of view we would be focusing on the rapid prototyping tool as one of the tools for prototyping our designs or models.

So, if last part in CAD would be automatic drafting in which we will be passing on the information or the finalized information to the next stage.

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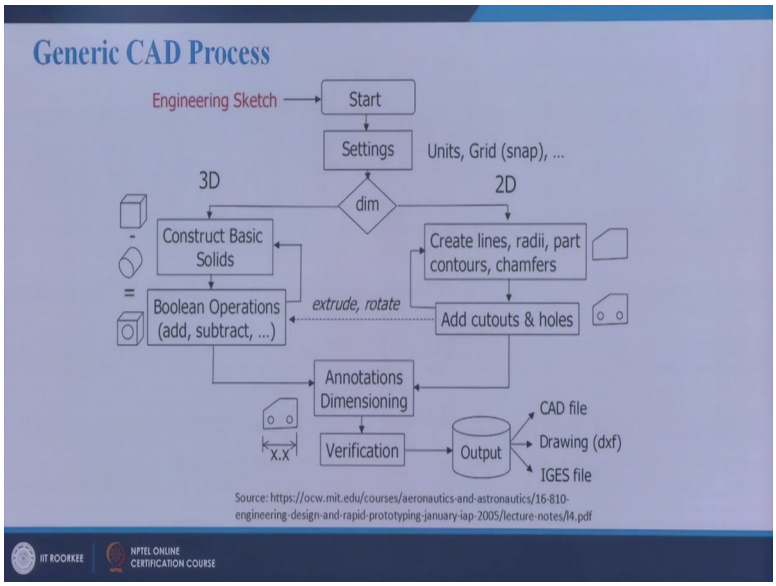

Now, this is a generic CAD process you can see taken from OCW open course where MIT EDU. So, you here you can see you have a engineering sketch maybe a rough sketch of a product that you want to make may be a rough design of your mouse that you

operate with the mouse with which you operate your cursor on the screen. So, if you can have a rough sketch of that mouse what can be the next stage?

When you start you put all your settings units grids whatever, maybe units can be whether you are going to use absolute unit you are going to use centimeters or a millimeters or what all those units and grid all that will be set here, then you have to see whether you are going to three dimensional or two dimensional model. If you are going to use three dimensional models, you can see this may be a cube cylinder hole inside square.

So, there will be this is maybe out by these two you can see you can generate a third geometry. There is a solid cube here there is a cylinder here, cylinder from cube you subtract this cylinder you get this shape. So, if you are working in 3D this type of operations you can do, you have a solid thing this is the thing you want to remove from this thing, this is the final product that you get. So, this type of modeling you can do in 3D from 2D point of view, you can create lines radii part contours chamfers like this you can add cutouts and holes like this. So, you can do a two dimensional CAD modeling you can do a 3 dimensional CAD modeling in which you can generate three dimensional volumetric shapes.

So, then you can do the annotations maybe changes and then you can do the final dimensioning length, breadth, width, centimeter, millimeter, kilometer whatever dimensioning is required verification of the drawing and it can go to the output, and output put can be a CAD file or a drawing which can have a extension of dxf or it can be IGES files. IGES files is usually used as a interface with the other analysis softwares and can be used as a input for the analysis softwares like the finite element method. So, you have IGES files output also coming from the CAD process.

So, in CAD process we may have a to we may choose a two dimensional modeling process, we may choose a three dimensional modeling process and accordingly we can use simple operations like this to in order to get our final shape. This is our final shape in three dimensional a modeling this is in two dimensional. So, we can make different types of shapes this is just the representational shapes, whatever shapes that you want to make you can make there are number of operations which can help you to get the exact shape

of the product that you want to make, and here you can see there is a command given extrude rotate.

So, you can use these commands in any standard CAD software to generate the exact shape of the product that you are trying to design. So, this has CAD has got lot of capabilities these days and is a very helpful tool for the designers.

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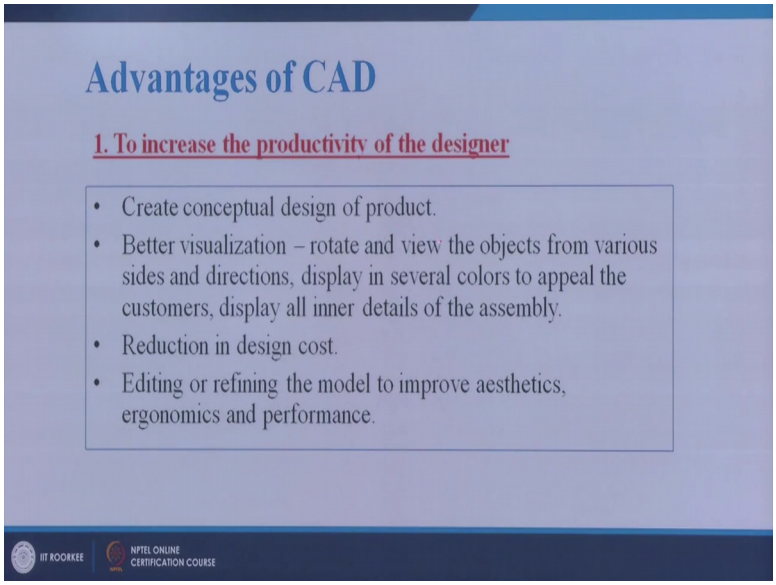

Now, let us conclude that what can be the advantages of using the CAD. First is to increase the productivity of the designer. So, it has completely revolutionized the process of design. So, we can see that using a screen very easily if you develop an expertise maybe or one software you will be able to make all the standard shapes and size even the non standard shapes and size is very easily.

So, it improves your productivity as a designer, create concept design of a product better visualization as we can rotate the views we can change the views we can have different views from different angles. So, display in several colors to appeal the customer display or inner details of the assembly. So, we can have cut section views also in case of CAD that is one thing, reduction in the design cost editing or refining the model to improve the aesthetics ergonomics and performance.

So, whatever design we have made we can analyze it from the ergonomics point of view, we can analyze it from the aesthetics different color com color combinations can be tried,

we can also sometimes performance may not be totally functional or totally possible, but in many cases we can try to analyze the performance also based on the CAD models that we develop. So, it improves our productivity.

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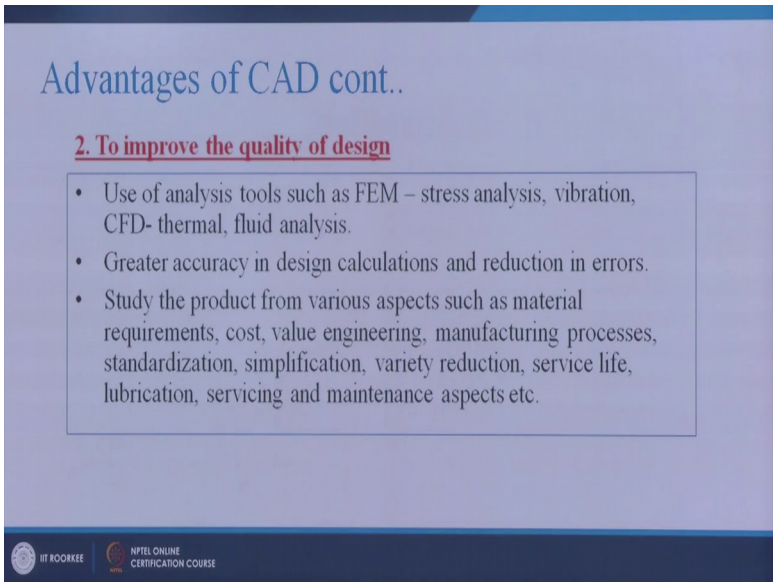

It improves the quality of designs, it can use of analysis of tools such as FEM analysis tools as I have already discussed, you can do FEM analysis based on the CAD model, stress analysis vibration analysis computational fluid dynamics thermal analysis fluid analysis can be done very easily.

So, we can integrate our CAD model with analysis software and you can do a complete analysis of the product, greater accuracy in design calculations and reduction in errors. So, human intervention is they are, but since it is system based and auto correction features are also there in many design software. So, the chances of error gets minimized and the design calculations are more or less accurate, then we can study the product from various aspects such as a material requirements cost value engineering manufacturing processes standardization simplification.

So, there are number of advantages of using the CAD software, and if you compare it from a manual design being developed by a draftsman, which is a design representation only a drafted information on a piece of paper, here we can integrate our draft or the geometric model with other number of other softwares and come out with a complete design of the products. So, it has got lot of advantages that quality of design also is better

because it has been analyzed not only from one point of view, may be from different points of view or that design philosophy in totality can be implemented using the softwares.

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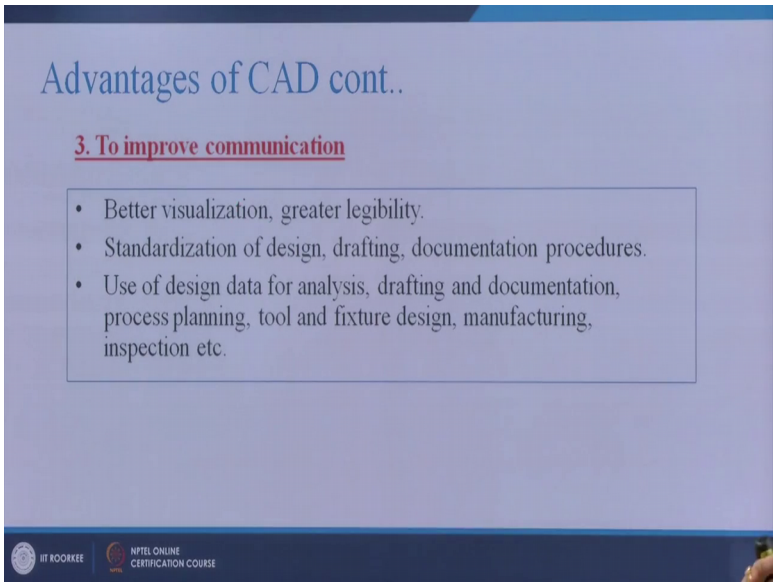

To improve the communication yes because many times, I may be using although many standards exist on numerous standards exist for the engineering drawings, but sometimes there may be a slight modification here and there by a person who may be using some known standard procedure.

So, in that case in case of CAD that is not possible, it leads to better visualization greater legibility standardization of design drafting the documentation procedure, because it is software based similar type of output would come out and which has to be interpreted by the other you can say people of the team also the similar manner, because it is standard approach, use of design data for analysis drafting and documentation, process planning tool and fixture design manufacturing inspection.

So, whatever standard output that we regenerate out of a CAD software, can be used as a data for the subsequent operations of product design and development.

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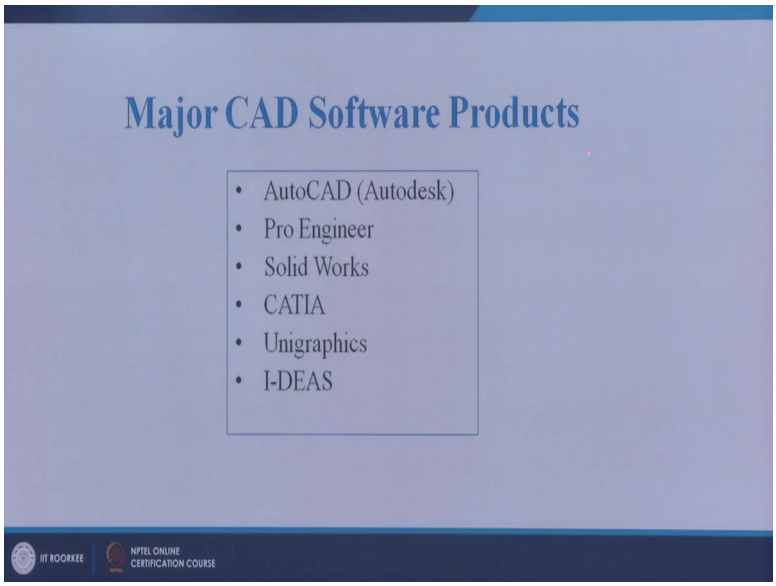

So, this is the last slide for today major CAD software products are AutoCAD, Pro engineer, Solid works, CATIA, Unigraphics ideas and there are number of other companies also which are these days developing the CAD software.

So, in summary CAD is a very good technique or very important technique for product designers and since in our course we have to discuss this topic of product design and development for 10 hours only it is not possible to have a complete tutorial on any standard CAD software, but I would advise each of the learner to at least the register for any company training or in your college wherever possible try to learn at least one or two CAD softwares, list is there you can even add to this list, you can appoint this list whatever software available you can just start working on the screen, set try to click various icons on the screen and try to design some products based on the computer aided design philosophy. Because it is going to be the most important we can say step in the overall product design process.

So, we can have the concept we can model the concept maybe rough sketch, but final output has to be very very technical in nature, it has to very very specific in nature and in order to generate that specific output for the next stages of the design process, we need to have knowledge of the CAD software. So, I would advise each one of you to learn at least one good CAD software for the product design process.

In our next class we will try to learn another tool which are very very helpful for the product design process.

Thank you.