Automation in Production Systems and Management
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Fundamentals of NC Technology - I
Lecture - 16
Introduction to Concept and Application of Numerical Control (NC) Technology

If you want to develop an automated system, NC technology or Numerical Control technology you have to use. You must have proper understanding of the NC technology, and how this NC technology is to be used for creating an automated system in manufacturing and production systems.

During this week as well as in the next week; we are going to discuss the fundamentals of NC technology.

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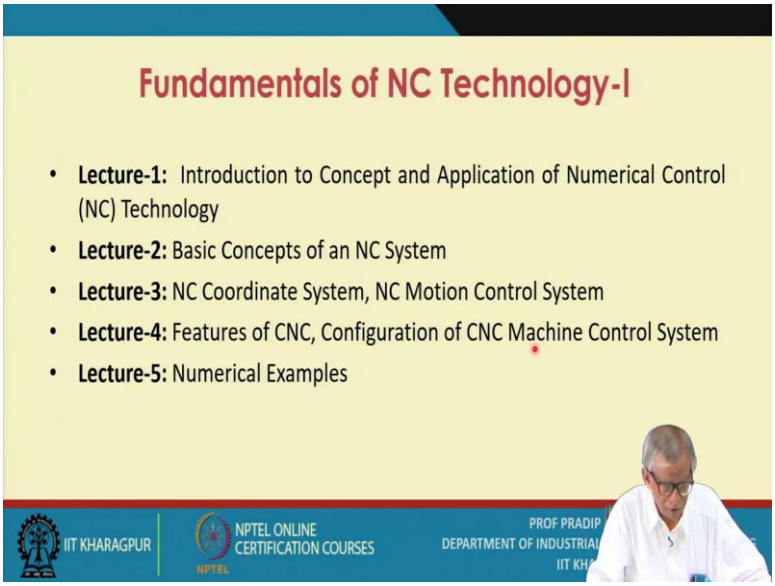

There are many issues to be considered when you refer to fundamentals of NC technology. Certain important aspects of NC technology we will discuss during the 4th week. And during the 5th week, we will also refer to other important aspects or issues related to NC technology or numerical control technology.

Now, during this week, we have 5 specific lecture sessions. First during this lecture session for half an hour, I will refer to the Introduction to the Concept and Application of

Numerical Control Technology. In the next lecture session, you will understand the Basic Concepts of an NC system or Numerical Control System.

In the third lecture session, we will discuss in detail the NC Coordinate System and NC Motion Control Systems. Suring the 4th lecture session, the features of CNC – Computer Numerical Control configuration of CNC Machine Control System. During the last session, there will be many examples of application of ancient technology.

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Let us talk about the Basic Concepts and Application of Numerical Control Technology. You should understand what is NC technology, why it is to be used, and for which kind of the manufacturing systems you can use NC technology, and what are the possible merits of NC technology.

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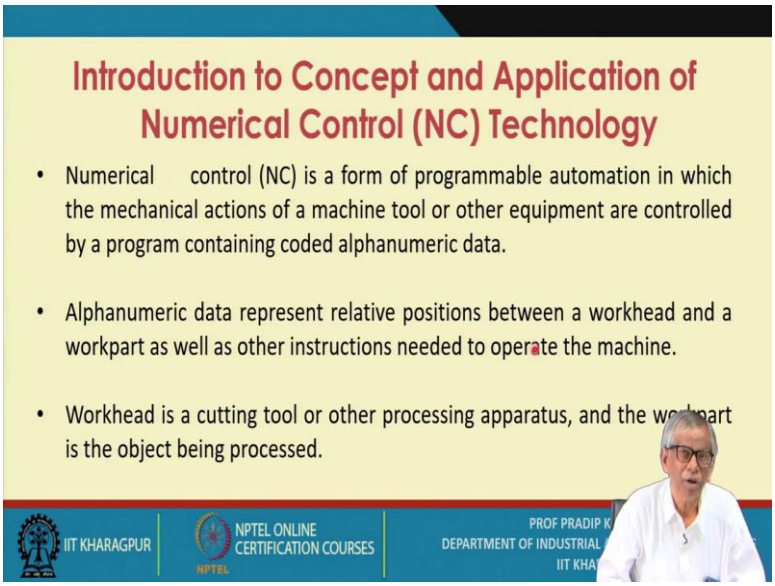

Now, briefly I will tell you the history of NC technology. The numerical control technology was introduced in the early 50s, 1952 and particularly in comparison with the traditional manufacturing system.

We will find that majority of the organizations across the world, the traditional manufacturing methods processes are becoming obsolete and they are trying to adopt these NC based technology. NC based technology has a gone through certain phases.

A numerical control or NC is a form of programmable automation. As you may be knowing that programmable automation you recommend when the varieties are more and, against each variety, against each type of product, the volume was less.

Numerical control is a form of programmable automation in which the mechanical actions of a machine tool or other equipment are controlled by a program. Sometimes, this is referred to as a part program. So, all the actions of a mechanical tool or any other such equipment are to be controlled by a program containing coded alphanumeric data, that means, basically a set of instructions.

The instructions are to be written encoded alphanumeric code. In course of time, when we discuss the part programming, we will come to know what are the possible languages you can use. Alphanumeric data represents relative positions between a work-head. Work-head is nothing but the cutting tool.

Suppose, a cutter is to be used or a cutting tool is to be used, the work-head is essentially the cutting tool and a work part. The work part is basically the part or basic raw material which is to be processed by reactions by the workhead of the cutting tool. Other instructions needed to operate the machines, when we write down the program, you will refer to the relative location of the work head, relative location of work part.

Work head is a cutting tool or other processing apparatus. Work processing apparatus for the welding you can use NC technology, for many other operations also you can use NC technology. The work part is the object being processed.

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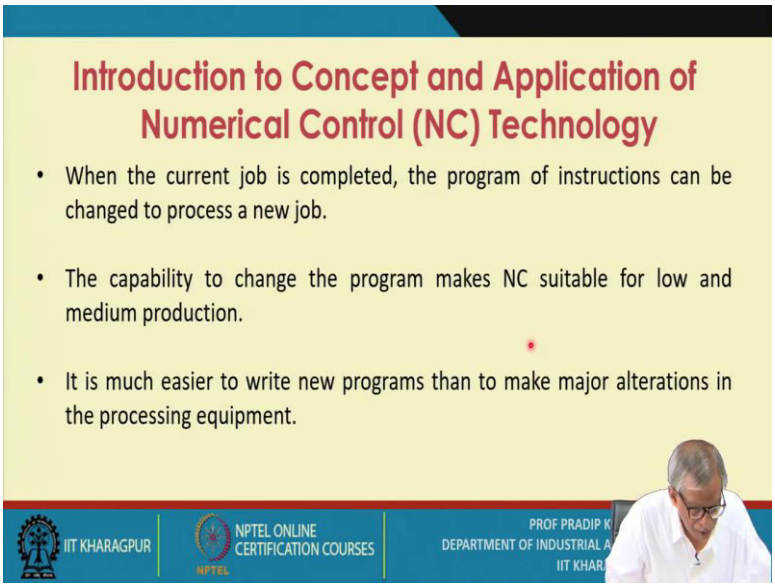

When the current job is completed the program of instructions can be changed to process a new job. That means, the kinds of machine tool you use, those are basically referred to the machining centres, not only one type of operation is made available, but a number of the operations are made available at that particular say machine tool or the machining centre.

The capability to change the program makes NC suitable for low and medium production, particularly when you deal with the batch production system. For batch production system or discrete part manufacturing system, you need to adopt the NC technology.

It is much easier to write new programs, then to make major alterations in the processing equipment. Essentially when NC technology was introduced it was a research project and R& D project.

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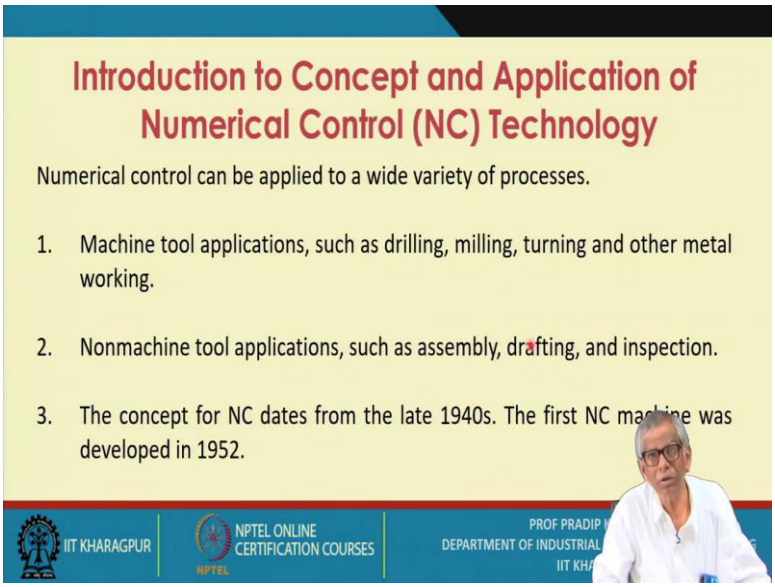

Later on when the NC technology became easier to implement, many companies, many manufacturing systems immediately adopted.

Numerical control can be applied to a wide variety of process not only for the metal machining. The first application is machine tool application such as drilling, milling, turning and other metal working. When you talk about the metal machining, four the kinds of the operations we refer to.

First one is the turning and its varieties, the second one is the drilling and its varieties, the third one is the milling and its varieties, and the fourth one is the grinding and its varieties. For metal machining definitely all kinds of the processes operations they are classified under four categories. For all these kinds of processes, definitely you can use the NC technology that is the first application.

The second application is non-machine tool applications such as assembly operations. As I have already told you that part manufacturing followed by the assembly in a typical batch production or discrete part manufacturing systems. This assembly is nothing but

the final product, For assembling operations, you can use NC technology. You should know the details about the design for the assembly.

Then the drafting operations and even for the inspection operation you can use NC technology. The concept of NC dates from the late 1940s. The first NC machine was developed in 1952.

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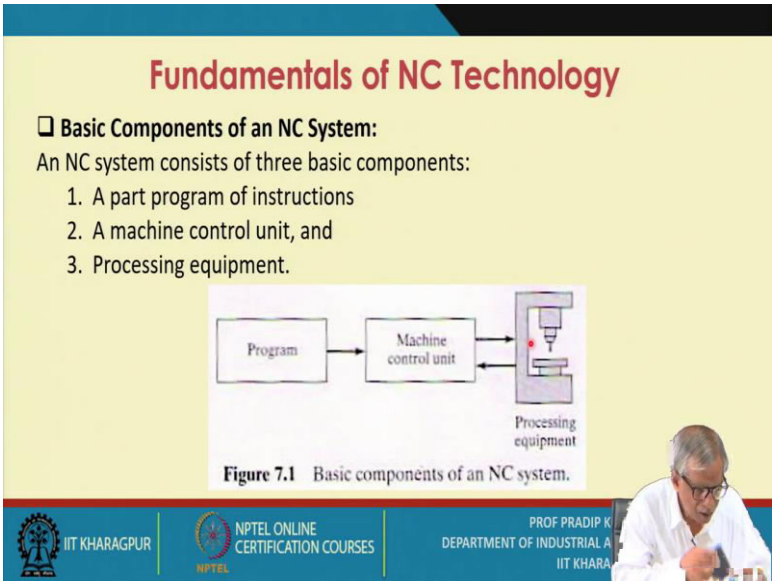

When we refer to the fundamentals of NC technology, the components of the NC system you must know. This is your starting point. An NC system consists of three basic components.

The first one is the part program of instruction. Program means basically program of instructions, you have to write down the part program. The second one is the machine control unit and the third one is the processing equipment, actual machine tool where the work part is getting processed.

Program mean program of instructions, actually are fed to the machine control unit. Basically the machine control unit does many kinds of activities, mostly it is acting as an interface and ultimately these instructions are given or the pre-specific actions are communicated to the processing equipment.

There are three components – program of instruction to be given to the machine control unit and the details about machine control units like the configuration of machine

control unit and how does it work, the program of instruction, the details about the program of instruction related system. Similarly, the machine control units and its configuration must be known. So, what are the sub-elements, what are the sub-components you find in the machine control unit, and what is the working of machine control unit?

Similarly, how do you represent the processing equipment and what does it do? As you have seen that this is an NC system, there must be proper integration.

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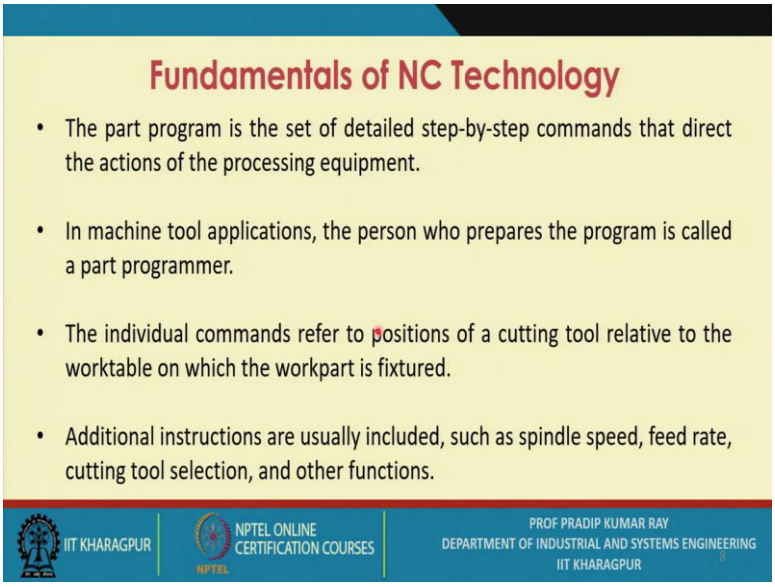

Now, let us talk about the part program. The part program is a set of detailed step-by-step commands that direct the actions of the processing equipment That means how the particular work part is to be processed, the process plan is known.

The process plan is known for the given work part, Initially it is in the raw material form. And as you start processing the raw material, you keep on adding the values, that means, the shapes and sizes are getting changed. How do you do that? You use the different kinds of carters or the cutting tools or the processing equipment.

You write down the part program for a given part or for given component and for that component your design is made available. The process plan is to be used, and immediately you start writing down the program in a particular language.

In machine tool applications, the person who prepares the program is called a part programmer. We will find that these new designation came in 50s and the part programmer is a person who knows the ins and outs of the functioning of the machine tool as well as he or she is having the ability to interpret the drawing for a part.

The individual commands refer to positions of a cutting tool relative to the work table on which the work part is fixtured. The work table will be there. There will be cutting tool and on the work table, you will have a fixture. And on the fixture, you actually position your work part. All these detail should be known and the coordinate system you need to use.

Additional instructions are usually included such as the spindle speed because whenever you create the process plan, it is created in such a way that you say that optimized process plan, in the sense that the kinds of the settings you do with respect to the process or the parameters- these settings are specified. A typical settings when you refer to and you should know what is the spindle speed, you should specify the feed rate.

These are examples in fact what type of cutting tool you are going to use whether it is HSS or it is some diamond cutter or the other functions you should specify. When you refer to the process plan, you get all the details.

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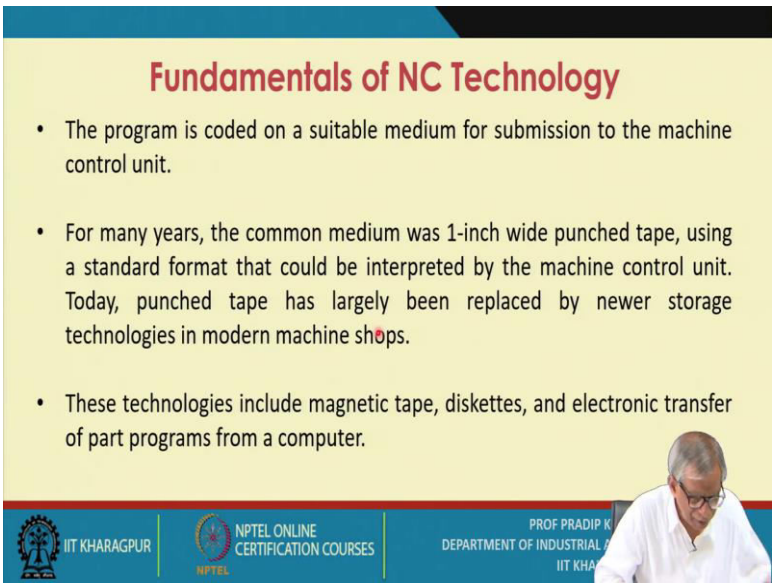

The program is coded on a suitable medium for submission to the machine control unit which can be easily interpreted. For many years, the common medium was 1-inch wide punched tape using a standard format that could be interpreted by the machine control unit.

Today, punched tape has largely been replaced by newer storage technologies in modern machine shops, but the basic concept remains same. Obviously, the medium will change, but the basic concept remains same.

These technologies include first is magnetic tape, then you start using diskettes, and today you use electronic transfer, or part programs from a computer. Initially in 50s, there was no computer, you have to design a specific machine control unit and those units are referred to as hard wired systems.

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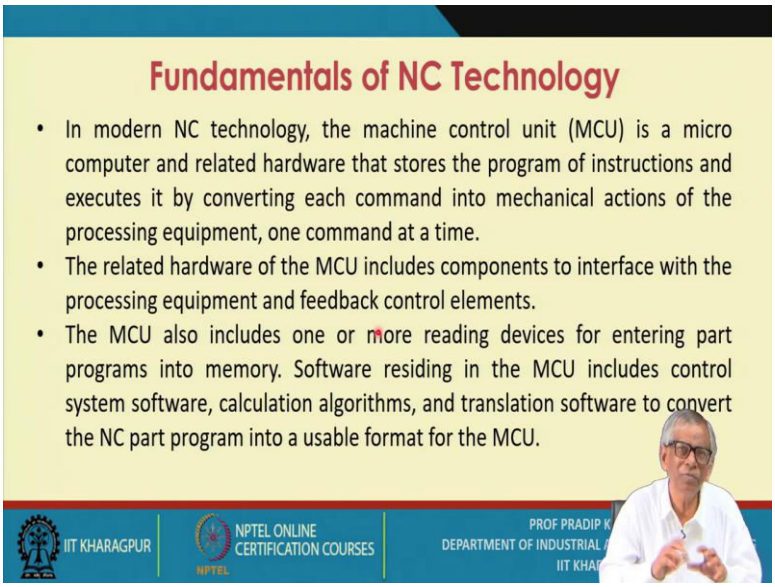

When you talk about machine control unit, it is nothing but the computers. When you start using the computer, the NC system is changed to computer numerical control. First it was NC, then it became CNC, and then the CNC is changed to DNC or Distributed Numerical Control.

In modern NC technology the machine control unit is a microcomputer and related hardware that stores the program of instructions is very easily you can do in a computer, and executes it. You have to create these functions, you start processing your equipment

with respect to the work part. Against each operation, you refer to the corresponding code of instruction. All these operations are executed by converting each command into mechanical actions.

When the material is getting processed, it is referred to as the mechanical action. Whatever the instructions you have given that is to be converted into specific mechanical actions of the processing equipment one command at a time.

As soon as you prepare your process plan, the sequence of operation also we will come to know. This sequence you determine in such a way that entire manufacturing process, with all its activities, becomes an optimized system.

The related hardware of the machine control unit includes components to interface with the processing equipment, and there will be two way interactions. Certain data, certain instructions you give to the processing equipment. And simultaneously when the process is on, you also start getting the feedback information.

MCU includes one or more reading devices for entering part programs into memory. Software residing in the MCU includes control system software, then calculation algorithms, and translation software to convert the NC part program into a suitable format for the MCU.

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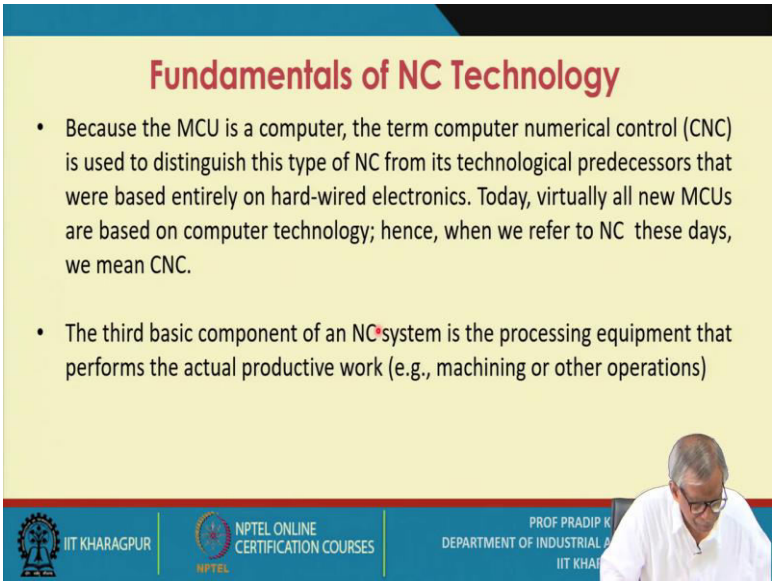

MCU is a computer, the term computer numerical control is used to distinguish this type of NC from its technological predecessors that were based entirely on hard-wired electronics. Today, virtually all new MCUs are based on computer technology; hence, when we refer to NC these days, we mean CNC.

In the 50s or even in till early 60s, we used to refer to NC technology, but today the computer has been introduced to almost all kinds of operations, whether it is an automated system, whether it is an online real time control system or offline quality control system, the computer is everywhere.

NC technology based on the use of computer is referred to as CNC. The third basic component of an NC system is a processing equipment that performs the actual productive work like machining and other operations.

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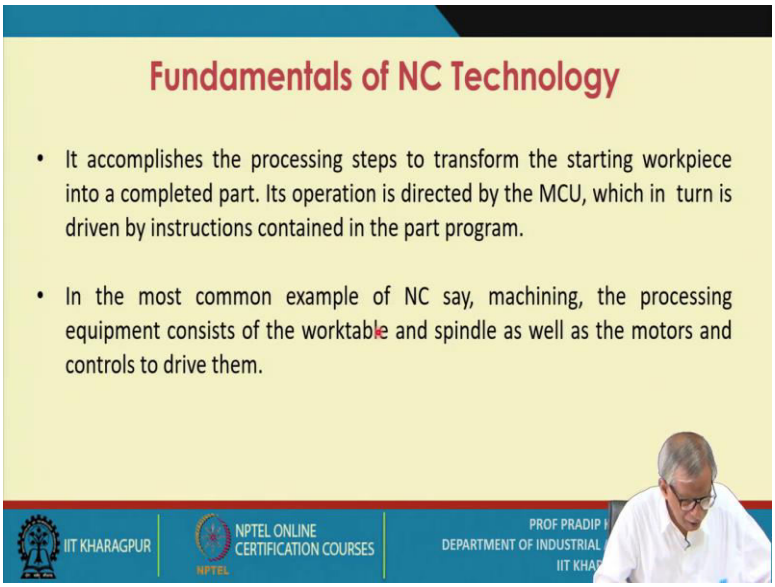

It accomplishes the processing step to transform the starting workpiece into a completed part. You have to follow a series of steps, its operation is directed by the MCU, which in turn is driven by the instructions content in the part program.

The most common example of NC is machining or metal machining, the processing equipment consist of the work table and the spindle as well as the motors and controls to drive them.

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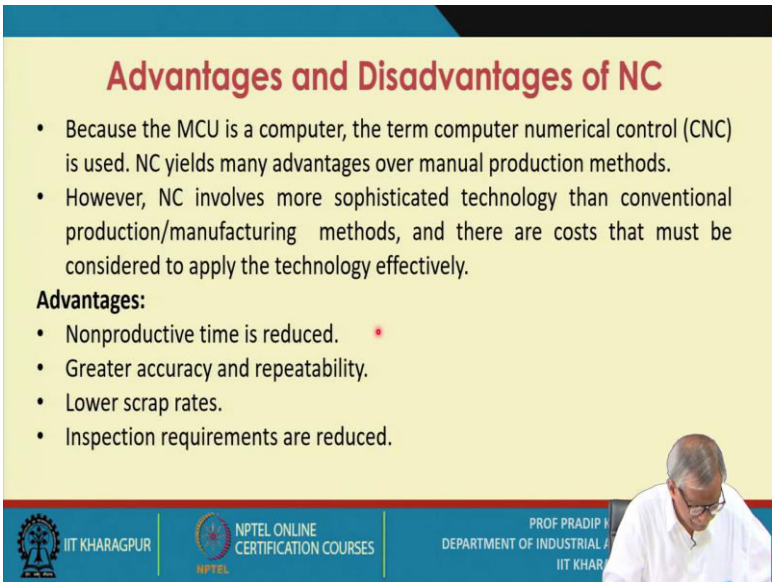

Because MCU is a computer, the term computer numerical control is used. However, NC involves more sophisticated technology than conventional production or manufacturing methods, that is why it is adopted and there are costs that must be considered to apply the technology effectively. So, what are the advantages? Non-productive time is reduced, greater accuracy and repeatability, lower scrap rates and inspection requirements are reduced.

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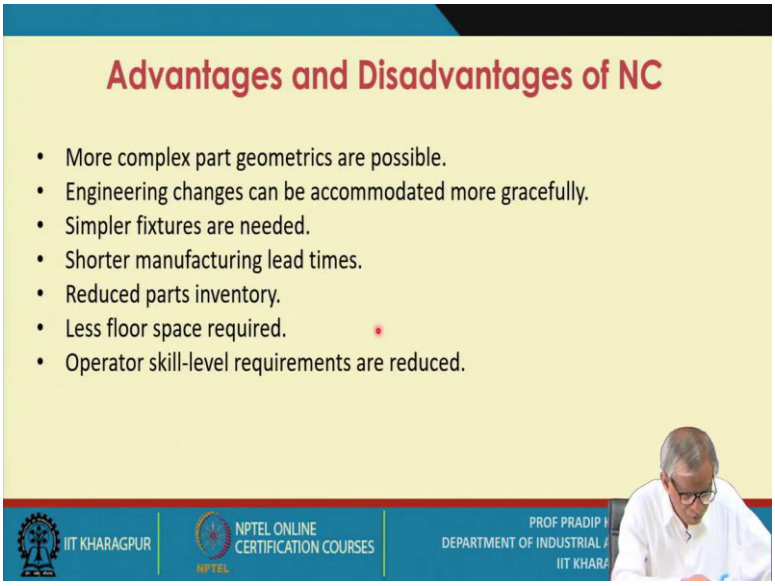

More complex part geometries are possible for which special kind of software you may have to use interpolation software. And the engineering changes can be accommodated more gracefully. Simpler fixtures are needed.

Shorter manufacturing lead time means, your productivity goes up, efficiency goes up and the reduced parts inventory, less floor space required, operator skill-level requirements are reduced.

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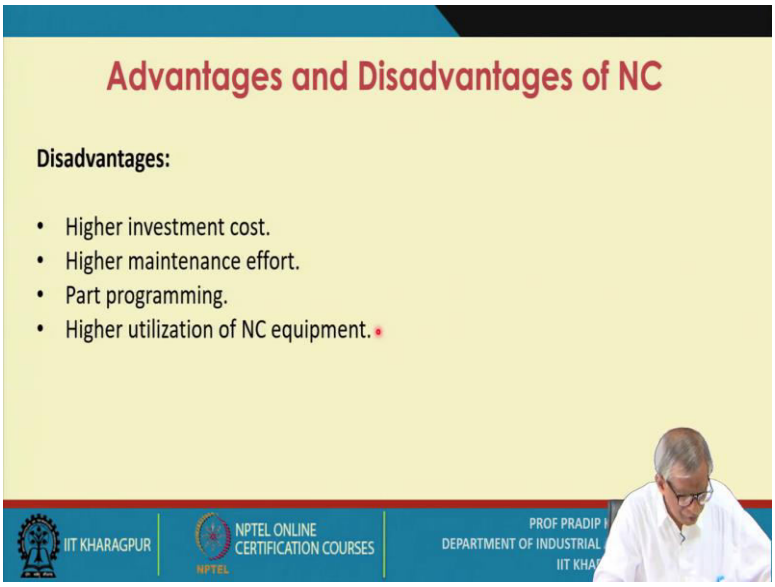

There could be certain demerits or the disadvantages. Higher investment cost, Higher maintenance effort, you should know the maintenance and the service aspects of those equipment. Part programming knowledge is a must, and higher utilizations of NC equipment.

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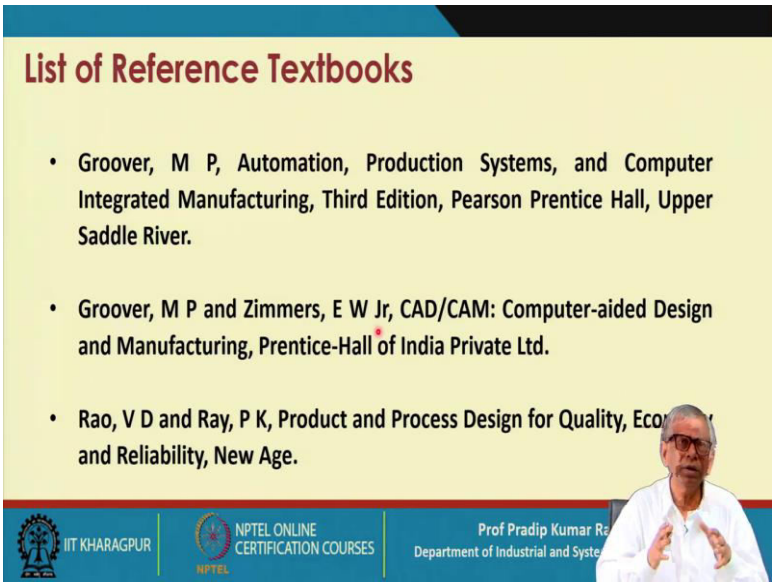

In our next lecture sessions, we will be referring to some other fundamental aspects related to NC system.