Automation in Production Systems and Management
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Fundamentals of NC Technology - I
Lecture - 18
NC Coordinate System, NC Motion Control System

We are discussing Fundamentals of NC Technology.

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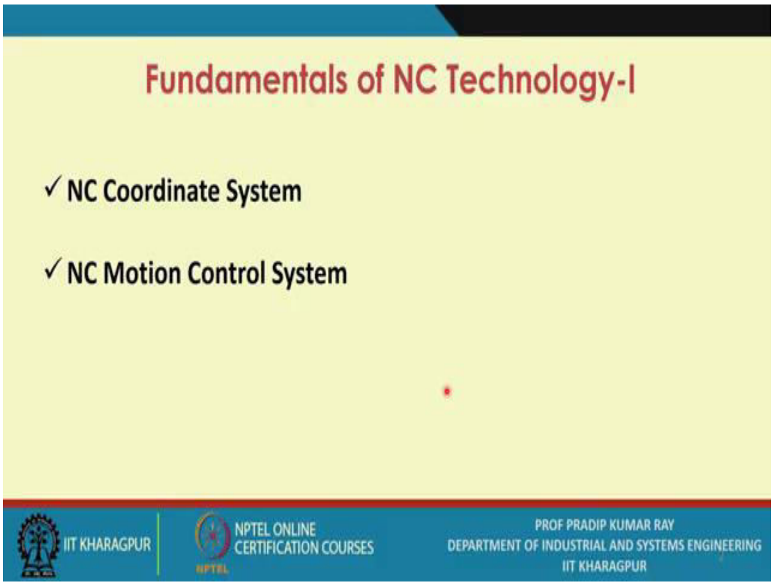

What are the basic components? One such basic component is the program of instruction. In other words, you have to write down the program for the given part.

Here you write down the part program. You should be aware of two important aspects in NC system. One is the NC coordinate system and second one is the NC motion control systems; you have to carry out the operations in a specific manner depending on the type of the operations you carry out.

As you may be knowing there will be work-head and there will be work part. The relative position of the work-head with respect to the work part must be known. For that, there are two types of parts- one is the flat part and alternatively you have the rotational part.

Depending on the shape of the work part as well as the location of spindle, you have to define the coordinate system. There will be sequence of operations, this coordination, this is the starting point and the ending point that must be specified in the part program.

We are going to discuss in the next in the half an hour the NC coordinate system and then NC motion control system.

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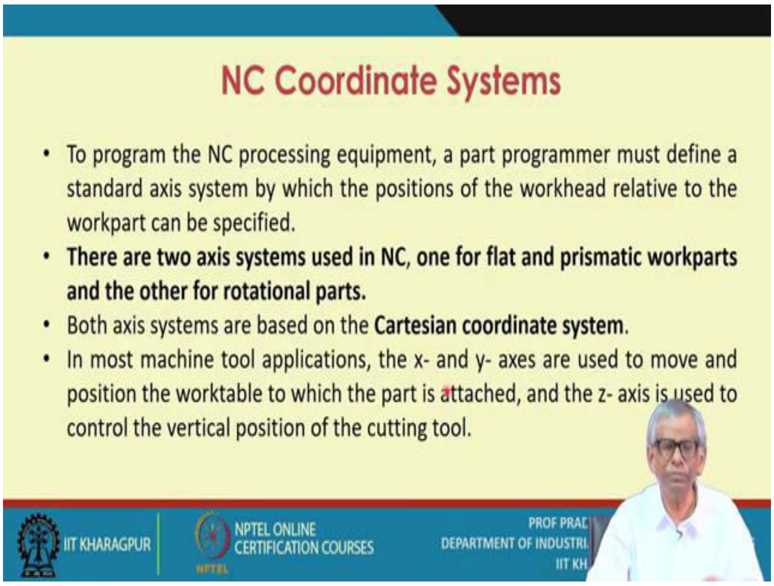

NC motion coordinate system is used for writing down the program for the part. So, you should have prior knowledge about the NC coordinate systems. To program the NC processing equipment, a part programmer must define a standard axis system. Cartesian coordinate systems, standard axis system by which the positions of the work-head relative to the work part can be specified. As soon as you try to define the positions or the location, certain coordinate systems you have to use.

There are two axis systems used in NC, one for flat or prismatic workparts and the other for rotational parts. Both axis systems are based on the Cartesian coordinate systems. In most machine tool applications, the x and y axes are used to move and position the work table in which the part is attached and you should be aware of the kind of the fixturing you should use.

The z axis is used to control the vertical positions of the cutting tool with respect to the position or the location of the work part .

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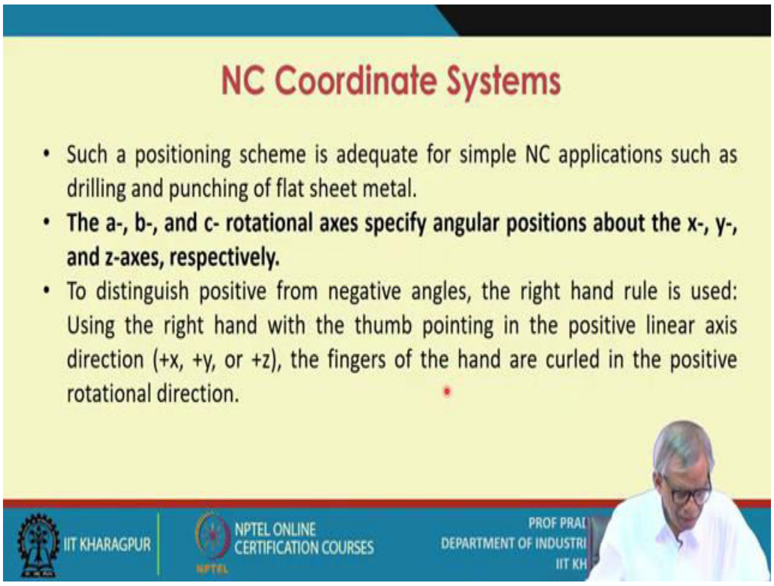

Such a positioning scheme is adequate for simple NC applications. like drilling and punching of flat sheet metal, sheet metal work is a very common in the work. When you go to the fabrication shop, there will be a sheet metal work of various types.

The a-, b- and c- rotational axes specify the angular positions about the x, y and z axis respectively. There could be rotation in the positive direction, there could be rotation in the negative detection. Those three rotational axes are specified as a, b and c.

This rotational axis you have to define against x axis or y axis or z axis. Then the direction of the rotation you have to specify and for that the right-hand rule you have to use. To distinguish positive from the negative angles, the right-hand rule is used. Using the right-hand with the thumb pointing in the positive linear axis, there will be a zero point and on one side there will be positive x axis and on the other side it will be negative x axis. Similarly, for the y axis and the z axis.

Against a particular axis, you point the thumb towards the positive direction along x or along y or along z. Then remaining four fingers of your hand are curled in the positive rotational direction. If it is curled within the inside, then it is a positive direction otherwise it will be a negative direction.

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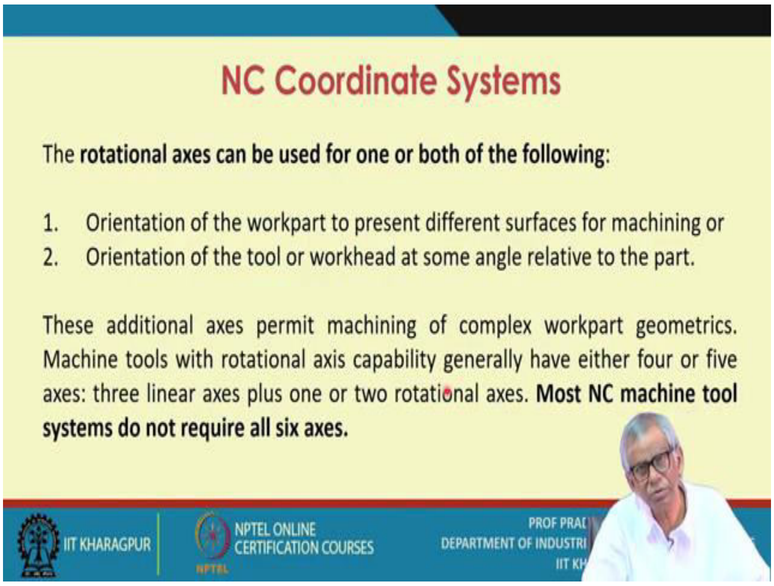

Normally this coordinate system altogether you have the six axis, x, y, z and a, b, c. Now why all these six axes required? Because NC machine tool is suitable for producing very intricate shapes and sizes. The entire process sometimes referred to as contouring.

The rotational axis can be used for one or both of the following a, b and c. The orientation of the work part to present different surfaces for machining. It may not be necessarily in the horizontal direction, maybe at an angle from the horizontal direction, or from the vertical direction.

First is the orientation of the work part to present different surfaces for machining and the second one is the rotational axis are needed to define the orientation of the tool or the workhead at some angle related to the part. These are to be defined in explicit terms when you write down the part program.

These additional axes permit machining of a very complex work part and complex work part geometrics. Machine tools with rotational axis capability generally have either four or five axes. There are very common four axes machine or five axes machines when you refer to the application of NC technology.

Three linear axes are common plus one or two rotational axes. Most NC machine tools do not require all six axes. If you want to have very intricate shapes then only you opt for six axes machine.

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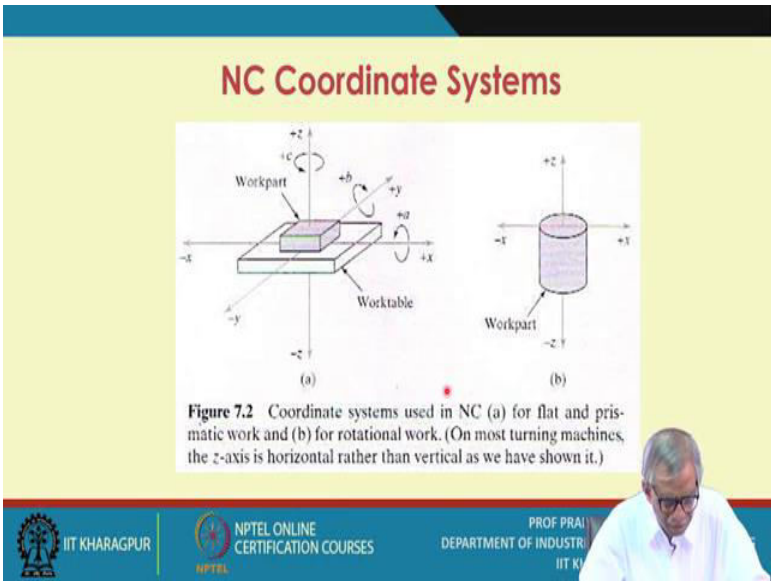

If you look at this particular figure, your understanding will be more perfect. When you use this three axes machine x, y and z, you find that there is work table on the machine tool and on the work table you place the work part in a particular location.

You need fixture to hold these objects, or the work part on the machine tool. There are different kinds of fixtures you use depending on the shape and size of the component, or work part shape and size of the object or the work part.

The center is somewhere here at the midpoint and you have the positive x axis positive direction, negative direction. Similarly, this is the z axis and y axis. Normally the z axis defines the path of movement of your cutting tool. The x direction in x axis follows the radial direction. x y plane you have to define and then you define the z axis representing so the movement of the cutter or the cutting tool.

For rotational work like turning operations the z axis is horizontal, rather than vertical. x means the direction of the cutter towards the center; it is moving along a path of the radial radius of the rotational part or the rotational component.

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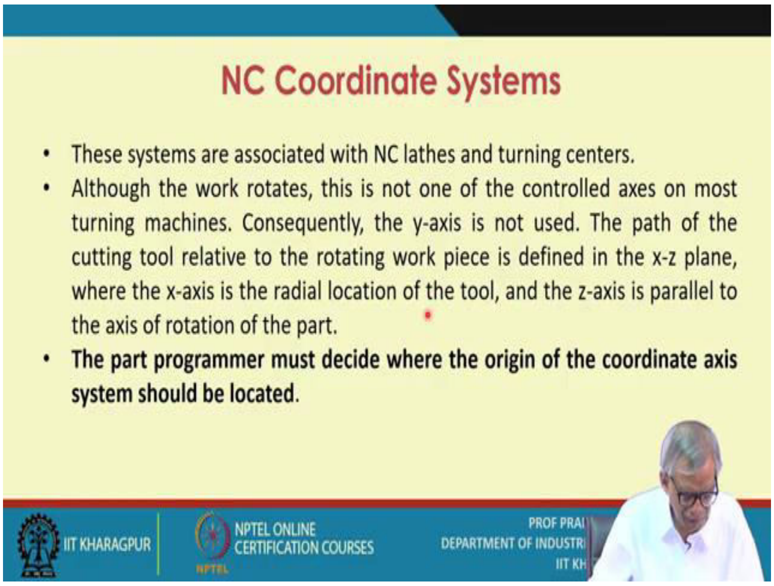

These systems are associated with NC lathes and turning centers. Although the work rotates, this is not one of the controlled axes on most turning machines, consequently the y axis is not used. So, only the x axis and the z axis you require for the rotational part.

The path of the cutting tool relative to the rotating work piece is defined in the x y z plane.

For the prismatic part, all the six axes you have to use whereas, for the rotational part only two axes x and z we have to use. The part programmer must decide where the origin of the coordinate axis system should be located.

Basically, it is at the corner of the work table normally and they specify this one. Once this location is known then only you start writing down your part programme. For different operations you need to know that the starting point and the end point. So, there must be some reference point.

There could be rotational axis that also you need to consider. Orientation of the part with respect to the three types of planes that also you must be able to define.

For any operation, the path is to be defined plus the starting point as well as the end point. The coordinate axis has to be mentioned and the location of the starting point.

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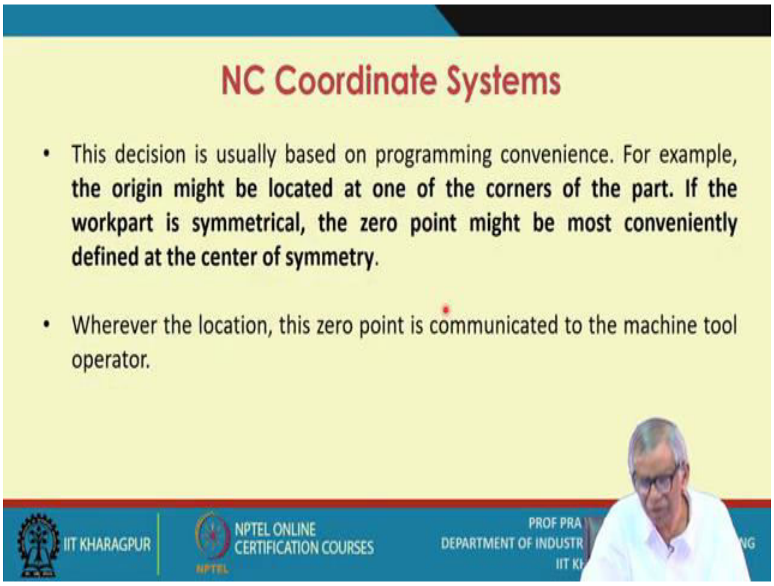

The decision is usually based on programming convenience.

For example, the origin might be located at one of the corners of the part, one of the corners of the part this is possible if the work part is symmetrical; the zero point might be most conveniently defined at the center of symmetry. If you refer to the figure, you will find that for a symmetrical part the zero point location must be at the center of symmetry Otherwise, you consider the zero point at the corner of the table, at the corner of work part.

So, wherever the location of zero point is communicated to the machine tool operator. (Refer Time: 21:16)

There could be four types of part programming methods.

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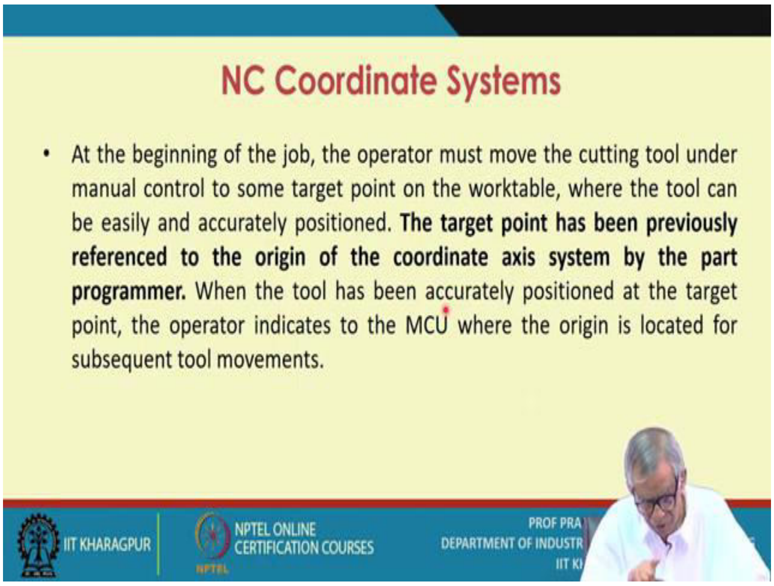

At the beginning of the job the operator must move the cutting tool under manual control to some target point on the work table where the tool can be easily and accurately positioned, means at the corner point, the table is located and you marked the zero point over there.

The target point has been previously referencing to the origin of the coordinate axis system by the part programmer. When the tool has been accurately positioned at the target point, the operator indicates to the MCU where the origin is located for subsequent tool movements. The tool path is to be defined properly.

Sometimes depending on the type of operations you have to define the tool path, sometimes you do not need to define the tool path. Whatever may be the path, your first objective is that at a particular location the tool should be engaged. Once this engagement or the operation is over then you move to the next location, but you do not need to follow a particular path.

On a particular plate you try to drill holes at different locations, drilling operations. So, you do not need to define the path you can follow, but you need to define the location of each and every hole for which the drilling you have to do.

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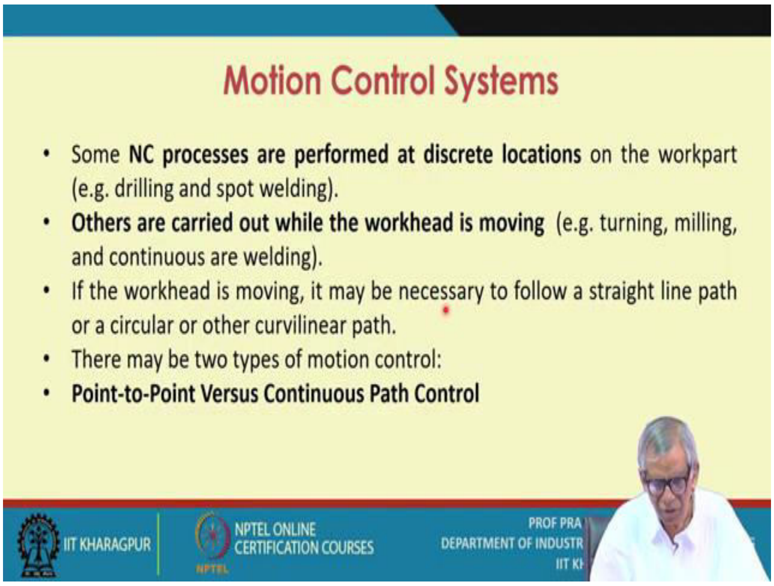

Now, let us talk about the NC motion control system. Because there has to be a tool path to be defined and the depending on type of operations you carry out, you need to define the motion control system.

Since NC processes are performed at discrete locations on the work part. For example, drilling and spot welding. One kind of motion control systems you have to define, but if suppose the workhead is to be moved on a particular path, different motion control systems you have to adopt you have to follow.

Suppose for drilling and spot welding, the location is to be defined and you do not need to control the movement of cutting tool on a particular path or a fixed path.

Whereas, if suppose the operation is turning, milling and continuous arc welding, you have to define the tool path and you have to move the cutting tool on the path already defined. If the workhead is moving, it may be necessary to follow a straight line path or a circular or other curvilinear path.

There may be two types of motion control- point-to-point versus continuous path control; For spot welding or drilling point-to-point whereas, for the milling operation you have to have continuous path control.

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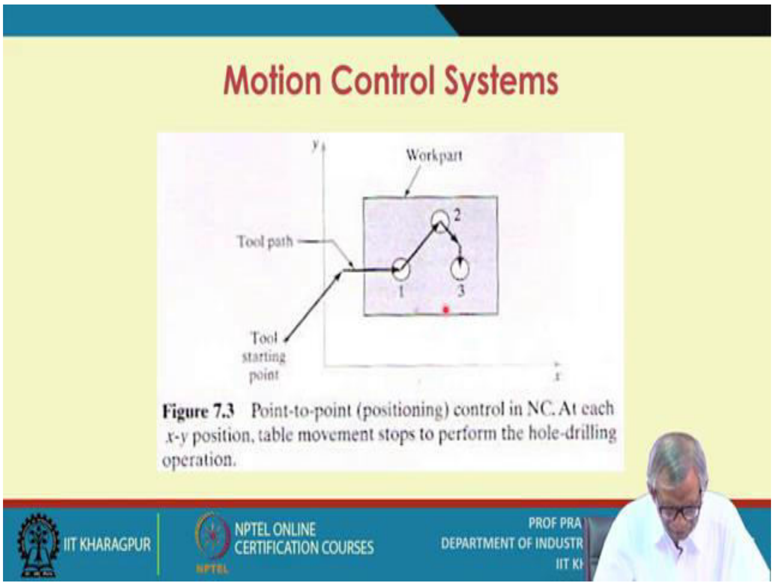

This is one example. This is a point-to-point in this figure. It is a motion control system, but it is point-to-point.

First is the tool path, it is the tool starting point from anywhere you start and ultimately you reach the first point, then you complete the drilling operations over there. Next you go to the next point. There also you do the drilling and then you move to third point, the location is specified. And the operation is carried out.

In NC at each x-y position table movement stops to perform the hole drilling operation.

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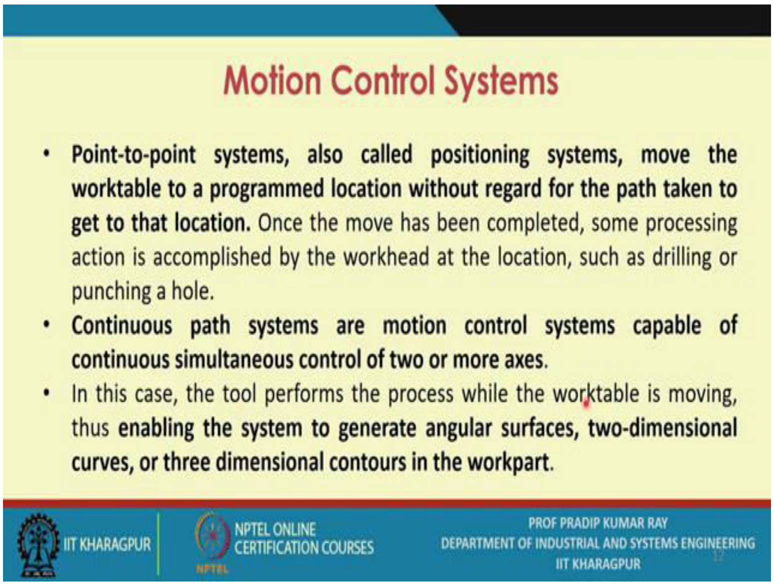

Mostly the work table you have to move to a programmed location with regard to the path taken to get that location.

The continuous path systems or motion control systems are capable of continuous simultaneous control of two or more axes. In this case the tool performs the process while the work table is moving, thus enabling the system to generate angular surfaces, two-dimensional curves, or three dimensional contours in the work plane

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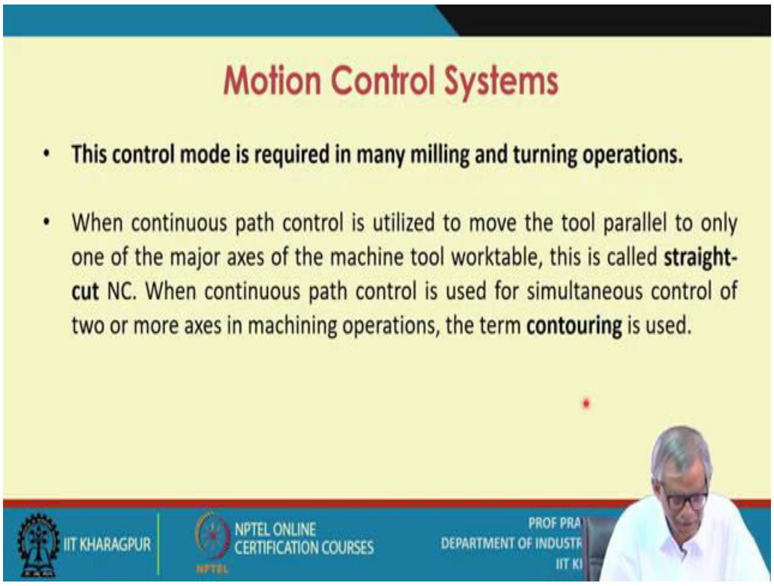

This control mode is required in many milling and turning operations.

When the continuous path control is utilized to move the tool parallel to one of the major axes of the machine tool work table, this is called straight-cut NC. When the continuous path control is used for simultaneous control of two or more axes in machining operations; the term contouring is used.

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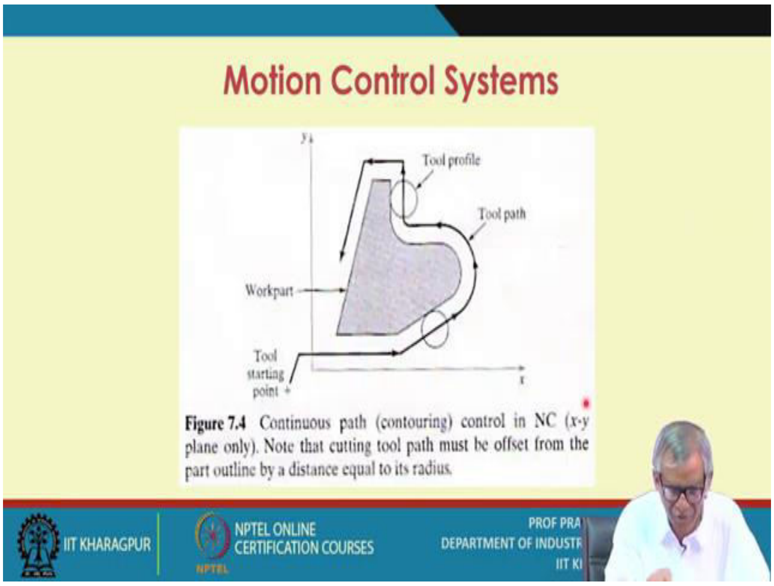

This is just one example of continuous path control. The cutting tool path must be offset from the part outlined by a distance equal to its radius.

The tool and the work part is also given; and tool starting point you have to define.

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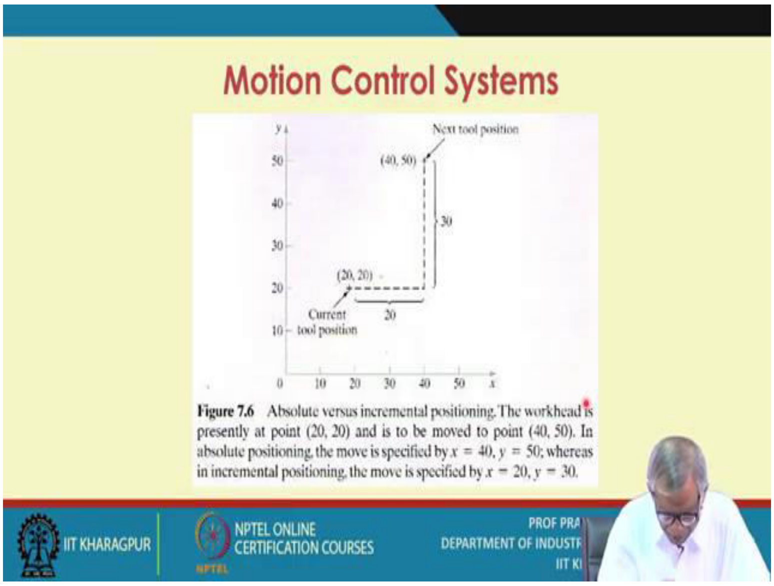

This is motion control system, but this is absolute versus incremental positioning. Either you can use absolute or you can use the incremental positioning.

Absolute positioning could be 20-20 and 40-50, whereas, relative position could be 20-30. With respect to the previous point, you have to define the location of the current point or position of the current point. that is why it is called the incremental positioning.

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