Computer Integrated Manufacturing
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Lecture No 30
Computer Aided Process Planning (Part 2 of 2)

Welcome to the course on Computers and Manufacturing System. So, what was the limitation with manual process planning, manual process planning, we need to have more and more men or manufacturing engineer, who are involved in accumulating data over a period of time. So, what happened was computers started growing and the data has now started getting normalized and the data has been started now getting stored in a common place.

Many data books have come into existence, every country has their own standards, machining standard books they have started releasing. So, now what has happened? The computer is existence, the data book is now normalized and it is also put in a structured form. So, now this knowledge or this data can be converted into a knowledge. So, now using the advantage of computer evolution and the data books coming into existence.

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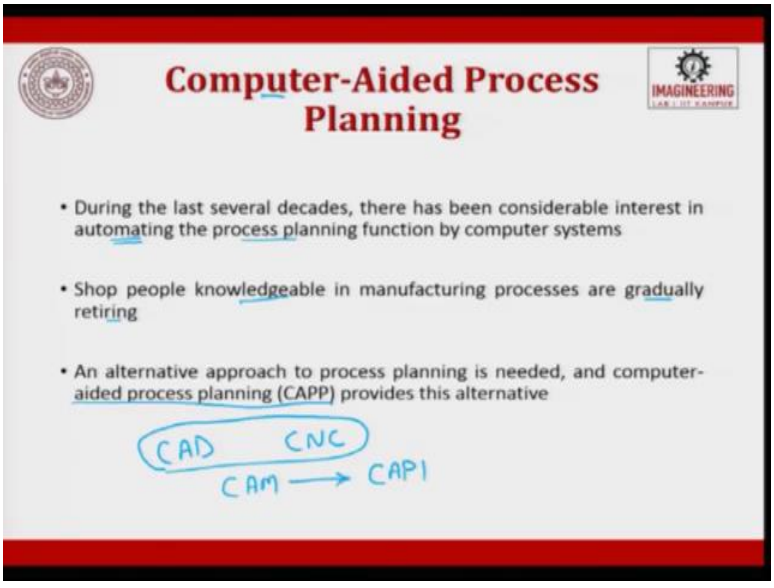

Computer Aided Process Planning has slowly become prominent, and existence, people have slowly started accepting Computer Aided Process Planning. Now, let us see, what is Computer Aided Process Planning? The evolution happened like manual, then going towards computer.

During the last several decades, there has been a considerable interest in automating, because earlier it was country based, now people have started doing manufacturing cross countries, now people have started accepting, let us have a world standard rather than country wise standard and parallely the automation has also started evolving.

So, considerable interest in automating the process plan function by computer systems started evolving. So, and slowly it was also become in costlier to have knowledge based people in the industry. And they were also getting gradually aged. So, the alternative for manual process planning is Computer Aided Process Planning, CAPP. So, CAD started evolving, then slowly CNC started evolving. Now, what is happening is? People have slowly started integrating these two and they have started talking CAM, and in CAM, one of the vertical is, CAPP.

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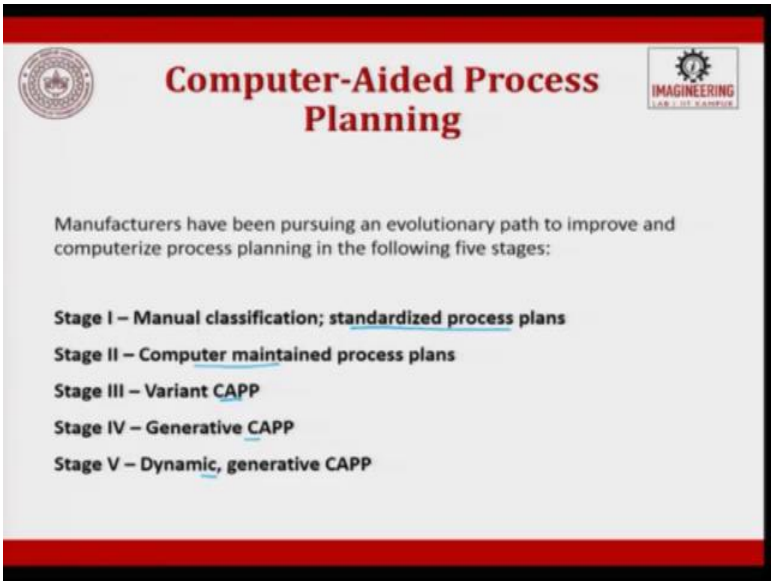

So, the manufacturers have been pursuing and evolutionary path to improve and computerize process planning in the following five stages. So, these are the five prominent stages, which have been evolved over a period of time. So, in stage 1, manual classification have started, so you have so much of data, now there is so much of data. Now, you have to do a cluster algorithm of those data.

So, what do you do? So, you try to cluster them based upon the shape, size, or aspect ratio, you started classifying the data whatever you had. And then for each classified data, you started

establishing a standard process plan or procedure. So, stage 1 was manual classification going on and for each classification, they started a establishing a standardized process plan. Then computers were used only for maintaining those data okay this, this, this, this, data was there. These are the cluster form and for this cluster, this is the process plan found.

So, now computer was used only to store and retrieve data, then slowly, slowly, the software algorithm started developing. So, the first step was leading towards variant process planning, the next one was leading to generative process planning, and the last stage is dynamic and generative Computer Aided Process Planning.

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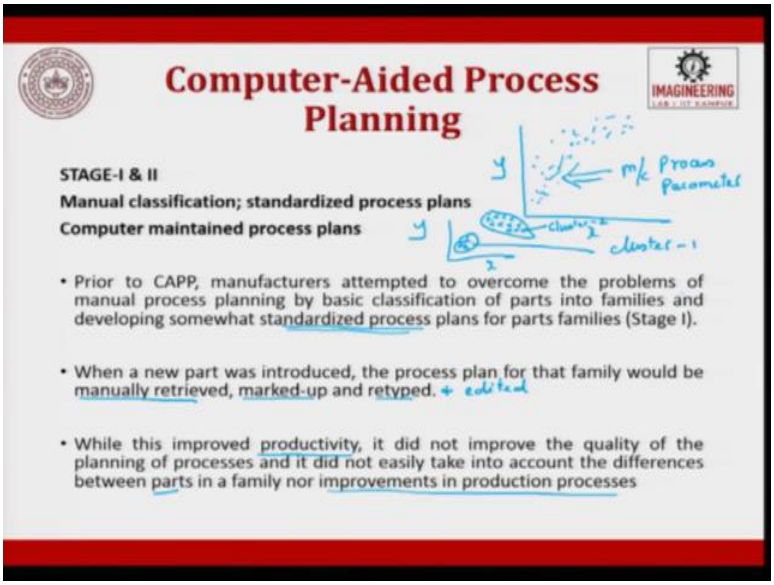

In manual classification and standardize session as the process. So, what I am trying to explain to you is, you have Y axis, and X axis, you have so much of data, so much of data are there. So, these data are nothing but different, different machining process. And some parameters you can try to have. Now, what do I do? With this data, I try to classify the data and form clusters. So, when I form these clusters there is a similarity amongst these clusters.

So, this is cluster 1, may be turning operations, this is drilling operation, cluster 1, then this is cluster 2. So, now this is what is manual classification of the data and how did you classify them? You look into the data whatever was there and then you grouped them. So, prior to CAPP,

manufacturers attempt to overcome the problems of manual process planning by Basic classification of the parts into families.

So, I always used to give this example to my students, suppose you go and buy vegetables from the market, from a market which is along the streets, or along the village. So, what we do is? We try to get everything in a big bag. And now we come back home and then what we do is? We start classifying them according to their shape, size, aspect ratio, color, and touch.

So, we classify them into several families. So, for example, all tomatoes put together, all potatoes put together, all onions put together. Now, all onions are stored and then the processing for onion is established separately, which is not going to be the same for cutting of tomatoes. So, now each are individual process plans established for each vegetable. So, that is what we have done.

So, manual process planning by basic classification of parts into families and developing somewhat standardized process plan for that particular family. So, for all onions, for all potatoes, for all tomatoes. So, let us do a similar analogy here, if all cylindrical parts, we try to do turning, all prismatic parts we try to do milling, all whole generation process you do drilling, and if the tolerances are high, you do drilling and boring.

So, that is what it is, for example you have threads, internal threads, external threads, internal threads, if you want to do on a cylindrical shaft, use a lathe machine. So, now what have you done? Looking into the part feature, you have classified and the machining process is also established. Now, standard is established, now looking into your tool availability, workpiece availability, machine status, you try to decide what are all the process parameters you have to use.

So, the standardization of process is nothing but turning operation and tweaking to individual requirements will be done by a manufacturing engineer at the shaft floor. But he at least closed or he is at least given a lead, that there is a standard process established for cylindrical shaft internal threading.

So, when a new part would introduce, so you know the now established all these things, when a new part comes, the new part is may having varying hardness, varying diameter, tools, size might vary, tool angles might vary. So, now what we do is, the process plan for that family would be manually retrieve and marked up and retype, plus it will also be edited to meet the requirements.

So, you will pull up that, look into the algorithm, fit in your data values and then you try to make this as a standard established in your routing sheet. While this improved productivity, I do not have to start from 0, but I start from a certain level, which can be equal easily tweak and the productivity improves, productivity is nothing but minimizing the input to maximize the output.

It did not improve the quality of the planning of the process and it did not easily take into account the differences between parts in the family nor improvement in the production process. So, these are the limitations. So, this is why from animal classification standardizing, we are looking for the second stage, or the third stage to evolve in the Computer Aided Process Plan.

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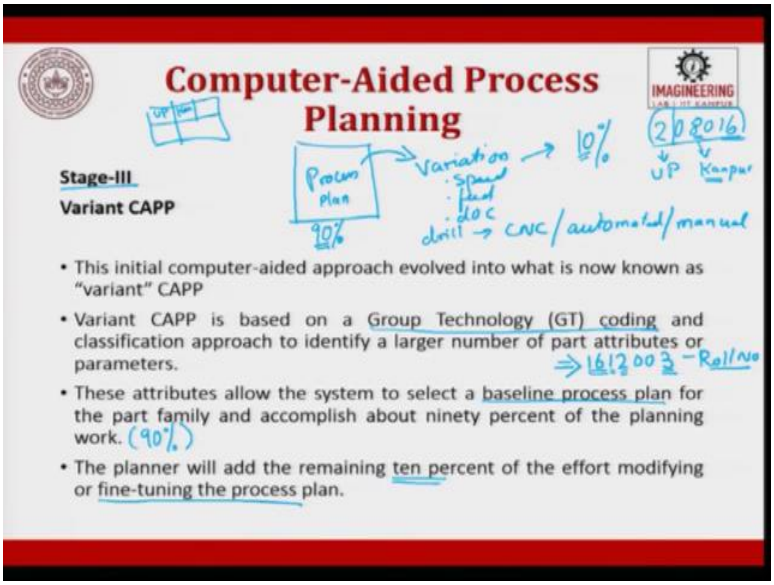

In the third stage of the Computer Aided Process Plan is the initial computer aided approach evolved into what is known as variant CAPP. What is variant CAPP? Variant CAPP is nothing but the process plan is already given, this is the basic. And now what I do is? I try to do some variation, like changing speed, feed, depth of cut, and suppose you have a drilling machine, you have one drilling machine, which is CNC.

Now, you want to change it to automated machine, or you want to do it in manual, supposed these are some of the changes, which you do on the master process plan to meet out your requirements. These are variations, which we do on the process plans to meet out the requirements. The variant is based on the group technology. What is group technology?

Group technology is nothing but the family what you did, grouping of similar things based upon shape, size, or manufacturing process, group technology coding and classification approach. So, what is coding and classification, for example let us take your roll number, your roll number is maybe 1612003. So, what is this? This is your roll number, so roll number in a factory is called as the part number.

So, how do you decide the part number, that is what is a procedure called as coding. So, here if you look at the roll number, we can easily say okay you are Y 16 batch, that means to say you joined in 2016 into a college, then you joined in the first semester and two is maybe you are an undergraduate or this two can be your department may be electrical engineering. And you have a roll number in the class as 3.

So, now what I have done is, I have taken some Ram, Shyam, anybody and I have quoted him into a number, which is called a roll number in your college and when it goes to factory it becomes part number, establishing this code is called as coding. It is not the computer program, but establishing a number for an individual part is coding. When you go to a part number in a factory what will happen is by looking at it they will quickly try to say, whether this part gets into engine assembly and what is the current status of the part.

So, the group technology coding does that for us, so variant CAPP is based on group technology coding and classification, classification I have already told you, approach to identify a large number of part attributes or parameters. These attributes allow the system to select a baseline process plan for the part family and accomplish about ninety percent of the planning work.

So, ninety percent is given here and only ten percent, tweaking will be done here, the planner will add the remaining ten percent of the effort modifying or fine tuning the process plan. So, ninety percent is already established here and ten percent variation is given. And this ten percent is a number which is a ballpark figure number, it can go 20 percent, it can go even to 2 percent.

So, please do not go by exact 10 percent values, so it can change depending upon the new part coming. So, you have established something already available, so you have to see that, for example let me give another example, every city in India has a pin code, for example Kanpur pin code where IIT is there is 208016. So, now let us this coding is done by the post office earlier.

Now, let us assume, there is a new letter coming to the post officer, or a postmaster. So, first thing what he does? He looks at the pin code and that is why government always used to say when you write an address, please give the pin code, because pin code gives the postman to easily classify to which state it has to go. He will first look at this digit and then he will quickly say this digit goes to Uttar Pradesh even Tamil Nadu it is 6 starts, if it is Bombay, it is 1, or Delhi it is 1.

So, you can see the first looking at one digit, he tries to put into the basket of all the post which goes to Uttar Pradesh. And in Uttar Pradesh what we do is? Next these two digits will try to say which is the city. So, assume that this is given for Kanpur, this is just an analogy I am giving. So, now looking at this, so it has already come into 1 Dabba (box).

So, that Dabba (box) tells about Uttar Pradesh, now it has reached Uttar Pradesh and now you have to say in Uttar Pradesh where it has to go. Then you have put Kanpur. So, now it just puts in the Dabba (box) of Kanpur and now in Kanpur, they have again classified it, they have coded it, they have coded it into several numbers have been given for several areas, 16 is given to Kalyanpur. So, just by looking at it, the postmaster will put it to a bin which comes up to Kalyanpur, or up to IIT.

So, this is coding, this is done and when a new letter comes what happens? It is easy for the postmaster, rather than looking into all the address, he just looks at the pin and classifies, that is what is done by this group technology coding and classification. Moment it has come to, it has coded and classified 90 percent of the data is given the planner has to work only on 10 percent. So, he reduces his time there will be no mistakes and there always be a scope for improvement.

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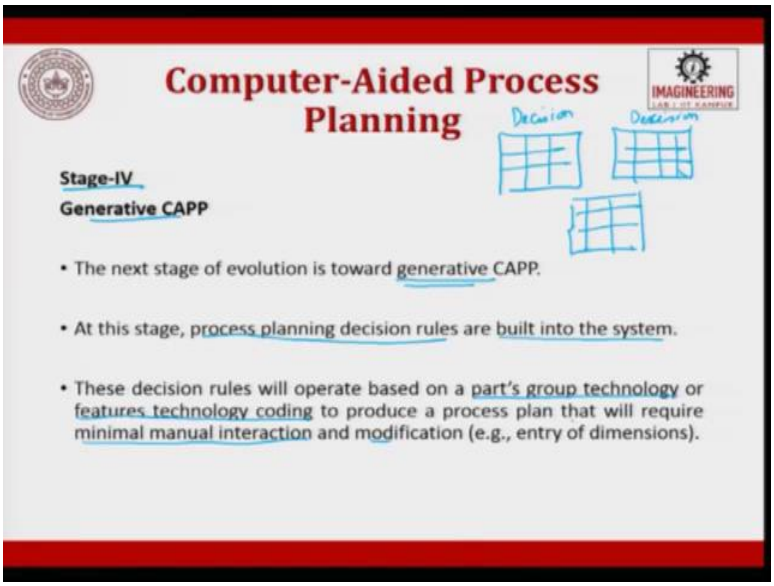

The fourth stage is going to be generative CAPP. So, in variant CAPP, what happens? There is a part family and that for that part family, there is a process plan well established. In generative type CAPP, what happens is? I know the basic knowledge, for example let us assume you are driving a car, you know the function of a steering, you know a function of accelerator, you know function of a brake and the clutch, and you know what is the gear. Supposed to do for you, while you drive a car.

So, all these basic things are done, depending upon the road conditions, you keep playing with these 3 pedals, steering and gear to meet out to the requirement. So, this is generative type method. So, in generative type, all the basic tables are established and there is no fixed program already given, based upon the input data, these are decision tables, based upon the table. Now, what happens is, you try to take a call and then you try to develop a process plan.

So, what is the advantage? Rather than trying to say that, if you are driving in the street like this, use this, this, this, this, this, this, you just say I am teaching you all the basic conditions, you are aware of all the basic conditions. Now, you coordinate between the 3 decision tables and come out with the process plan. So, the advantages, the server, the knowledge, whatever is stored is not exactly focus to one requirement. It is now made generic.

So, when it is generic, what happens? There is a lesser amount of data stored, but there is a good algorithm evolved. So, now when a new product comes, it is very easy to evolve or generate a plan, or in the previous one already existing tweaking, that is variant, generative is I know the basics, I know this is what it has to do, I generate the plan. So, here it is more precise and it is more generic, suppose in the variant, if a new part comes and nothing is already available, then the process planner has to start from 0. Since he knows the logic.

So, what will happen? It will quickly help him in evolving, so minimum knowledge base, maximum accuracy, it can come and a new you product comes generative CAPP is more useful than variant CAPP, at this stage the process plan decision rules are built into the system, just like what is decision table? Decision table is something like your excel file, you have X and you have Y. So, there are suppose 3 different, you have several columns, several rows and you can have a frame, on frame, on frame.

So, this will give the knowledge to the next frame, from that frame to the first frame, so the first frame will give you all the options and you will try to get the output. This decision rules will operate based on parts group technology or features technology coded to produce a process plan that will require a minimal manual interaction and modification. So, this is the latest and this is what nowadays Computer Aided Process Planning is doing.

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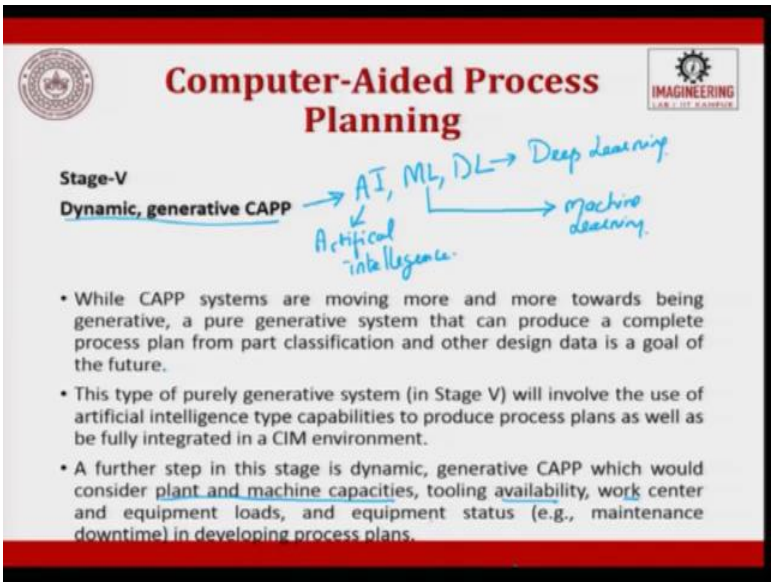

What is dynamic generative CAPP? While CAPP systems are moving more and more towards being generative, a pure generative system that can produce a complete process plan from part classification and other design data is a goal for the future. So, even without a manual intervention, that means to say the options are given verifying the options and then going. The system itself generates and give that is called as dynamic generative CAPP.

So, even in generative CAPP what happens? There can be 4 options given, and we are only talking about a very small feature here, like turning, drilling, but when you look at a dye which is made for injection molding, there are several features and these features has to be done in a sequential manner. And when you do it in a sequential manner, you have to take reference of previous one and then go.

So, now here comes a challenge, where to take reference, how to take reference. So, even in generative CAPP, many a times there can be 4 options given to the planner to evolve. But in dynamic, what we are saying is? Not even that variation should be there, exactly give what is the output and start getting the output. This type of purely generative system in stage 5 will involve the use of artificial intelligence type capability to produce process plan as well as be fully integrated in a CIM environment.

So, this is nothing but using AI, ML, and DL, artificial intelligence, machine learning, and deep learning. These are the bus words which are now talk more in manufacturing, when we are looking for CIM computer integrated manufacturing environment, these techniques are nowadays exhaustively used in process plan. A further step in this stage is dynamic and generative CAPP, which would consider plant, machine capability, tool availability, then work center, equipment loads, and equipment status, in the developing process.

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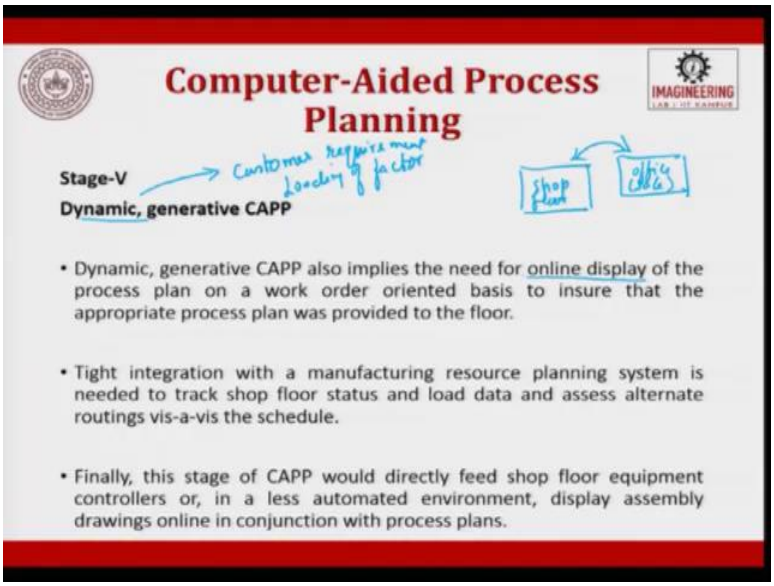

In dynamic generative CAPP, also implies the need of online display of the process plan on a work order oriented based to insure that the appropriate process plan was provided to the shop floor. So, in here when we talk about dynamic, we are trying to keep customer requirement also, customer requirement and the current loading of the factory, loading a factory, that means to say what are all the machine loads and how are these done.

So, what happens? We start looking forward for optimizing machining center usage, tight integration with a manufacturing resource planning system. So, we are now trying to integrate a shop floor with your office, where they are involved in more of sales and service. So, this interaction is going to happen.

Now, why is this important? Looking into the shop floor, looking into the availability of the machine, looking at the availability of the parts. Now, you try to talk to the office of sales and say this is possible, this is not possible and moment they say why do not do this, then immediately the shop floor, will be should be able to tweak those the part program, the availability of the tools, such that they meet out to the requirement.

So, tight integration with the manufacturing resource planning system is needed to track shop floor status and load data and assess alternative routing vis-à-vis the schedule. Finally this stage of CAPP

stage 5, would directly feed shop floor equipment controllers, or in a less automated environment, display assembly drawing online in conjunction with the process plan.

So, this is the latest, people are working on it, till the fourth stage it was only shop floor control and computer which is in the shop floor will try to give a data to the process planner. But in the last stage dynamic, it is now going to be completely automatic. And here it is going to look at the availability of the tools, many a times in process plan, he might say do this, this this, this this. But he might not be aware of the tools, which is there with him the work piece quantity and stock.

What is quantity what I mean to say what is to be done and stock is what is already there and raw materials available with him. So, now in dynamic generative process plan all these things are done, why because if one good machine is already loaded 200 percent, then they will look for alternative machines which are not so good in producing quality now, but tweaking some fixtures there, you can try to produce, that evolution of knowledge is called as dynamic generative CAPP.

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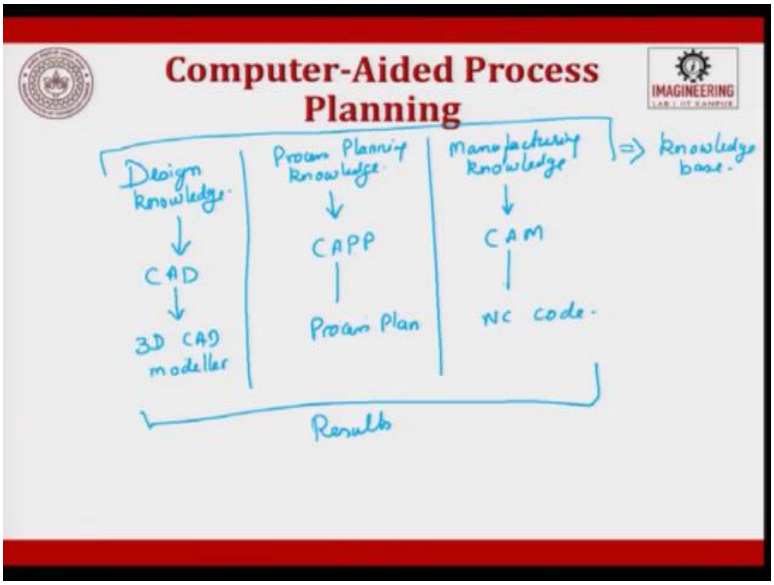

So, if you want to put the Computer Aided Process Plan in a schematic diagram, we have design knowledge, this leads to CAD system and this goes to 3D CAD modeler. So, this is one vertical, next is process planning knowledge, this will lead to CAPP Computer Aided Process Plan and this gives you a process plan. The other one is manufacturing knowledge, this goes to CAM, and this goes to NC code.

So, these are the results and the top one is the knowledge base. So, design knowledge, process knowledge, manufacturing knowledge, manufacturing knowledge, leading to CAM, process planning to CAPP and design knowledge to CAD. So, from here model, process plan and NC code, we generate.

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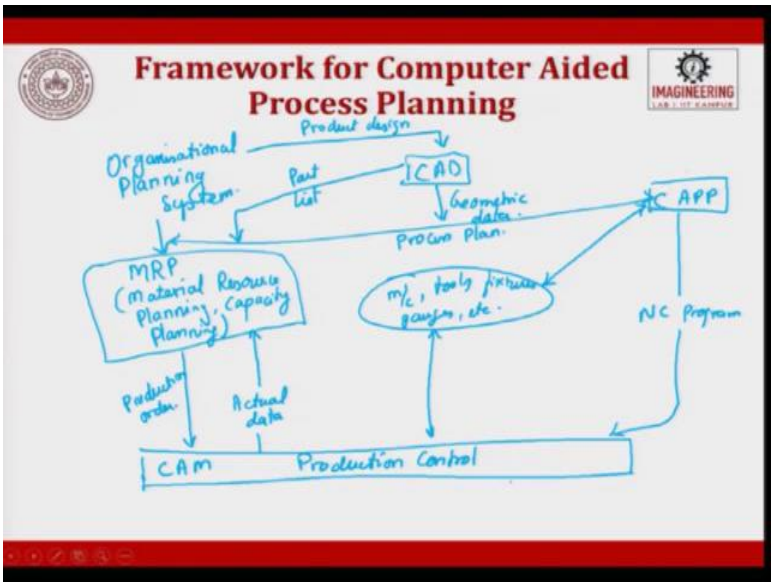

So, let us see the framework for Computer Aided Process Plan. So, here we will have organizational planning system, then we will have MRP, which is nothing but Material Resource Planning. And we also talk about capacity planning, then we will have CAM. So, this we will have actual data, then this is production control, and have CAD here, this is going to talk about product design CAD, and this is going to give me geometric data. And from CAD I also get the part list, I get a part list.

So, here what is there, in the factory is going to be machine, tools, fixtures, gauges, etc. So, this is going to be CAPP, so there is going to be an interaction between CAPP and CAM, and here you will have a straight line with joints these two floors, which is nothing but a process plan. So, this will try to talk to production control and CAPP will try to talk to NC program, you see everything is getting integrated inside a factory environment.

So, this will be the frame total frame, so you have organization planning system, from there it will go to MRP, from MRP you will go to CAM. So, this is nothing but the production order and then

you will have resource planning, we will see all those things in little details, as and when the course keeps going, what is MRP, what is resource planning, all those things.

But currently you should understand this is the framework of Computer aided process planning, where in which we get the data from materials resource process planning CAD. So, this data comes CAPP and CAPP, data is given to NC program and this keeps talking to each other to develop a process plan for machining a part or developing a part.

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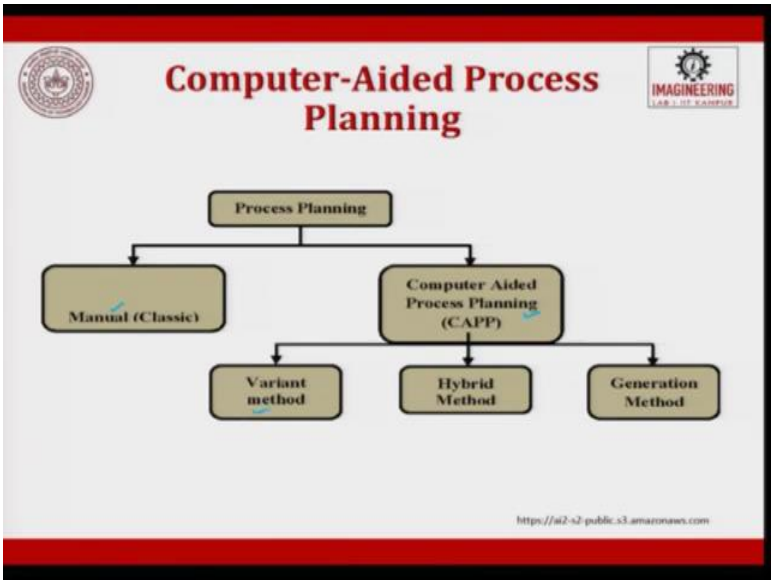

So, whatever we have studied till now, if you want to put it in a block diagram, we have a process Plan, which is manual process plan, and when the Computer Aided Process Planning, the Computer Aided Process Plan. Now, is classified into variant, hybrid, and generative.

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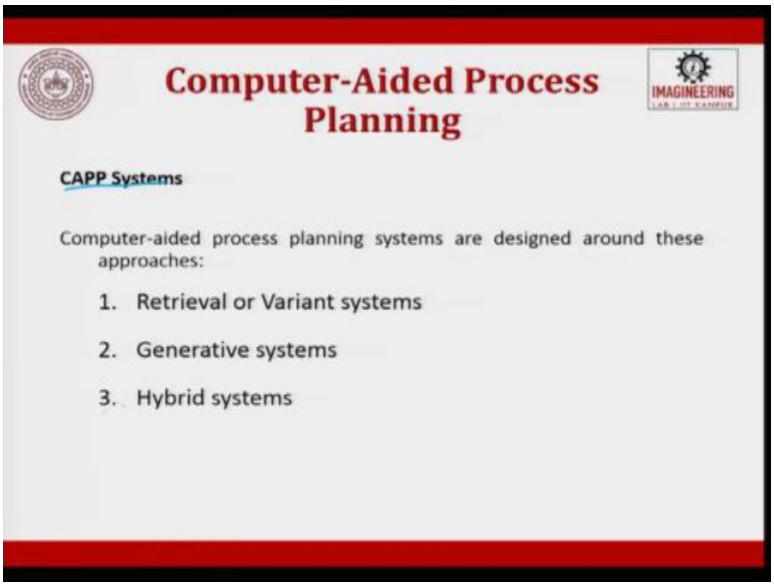

Now, let us look into Computer Aided Process Plan, Computer Aided Process Planning are designed for retrieval, or variant system. Next is generative system, we went through it little bit, then the last one is going to be hybrid systems.

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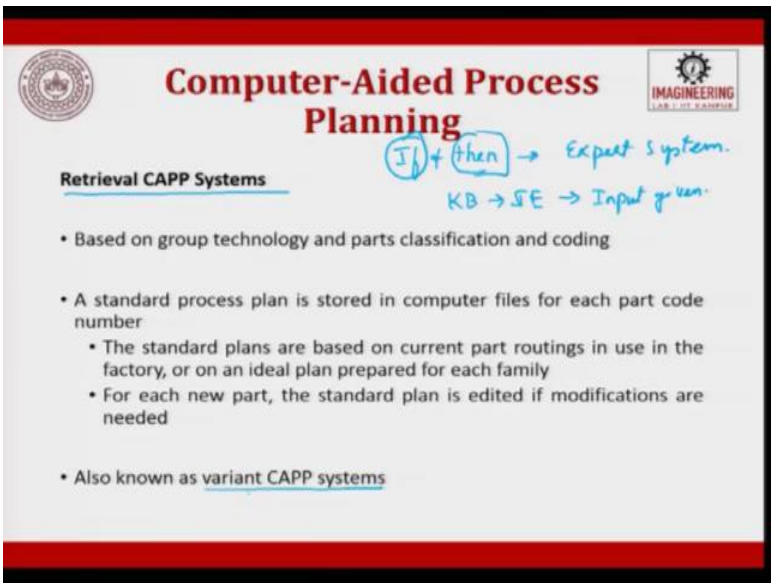

So, what is generative type CAPP, based upon the group technology and part classification and coding, standard process plan is stored in a computer file for each part code number. So, a standard plan are based on current part routing in use in the factory, or on an ideal plan prepared by each

family. So, already whatever is there, which is stored you just call, so it is basically if and then statements will be used to get.

So, it is basically and expert system will be used here. If these are the conditions, then lead to this answer. So, you will have a knowledge base, you will have a inference engine and then you will have input given. If there is a traffic congestion over Delhi and if the flight is, if there are lot of flights land up and if there is a visibility problem, then please do not start the flight. So, that is if and then.

So, retrieval system CAPP is basically working on if and then system only. So, here what will happen is, a standard is already established. So, you put the part number and call for the part number, then immediately the process plan will be shown in front of you, and you start working on it, you are there is no knowledge, whatever is available there you bring.

And when there is a new product coming it will be very difficult for you to establish and run. So, it will work on only retrieval, whatever is stored it retrieves and you start working. A standard plan are based on current part routing in use in the factory, or an ideal plan prepared for each family, for each new part the standard plan is edited if modifications are needed, also known as variant CAPP, retrieval or otherwise known as variant CAPP is almost the same.

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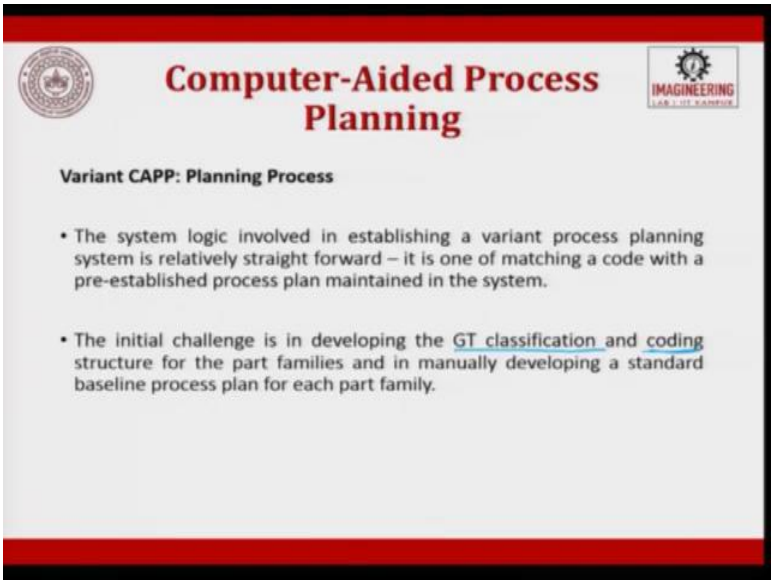

The system logic involved in establishing a variant process planning system is relatively straight forward. It is one of matching a code with a pre-established process plan maintained in the system, many a times when you go to a textile shop, when you try to go to your cloth shop. So, what you say? You say here is a cloth I have can I get a similar color cloth.

So, immediately what the person does? He keeps in your left hand or right hand the cloth what you have given to him, goes to the showroom or goes to shelf, where there are similar colors, identified he plays a set besides each other and then tries to pick up the closest match and say please sir see this.

So, this is the way, variant CAPP also works, you have given something, the computer will quickly try to match with already existing one, and then which were closely match as it pulls out from its library function and displays it in your front. This initial challenge is in developing the GT classification and coding, how do you classify it, because when I gave you an example of a textile cloth, it was easy. But in a factory what is there is, you have to establish a coding system.

So, now you establishing a cording system and there are several codes, which are already there, for each code, code is nothing but a part number, each part number as a process plan, you just pull out that and start using. So, initial challenge is in developing the GT classification and coding structure for the part family and in manually developing a standard baseline process plan for each part family. Initial it will be difficult, then on it becomes easy, the first time you have to establish there it is a challenge.

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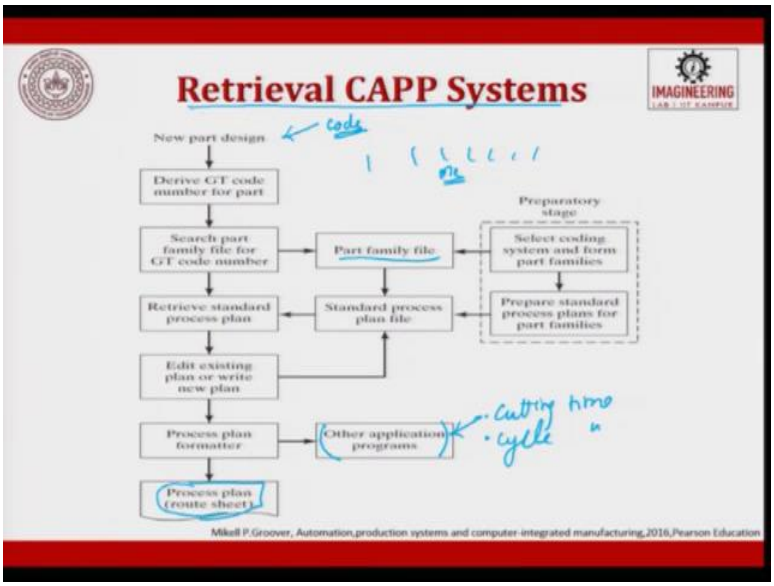

So, when we look at a retrieval CAPP system a new part comes, forget first the new, let us take it as a new part, new part comes inside. So, what it derives? It derives GT code number for the part, a new part comes into. So, what it says it, please give the code for the part, you cannot give the shape of the pat, you have to say a code number. So, put the code there.

So, you get an admission in a college, the first day what you have been given is a roll number, why? Hence for in your duration of stay in the college, you will be addressed as against the roll number not against to your name. So, it will be given as a code number, so for example there are some 8 branches, and you come and opt for Mechanical.

So, now already there are mechanical students in your senior batch, so you have to follow the same code in pattern for you accept for a change in the year of joining, that's what you do. So, derive a GT code number for the part, then search part family file for GT code number, look into mechanical last year what have you given pull it out and then take the same, change whatever is required.

So, here what we do is? Part family are files are looked into and then what we do is, we tried to look into the proprietary stage, whatever you have done earlier, selecting coding system, and forming part family, which you have done already for Mechanical. So, you pull that, from that and

then you see, so standard part family files and standard process planning files are retrieved and it is given.

So, based on that, you try to retrieve the standard process plan, aided process plan and again compare it once again with the standard. Then now you have a process plan formatter and then you have a routing sheet, which is established. And if there is any changes to happen, or other applications to be done, from the process plan formatter, you try to do, for example this applicator is calculating the cutting time, calculating the cycle time. So, all these things are done in the retrieval CAPP system.

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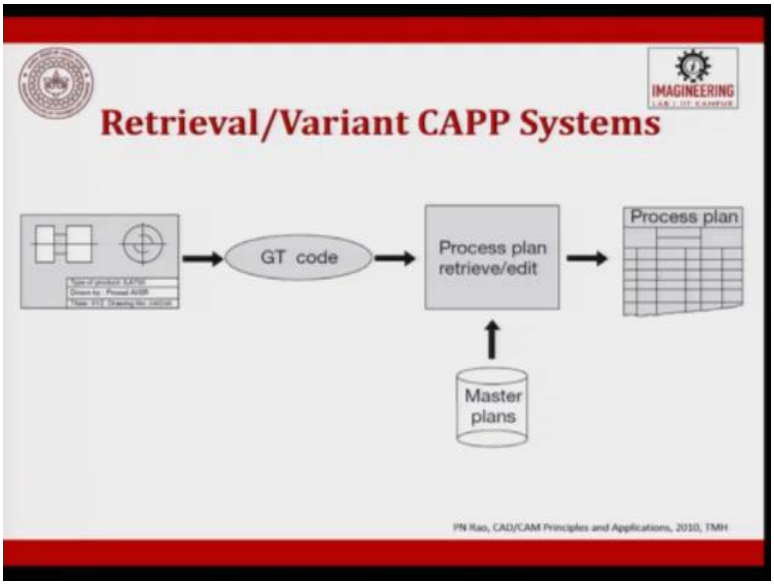

So, in a retrieval CAPP system, or a variant CAPP system, you can see a new part coming, a GT code getting established, a process plan retrieval is done, a process plan is retrieved, when you start doing this process plan retrieval editing, you pull out something from the master plan and then you started editing. So, that you try to meet out to the existing part.

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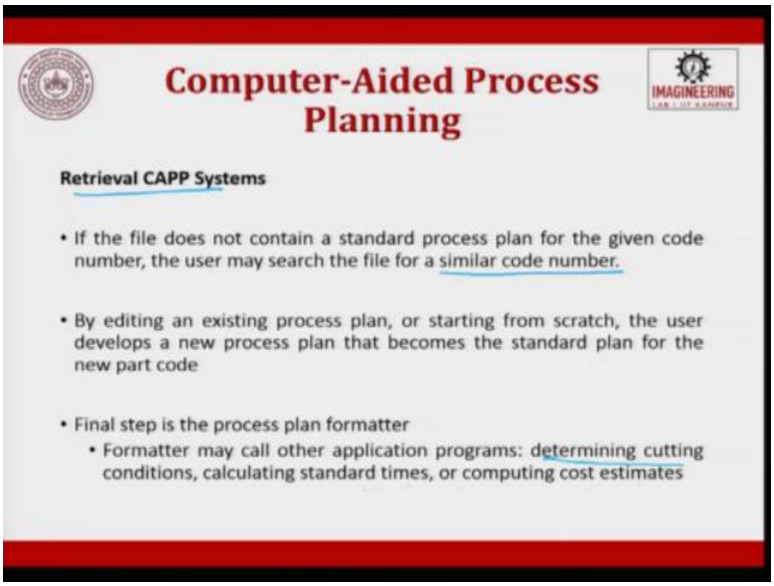

If the file does not contain a standard process plan for a given code number, the user may search the file for a similar code. I do not get the exact code, but now what I do is, I look forward for a similar code. So, now similar code number is taken out, you edit it to your requirements and finally you make a formatter. The formatter make all other applications, like determining the cuttings conditions, calculating the standard time, computing cost, all these things will be done. And finally you will try to give the generative CAPP, gives the final option.

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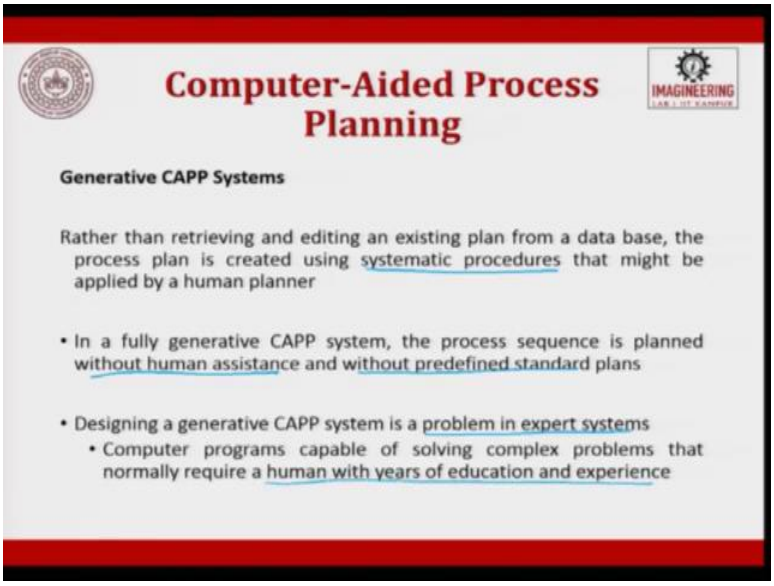

So, in generative type what happens, rather than retrieving and editing an existing plan from the data base, the process plan is created using systematic procedure that might be applied by a human planner. This is what I said driving a car, you have being taught to drive a car, the logics told, the inputs given. Now, depending upon the situation, you try to menu and you tried to play with the 3 and try to do it.

In a fully generative CAPP system, the process sequence is planned without human assistance and without predefined standard plan. So, here there is not a set condition told to you, but the logic are taught to you. Designing a generative CAPP system is a problem in expert system, expert system, variant, retrieval, works on the law logic of if and then.

If you have a new product and if you can somehow understand the new product and put if, if condition then comes. Expert system works exhaustively very well in the variant and retrieval system. But in generative type, you are supposed to use artificial intelligence, neural networks, and fussy logic.

So, the particles were algorithm and Colony algorithm, these are all used where in which the data is there the algorithm is taught and their evolution of result is different. So, the computer program capable of solving complex problems, that normally require a human with years of education and experience, which is what is done in generative type.

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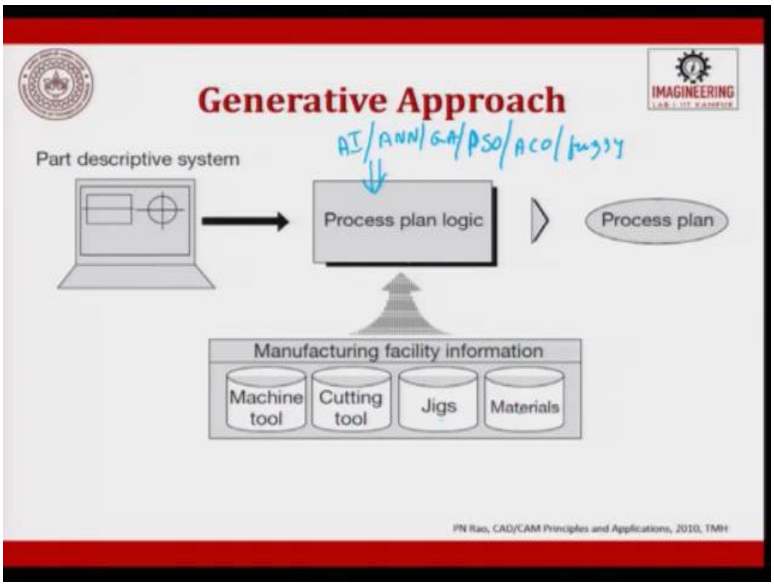

In generative type, I told you this is a part new part coming into these are all the process plan logics. So, this is what, we use AI slash in AI we use ANN slash genetic algorithm, PSA, PSO, then people talk about ant colony optimization, the fussy logic. So, all these things are brought in here. And all these things uses this are the data base for this algorithm to work, and then what you get out is a process plan.

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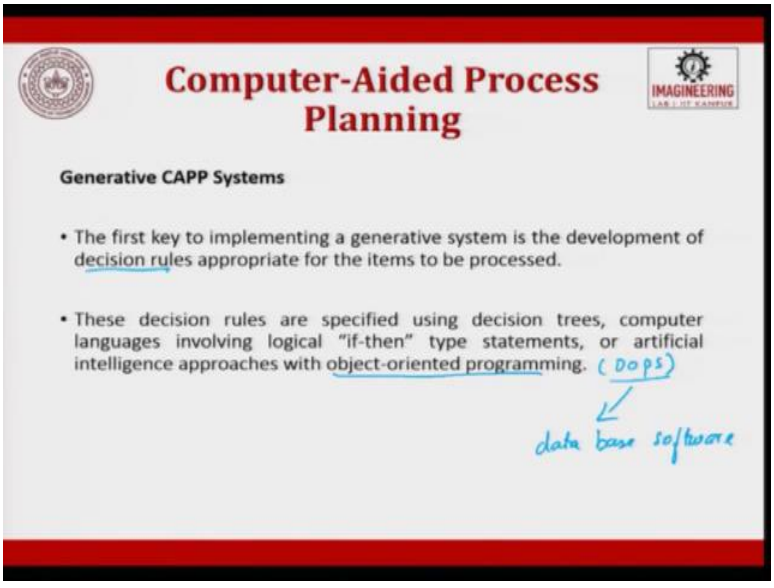

The first key to implement a generative system is the development of a decision tree, appropriate for the items to be processed, decision tree. So, this is what I told you, we teach you basics, this decision rules are specified under decision tree, computer language involving logical, "if- then" type statements, or artificial intelligent approaches with object oriented programming.

This is what is called OOPs, object oriented program OOPs, which is exhaustively used in data base software's. Why? Because you have so much of data, how are you going to logically store the data, such that the program can quickly work and retrieve and bring you the output.

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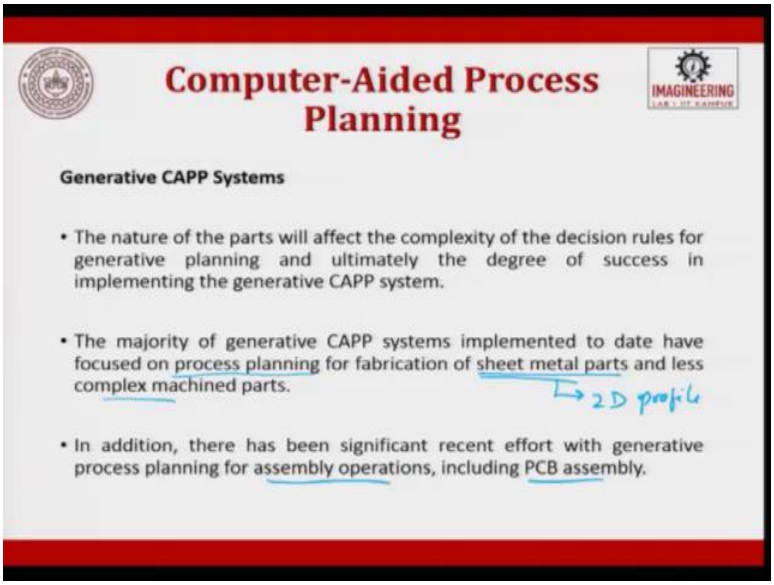

The nature of the part will affect the complexity of the decision rule of generative planning and ultimately the degree of success in implementing the generative CAPP system. The majority of the generative CAPP system implements to date have focused on process planning for fabrication of sheet metal parts or less machine complex part. In addition, still it is going, still it is evolving, generative has not reached his maturity.

In addition, there has been significant recent effort with generative process planning for assembly operations including PCB assembly. Sheet metal is why it is so prominent in sheet metal is? Sheet metal is 2D profiling. So, it is thickness is too small and along the thickness there will not be any variation X and Y there can be a profiling or there can be a geometry. But where is when you do machining of a 3 dimensional object, there is along the Z direction there is a variation. So, that

makes the life more complex for generative type. So, it is exhaustively used for sheet metal and PCB assembly.

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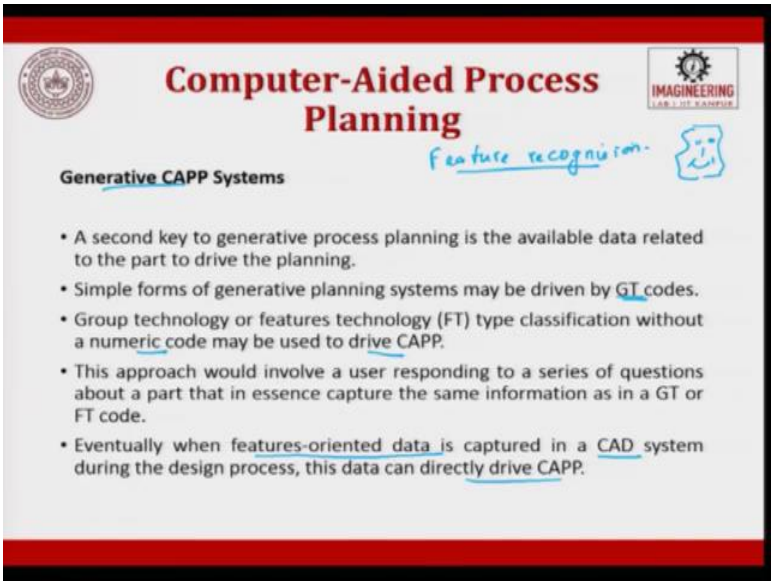

The second key of generative process planning is the available data related to the part to drive the planning. Simple forms of generative process planning systems may be driven by GT codes. So, GT or features technology FT, type classification without numerical code may be used in derived CAPP. So, this approach would involve a user responding to a series of questions about the part, so you are asking questions and you start putting all those questions in that.

So, then answer to those questions, then finally what comes out will be a generative CAPP, which eventually will work on feature oriented data is captured in a CAD system during the design process, this data can directly drive CAPP. So, in CAD also, I was trying to talk about feature recognition. So, if there is feature, so in this feature eye are feature, nose is a feature, mouth is a feature, for each feature there is a process plan already established.

So, when you put this entire object into a CAD, the quickly it will extract those data's, then go to feature based process plan, which is already there, which will be in logics. So, it will quickly pull all those things and come back and tell you what is the best process plan to be used. So, this is generative type process plan.

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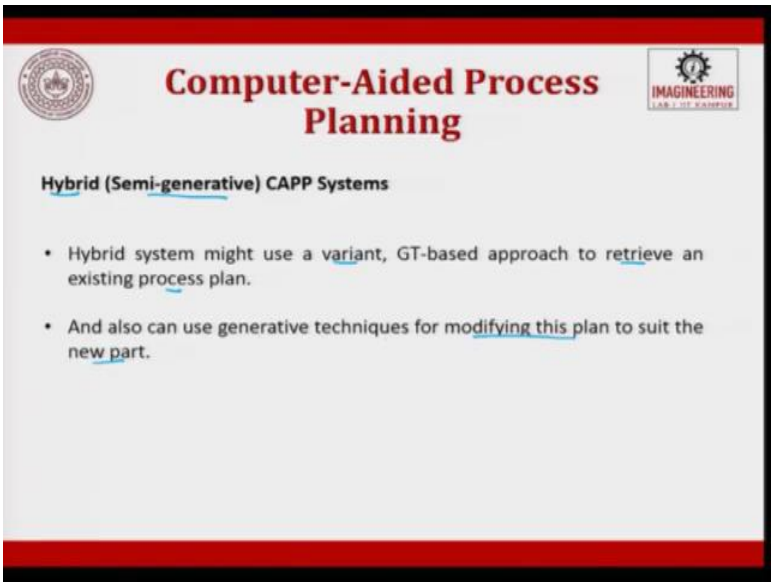

And there is a hybrid, which is semi generative CAPP, which is in between variant and generative, hybrid system might use variant GT based approach to retrieve and existing process plan. And also can be used generative technique for modifying the process plan to suit. So, neither variant, nor fully generative hybrid CAPP are used today, exhaustively what is used in CIM environment are, hybrid CAPP system only.

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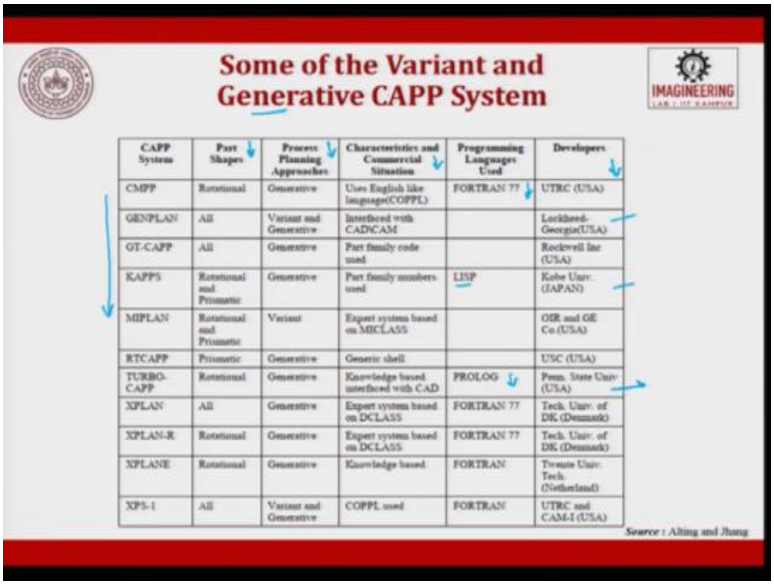

CAPP System	Part Shapes	Process Planning Approaches	Characteristics and Commercial Situation	Programming Languages Used	Developers
CMPP	Rotational	Generative	Uses English like language(COPPL)	FORTRAN 77	UTRC (USA)
GENPLAN	All	Variant and Generative	Interfaced with CADCAM		Lockheed-Georgia(USA)
GT-CAPP	All	Generative	Part family code used		Rockwell Int. (USA)
KAPPS	Rotational and Prismatic	Generative	Part family numbers used	LISP	Kobe Univ. (JAPAN)
MIPLAN	Rotational and Prismatic	Variant	Expert system based on MICLASS		OIR and GE Co.(USA)
RTCAPP	Prismatic	Generative	Generic shell		USC (USA)
TURBO-CAPP	Rotational	Generative	Knowledge based interfaced with CAD	PROLOG	Penn. State Univ. (USA)
XPLAN	All	Generative	Expert system based on DCLASS	FORTRAN 77	Tech. Univ. of DK (Denmark)
XPLAN-R	Rotational	Generative	Expert system based on DCLASS	FORTRAN 77	Tech. Univ. of DK (Denmark)
XPLANE	Rotational	Generative	Knowledge based	FORTRAN	Twente Univ. Tech. (Netherland)
XPS-1	All	Variant and Generative	COPPL used	FORTRAN	UTRC and CAM-I (USA)

So, these are some of the variant and generative CAPP systems, which are available in the market today. So, CAPP systems is CMPP, GENPLAN, GT CAPP, CAPPS, MIPLAN, these are all different CAPP system, which are commercially available. And I have said for what type of shape, it is all geometry for all it is rotational and prismatic, it is only for rotational.

So, here it also tells you whether it works on generative type, or variant type. Then it also tries to tell you the characteristic and commercial situation, what are the interface to be used for this. Then what is the program which is used LISP is followed is used in AutoCAD also LISP. So, you can write a library in AutoCAD, so that is we used LISP or FORTRAN 77, or PROLOG is used, for writing those programs, in the interface.

So, that it can use the software to use, who are the developers also I have given. So, some are developed in the university, some are developed in the industry, here you can see a US based here, you can see University based, there are some industries are also playing a major role in it. So, even today there is nothing called 100 percent generative, perfect CAPP system, they are all still in the hybrid stage, towards evolution.

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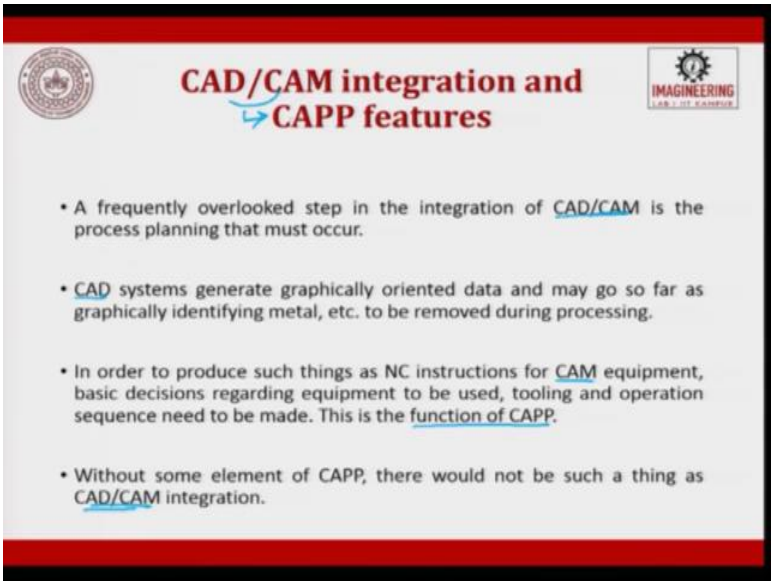

So, the CAD, CAM integration of CAPP feature, a frequently overlooked step in the integration of CAD and CAM is the process planning. CAD system generates graphical oriented data and may go so far as graphical identifying metal, etc, to be removed during the process. In order to produce

such things and NC instruction from CAM equipments, basic decision regarding equipment to be used, tooling operation sequence are to be made, this is a function of CAPP.

So, we are talking about CAD, you are talking about CAM, and we are talking about a function of a CAPP. Without some elements of CAPP, there would not be such a thing called as CAD, CAM integration. So, between CAD and CAM, CAPP is the biggest vertical, which has to play a role in understanding the drawing, converting into a manufacturing part.

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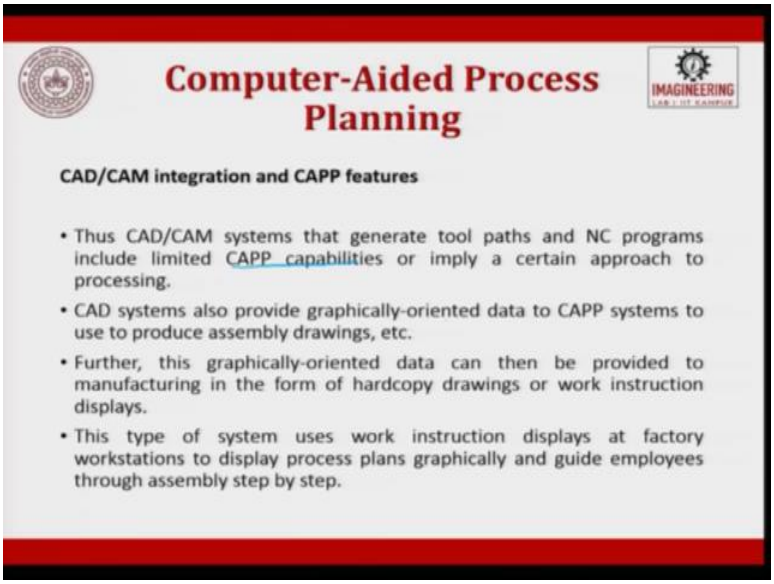

Thus, CAD, CAM systems, that generate tool path and NC programs include limited CAPP capabilities, or imply a certain approach of processing. The CAD system also provides graphical oriented data to CAPP system to use to produce assembly drawing. Further this graphical orientation data can then be provided to manufacture. So, this is how a CAD and a CAM is integrated by using CAPP.

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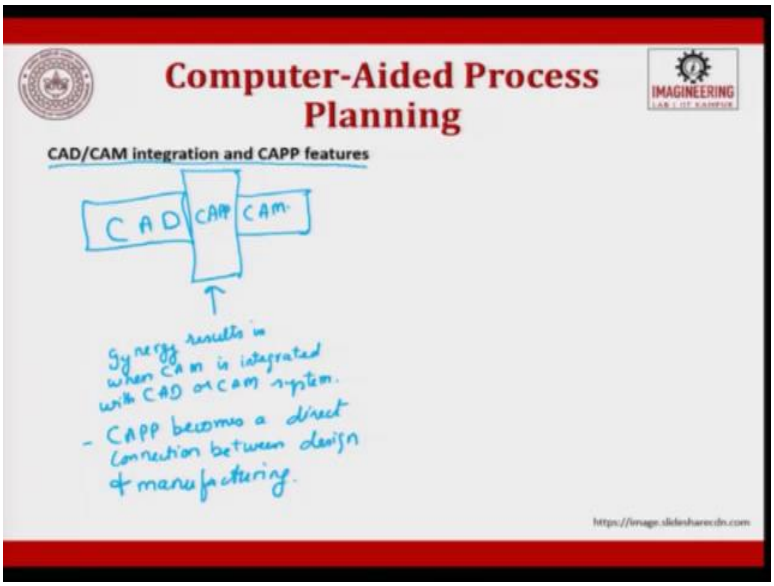

So, here let us just see CAD here, this is CAD, where we have studied all the graphical thing, then we have a CAPP here, then we have a CAM here. So, the function of a CAPP is going to be it gives you a synergy results in when CAM is integrated with CAD or CAM system. So, CAPP becomes a direct connection between design and manufacturing. So, this is the way CAPP features in between CAD and CAM, this is very important.

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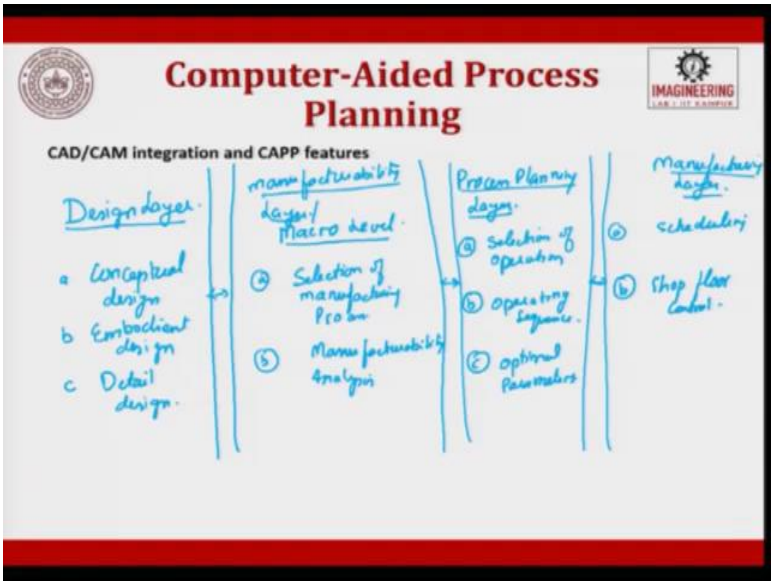

So, if you look at it, so we have a design layer, we will have a manufacturing layer, then we have a process plan, process planning layer, and then we will have again a manufacturing layer. So, this one is manufacturability layer and which is nothing but a macro layer, at a macro level. So, here you will have conceptual design, a, you will have embodiment layer or design, b, c, you will have detailed design, these are all the design layer.

In manufacturability layer or macro layer, we will have a selection of manufacturing process, and then b, you will have the manufacturability analysis. So, this is a vertical, this is a second vertical, so here in process plan we will try to do a selection of operation, then b, we will try to have operation operating sequence these are information will get c, we will try to get optimum optimal process parameters.

In manufacturing layer, we will try to get a, scheduling, b, is shop floor control. So, all these things are linked, two way communication will happen between design layer, manufacturability layer macro-level, then process planning layer and manufacturing layer. So, you will have several layers, so this is how a CAPP is getting integrated into a CAD, CAM system in real time, when we talk about computer integrated manufacturing.

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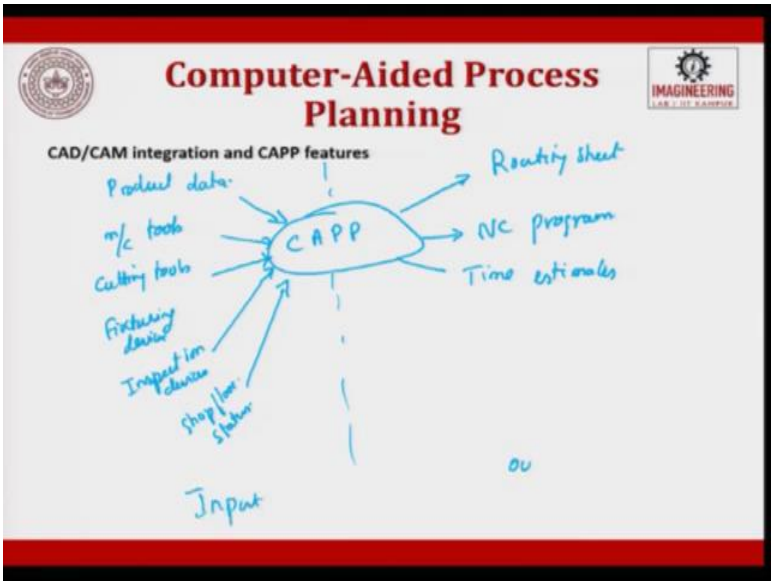

So, CAPP, will give you routing sheet, will give you NC program, will give you time estimate, 52:33 and what is given to CAPP is product data, machine tools, cutting tools, these are all the

inputs which we give for CAPP. Then we give fixture device, then we give inspection device, these are all the inputs.

So, we are talking today about the dynamic one, generative CAPP, so you see all these data are given, then you will also give the shop floor schedule status. So, all these things are given to CAPP, these are all the in, which is given and these are all the out, you take from a CAPP system.

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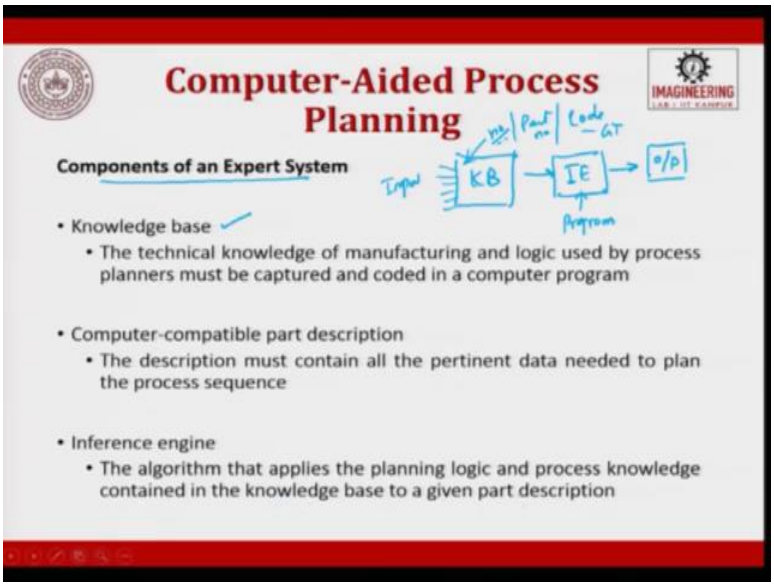

So, what are the components of an expert system, you as I told you earlier, you will have a knowledge base, this is KB, knowledge base, you acquire data from all people in terms of questions over a period of time, whatever it is, a technical knowledge of manufacturing and logic used by process planner must be captured and coded in a computer.

So, this is called as knowledge base. So, knowledge base means, once you acquire all these things, it has to be stored as against a number. So, that number is nothing but a part number, that is nothing but a part number and part number is nothing but a code, which is done by GT. Then computer compatible part description, the description must contain all the pertinent data needed to plan the process sequence.

Then inference engine, knowledge base then it is an inference engine, knowledge base you collect data from all, these are input. This is knowledge base stored, then inference engine here you write a program, software. And then what you take it out is the output, the algorithm that applies the

planning logic and process knowledge containing in the knowledge base to a given part description is done in an inference engine.

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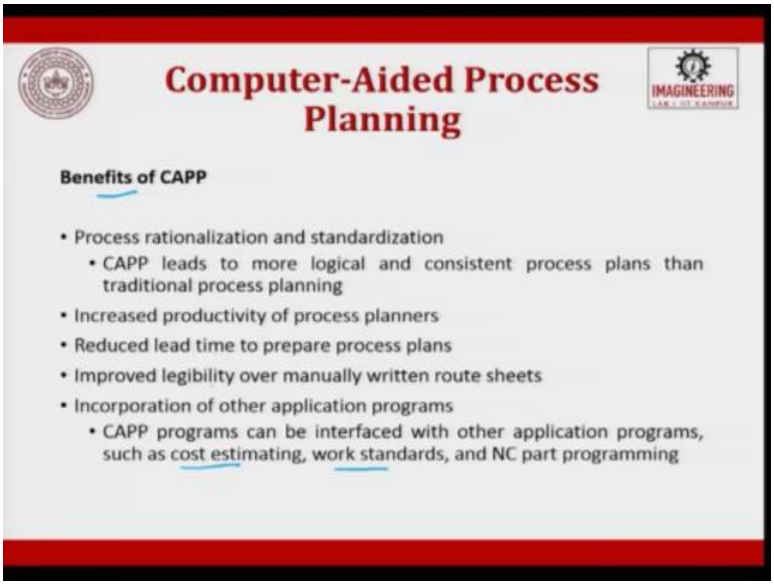

And then finally you get the output, what are the benefits of CAPP, so the process rationalization and standardization happens. So, because of that what will happen is, you do not have to store many part numbers, now you will store only lesser part numbers. So, you can quickly go retrieve the data, edit the data to meet at your requirement. CAPP leads to a more logical and a consistent process plan than traditional process planning.

So, traditional process planning, every part number will be there, it will have all the sequence. Now, it will occupy a huge data base, so when it is there a huge data base, the error is prone to happen, the storage space becomes, the retrieval become difficult, then you need a huge server space to use it.

So, increasing productivity of process planner can happen by using CAPP, reduced in lead time, improves legibility over manually written routing form can happen. Incorporation of other application programs can be integrated with CAPP. So, that you do a cost estimation, work standard, and a NC part program can be done.

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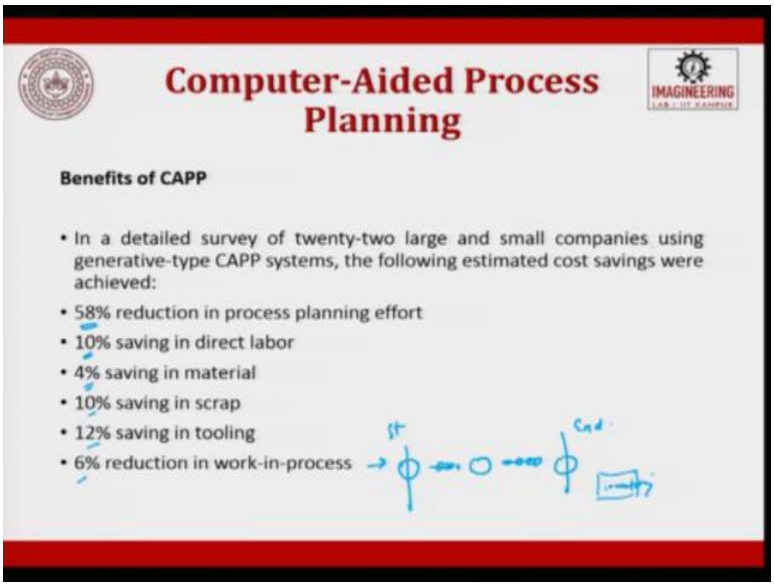

In detail survey of twenty two large and small companies using generative type process planning, 58 percent of the reduction in the process planning efforts have been done, 10 percent in the labor cost, 4 percent in materials, 10 percent in scrap, 12 percent in saving tools, and 6 percent reduction in work in process, work in process is nothing but you are trying between one station the other station, other station, the part is moving.

From the start before the end, the parts which are lined up or called as work in progress, which cannot be sold, but with existing in your factory, which is not also can be stored in terms of inventory. It is in between inventory can be a semi finished process or a part, benefits of CAPP.

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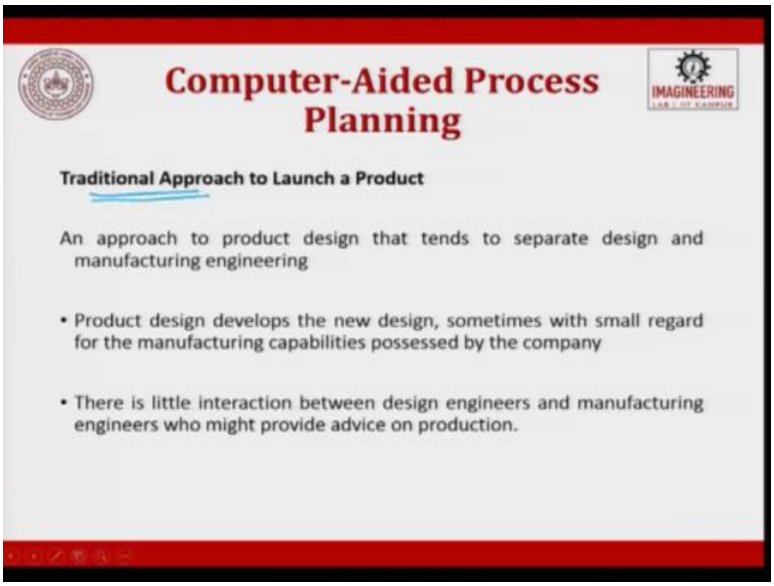

So, the traditional approach to launch a product, an approach to product design that tends to separate design and manufacturing engineering was the traditional approach. The product design develops a new design, sometimes with small regard for the manufacturing capability possessed by the company. There is a very little interaction between the design engineer and the manufacturing engineer, traditional approach when a new product is launched.

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When the emphasis of planning for the future is distinct from the process planning, because it is concerned with products being contemplated in the company's long term plans, rather than product currently being design and released. So, the emphasis of planning was further done at this stage. So, now this lead to advanced manufacturing planning attempts to forecast the new products that will be introduced in the two to 10 year future will also be done by using of this CAPP.

So, how many new products have come, based on the new products I will understand okay the product life cycle is going to be short. So, I have to prepare myself for the next possible variations. And to determine what production resources will be needed to make those future products, we use manufacturing planning.

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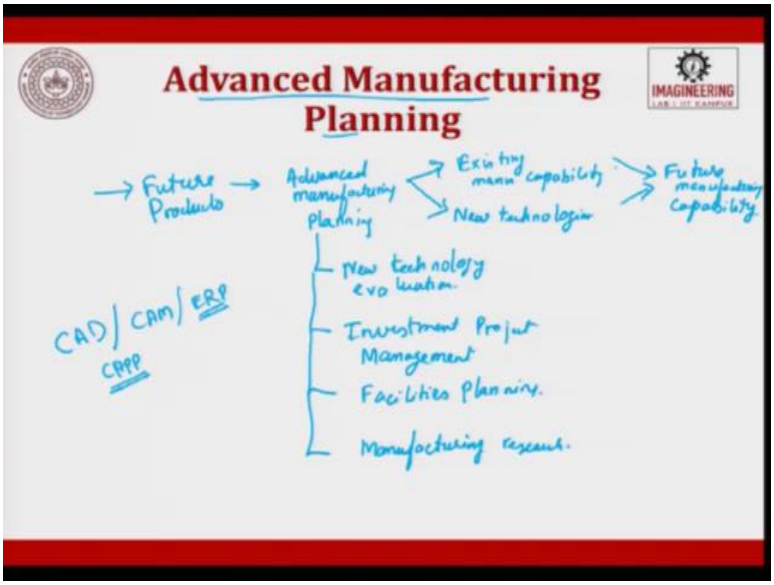

So, in a schematic diagram, if I have to represent the advancement of planning, it will be future products, then it will be advanced manufacturing planning, this has two classifications, one is new technology, the other one is existing manufacturing capability, then this will give to future manufacturing capability. So, this advanced planning will look at new technology getting evolved, new technology evaluation, investment project management, then it is facilities planning, all these things are for future, we are doing and then finally you will get manufacturing research.

So, this is new product process strategy, so you have all these data, these are flowing like this, this is flowing like this. So, if you see that advanced manufacturing planning today is trying to take all

the new technologies, investment, facilities, manufacturing, what is a lead time, how is the product going to perform, what is customer feedback, all these things are getting integrated earlier, at some point of time we were talking about CAD and CAM.

Now, we are trying to talk CAPP in between, now we are trying to talk about also trying to bring in ERP enterprise resource planning, into the CAPP. And now CAPP is getting move to the next era of dynamic CAPP.

So, where it also looks at how are the new products going to perform what is the technology and how is the old technology information used to change, for example as an when the new evolution of Smartphone's keep coming, quickly an individual tries to learn and then starts work, using the Smartphone. In the same way CAPP, whatever was already existing people are using it as an when the new thing comes, they learn it. And then they start using it for the futuristic requirements.

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So, the activities which are involved in manufacturing planning, new technology evaluation will happen. And then you will have investment project management, facilities planning, and manufacturing research and development. So, all these are the activities in advanced manufacturing planning.

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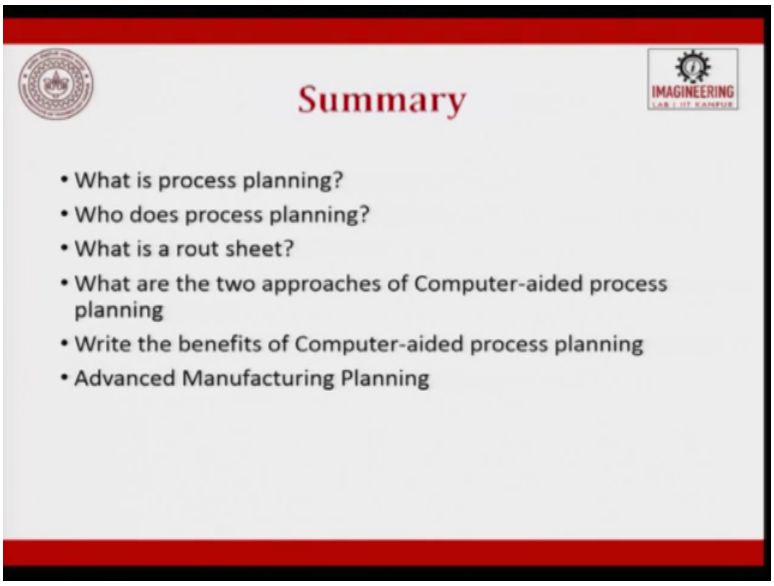

So, to recap, what we have studied in this process planning is, we studied what is process planning? Who does process planning? What is a route sheet? Then what are the two approaches in Computer Aided Process Planning? What are the benefits and to conclude what are all the advanced manufacturing planning which is happening in the latest industries today?

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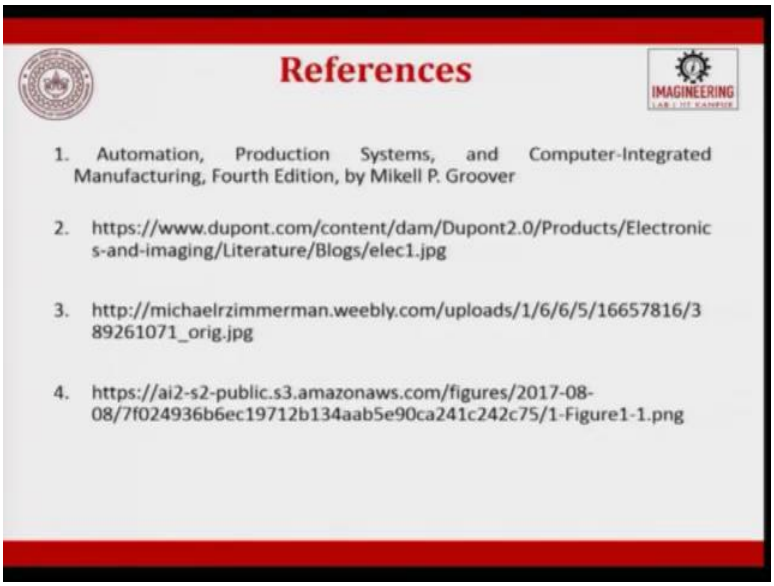

So, these are the references, which we have followed and thank you very much.