Automation in Production Systems And Management
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Lecture - 03
Product – Process - Flexibility Matrices, Four Plane Concept of Manufacturing

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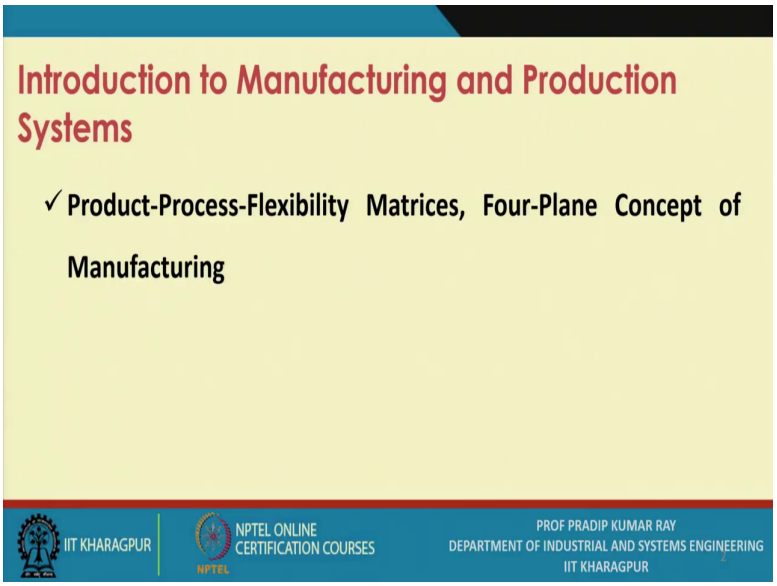

Next we will discuss two important issues related to manufacturing and production system, one is the Product-Process-Flexibility. With reference to the volume variety relationship, we have defined the different types of automation. Now, your focus will be on the process before you go for making the system an automated one.

You want to make the operations as you get from a process automated. There will be hardly any human labour, there will be mechanization. In fact, that is the primary condition before you go for the automation and what kind of product you are dealing with this must be known; whether what kind of automated system you will opt for.

Similarly, what kind of process you are dealing with and related to the process what kind of automation is required and the third one is in today's context we will find that the majority of the production systems are made very flexible.

What is the flexibility dimension or level of flexibility of the system? The relationship between the product, process and flexibility must be known. And along with the manufacturing of the processes we will also come to know what are the other the sub systems you have in the production systems. This is referred to as the Four-Plane concept.

The manufacturing processes will come, but definitely not at the first level. at each level, what sort of activities you are supposed to carry out as far as your production system is concerned, working of the production system we are bothering about, how does a production system work. Now, at this stage we should define what is production.

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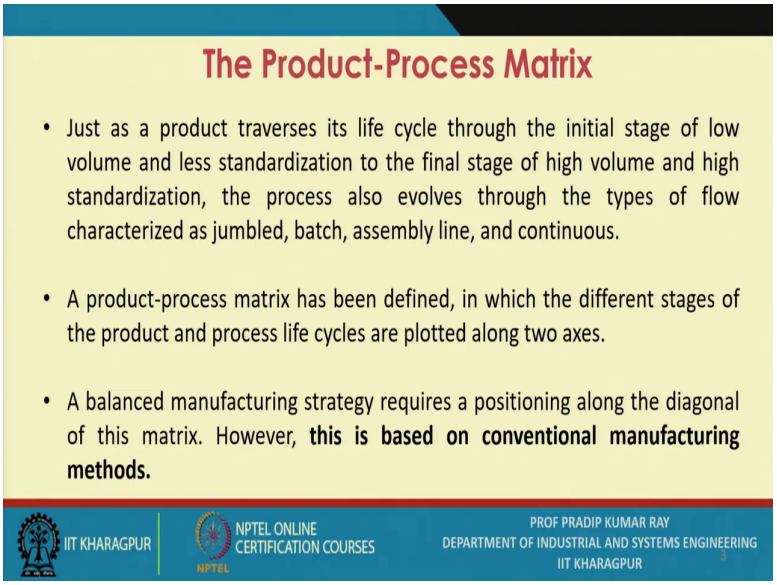

In the given context the production is defined as a kind of a set of activities. Now the question is that what are these activities? There are three activities in production we always refer to, first one is fabrication of any type.

Fabrication means, essentially the kind of work you do to change the shape and size of the materials you have a fabrication shop like say rolling, welding, then assembly, then and the machining operations.

Second one is the assembly and the third one is stage wise inspection.

Whenever we use this term production, we refer to three activities explicitly; first one is the fabrication of any type, second one is the assembly and third one is stage wise inspection. Now, when you refer to the product-process matrix, just as a product traverses its life cycling through the initial stage of low volume and less standardization like when you start developing your production system, why do you install a production system? Because you have already analyzed or you have selected a particular product and that product is just maybe at the initial stage; that means, it is a new product, but the design may be absolutely a new design and there is lot of changes required, you cannot say that the design is a matured one.

This is at the initial stage and for that you have actually started producing, but you are not sure about its demand. Initially you say yes, this product is a new one and there is a possibility of the high demand, but it takes time to get the market.

Initially as it is a new design. In all likelihood, that the design or the part may not be considered or the product may not be considered as the standard one- the low level of standardization as well as the low volume.

Then, subsequently the product is selling, you can increase your market share and , the number of units to be produced per unit of time, this number is increasing, in all likelihood, if it is a success story that you move from the low volume to high volume in course of time; and from low standardization to high standardization.

But it takes time for certain products, for certain manufacturing system, it may be 5 years, for another product it could be $2^{1/2}$ years, for the third product it could be 7 to 8 years, there is no such fixed rule. You try to improve or increase your market share.

The process also evolves through the types of flow characterized. When you visit a job shop you will find that there is no smooth flow of materials within the system, but once you visit a continuous processing, you will find that there is absolutely the smooth flow of materials within the production system.

What are the kinds or the types of flow of materials within the production system that you observe? There are different kinds of types of flows, the first one could be jumbled one in the typical job shop.

Next one is the batch, third one is assembly line and the last one is the continuous assembly line.

But if you say that, the production system is the job shop, you say it is the flow pattern is not yet been fully defined, it is a jumbled one. And when you refer to the batch production system, in the part manufacturing you may get a particular flow, flow may be accepted, but when you go to the assembly shop, you may not find any flow of materials; that means, it is an erratic pattern. A product process matrix has been defined in the different stages of the product and process life cycles are plotted along two axis.

These are the two terms we use, first one is the product life cycle and the second one is the process life cycle the product life cycle. There are four stages in the product life cycle, the first one is referred to as the introduction.

Then in the next phase is referred to as the growth, then you have the saturation phase and the fourth phase is referred to as the decline phase, the y axis represents the sales and the x axis represent the time.

A product is born and the product also dies. Usually what happens that, when the product reaches the decline phase, you just cannot just compete with other products or there would be many reasons. The main reason is maybe the technology we use for the product that technology might have become the obsolete. Your competitors are producing the products with a better technology or the state-of-the-art technology. If you can introduce say the new technology in your existing product sometimes this modification is also possible; again this you come out from the declined phase and again you come back to the saturation phase or at least in the growth phase.

The product life cycle similarly the process life cycles. You can start with a general-purpose machine tool, then the special purpose is like this and ultimately you can reach FMS.

The process life cycles also can be defined and you can identify the specific phase. When you visit a particular plant, when you visit a particular production system you look at the production system and you should understand that at what stage your process is right at this point in time.

A balanced manufacturing strategy requires a positioning along the diagonal of this matrix. There are three dimensions, the first dimension is the product, the second dimension is a process and the third dimension is essentially flexibility. This is based on conventional manufacturing methods, that means, essentially, we do not talk about the automation.

For a given set of part types, a firm has a choice between conventional and flexible modes of manufacture, you try to classify your production system into two categories. In the first category we are following the conventional approach.

When we say we have moved to the second category, then you say yes, we are making our system the flexible one.

There are two kinds of flexibility-one is the product flexibility and the second one is a process flexibility. Usually, if you believe in the conventional manufacturing system, you do not bother about the process flexibility, you may be bothering about the product flexibility because the product must be changing over the time period. Now, later on many companies have realized that unless and until you incorporate process flexibility at an acceptable level, you cannot accept or change a product mix.

Even if there is a change, product mix has sufficient market share, there is a demand for the change, but unless it is supported with the flexible process or process flexibility, you cannot produce and there will be inherent deficiency in the system. There should be perfect match between product flexibility and process flexibility.

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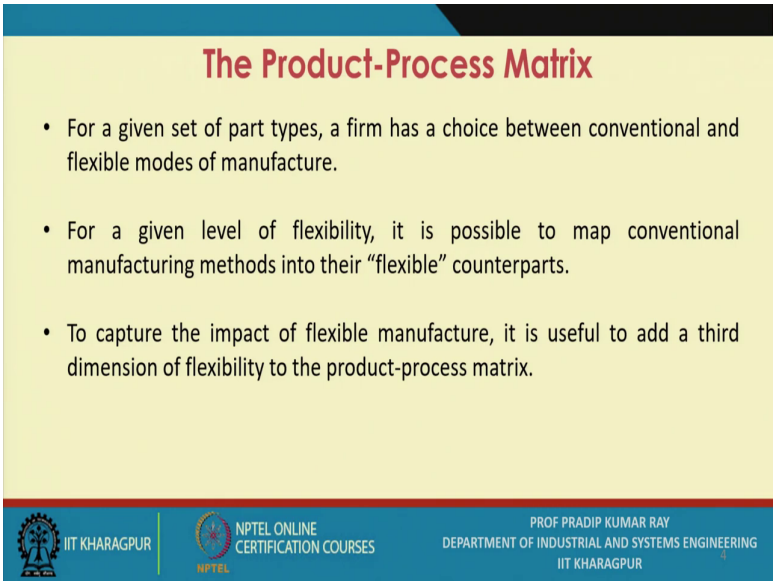

For a given level of flexibility, it is possible to map conventional manufacturing methods into their flexible counterparts, because a product is predefined, process is also predefined at this point in time you have selected the product, you have already selected your process, now we have to identify the what kind of the flexibility you must have so to capture the impact of flexible manufacture, it is useful to add a third dimension of flexibility to the product-process matrix.

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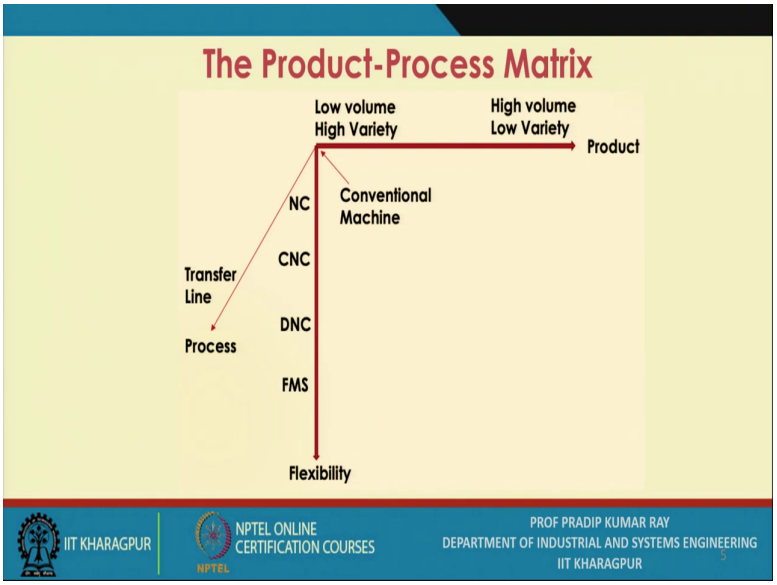

This is your product process matrix- low volume high variety is the starting point; it is a typical job shop initially you start with the job shop stage; you start producing any number of parts or the components or the products.

Suppose, you start with ‘n’ number of the products. As the time passes, you will find initially there maybe 50 such products you have been dealing with. Later on you will find that only a few products say out of 50, 10 products you have a fixed market as well as you have sufficient competence.

You have sufficient knowledge, the design knowledge as well as the manufacturing knowledge to produce most accurately or to produce only 10 or even 5 such products maintaining its quality; that means, from the generalist now you are becoming a specialist.

Out of say five or six selected products, you may be concentrating on just one or two and when you concentrate on one or two, your company will be known by your product and that product you can produce, on the mass production basis; that means, you may opt for continuous processing. There are many instances where you will find that initially the company, they started with few job shops and in course of time, maybe it takes the 20 years’ time or say 15, 10 years of time, now it has become a production system where only few products are produced in large numbers or in the large volume.

From the job shop or piece production system you move to the mass production- low volume. For the low volume high variety, that is basically hard automation or fixed automation whereas, if it is a low variety high volume and it is a high variety low volume, it is the programmable automation.

These are the changes when the product life cycle is concerned and high level of standardization. The second axis is basically related to the process in the process first one is the conventional. The first one is jumbled, then you have the assembly line or the batch production, the process batch, then you have the assembly line and the last one is continuous processing or the transfer line. As far as the process is concerned, the third dimension is flexibility. First one is the general-purpose machine. The flexibility is less then you opt for general purpose machine.

Flexibility is more than the conventional machining; then you opt NC technology, then you go for computer numerical control (CNC), then distributed numerical control and the last one is the FMS. If you can opt for FMS, the level of flexibility is at the highest and it is 100% automated system.

Suppose today you have a general-purpose conventional machine. Now, suddenly you want to move to FMS. In all likelihood, it will be failure case because while you try to change your system from conventional to the state of the art, the automated system, you cannot move to FMS.

Because when you move to FMS, your layout is to be changed, your manufacturing systems to be changed and for each system you have different configurations.

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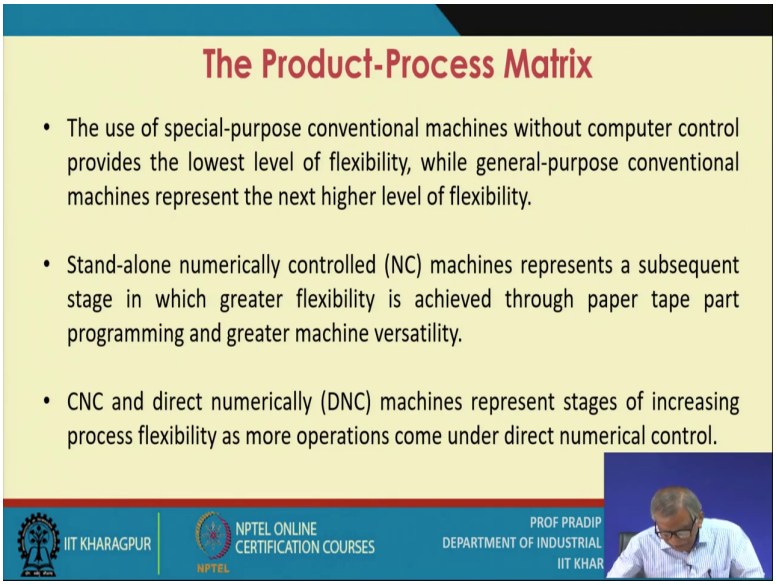

The use of special purpose conventional machines without computer control provides the lowest level of flexibility. Whenever we say there is a conventional machining, we assume that there is no use of computer. General purpose conventional machines represent the next higher level of flexibility.

Stand-alone NC machines represent a subsequent stage in which greater flexibility is achieved through the paper tape. This NC technology is introduced way back in 1952.

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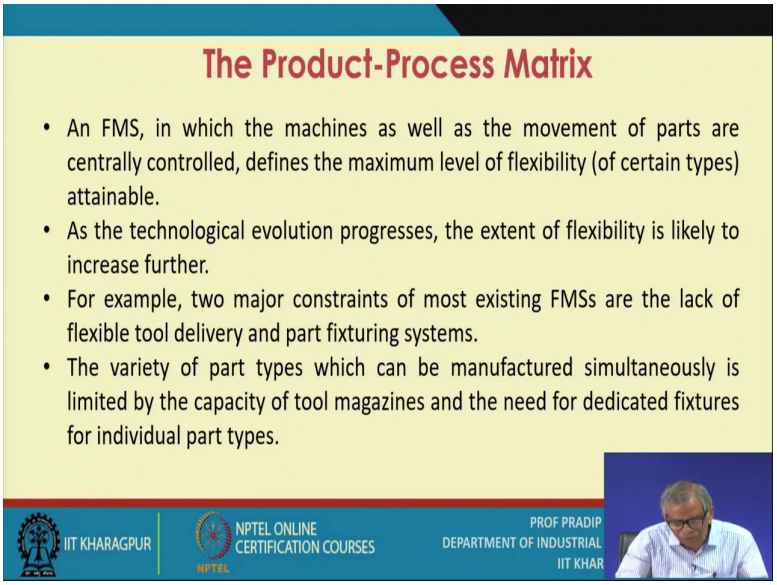

Numerically Controlled Machines DNCs represent stages of increasing process flexibility as more operations come under direct numerical control. Direct numerical control means one central computer can control a large number of machines, simultaneously controls the performance of a large number of machines.

An FMS in which the machines as well as the movements of parts, automated storage and refuel systems are centrally controlled defines the maximum level of flexibility of certain types attainable. As a technological evolution progresses the extent of flexibility is likely to increase further.

For example, two major constraints of existing FMS are the lack of flexible tool delivery and part fixturing system. We will consider the variety of part types which can be manufactured simultaneously and is limited by the capacity of tool magazines. There are different types of tool magazines you use in CNC machines, the need for dedicated fixtures for individual part types.

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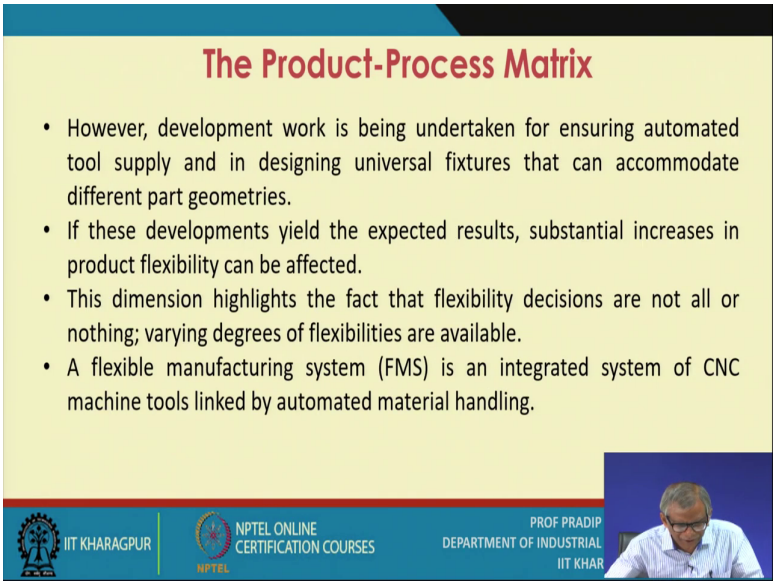

However, development work is being undertaken for ensuring automated tool supply and in designing universal fixtures a flexible manufacturing system that can accommodate different part geometries. An FMS is an integrated system of CNC machine tools linked by automated material handling.

There are automated storage and retrieval systems, material handling system and definitely the CNC machine tools you use, plus the inspection equipment you use, which are referred to as coordinate measurement machine.

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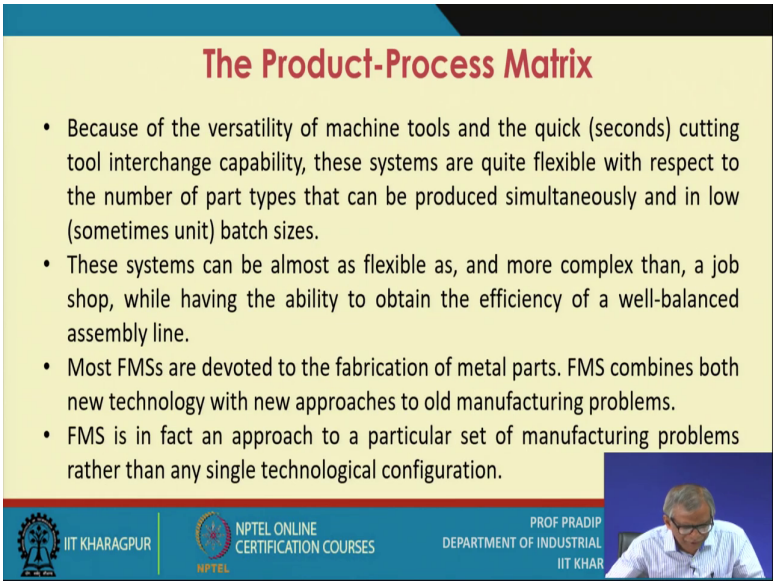

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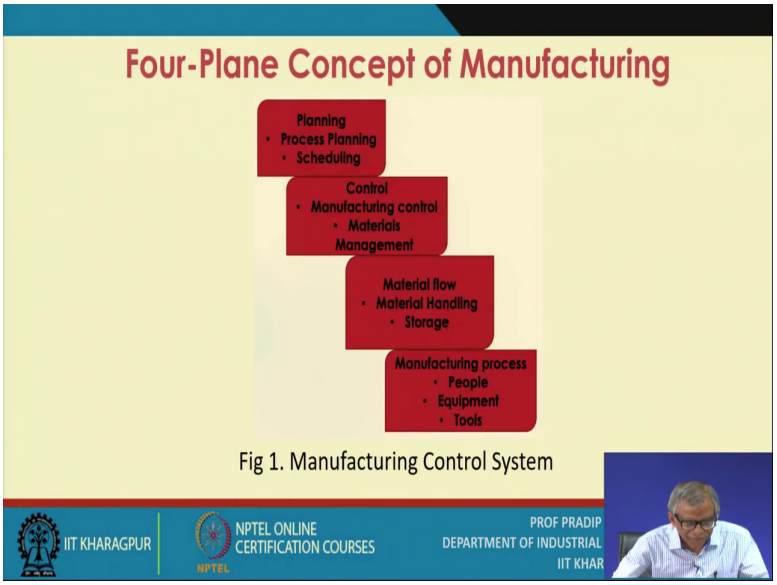

Before I close this particular lecture, I will mention certain points related to the Four-Plane concepts. How do you look at your manufacturing system? How do you look at your production system? First you must consider the planning part and when you talk about planning, you refer to process planning as well as the scheduling.

The scheduling part is very important, and under certain conditions you can automate your process planning activities. Then the next important part is the control- production control, manufacturing control.

In materials management section, you have to create your materials management system and many activities can be made automated one within the materials management functions. Then you come down to material flow part material handling and the storage facility.

In all these activities you can introduce automated systems of different types and at the ground level you have the manufacturing process and when you talk about the manufacturing process, you refer to the persons working with the manufacturing system, then the kinds of equipment you use and the tools you use, like say different kinds of cutting tools you need to use.

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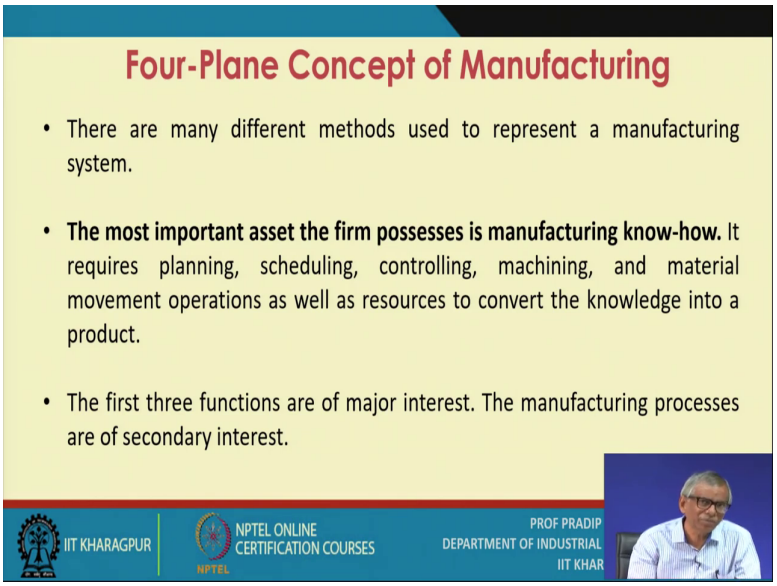

There are many different methods used to represents a manufacturing system. The most important asset the firm possesses is manufacturing know how and then the first three functions are of major interest. The manufacturing processes are of secondary interest.

First you talk about the planning part, then you talk about basically the control part, then you talk about the material flow part and you just verify to what extent the automated systems can be incorporated when you are successful, those are the necessary conditions.

Then you come down to absolutely at the shop floor level and you look at your manufacturing systems and you check that what extent the manufacturing system can be made automated.

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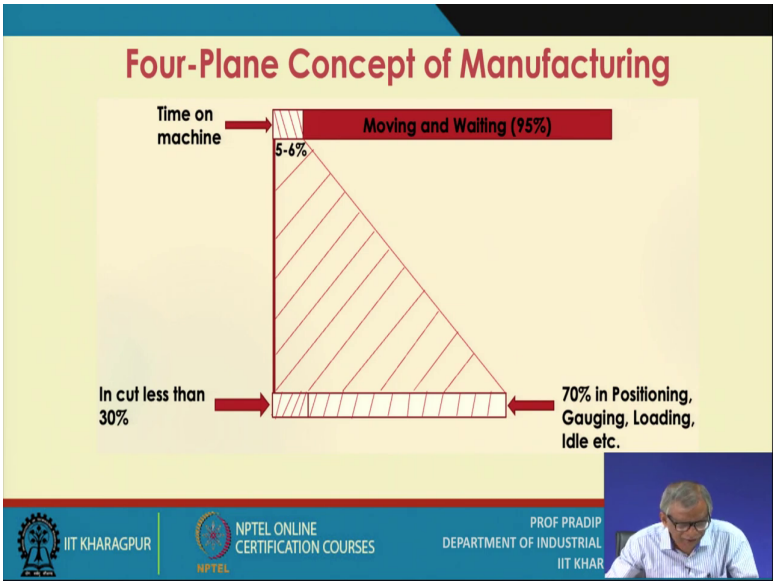

This is the total systems approach and when you talk about this manufacturing system, the moving and waiting time is 95% time on machines and within these 5 to 6% in cut conditions. Just you look at this particular figure you will find that the 70% in positioning, gauging, loading and idle time.

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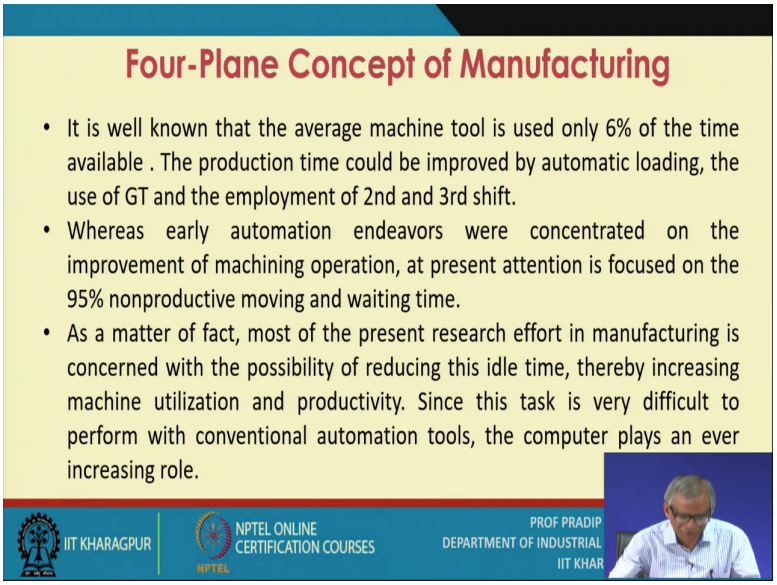

In today's context, when you talk about the manufacturing system there is a term, we use called throughput time. It has got the four components- first one is a set-up, next one is the processing, the third one is the transfer and the fourth one is waiting.

Today, what we try to focus, definitely the automated system you produce you propose for the processing, but before you propose automated system for processing, make sure that you have the minimum waiting time, you have the minimum transfer time and you have minimum setup time.

As a matter of fact, most of the present research effort in manufacturing is concerned with the possibility of reducing idle time, the setup is non-value adding, waiting is non value adding similarly, transfer is also non value adding, only the processing is value adding.

When you opt for automated system, make sure that only those activities which are value adding they are made automated and non value adding activities must be eliminated as far as possible.

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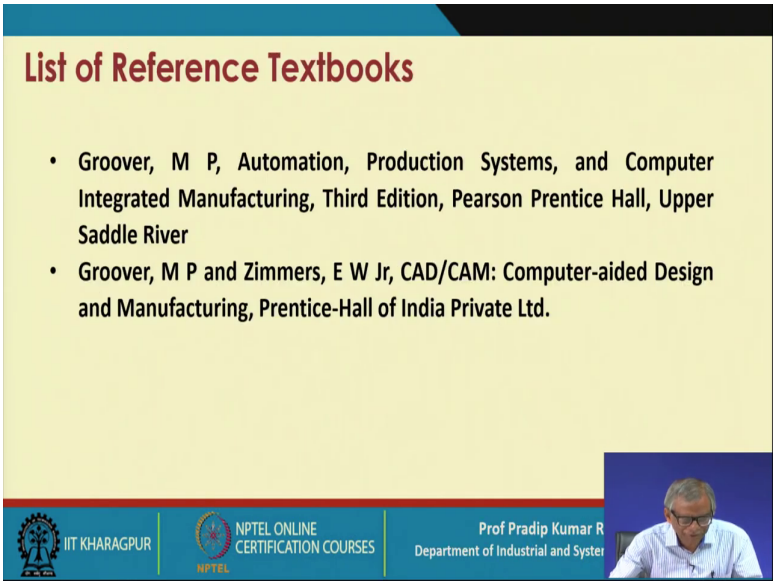

This is the pre-condition. You have to prioritize your goals and accordingly you take steps for making your system an automated one.