Automation in Production Systems and Management
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Fundamentals of NC Technology - II
Lecture - 21
Distributed Numerical Control (DNC) and its Configuration

During this week, again we will be referring to NC technology in the current era referred to as the DNC or distributed numerical control.

There are fundamental concepts related to DNC and during this week for the next lecture sessions, I will be referring to the fundamentals of NC technology with reference to distributed numerical control. Many companies have adopted distributed the numerical control.

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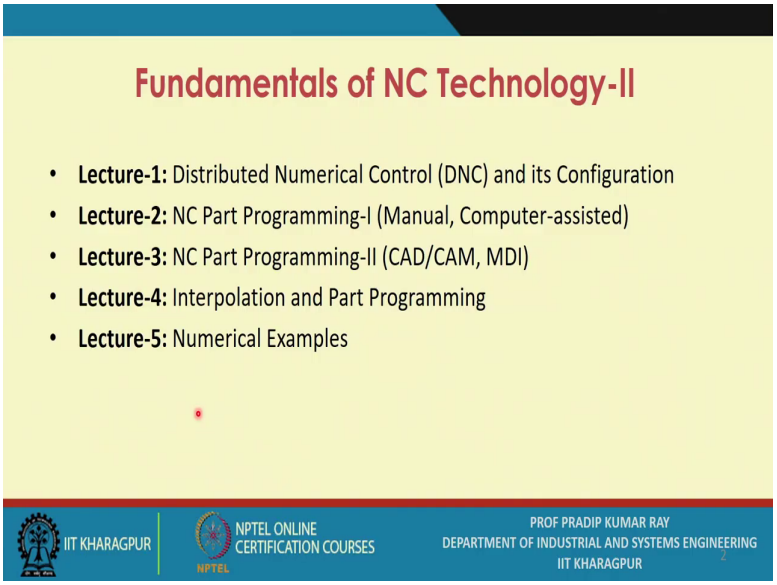

There are many other the fundamental issues which also we should cover like NC part programming. I have already mentioned that there are four methods of part programming, each method I am going to discuss and then, I have also mentioned about the interpolation. Any NC system you install, or implement, you start working with, you will be using many kinds of interpolation software.

First lecture session, we will be discussing on the distributed numerical control. From CNC we move to DNC and we are going to discuss the DNC and its configuration.

Next lecture session, we will be covering two types of NC part programming methods, one is the manual one and the second one is the computer-assisted. In the subsequent lecture sessions, we will be referring to two more methods being used for NC part programming. One method is based on the CAD-CAM-based and the second one is manual data inputs. The details about these two methods also we are going to discuss.

In the 4th lecture sessions, we are going to discuss in detail the interpolation and how it is related to the part programming. And during the last session lecture 5, the several examples we will discuss.

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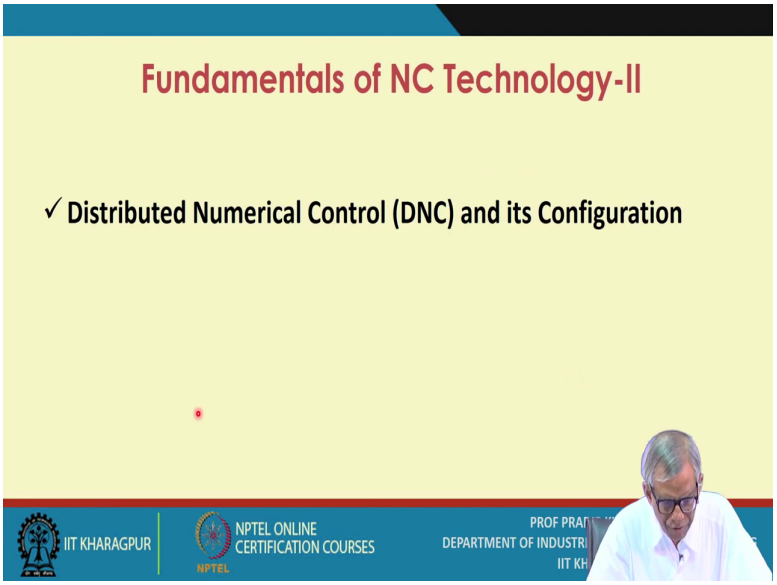

Now, let us discuss about the distributed numerical control or DNC and its configuration.

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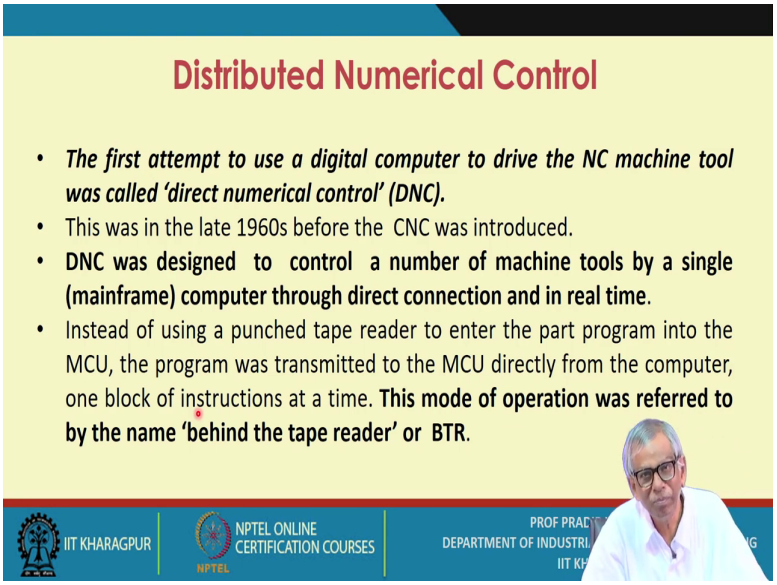

When the NC technology is introduced in 50s, it is referred to as NC. The NC move to DNC, but those days the DNC means direct numerical control, whereas, this DNC means distributed numerical control and before you reach the DNC, you must first reach the CNC level.

So, first you develop your CNC system with respect to a particular machine tool. Suppose you have a manufacturing shop or the manufacturing systems and in the manufacturing system, there are some 20 or 25 machine tools, and for each machine tool, the NC technology can be used, it is not the conventional processor. It is a NC numerical control-based process.

First you develop CNC and then you try to include CNC only for one machine tool and subsequently, you try to include all other machine tools in the same system and link it with the same computer. You will have just one main computer and then, this one main computer is linked to not only one machine tool, but also with several machine tools and at each machine tool, there could be the computer system also.

You have a primary computer; you may have a secondary computer. The entire network you create and this system is called as distributed numerical control. You have written different part programs for hundreds and thousands of parts for getting produced by these *n* number of machine tools.

All these part programs are stored in the main computer and there could be always uploading of the data and also the downloading of the data that means, there is always the two-way interactions, the interface two-way interface you have.

The first attempt to use a digital computer to drive the NC machine tool was called direct numerical control. This was in the late 60s before the CNC was introduced. DNC was designed to control a number of machine tools by a single mainframe computer through direct connection and in online real-time system.

Instead of using a punched tape reader to enter the part program into the MCU, that was the original system, the program was transmitted to the MCU directly from the computer, one block of instructions at a time and this mode of operation was referred to as behind the tape reader or BTR. You can bypass that the tape reader. So, you write down the program and the program are stored in the tape readers.

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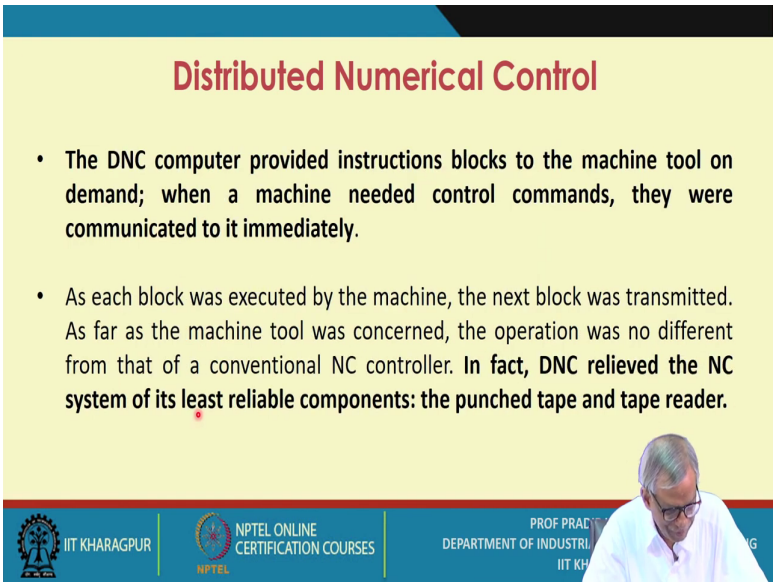

The DNC computer provided instruction blocks to the machine tool on demand where a machine needed control commands. They were communicated to it immediately.

The least reliable the component in the whole system that is called tape reader, unnecessarily it is making the whole system and unreliable one.

As each block was executed by the machine, the next block was transmitted one after another. As far as the machine tool was concerned, the operation was no different from that of a conventional NC controller.

you have the linked to each and every machine tool, but that MCU was not a computer, it was essentially the hardware system. The DNC relieved the NC system of its least reliable components, the punch tape and the tape reader.

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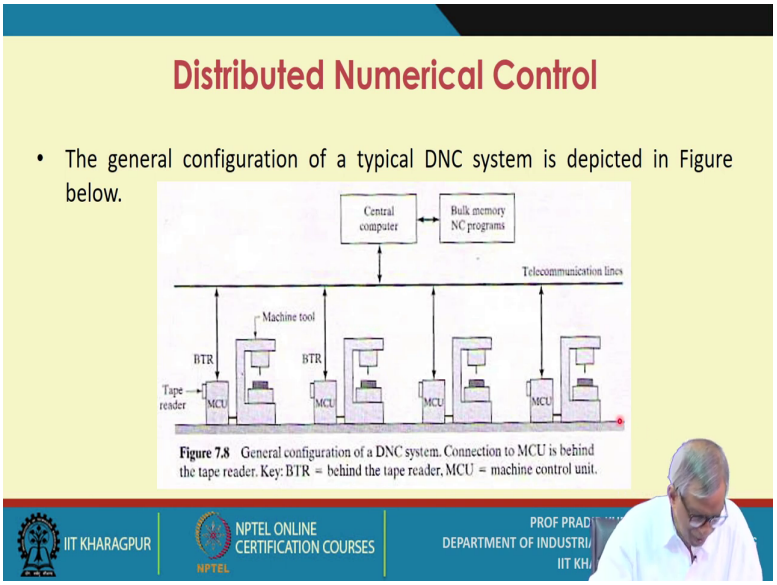

This is a typical DNC system. Look at this figure, what you find that you have the central computer, and you have the bulk memory and NC programs, all sorts of NC programs which we have written are to be transferred to the memory of the main computer.

This main computer is linked with individual MCU, individual MCU you create for each machine tool. How many machine tools you have? One, two, three, four and so on.

You have the MCU and you have the tape reader, you have a direct communication to the MCU bypassing the tape reader, behind the tape reader, you can link it. This is link main computer with each and every machine tool. So, that was a system, that was a communication link and this is the general configuration of a DNC system, the connection to MCU is behind the tape reader.

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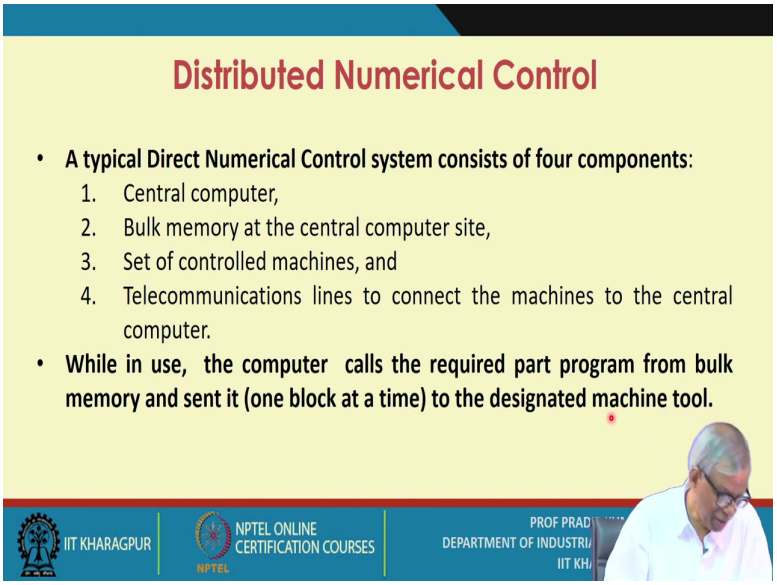

A typical direct numerical control system consists of four components: central computer, bulk memory at the central computer site, set of controlled machines, telecommunication lines to connect the machines to the central computer. While in use, the computer calls the required part program from bulk memory and send it one block at a time to the designated machine tool.

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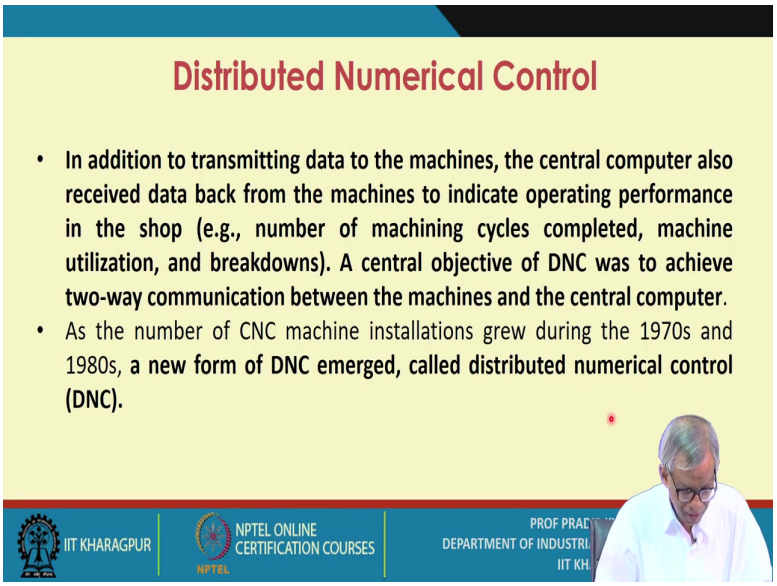

In addition to transmitting data to the machines, the central computer also received data back from the machine is a two-way interface. You send certain data to the machine tool and as the machine tool starts working, you need to performance mainly performance related data from the machine tool.

Setback from the machines, you are getting certain information to indicate operating performance in the shop that is the number of machining cycles completed or the number of parts you have produced. As of now at time $t = t$ the machine utilizations and breakdown- whether there is any occurrence of breakdowns or not.

All these events you constantly try to monitor in an online real-time control basis. Central objective of DNC was to achieve two-way communication between the machines and the central computer. As the number of CNC machine installations grew during the 1970s and 80s, a new form of DNC emerged, called the distributed numerical control.

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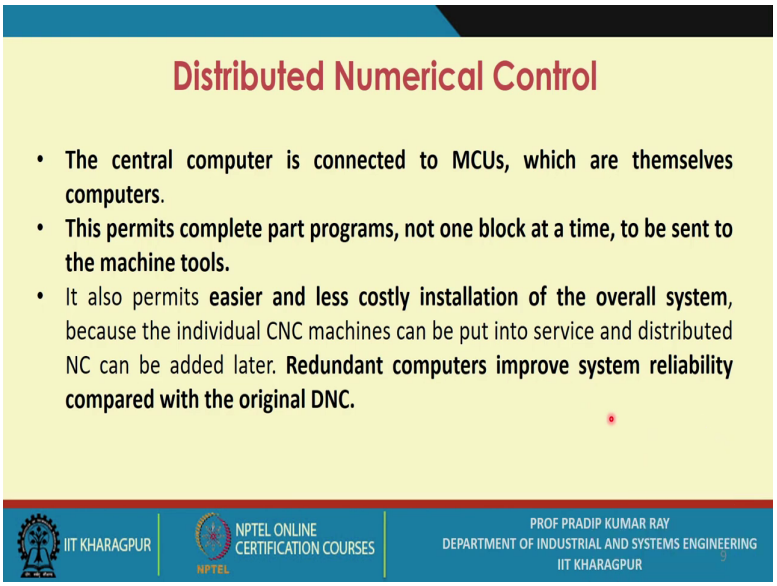

The central computer is connected to MCUs, which are themselves computers. You have one central computer, and this central computer is linked with individual machine tool-linked computers.

This permits complete part programs not one block at a time to be sent to the machine tools, it is not like sending this part programs in a sequence, the line by line or say the block by

block. The entire program you send it to the computer to the individual computer located at each the machine tool or individual machine tool.

It also permits easier and less costly installation of the overall system; because the individual CNC machines can be put into service and distributed NC can be added later. There is a configuration for DNC and two specific configurations you will come to know.

Redundant computers improve system reliability compared with the original DNC. Redundancy is very important concept while you try to improve the system reliability. There are many ways you can improve the system reliability-one such the method is to increase the level of this redundancy in the system.

Some extra the systems you add in the configuration depending on the kinds of systems you are handling. You can allow low-level the redundancy or high-level redundancy.

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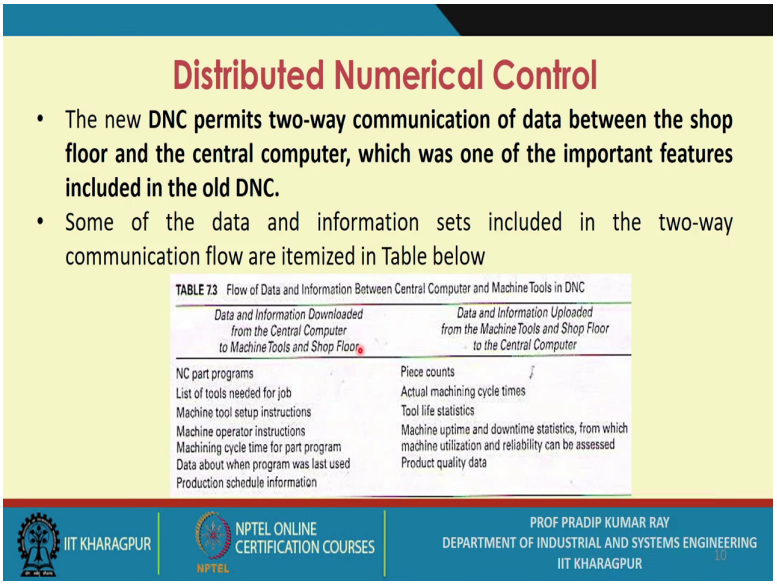

For the DNC systems, you have to check whether the redundancy is required or not, and in many cases, when you deal with large number of the machine tools, you want to make it as reliable is possible, the DNC system distributed numerical control.

The new DNC permits two-way communication, two-way interface of data between the shop floor and the central computer which was one of the important features included in the old

DNC. Some of the data and information sets included in the two-way communication flow are itemized in the table below.

Data and information downloaded from the simple computer. You are at the machine tool level, you are the machine tool operator. Your machine tool is linked with the main computer and you are also aware that related to the parts, you are going to produce the corresponding part program.

Once a part program is to be downloaded from the main computer and these part programs for all these parts which we are going to produce. These are already stored in the main computer; you have to download many kinds of the data and information from the main computer, or the central computer in machine tools and the shop floor.

When I say the machine tools and the shop floor, there are certain activities which are the direct one that is related to the machining the parts or manufacturing parts, directly those operations, but there is auxiliary activities also or indirect activities that also are to be carried out.

Those are sometimes related to the shop floor activities, like related to the material handling, related to use of the coolants or the removal of the chips or many kinds of wastes, first information you need to download that is a NC part program for the given part. List of tools needed for job, cutting tools, mostly. This information is already stored in the main computer. So, why do not you download it?

The machine tool set up is a very important activity before you produce one particular part in certain numbers or in a particular batch size or the large size say 50 or 5000, you must know that how many the setups you require and you have to carry out this activity- setting up of the machines in a particular way.

Machine tools setup instructions are mainly related to the speed, feed, depth of cut or say the kinds of material you handle, raw materials related to certain information and how many the parts or how many units you are going to produce.

How to run the machine all these details information you will be given. Machining cycle time for part program means to produce one unit of the part, how much cycle time you require as per the part program.

Data about when program was last used. May be the same part you produced in last week. This information must be given to you in this week also, you are going to produce the same part. The number of units may be different, but the same part, that information is given to you.

The production schedule information, it is like say immediately after you produce this part 1, whether in certain quantity or the units, whether you are going to produce the same part in the next schedule or say in the next shift or the next hour, those details should be mentioned in fact.

We get this information. NC part program, list of tools needed for job, machine tool setup instruction, machine operator instructions, machining cycle time for part program. You will get an idea that yes, if the cycle time is known, how many the units you can produce per hour, in the next one hour or the next two hours, then data about when program was last used.

The production schedule information, when you say that may be in the previous month, I have produced the same part, immediately you will be remembering that what was your performance; whether there were some problems while you process this work part and all lot or not. Those detailed information you will be referring to whether the kinds of problems the maintenance related problems you might have faced. All these details you can refer to.

The data and information uploaded simultaneously from the machine tools on the shop floor to the central computer and soon as you start working with the machine tool, the data are getting generated and many types of data you generate, those definitely you can store in your computers, directly link with your machine tool, but simultaneously, certain information and data you send to the main computer or the central computer.

The first one is the piece rates that means, how many the units at this point in time $t = t$ you have produced, that information you have to update. Actual machining cycle times. When you get this information, that information you have downloaded that is for the given part, this

is the expected cycle time, they expect the actual cycle time will be different from the expected or the estimated cycle time.

This data you feed to the main computer so that in the subsequent cycle or in the subsequent production run, you will be getting the updated cycle time for the same part.

Tool life statistics, tool life statistics VT^n = constant. This is the tool life, T, whether you have this information or not.

Normally, based on the tool life, you optimize the manufacturing process. The tool life statistics, machine uptime and downtime statistics from which machine utilizations and reliability can be assessed, and the last one is the product quality data; that means how many units are really acceptable to you.

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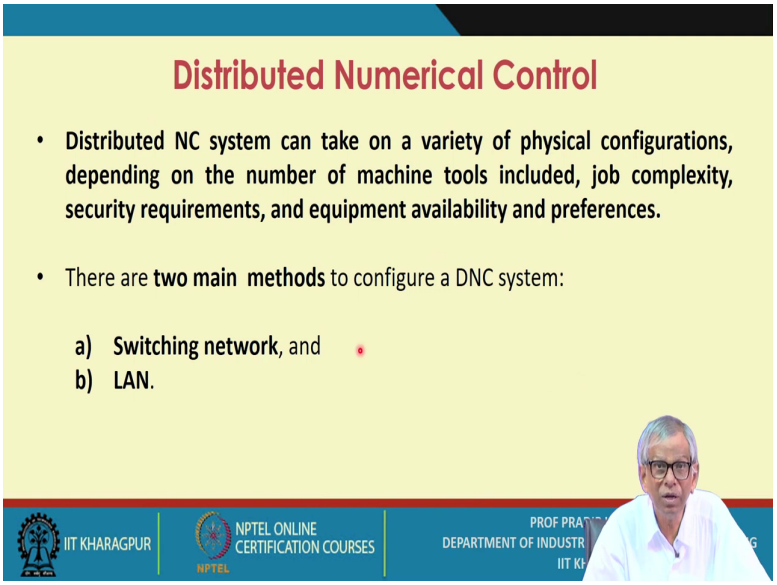

Distributed NC systems can take on a variety of physical configuration, depending on the number of machine tools included, job complexity, security requirements and equipment availability and preferences. You can use several kinds of configuration network. There are two main methods to configure a DNC system.

First one is the switching network or alternatively you can opt for the LAN network.

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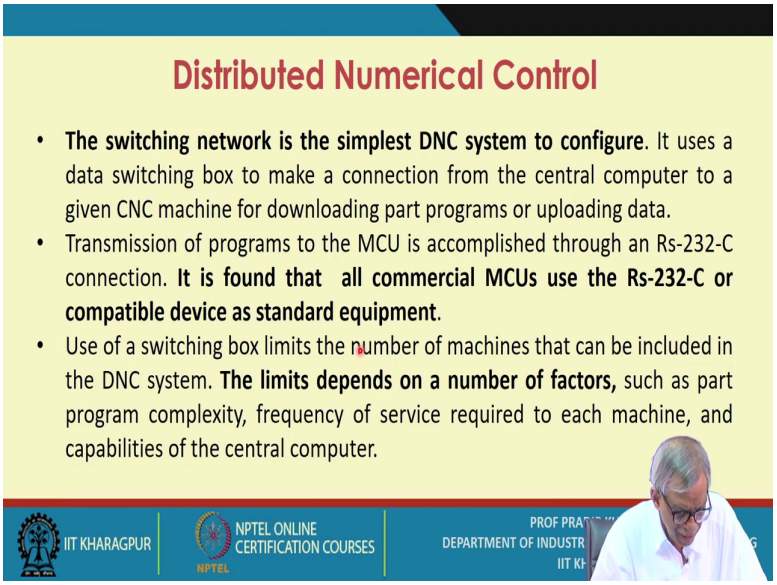

The switching network is the simplest DNC system. Transmission of programs to the MCUs is accomplished through an Rs-232-C the connection. It is found that all commercial MCUs use the Rs-232-C type compatible device as the standard equipment.

Use of a switching box limits a number of machines that can be included, that is the main limitation of switching box. These limits depend on the number of factors such as part program complexity, frequency of services required to each machine and capabilities of the central computer.

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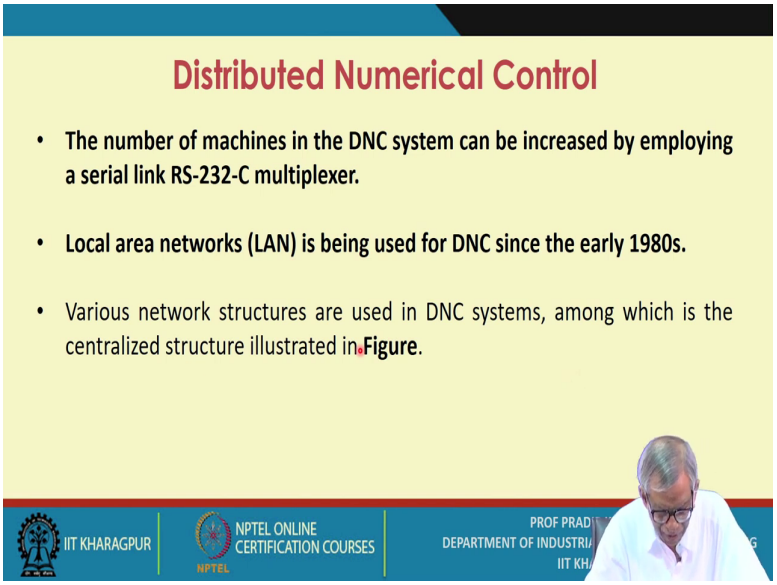

The number of the machines in the DNC systems can be increased by employing a serial link multiplexer. The local area network has an alternative to the switching box, switching network you also can use.

Various network structures are used in DNC systems among which the is the centralized structure illustrated in figure.

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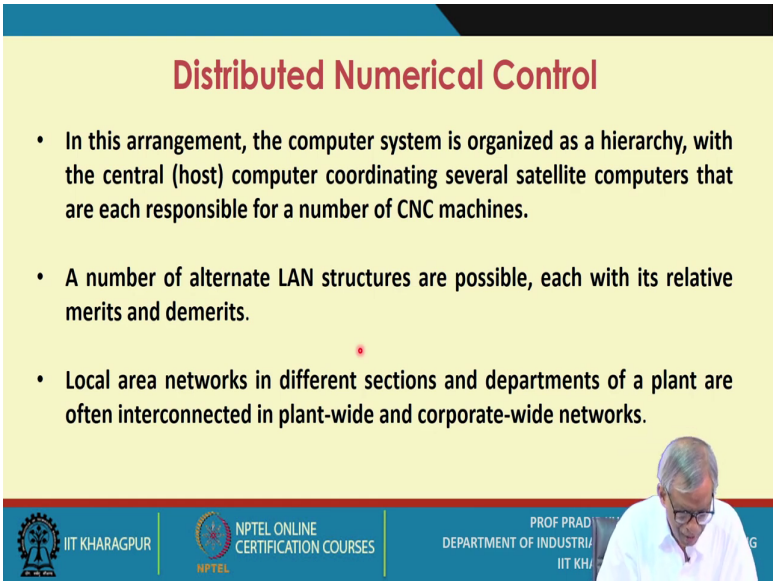

In this arrangement, the computer system is organized as a hierarchy, with a central host computer coordinating several satellite computers you have, you have the factories in multiple locations.

With the satellite computers, in the multiple the countries, you may have several DNC systems and all these DNC systems can again be the network under the LAN. Number of alternate LAN structures are possible each with its related merits and demerits.

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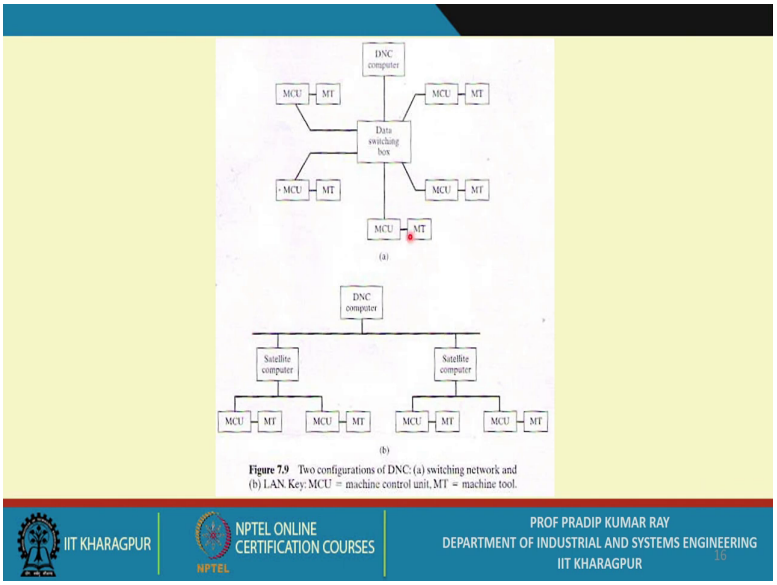

Figure 7.9 Two configurations of DNC: (a) switching network and (b) LAN. Key: MCU = machine control unit, MT = machine tool.

So, this is the network. This one is the switching network. You have the data switching box and the main computer is linked with the data switching box and the individual MCU, an individual machine tools or the processing equipment is linked with the main the switching box.

At certain point in time, one switching box can handle some around 200 machine tool simultaneously, but there is a limit.

You have the main computer and it is linked with many satellite computers and then each satellite computer is linked with a large number of machine tools and against each machine tool, there is an MCU.

Those are the individual computers linked with individual machine tools. A large number of machine tools you can link with a satellite computer and satellite computer is linked with the DNC main computer. For each location, you may have one satellite computer.

These days you will find that majority of the companies are having the factories with multiple locations, multiple countries and you have to adopt the LAN network, but initially you started with the switching matrix network .

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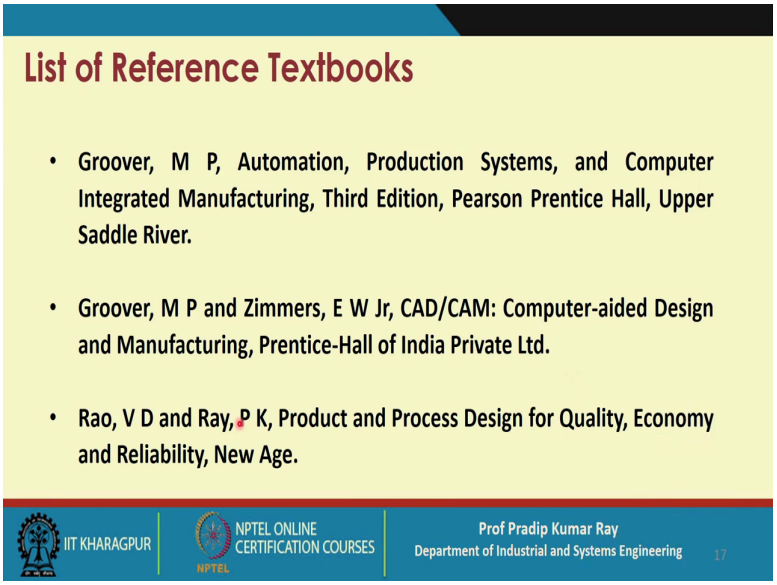

So, with this, I have introduced the concepts of DNC, the features of DNC, why DNC is to be used, what are the different types of the configuration of DNC.

In the subsequently lecture classes I am going to discuss the NC part programming part as well as I will be discussing the interpolation and how it is linked with the part programming quality.