Automation in Production Systems and Management
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Flexible Manufacturing Systems - II
Lecture - 43
Tool Allocation Policies in FMS, Numerical Examples

When we try to implement an FMS in a manufacturing system, we need to deal with a number of problems and in the previous lecture sessions, we have identified all these problems and all these problems are to be addressed simultaneously. For a particular problem, we are trying to formulate the problem and we try to understand that how the system is working vis-a-vis that particular problem, we need to identify the decision variables, the constraints and objectives.

Wherever possible, we need to use the mathematical-based approaches and suppose under certain conditions you are unable to apply certain kind of mathematical modelling, then you may opt for heuristics or you may opt for simulation approach.

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During this lecture session, I will be referring to one particular problem called tool allocation problem and this particular topic that we are going to discuss is referred to as tool allocation policies in FMS.

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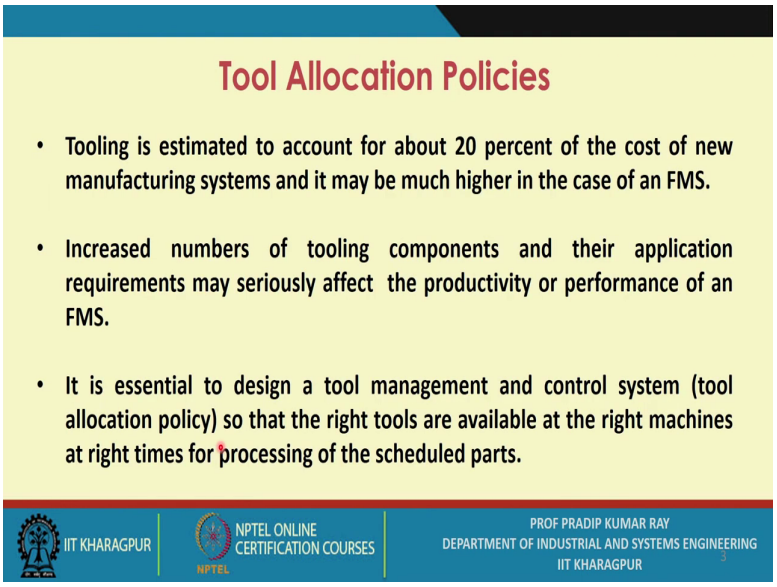

In FMS, there will be always machining centers and for processing parts, you need different types of cutting tools and for holding the cutting tools, you have a holder on the machining center and this is referred to as the tool magazine.

Tooling is estimated to account for about 20% of the cost of new manufacturing systems and it may be much higher in the case of FMS. The tooling cost is a significant portion of the total production cost. Your tool management system should be such that it remains very efficient, it remains cost effective and it remains highly efficient.

The tooling or the tool management system may not act as a bottleneck. If it acts as a bottleneck, then it may so happen that your idle time will be more as well as the throughput time or flow time within the system also will be very high.

These conditions are not accepted when you try to implement FMS. Increased number of tooling components and their application requirements may seriously affect the productivity or performance of an FMS. It is essential to design a tool management and control system.

Whenever we refer to the tool allocation policies, the kinds of the policies you adopt will be affecting the performance of the tool management and control system in an FMS. Is the right kind of tools are available at the right machine at the right time for processing of the schedule parts?

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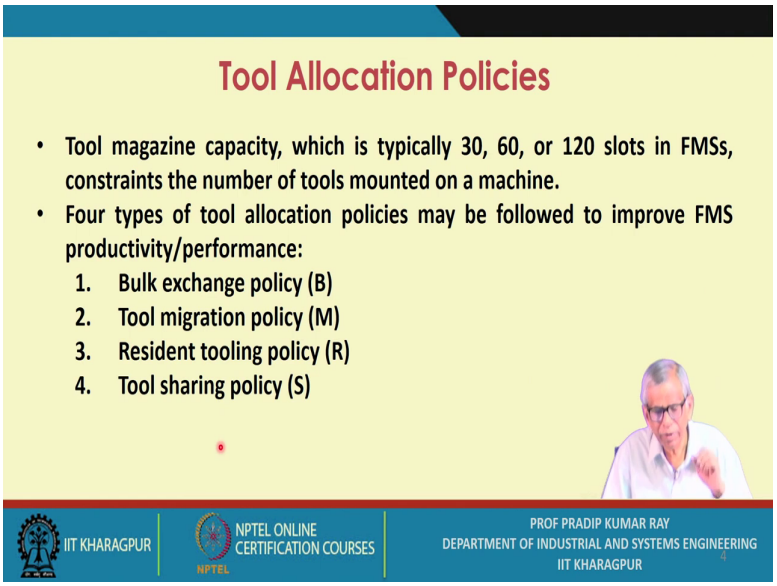

You select a particular part and for processing that work part on FMS, you need to have the right type of the tool at right time with the right kind of the performance so that it fits exactly with the requirements of the part as per its design. The tool magazine is a kind of the tool holding system in a machining center of an FMS.

The tool magazine capacity, which is typically 30, 60, or 120 slots in commercial flexible manufacturing systems, constraints the number of tools mounted on a machine. Suppose, you say that in one particular set of an FMS, I will be processing 100 parts.

These 100 different types of parts in one particular lot against a particular set, even if it is it is feasible, depends on whether 100 types of parts you can process with a set of the cutting tools and that set of cutting tools is made available in the given tool magazine.

If it is 120 slots capacity, possible; but if it is a 60-slot capacity, it may not be feasible. The capacity of the tool magazine determining the number of the different types of parts, you try to process in each batch. When you try to make it slightly flexible, you perform the batch.

The flexible approach you need to check or need to verify, whether it is possible or not and if you use a flexible approach, there are certain advantages. Four types of tool allocation policies may be followed.

First one is the bulk exchange policy. Second one is the tool migration policy.

The third one that is called resident tooling policy. the notation is R and the last one is the tool sharing policy. So, these four varieties are available. Given a particular situation, you have to use one particular policy and you select the policy in such a way that your system remains efficient as well as cost effective. You are using your FMS in such a way that the total throughput time is minimum or the flow time remains at a minimum level.

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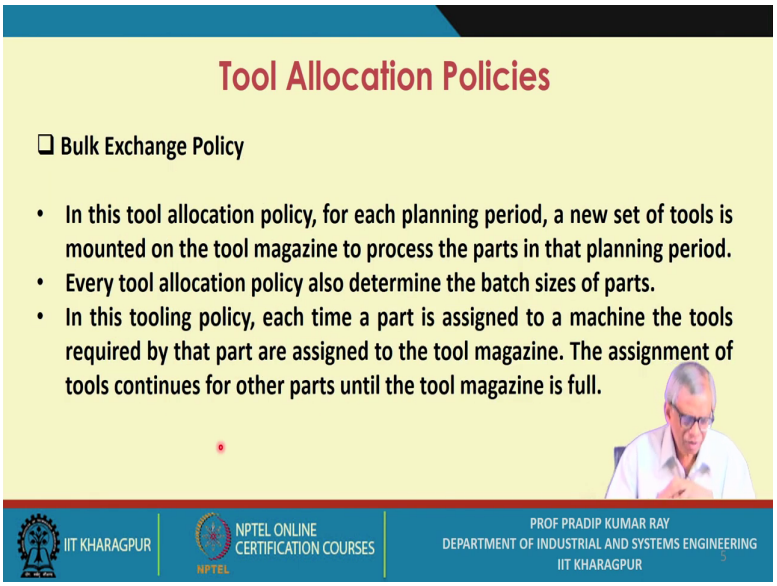

Let me explain bulk exchange policy. In this tool allocation policy, for each planning period, a new set of tools is mounted on the tool magazine to process the parts in that planning period. You say that yes, my planning period is 1 hour or 2 hours and you try to select a number of parts from the population of parts.

The process plan against a particular part is known in detail. What is the expected process time as well as the setup time against a particular machine tool mentioned in the process plan?

In a process plan you find that, against a particular part, the operations required and against each operation, the kind of machine tool required and against that particular machine tool, what is the setup time and what is the processing time per unit; this information is made available with you.

You pick up one part and you get this information on the setup as well as on the processing time and then, you check that for a given part what kind of the cutting tool is required? These information is made available in a process plan.

You just select that particular cutting tool and you put it in your tool magazine. This process continues and ultimately when the tool magazine capacity is full, all these 30 slots or 60 slots or 120 slots are used.

The corresponding number of parts will be your batch size. Now, you start processing the entire batch and as soon as one part processing is over for the cutting tool which is there in the magazine, you just remove that cutting tool.

As entire batch is processed ,that particular tool magazine becomes empty. You just repeat the same procedure for other parts. Every tool allocation policy also determines the batch size of the parts.

In this tooling policy, each time a part is assigned to a machine, the tools required by that part could be just one or for certain part may be more than one tool. The tools are assigned to the tool magazine and the assignment of tools continues for other parts until the tool magazine is full.

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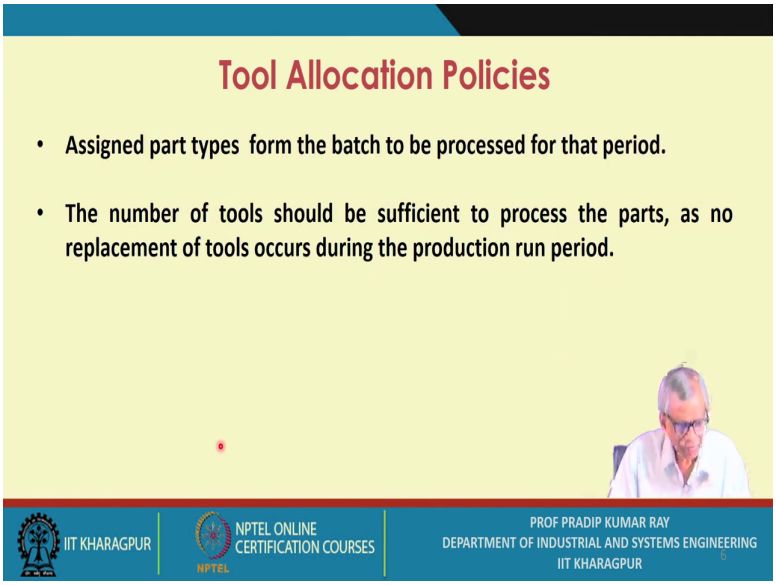

The assigned part types thus form the batch to be processed for that period. The planning horizon could be 1 hour or 2 hours or it could be 1 shift, depending on the kind of part, the processing time, the setup time. The number of tools should be sufficient to process the part as no replacement of tools occurs during the production run period.

To process the entire batch of size n, n number of parts. n could be 50, n could be 45, whatever it is. The entire process flow time will be known to you, and that is basically the production run period, production run length.

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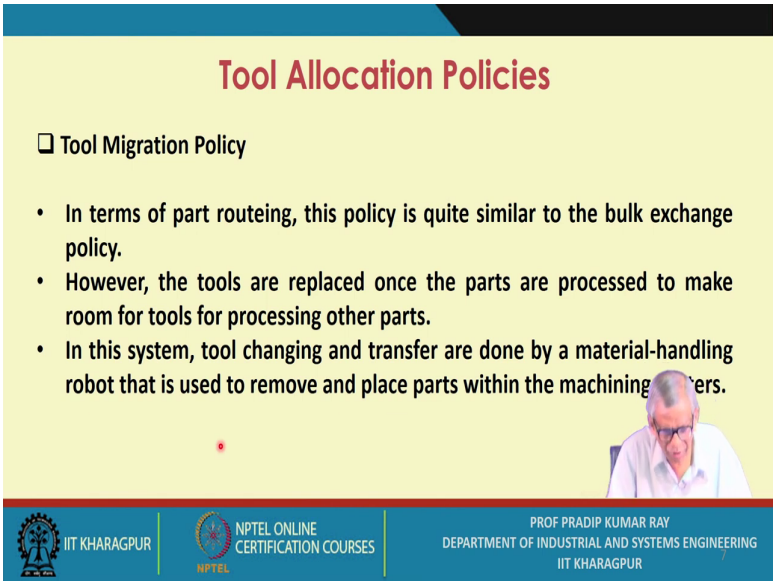

Batchwise you process. The tool magazine initially becomes full and then it becomes empty. Again for the next batch, it becomes full and ultimately, when the processing of the next batch is over, again it becomes empty. This process continues- bulk exchange policy. What is tool migration policy? In terms of the part routing, this policy is quite similar to the bulk exchange policy.

When you refer to a particular part and its process plans, look at the process plan and you look at its sequence of operations, immediately, you get that information related to routing of the parts. The tools are replaced once the parts are processed to make room for tools for processing other parts.

It is a flexible approach. You start with processing for the first part. The batch is already formed, the tool magazine is full. As soon as a few parts are processed, certain slots are made available in the tool magazine.

The new types of the cutting tools you can use. Now, you can insert those new tools, you can identify the corresponding parts and you go on adding those parts as the old parts getting processed. So, the tools are replaced once the parts are processed to make room for tools for processing other parts also. In this system, tool changing and transfer are done by a material handling robot.

When you deal with automation in any manufacturing system, any production system, the different kinds of material handling systems you have to use and to what extent you can use the robots of different types for material handling? That is a very important issue.

When we will discuss about the FMS layout, we will be directly referring to the kinds of the material handling systems you may have to use in an FMS and to what extent the layout of an FMS is essentially defined or determined by the kinds of material handling systems you use. A material handling robot is used to remove and place parts within the machining centers.

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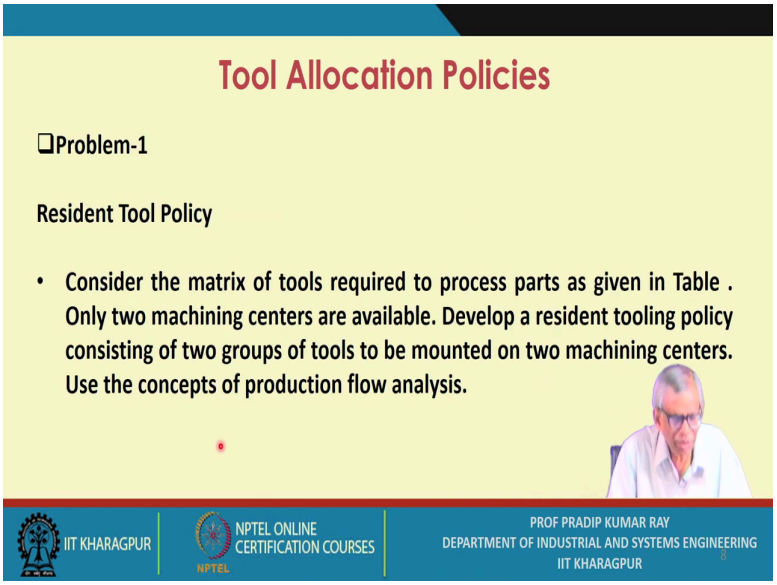

Now, let us the talk about the resident tooling policy. Suppose you have 4 NC machining centres within a particular FMS. Against each machining centre, you have one tool magazine and you have a population of parts.

So you have already applied the group technology principles and you have converted the manufacturing system into cellular manufacturing system. Each machining center can work independently and each one may be referred to as a machine cell or work cell.

This particular work cell is dedicated for a particular set of parts. First you have to identify those set of parts, and the corresponding tools you select and this tools you hold or you just place it in the tool magazine.

You will have the independent set of parts or independent set of the tools or cutting tools in all four locations. In all four machining centers or work cells, the cutting tools are permanently stationed.

Suppose, you have been running your discrete part manufacturing systems for a long time and more or less your product mix is stable.

The number of varieties of parts that you will be dealing with maybe in 1000s, maybe 50000, maybe 60000; as you have been designing, you have been manufacturing, you have been selling a number of the products in standard form. There is hardly any change in the part mix.

You are running a very stable system and the stable system is a controllable system. If you have this kind of stable and controllable system, why don't you opt for the resident tooling policy? There will be certain changes, new requirements, new parts will come; but those the parts you have to deal with rarely.

If a new part joins in the system, how to deal with that particular part; that means, how to manufacture the part with a resident tooling policy? This is the main purpose of adopting resident tooling policy in a manufacturing system. Now, let us refer to a particular numerical problem. Consider the matrix of tools required to process parts as given in the table.. Only two machining centers are available.

Develop a resident tooling policy consisting of two groups of tools to be mounted on two machining centers. Use the concept of production flow analysis.

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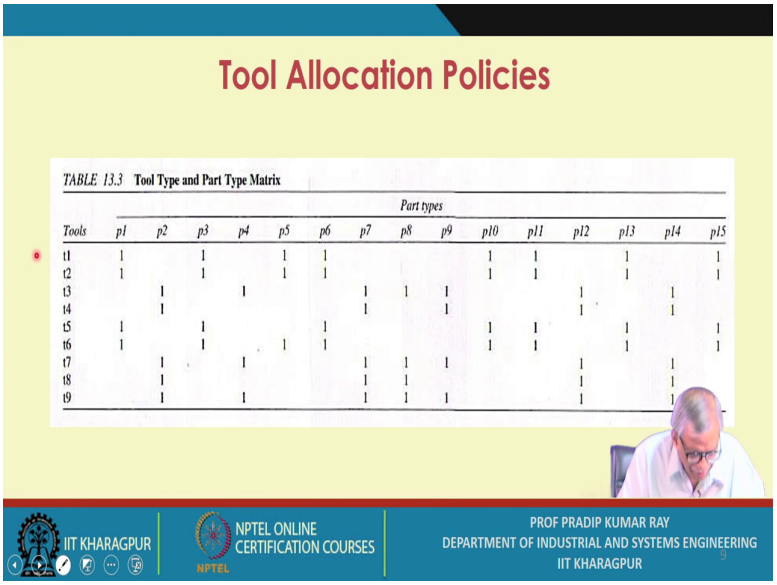

Before you implement FMS, make sure that your manufacturing system is converted into a cellular manufacturing system. You have to go for cell formation and for forming the cell, you may use one or more of the approaches.

How many the cutting tools you have? Here, you have 9 cutting tools and 15 parts and this matrix.

This is basically the part tool incidence matrix. This is your total requirement. How many machine cells you will form? How many machining centres you will engage that you have to decide and thenyou apply the production flow analysis.

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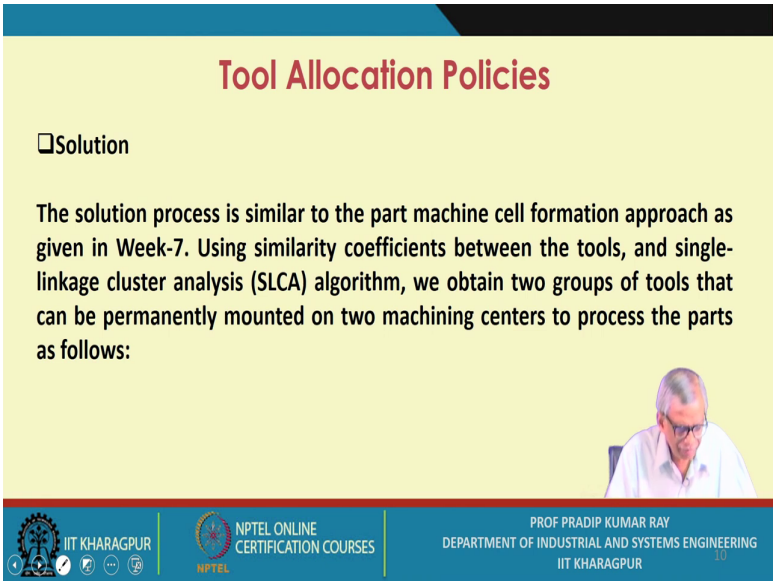

The solution process is similar to the part machine cell formation approach as given in week 7. Using similarity coefficient between the tools, and the single linkage cluster analysis, we obtain two groups of tools that can be permanently mounted on two machining centers to process the parts as follows.

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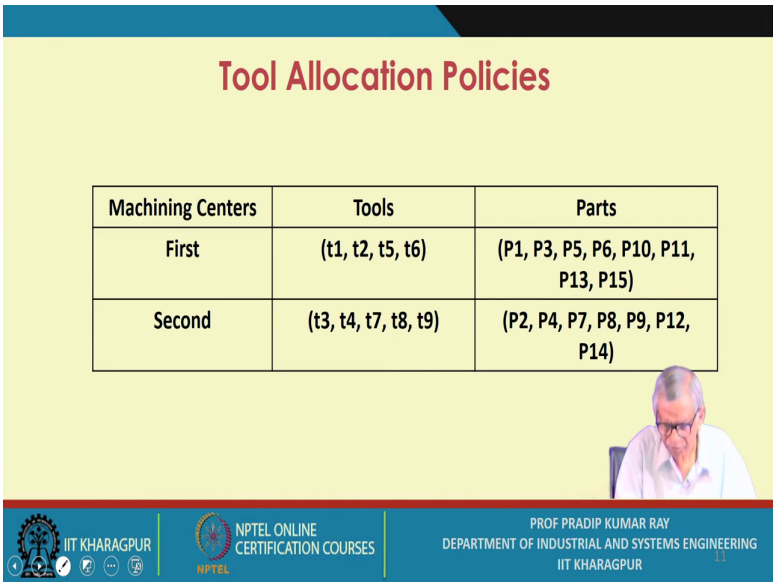

This is the solution. You have the first machining center. The second machining center, you have these tools t1, t2, t5 and t6 and other tools are given in the second machining center.

Those are to be loaded and these tools are to be placed in the corresponding tool magazine and this set of tools will be used to process this set of parts.

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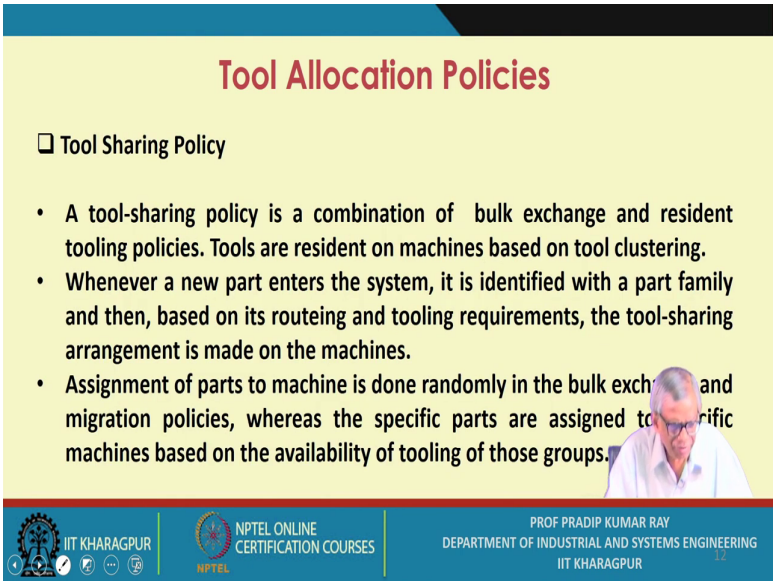

The fourth tooling tool policy is referred to as tool sharing policy. A tool sharing policy is a combination of bulk exchange and resident tooling policies. Tools are resident on machines based on tool clustering. Whenever a new part enters the system, it is identified with a part family and then based on its routing and tooling requirements, the tool sharing arrangement is made on the machines.

Assignment of parts to machine is done randomly in the bulk exchange and migration policies, whereas, the specific parts are assigned to the specific machines based on the availability of tooling of those groups.

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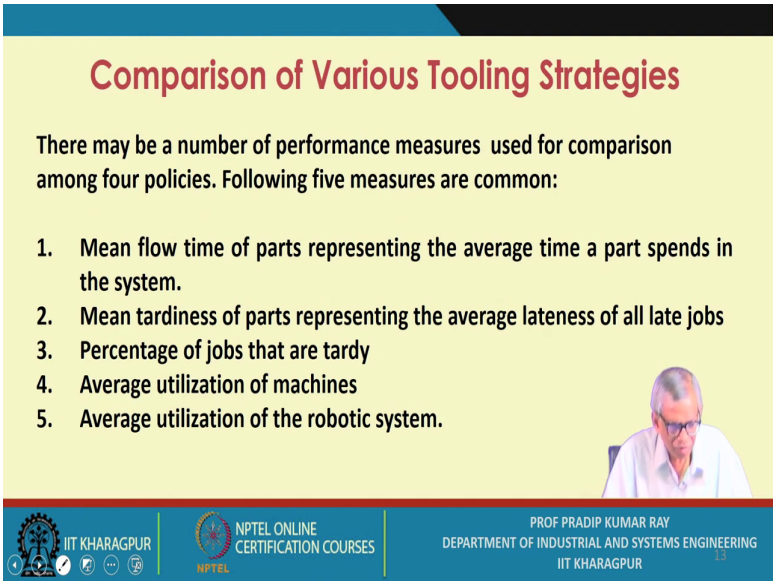

How do assess a particular tooling policy? How your FMS is performing that is to be checked? There are five measures; one is the mean flow time-the average time a part spends in the system, the time when it enters, the time when it leaves the system. Partwise you have this data and then you can calculate the mean or average flow time.

Mean tardiness of parts representing the average the lateness of all late jobs; percentage of jobs that are tardy; average utilization of machines.

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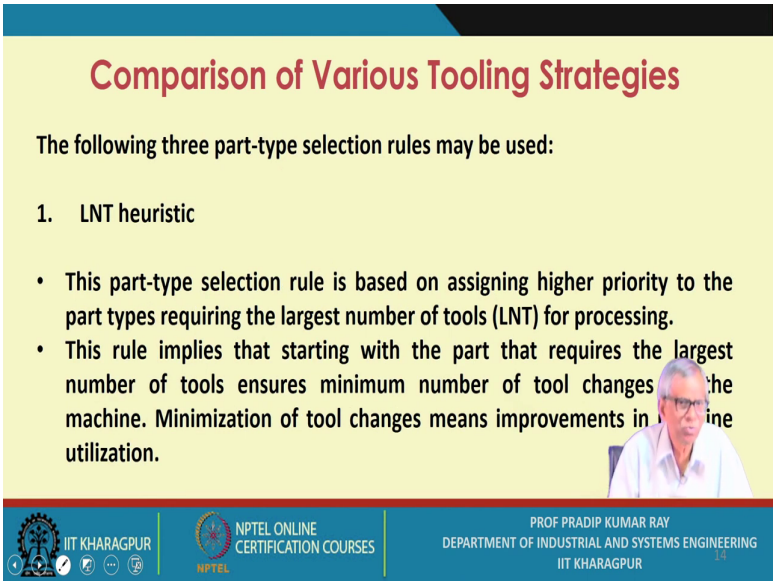

Average utilizations of the robotic system. How do you compare between different tooling strategies? One particular approach is called simulation. You have to select the parts and for the selection of parts, there must be certain priority rules. There are three priority rules which are very common.

First one is the LNT heuristics or LNT rule. This part type selection rule is based on assigning higher priority to the part types and requiring the largest number of tools for processing. This information you get from the process plan and you are given a population of parts and from the population, you have to select a particular part. The basis of selection is LNT rule.

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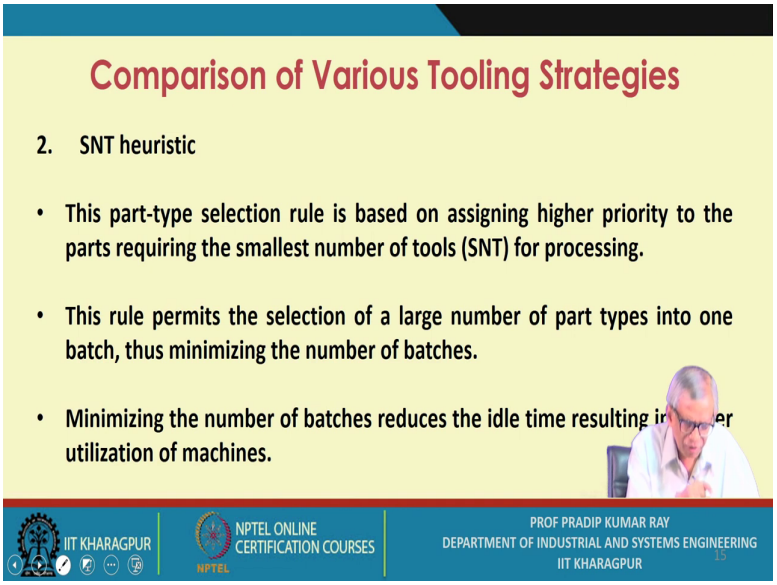

Alternatively, you can also use SNT rule.? This part type selection rule is based on assigning higher priority to the parts requiring the smallest number of tools. There are certain advantages of this rule.

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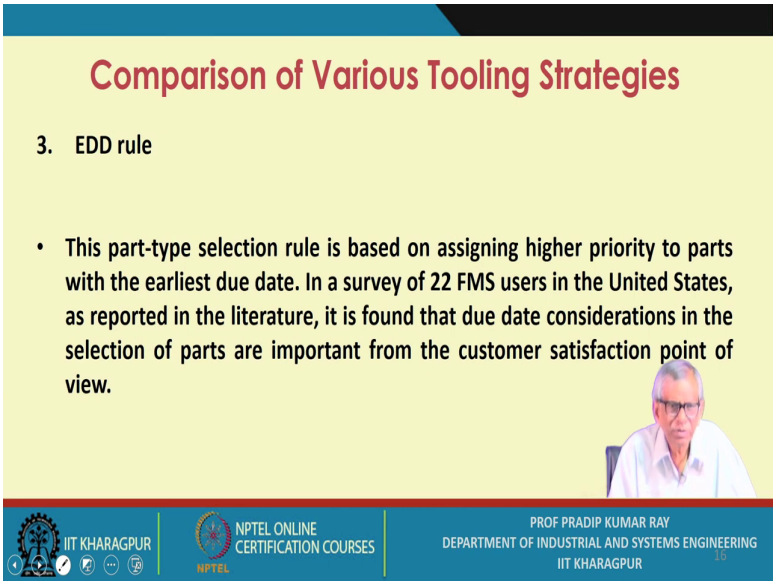

The third one is earliest due date rule. Against a particular part, it is assumed that the due date is known. You select that part which is having the earliest due date. This part type selection rule is based on assigning higher priority to parts with the earliest due date. In many cases,

we will find that the FMS users opt for this particular rule to meet the customer requirements on time.

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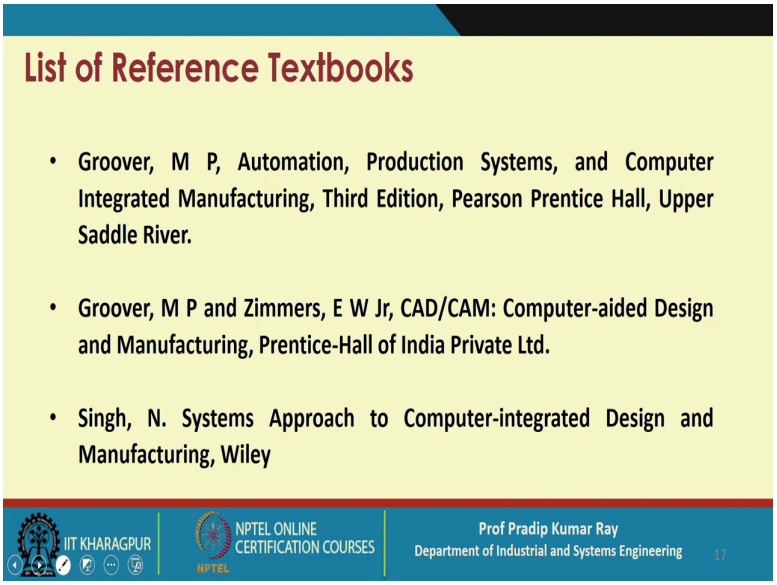

We have discussed in detail the different types of tool allocation policies and you should be aware of different kinds of priority rules and in a given particular FMS, you have to assess the performance of the FMS system as far as this tool allocation policies are concerned by monitoring and controlling five types of performance measures.