CAD/ CAM
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Lecture No. # 03
What is CAD/ CAM

Now this lecture is in a way we can say an introduction to what is called as a CAD/ CAM which is an integrated view of design and manufacturing.

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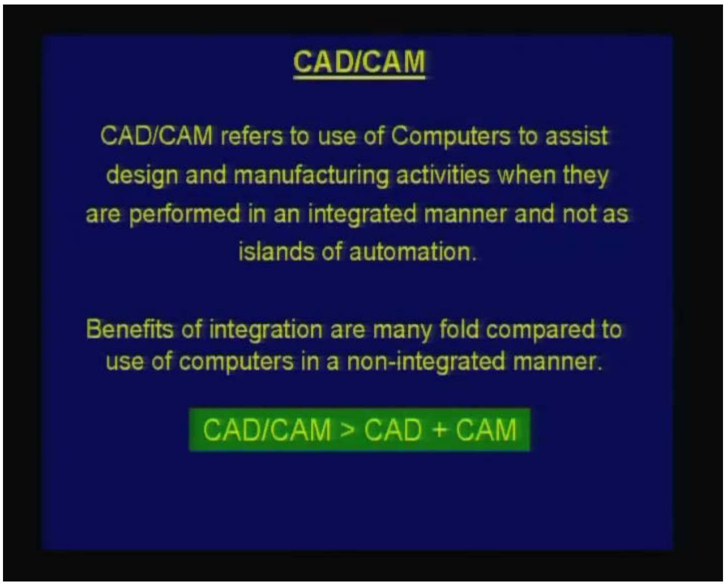

Now CAD/ CAM can be defined as for example computers to assist design and manufacturing activities when they are performed in an integrated manner and are not as islands of automation. What we did in our earlier lectures is more like a islands of automation. A computer based automation of a design process and computer based automation of some of the manufacturing activities more in a separate way but now we are looking more in a integrated manner. And it is also true that benefits of a CAD/ CAM would be much more when you do it in a much integrated manner. There are like organizations who use computers only for design process. Then there also organizations who use only for manufacturing processes then there are organizations who use them separately.

Then you also have a class of organizations who actually look it more from the integrated point of view. So by the word CAD/ CAM, one usually refers to this particular thing. But if you really look at the definition which is given for CAD/ CAM, particularly from various books which are published you may come across various definitions and domains. The reason is the subject has award over like 40, 30, 40 years and the definition is also continuously changing. For example a book which is written something like about 20, 25 years back there were certain CAD/ CAM technologies but if you really look at now there is a more integrated approach compared to what it used to be a few decades back. So I have put that CAD/ CAM is something which is greater than CAD plus CAM that's what is the basic summary of the definition.

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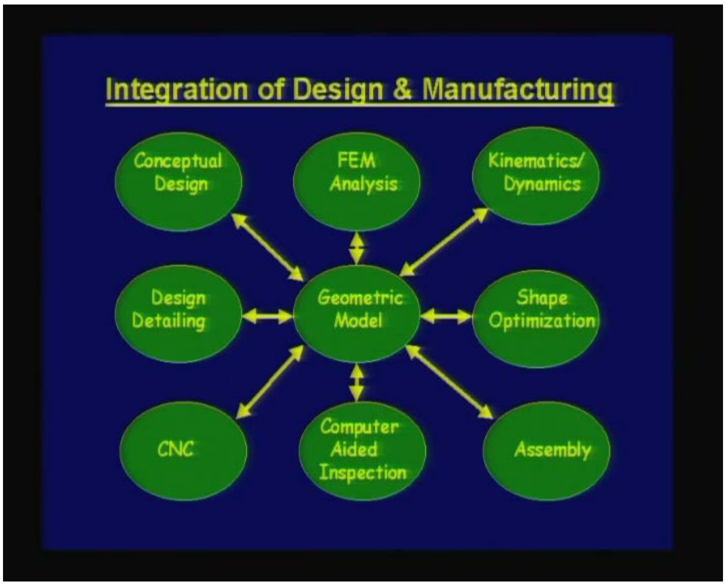

Now this particular picture should give in a way an integrated framework for computer aided design and manufacture. If you look at for example what we discussed earlier is in our first lecture that computers can be used for the design process. They can be used at a conceptual design process and more so in a design detailing or analysis or configuration kind of a design and also in terms of carrying out analysis like finite element analysis. They can be applied for analysis like kinematic and dynamic analysis. So one can think of let's say using a CAD tools in this particular domain and restrict to only use of computer to this domain and call it is a CAD, that's very valid definition. And in the second lecture, we looked at particularly use of computers for manufacturing like CNC program generation or computer aided inspection. We also looked at computer aided assembly. So this can be considered as more of a computer aided manufacturing.

Now what is shown here is only a set of activities. This is not complete design and manufacturing activity. Design and manufacturing activity overall involves many other activities which are not shown here. So this is just a representatives like. Now these activities which we call as a computer aided design and then computer aided manufacturing, they are all related with, they can be related using let's say a concept of geometric modeling. So this is called as a geometric modeling based integration of design and manufacturing. Now what is really happening in a typical product design and manufacturing process is somebody may start with a design, go for analysis tools, may come up with a optimization and finally arrive at let's say a design detailing. During the design process, the geometry continuously evolves. So you start with nothing and at the end of a design, when you say that I have completed my design and I have documented that means one of the aspects of your design information is geometry, in fact key information is geometry.

So the geometric model continuously evolves as a part of a design process. You may have seen people who are using computer aided tools for example a designer sits in front of a computer then start with the design process and starts with let's say adding a few features like start with a simple, you can say start with a simple geometry and continuously modify this particular geometry as a part of the design process and during this particular process, you have to check for certain functional requirements.

You have to check whether the design geometry will do the indented functions satisfactorily or not. So for those situations you use analysis tools and based on the feedback from the analysis, you modify your design and this is you can say an iterative process. It's like you cannot say that design is a sequential process, you start with a step one and end with a step 7 or step 8 where there are no iterations. It's an iterative process and that is what is usually done in this.

Now the geometry evolves as a part of design. Now the same geometry is required at various stages of manufacturing. For example if I want to, suppose if I have a component which has to be manufactured on a CNC machine let's say it maybe a CNC machining center or it may be a CNC punch press or it may be a CNC arc welding machine. Now one of the inputs to generate the CNC program is geometry. After all what is manufacturing. Manufacturing is like one of the ways of looking at is realizing the design geometry through various manufacturing processes. So, since you are realizing the same geometry which has been designed by the designer so geometry forms one of the key inputs in any manufacturing. We also looked at computer aided inspection in our last lecture.

So one way of or the major objective of any inspection process is to see that the manufactured geometry meets the design geometry within certain tolerances. That means there is not much deviation in the two. So you are again using the geometry which has been designed, you are getting a geometry which comes from the manufacturing like after a component is manufactured, I can measure it on a CMM and model the manufactured geometry and then compare with the design geometry which is available and see whether the part meets the, you can quality requirements or not.

So again geometry is an input and in assembly also we know that you make use of the geometric features of various parts to carry out the assembly process or even to automate the assembly process. When you say that there are two parts which are mating and they have a mating relationship. So this relationship is usually expressed in terms of some geometry. For example you say that a solid shaft mates with a hollow shaft, you basically make use of the outer cylindrical surface of a solid shaft and inner cylindrical surface of a hollow shaft and say that these are the two mating surfaces. So, again you are making use of a geometry which is a part of, which comes as a part of a design. And so what we really look at here is this is, geometry evolves as a part of a design process and it is used by a manufacturing process.

Now if this is true then one should really like I have put the arrows how the geometry is basically modified or input from various activities. You see that the arrow has two directions, it is not necessary that design only gives a geometry and there is no modification. It goes through modification like when I carryout a finite element analysis, I give a input geometry, carryout the analysis and I see that either it doesn't meet the strength requirements then I can go on change its geometry like change the section, so that now it has a better strength kind of a thing. So geometry is modified as a part of process. It is true that in a manufacturing activities also there is a feedback which is sent to geometric model for basically changing the geometry like I carryout let's say we discussed about what is called as a design for manufacture and design for assembly.

So in DFM and DFA, what one is trying to do is that carryout the manufacturing operation either in real world or a virtual world then based on the feedback, you are actually trying to modify the geometry or suggesting some changes so that a component can be component can be manufactured in a more optimum manner. So all the activities which pertain to design and manufacturing, they take a geometry as a input or they return the modified geometry based on certain feedback. So when I am actually working in an environment like this, I can call it is a CAD/ CAM. So the CAD/ CAM is something more than pure computer aided design or computer aided manufacturing. Now this type of framework is also used in many CAD/ CAM systems like when you use a software let's say a CAD software or a CAM software or whatever it is, you may have a software which actually can do only one of these functions like there are number of finite element analysis packages which can do stress analysis, heat transfer analysis or CFD analysis or electromagnetic analysis and the purpose of software is only to do analysis. So it pertains to one aspect of a design. I may have a software which does only kinematic and dynamic analysis and nothing else or I can have which helps only in terms of helping in a conceptual design like I can use some innovation tools which are software based which can help me in conceptual design process. We also know that there are software packages which can do only a CNC program generation and nothing else.

Similarly you have a software which specializes purely in assembly. Now when you say a CAD/ CAM, one approach is that you are putting together all these individual software's and trying to integrate in some manner that means you have a links from one to go for another. And this kind of framework is designed by the person or an organization which is trying to use all these software packages. A second way of looking is that if I have a software which has all these modules like I buy a single software that means under one umbrella, I should be able to do all these activities that is another approach. So when you say a CAD/ CAM systems like usually you may have come across a term what is called high end CAD/ CAM systems.

So what one means by high end CAD/ CAM systems is that a system which has like modules for all these activities and you are able to do all these activities under a single software or under a single umbrella but it is not necessary. If I prefer to go in terms of using individual software's I can always, for example use the packages but when I am using a separate packages there is a one thing which one has to do is that there is a geometric data has to be transferred from one system to another continuously. So this is called as a geometric data exchange like this shows a geometric data exchange which has to be done, like if I am using an individual pieces of software I have a geometric format in which like I have a software one which stores geometry in certain format.

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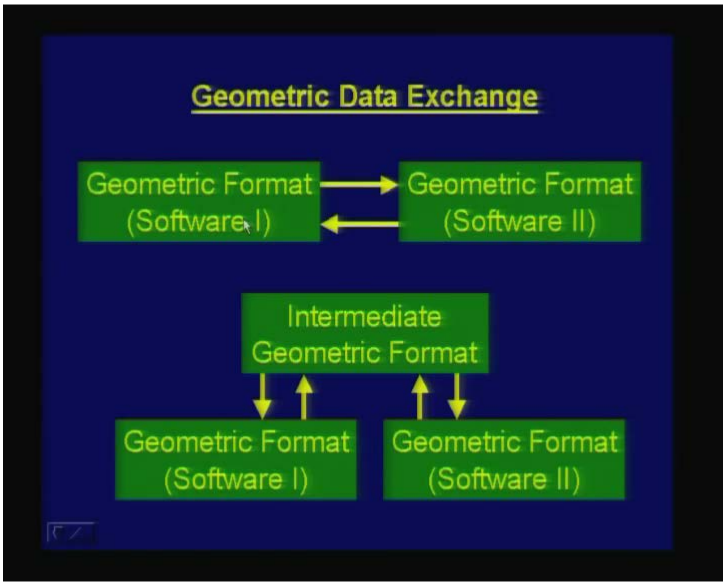

Then I have another software where this geometry has to be translated or transferred. Then I have a second software where the geometric format is different. Now whenever there is a change in geometric format, a data transfer is necessary from one system to another. Now this is necessary because like for example if I want to store a geometric entity, there is no unique way it can be stored like if I take a simple example of a circular arc, I think we discussed this sometime back also. Suppose if somebody has to represent or store a circular arc, what should be the input. Somebody may say it should be stored by inputting let's say a center point of the arc, start point or end point, radius, start angle, end angle. You may not need all these values.

Any combination or certain combination of this is enough to store a circular arc uniquely. So a package one may store in some manner. The package two may store in some other manner. So, whenever there is this thing I need to translate. So the two arrows which you are seeing here are another pieces of software which are called as geometric data translators which take a file from software one and transfer it to a format which can be read by another software and you need a bi-directional translators in order to have an exchange from one particular system to another. Other way of looking at geometric data translation is in order to move from let's say one particular system, one particular software to another particular software I don't have a direct translator between these two packages but I make use of some intermediate format which can be a standard or which can be you can say in a universally accepted format in some manner and I can have a translation translator to convert it from let's say geometric format of software one to let's say this intermediate format and then I can have translator which goes from intermediate format to a geometric format.

If I want to move it in the other direction, I have to follow the second set of translators which are available. So this is another you can say, another way of doing a translation process or transferring the geometric data from one system to another. Now somebody may say which one should be, which one is like more preferable kind of a thing. Here I am using only a two translator whereas here I have a four translator. This actually depends on various factors. Usually the direct translation is more reliable.

Sometimes what happens is when I am going through an intermediate format there may be some information which may be lost. So somebody may say this is a more reliable option but there is also advantage of this. Imagine I have a, for example a 7 different systems which have 7 different formats and if I have to have a translators for converting from one to another, if I follow this approach how many translators do I need. No, you need between any two combinations. For example 1 to 2, 1 to 3, 1 to 4, so you need basically a 7 c 2, 7 c 2 is the combination into 2 because it's a bi-directional translator whereas here I have a 14 translators because you are going through intermediate and then doing this. So the number of translator in that kind of a situation this maybe a more beneficial whereas here if I am going for a bi-directional then I need many more translators then as the number of systems among which the data transfer increases that means more the systems, the better would be this kind of a system. And this also has an advantage that you are making use of an intermediate format which is like more universally accepted.

So if I have to communicate, if there is a communication if the data has to be transferred let's say from one system to another system or one organization to another organization there has to be some you can say an acceptable standard through which people can communicate. So this is another way in which it has to be done. And the geometric data exchange is becoming more and more important as we discussed earlier like a big organization would like to subcontract or by major components from another this thing but as a part of this, you are actually trying to transfer the data. For example if I take an example of an aircraft company, so an aircraft company may buy engines from three different companies who are specialized or who specialize only in engine manufacturing.

So, naturally you require the geometry which is related to, geometric data related to engine if I want to carry out the assembly or virtual assembly operation when I am designing an aircraft. So since I need a continuous data exchange if I have some kind of an universally accepted format, many people can communicate so that is a major advantage of this process. So with this objective in mind, there are number of geometric data translators which have award over a period of time like some of these translators are shown here like you may have come across a term IGES.

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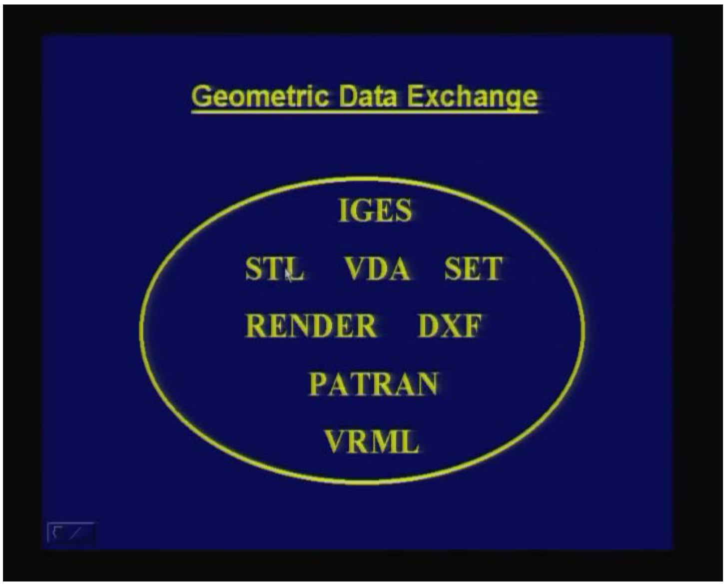

IGES is an ISO standard which is the first, one of the first standards which was designed or you can say developed for the geometric data exchange. And most of CAD/ CAM systems, those systems which do pure computer aided design, pure computer aided manufacturing give some kind of an interface with IGES, so they give a translators to translator the data from and to from IGES so I can carry out this particular process. Then STL is another format, this is called as stereo lithography format and this format is used usually more common in rapid prototyping machines. So in all rapid prototyping machine, I have to, input is a CAD model, so there are variety of CAD, variety of rapid prototyping machines which are available in the market.

So what is data? Like all of them they accept stereo lithography or a STL format or most of them. Similarly you have, different nations have their own standards like VDA is a German standard, SET is a standard used by French. So there are national standards which are developed for geometric data transfer. DXF is a standard which is developed by one of the CAD packages but is also quite popular for data exchange. RENDER is another format which is usually used for computer graphics application. PATRAN is also a standard which is very commonly used for many finite element applications and others. And VRML is again another format to define and translate the geometry which is basically developed for web applications.

Now best way to understand the VRML which actual stands for virtual reality modelling language is all of you use world wide web for browsing and for interacting or for certain applications. So you also come across images. Images are usually stored in either gif format or jpeg, so gif and jpeg can give you only an image which is a two dimensional image. Suppose if somebody has kept a pot model somewhere and I would like to basically click and rotate it and I would like to see it from different views. So I want a three dimensional geometry in order to interact then you can go for a VRML. So what you do as a part of VRML is suppose I create a pot model and I convert into a VRML format using a translator which is available and put it on the web and throw it open for others to use and interact.

So others can open, what they are basically looking at is not just a static image but they are able to interact and walk through the pot or pot assemblies and get a better picture this particular. So VRML is mainly for the, is primarily or more commonly used for the World Wide Web applications. So these are some of the formats, again this is not a very comprehensive. There are many package to package translators which are developed but some of the commonly used geometric data exchange formats are shown here. So these geometric data exchange format somewhere sit here and then you have a translators from various packages and that’s how the data exchange happens.

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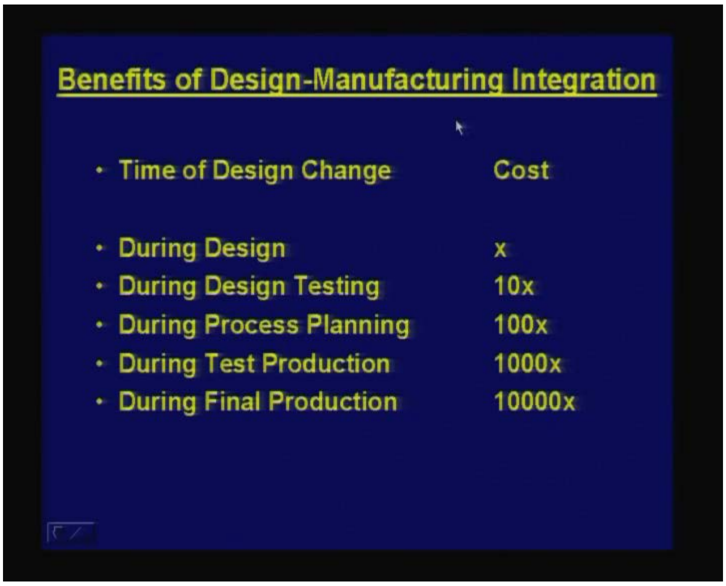

Now we discussed that in a typical CAD/CAM environment, you have a more integrated approach where various design and manufacturing activities continuously either use the geometry or update it etc. Now this particular slide basically gives that kind, an environment like an integrated environment is very very useful in order to reduce let's say product development, time and cost. In any new product design and development process, you never arrive at let's say a particular design in one step. It's a continuous process, an iterative process. The design undergoes change during conceptually design stage, during detail design stage, during analysis, during manufacturing. So there are various stages at which the geometry undergoes change. But it's also important that when the changes usually occur. For example if I carryout any number of changes in my design during the design stage itself, it costs less but once I have let's say finalized a design, now I am going for a functional testing. If I try to change a design then it cost little more, you have to go back and do the design process. So it has been tested now it has, you have a detailed drawing, detailed design of this and you are going for manufacturing, the first step is a process planning.

At the stage of process planning you realize that there are problems with the design geometry and you change it, you have a more cost which is associated. Process planning is ready, now you are actually going for a production and if the design changes happen at that stage, it cost even more and during final production or let's say it's in the market and the actual, you can say a problem with the geometry is coming from let's say as a feedback of customers etc then you have more cost implications. So basically the purpose of showing this particular picture is one may have to account for all these things that means change of design during these stages may not be like you cannot avoid them, one has to reduce as far as possible.

And secondly if these considerations can be brought down at the design stage itself like when we say design for manufacturer or design for assembly, some of these design changes which may happen you are actually trying to do it here. So if I go through a sequential process then I have a problem. If I go through an integrated approach where all these considerations are taken care at the design stage itself then you have a benefit. So the advantage of integration is evident from this that you are considering these aspects but at a design stage with a less cost implications rather than doing them in a very sequential manner, first design next manufacturing you have more cost implications which are here. So that is the basic you can say the benefit, major benefit of CAD/ CAM over individually CAD plus CAM which we had.

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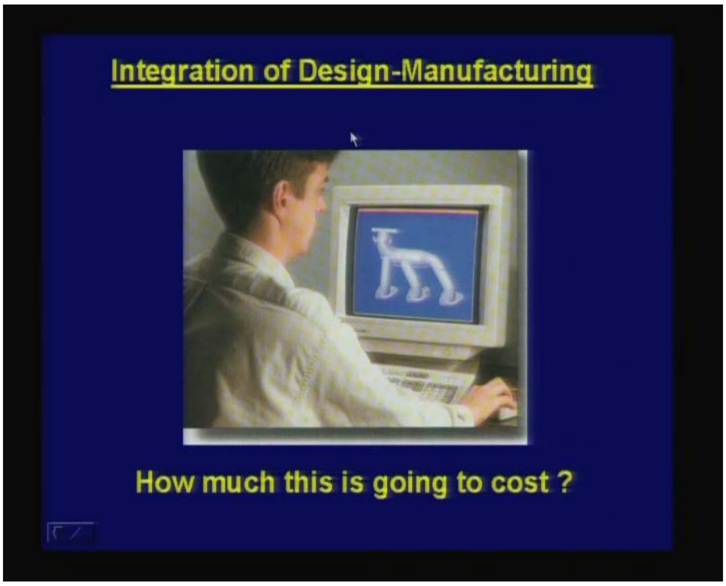

Now this kind of framework which we discussed where geometry forms a basis for integration, for integrating the design and manufacturing was like basically developed in late 70's and early 80's. So from early 80's itself you have a framework like this which is already there as a part of packages or you can say major high end CAD/ CAM packages where geometry based integration is already there. But in recent years, particularly in last two decades it has been realized that integration based on purely geometry is not enough. So what is happening is the information which is exchanged between various activities is design. That is you can say a geometric information. So, geometric information is only a one part of design information. There may be a much more data or much more information which may be associated with a product. So if you are doing purely a geometric data transfer and geometric data exchange, you have a benefit you are working in an integrated manner but you can go beyond geometry and do that. For example we can look it from an example.

Suppose I am trying to carry out a design process and I would like to know how much this part is going to cost me. It's not a very easy question to answer. I may have very good integrated framework where there is a geometric date exchange happens but still it's difficult to answer this question. The reason is what constitutes let's say a cost of a product. There are many things, you have a material cost, you have a manufacturing cost, you have an inspection cost, there are various cost which put together will basically form the cost of this thing. Suppose I take at let's say one aspect of this, a manufacturing cost. So, naturally I have an integrated framework where I can go and let's say carryout let's say an NC program or this kind of a thing and know what kind of manufacturing or how to manufacture this particular product. Now when it comes to a manufacturing cost to, its not very easy to do that because if I am trying to find out the manufacturing cost I should know various other costs like what are the material cost, what are the tooling cost, which manufacturing machines will be used and if I am using a certain manufacturing machines and manufacturing process whether they are available in my organization or not or I have to buy it or I have to subcontract.

All these decisions have to be taken in order to answer this particular question and as a part of this, geometry alone cannot help. Just take an example, I know that this component is going to be manufactured by let's say a process like a die casting or let's say a component has to be manufactured by machining. Now you input a geometry because you have a very good framework for inputting and like exchanging the geometric data. I cannot decide the cost purely based on geometry. Maybe I need what kind of tolerances this particular part has, what kind of surface finish is required on this particular part and the type of surface finish which is required will be decided by what is the functionality of a product, what is the intendment function of the component.

So, since you require more information than more information than geometry like I took an example of a tolerances or a surface finish, exchanging pure geometric information is of some help or of some benefit but a better information exchange mechanism should take the complete product information into account. So that is what has been a realization of last you can say 20 years. And now people are trying to bring again a framework for an integration where you have a CAD/ CAM but the information exchange is beyond geometry which includes the complete product information. So this is usually called as a product modeling like this basically summarizes what I said just now.

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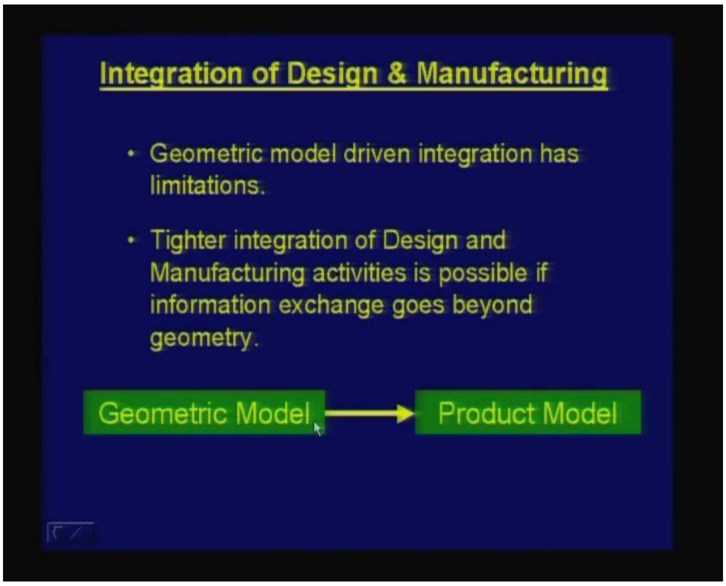

So if I want a tighter integration of design and manufacturing, information exchange should go beyond geometry. So I move from geometric model to what is called as a product model. In a product model geometry is a subset but it includes many other information's which are usually needed for taking certain decisions.

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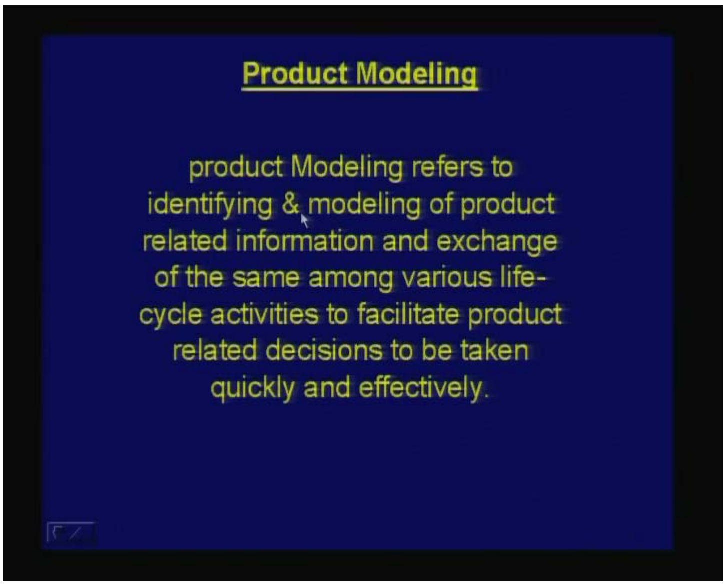

So a product modeling can be defined as basically an information and exchange of related to all the life cycle activities. I think the word life cycle comes here. Life cycle is an important word to know. So far we have been discussing about design and manufacturing. When you say that there is a product, design and manufacturing are only a certain phases in a product life cycle. Now a life cycle may include information which is beyond design and manufacturing like once the manufacturing is over you may, you would like to bring let's say a marketing information or how to maintain this particular product. How the product should be maintained also requires product related information and how the, let's say the product life is over I want to dispose of the product, so let's say whether it's possible to recycle this particular product or not, even that information is a part of a life cycle.

So life cycle is from the birth of a product till you dispose it off, this particular product all the information which is related or which is required, all the product information which is required is usually put as a part of product modeling. So exchange is possible not only between design and manufacturing, you can go for other activities too which are possible. So the product modeling is like you can say product modeling based integration is now a focus in many of the CAD/ CAM activities. Now what information other than geometry is required? There can be many, you can say many different type of information which one may require as a part of life cycle.

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Even if I look at design and manufacturing point of view, I have put a few of these, this is again not a complete list, this is only a sample information other than this function. Do I have let's say a framework where given a particular product, I am able to define what is the functionality of a product like when you store let's say a particular part, let's say if I take, suppose somebody has a design for a connecting rod in a computer aided design package, so you retrieve. You know that this is a connecting rod or somebody may label it as a connecting rod but the person who is trying to retrieve may not really know what is the intended function of a connecting rod or what this particular part is supposed to do. So I should be able to store the functionality also.

I should be able to store what are the specifications and constraints like you may design a connecting rod for various applications, some maybe for a very corrosive applications. So you have a constraint that this is a connecting rod, this is the function of this but it has to work under certain constraints. Those can also be stored and what are the specifications for which this has been designed. Geometry we have already discussed with which we are familiar. Design history, the designer who tried to design this particular connecting rod has gone through a number of versions. So what are all the versions, how did the design start, how the modifications were carried out and why these modifications were carried out, you store the complete design history.

Now design history also helps one to know, suppose if I am going back for a redesign which is already been done in the past and there was some disadvantage you don't have to repeat. You can just retrieve the design history and know what is the problem in let's say changing the design in certain manner. Material information, material information is so critical for all the design, manufacturing, recycling, maintenance for all sorts of applications, assembly and bill of materials, tolerances and surface finish, process data. You would also like to say that once the process plan for the component is generated, you would like to store that also that this is the you can say the complete process plan for the component or I may have some business information related to this particular thing. So if I can design a file just like an IGS, IGS file can store a geometry but if I have a file which can store also this information and much more then you say that you have a product model and I can have exchange which is possible based on the product model. Now one of the solutions which is given for this is what is called as a STEP. IGS is an international standard, ISO standard.

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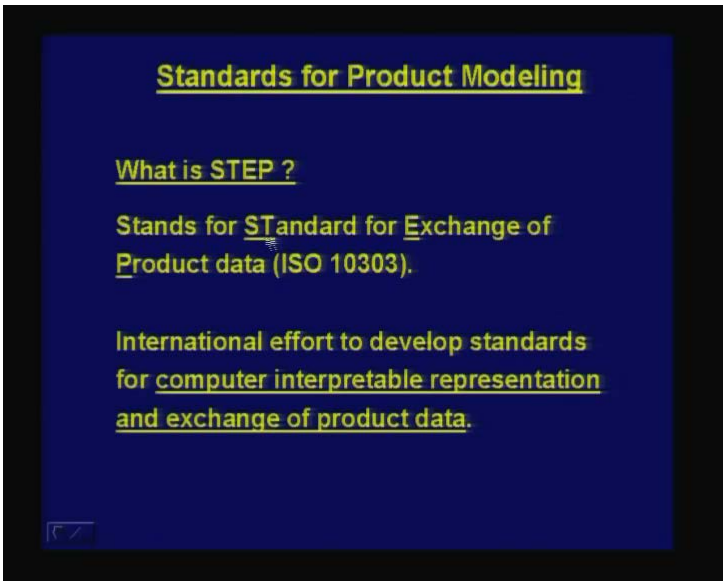

Similarly STEP is another standard which has been developed to exchange the product information. Now this is given basically, STEP stands for standard for exchange of product data, ISO 10303 is the number for this. So what is the purpose of STEP is it's an international effort, many countries have come together to develop this particular standard which basically consists of computer interpretable representation and exchange of product data. It's not geometric data, geometry is included as a part of a STEP but it has other information which is related to product which we have looked at this.

Now just to give an example like suppose I model, I design a product in one of the packages and I assemble it, so I have a assembly information. Assembly information includes what are the components which have put together and what are the mating relationships. Now if I want to take this assembly to another CAD/ CAM package, suppose if I have a translator, geometric data translator like IGS it's not possible to do that. What you have to do is I can take the individual geometries of the components to another package and do the assembly there because IGS will not give you a provision to also store the mating relationship.

Now suppose if I have a STEP file, a STEP has a provision to store the assembly information also. So, once I prepare an assembly of the product I generate a STEP file, take the STEP file in another package and open it, you can also see that the assembly information is preserved, all the mating relationships are preserved. So it's like an example of going beyond geometry and it's possible to do that. Most of the CAD/ CAM systems now they also give STEP as a translators. In fact IGS and STEP are the two common which you will find with most of the CAD/ CAM packages which are available in the market, I can always create a STEP file. I can use STEP purely for geometry purpose also but I can, suppose the component has been given certain tolerances and I want that these tolerance information also be exchanged between packages, it's possible to do using a system like a STEP.

Now another important concept. So the basic summary which is wanted to do is that if I go for let's say a design and manufacturing integration framework which is more like STEP based then you have further advantages. That means more decisions can be taken quickly and it also has lot of cost implications.

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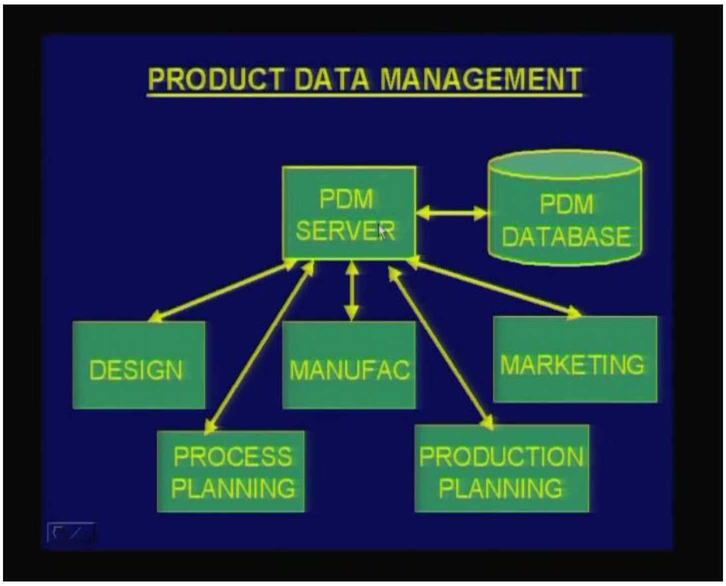

Another way a product can be managed and exchanged is what is called as a PDM or product data management software. What basically product data management consists of is it has a server which is basically a computing system, which is used to exchange information between various departments. Then it also has a database where the information is stored. And if there are many you can say departments in an organization and all of them they are concerned with the same product, somebody is designing, somebody is manufacturing, somebody is inspecting, somebody is preparing a process plan for that. And this design is continuously undergoing a change. So how do I tell others that the design has changed is if the design can be stored centrally in a server and if everybody refers to the same design then you have a something, a framework which can be used to communicate.

For example somebody has started with design and come up with a first version of a design and posted it on a PDM server. So other, the movement somebody posts or somebody says that a design has been admit to PDM server, server also sends information either through email or this thing that a design for this is now available on this. So other departments who are concerned with that particularly product can look at that design and see. For example a process planner can generate a process plan and see that there is a problem. So there is a problem if you modify the geometry in let's say this manner, process planning would be much more optimum. So process planner will modify the geometry and post it on a PDM server which is again broadcast to all the other departments.

So designer can again go back and see whether the geometry which has been modified by a process planner, does it still meets the functional requirements because designer is more concerned whether it will do the intended function satisfactorily or not. Since, a product information is critical to many people, so if everybody is modifying then they can always post it or they can put it at a central place, so this will have a various versions.

Suppose if the design has undergone let's say 10 times a change from version 1 2 3, all the designs are stored. If somebody wants to refer, why this has happened and how it has happened, one can always take back. And PDM can store information in various ways, it can be a text file, it can be an image or it can be an IGS file or it can be step file or it can be CL data that is cutter location data which has been generated as a part of program. So all the information which pertains to product, you put it on a central place which facilitates people to exchange the information quickly. Otherwise suppose if I do not have such a framework, somebody carries out a design then you send the information to all the departments so you are and the person may receive let's say you send it as a post or as a drawing then somebody may look at and take some time to feedback. Information is not instant whenever there is a update or this thing. So there are always delays which can be and also since you are sure that most of the people who are working with the same product, they are not working with different versions of a design because the most latest version of the design is available is told by what the PDM server has. So this kind of software is also nowadays becoming very common in fact many of the organization in India and abroad, major organizations they use this kind of framework.

And there are at least half a dozen very popular PDM software's which are available in the market. So when I buy a CAD/ CAM packages, I also buy a PDM software so that I will have this kind of thing. For example if I am using a package and I want to store my design in a format which is specific to that package, I can also put a file related to this. So PDM server need not have the formats which are only ISO standards or this thing. So it can be anything which can be used either in the form of data or in the form this thing but it's usually a digital data that means you have information in a digital kind of a thing. So a format like STEP together with like an information like PDM facilitates a fast exchange of information among various departments. And such a framework is used to reduce the, basically the product design and development time and also it has a cost implications. So that is basically I would say that a summary of this particularly lecture.

What we tried to do is that instead of using computers purely for a design and manufacturing point of view, you are working in a more integrated fashion either by exchanging the geometric information or by exchanging the product information and this exchange of information could be through a framework like product data management system which are available. So usually what happens is if somebody has to implement such a framework, in fact it is very common that an organization has 10 different branches in the country or across the globe and there is a one particular you can say branch which actually designs whereas the other branch takes care of the manufacture which are thousands of miles away but everybody works with the same PDM system like there is a central PDM server which is serving all the let's say 10 or 15 branches of the company, so as and when let's say a particular geometry or a product information undergoes a change, you post it and people can communicate kind of this particular this thing like for example Indian railways uses a product data management system for exchange of this kind of information.

So there are many such examples in India and abroad where people use CAD/ CAM systems together with a PDM for, we can say for major benefits which can be achieved. So I will just stop it here maybe I can take up a few questions. So during this particular lecture if you have any doubts so then you can clarify or you want to add anything to this, you can also add. So the question is are there any examples of PDM software. Yeah, for example there is a PDM software by the name WINDCHILL then you have a PDM software by the name METAPHASE then you have a PDM software by the name iMAN.

In fact these are all different, PDM software is basically used by also developed by different people who develop the CAD/ CAM systems. Sometimes like you also have a very good compatibility between a specific CAD/ CAM package and a specific PDM software because they have been developed by the same company or same software. So these are available in the market which people use or I can have my own in-house like a framework for a PDM. It's not difficult to do because only thing is PDM software gives you is the communication aspect is very well taken, otherwise you have to have all the modalities for communication and if suppose somebody is going to post a design what would be the format everything has to be designed. Otherwise it's more or less pre-decided in a PDM kind of a framework. So these are some of the examples. Any other question? If there are no questions, so what we basically had as a part of these three lectures is to look at a computer aided design separately, computer aided manufacturing separately and an integrated framework for CAD/ CAM is what we cover today.

Now based on these three, you can say introductory lectures, now we will look at the some of the individual CAD/CAM applications as a part of our subsequent lectures and also more, so keeping this framework in mind that is more important like one can always study, there are books on CAD/CAM and there are also curriculum in CAD/ CAM where these functions are separately studied but without this integrated framework in mind and it's very very important particularly if you look at the way industry operates now and the way they are moving, this integrating framework is becoming more and more common. So we will study the individual functions and also this framework but always keep that we are looking at CAD/ CAM not at computer aided design or manufacturing which are separate. So I will just stop it here.