Automation in Production Systems and Management
Prof. Pradip Kumar Ray
Vinod Gupta School of Management
Department of Industrial and Systems Engineering
Indian Institute of Technology, Kharagpur

Automated CAPP (Part-I)
Lecture - 52
Basic Steps in Process Plan Development

During this lecture session, I will be now discussing how do you create a process plan document. Once the functions are known, you have to prepare a process plan document.

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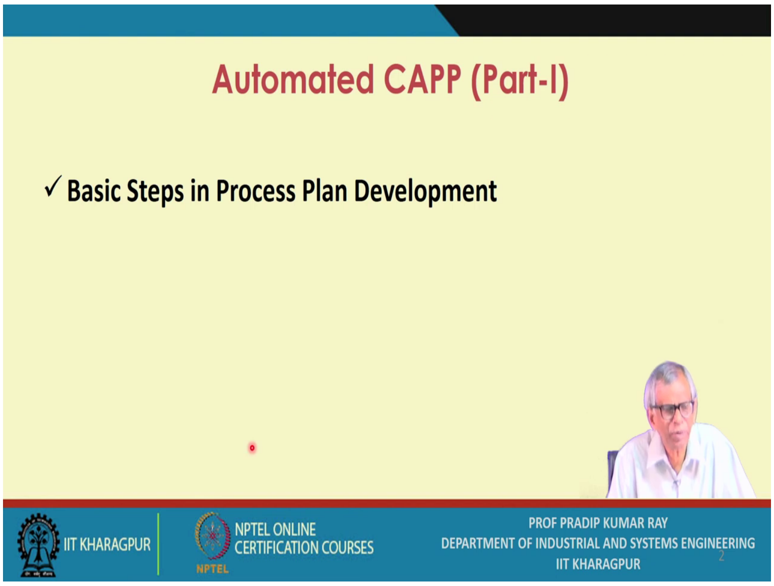

The topic I am going to discuss during this lecture session is the basic steps in process plan development.

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The development of process plans involves a number of activities.

First one is Analysis of part requirements. Second one is Selection of raw work piece. Third one is Determining manufacturing operations and their sequences. Fourth one is Selection of machine tools. Fifth one is Selection of tools, work holding devices, and inspection equipment. Sixth one is Determining machining conditions (cutting speed, feed and depth of cut) and manufacturing times (setup time, processing time, and lead time).

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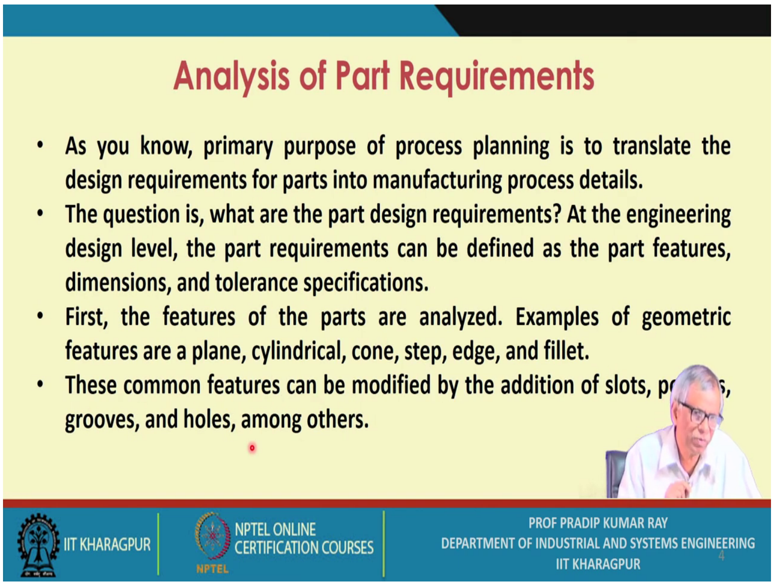

The primary purpose of process planning is to translate the design requirements for parts into manufacturing process details. The question is, what are the part design requirements? At the engineering design level, the part requirements can be defined as the part features, dimensions, and tolerance specifications. First, the features of the parts are analyzed. Examples of geometric features are a plane, cylindrical, cone, step, edge, and fillet. These common features can be modified by the addition of slots, pockets, grooves, and holes, among others.

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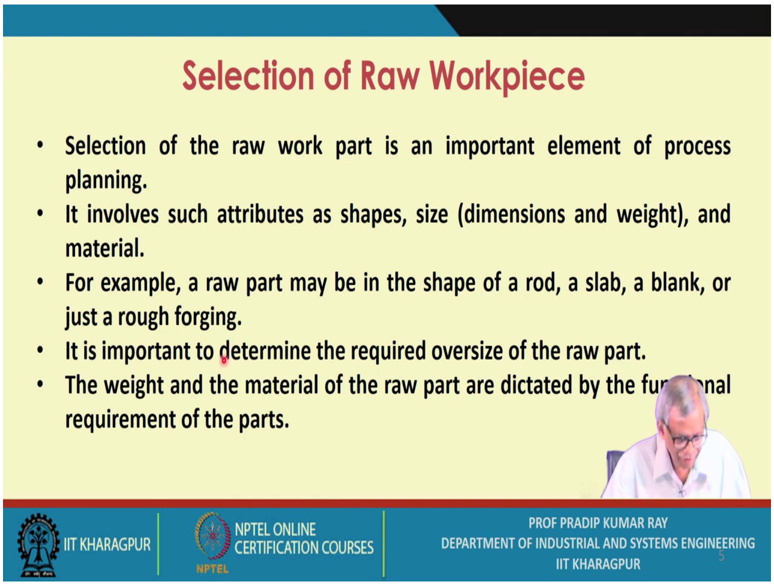

Selection of the raw work piece is an important element of process planning. It involves such attributes as shapes, size (dimensions and weight), and material. For example, a raw part may be in the shape of a rod, a slab, a blank, or just a rough forging. It is important to determine the required oversize of the raw part.

The weight and the material of the raw part are dictated by the functional requirement of the parts

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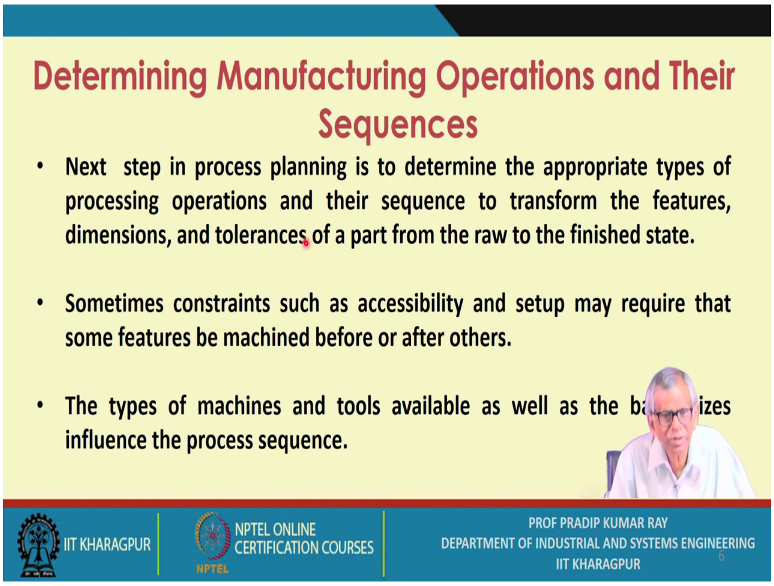

The next logical step in process planning is to determine the appropriate types of processing operations and their sequence to transform the features, dimensions, and tolerances of a part from the raw to the finished state.

Sometimes constraints such as accessibility and setup may require that some features be machined before or after others.

The types of machines and tools available as well as the batch sizes influence the process sequence.

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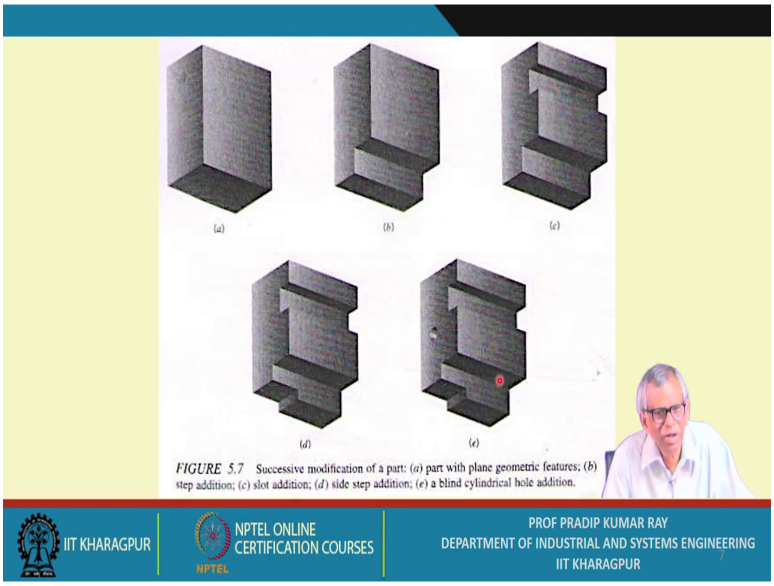

Now, this is an example from the textbook. (1) is part with the plane geometries; this one is actually the step and this is the slot and this is the additional step; that means, this is in the perfect raw form, then you start changing its shape.

So, this is basically one step, this is a slot, this is another the step and this one is a cylindrical hole and it is a blind hole. Initially the shape was like this, now the shape has been changed to this particular form. What is the basic raw materials, what are the operations to be carried out and for carrying out those operations which kind of the cutting tools you require, as well as the what kind of manufacturing of the processes you need, or the machine tools you need?

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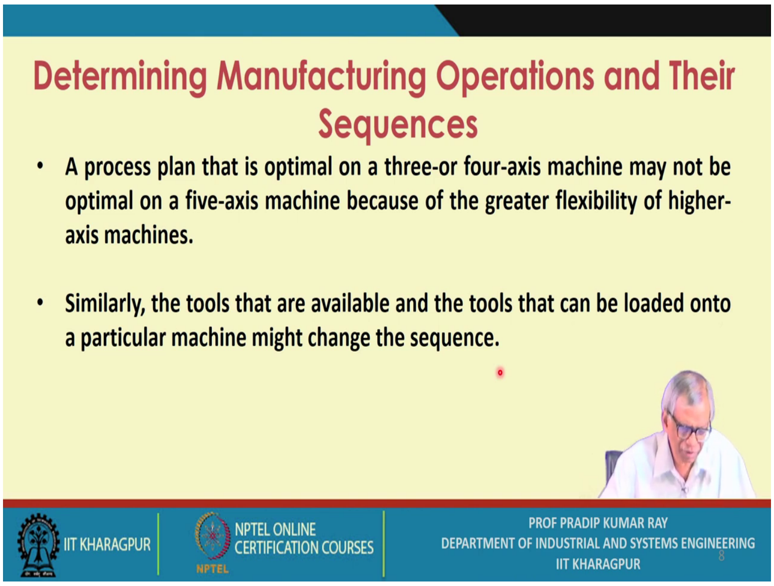

For example, a process plan that is optimal on a three-or four-axis machine may not be optimal on a five-axis machine because of the greater flexibility of higher-axis machines.

Similarly, the tools that are available and the tools that can be loaded onto a particular machine might change the sequence.

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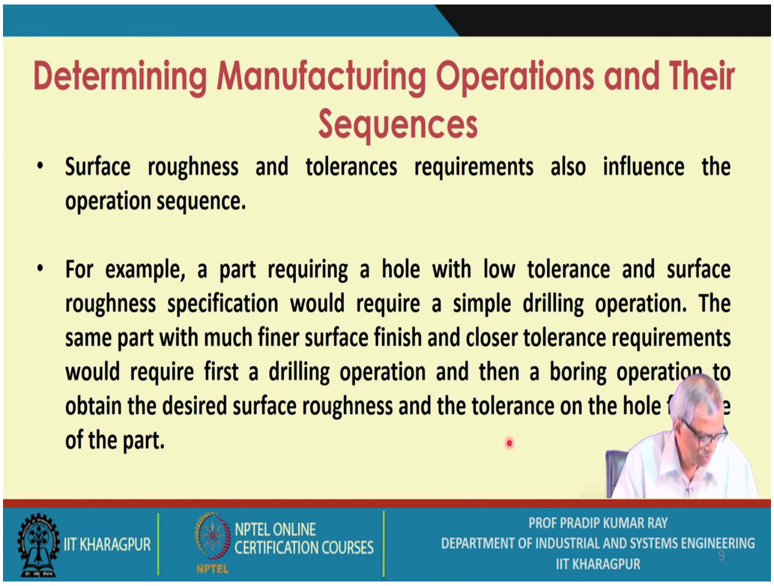

Surface roughness and tolerances requirements also influence the operation sequence.

For example, a part requiring a hole with low tolerance and surface roughness specification would require a simple drilling operation. The same part with much finer surface finish and closer tolerance requirements would require first a drilling operation and then a boring operation to obtain the desired surface roughness and the tolerance on the hole feature of the part.

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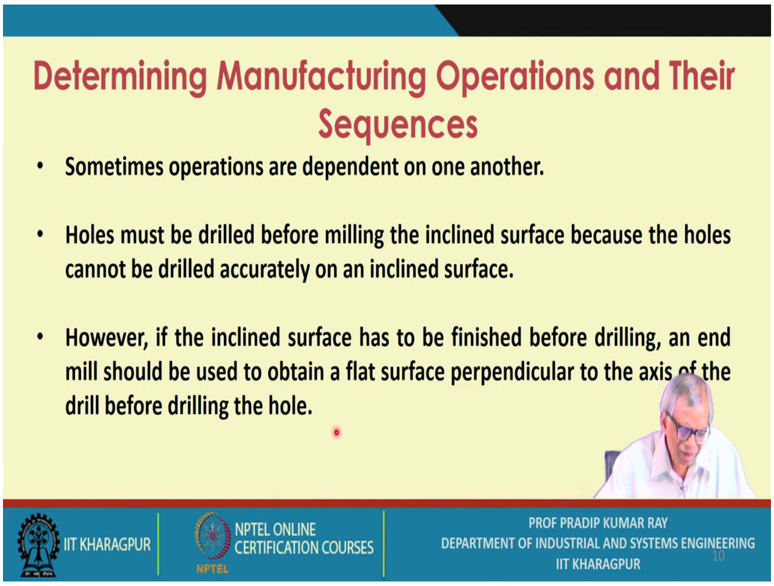

Sometimes operations are dependent on one another. I already have cited one example, milling versus the drilling, the holes must be drilled before milling the inclined surface, because the holes cannot be drilled accurately on an inclined surface.

It is very difficult to drill the hole, but then again you may not get the tolerance. The concentricity or the perpendicular may not be acceptable to you. However, if the inclined surface has to be finished before drilling, an end mill should be used to obtain a flat surface perpendicular to the axis of the drill before drilling the hole.

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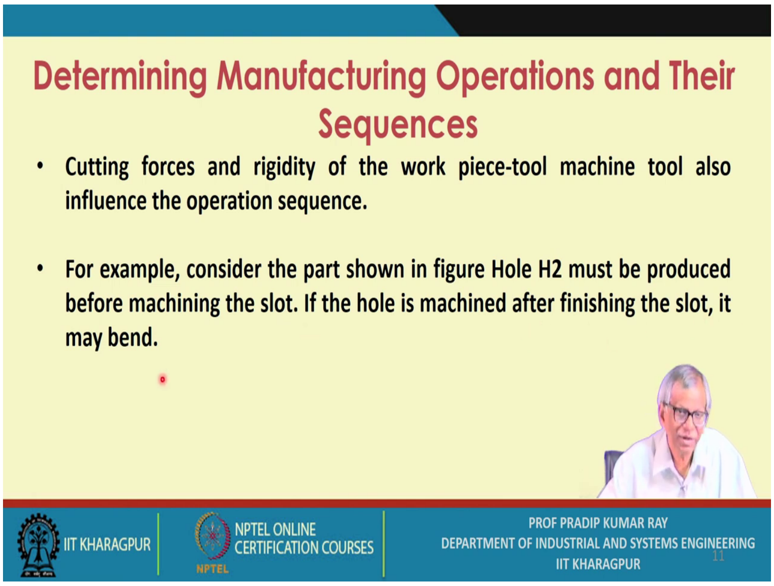

Cutting forces and rigidity of the work piece-tool machine tool also influence the operation sequence. For example, consider the part shown in figure Hole H2 must be produced before machining the slot. If the hole is machined after finishing the slot, it may bend.

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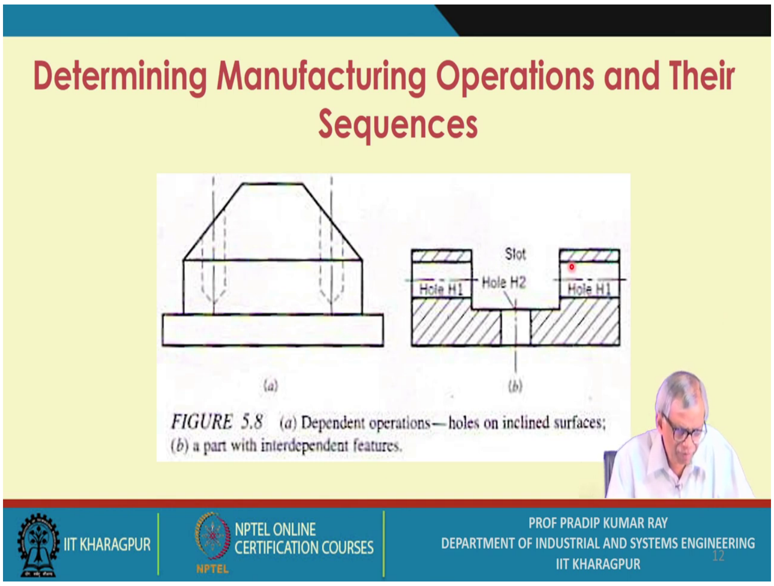

The second example is this is a slot to create. First you go for the drilling, and then you go for the milling operations.

What is the basis of proposing the sequence of operations for a given a process plan?

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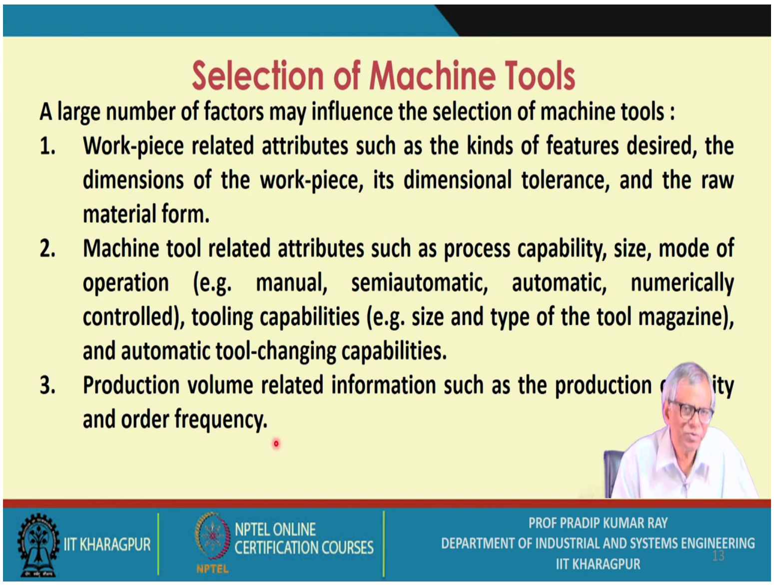

A large number of factors influence the selection of machine tools:

1. Work-piece related attributes such as the kinds of features desired, the dimensions of the work-piece, its dimensional tolerance, and the raw material form.

2. Machine tool related attributes such as process capability, size, mode of operation (e.g. manual, semiautomatic, automatic, numerically controlled), tooling capabilities (e.g. size and type of the tool magazine), and automatic tool-changing capabilities.

3. Production volume related information such as the production quantity and order frequency.

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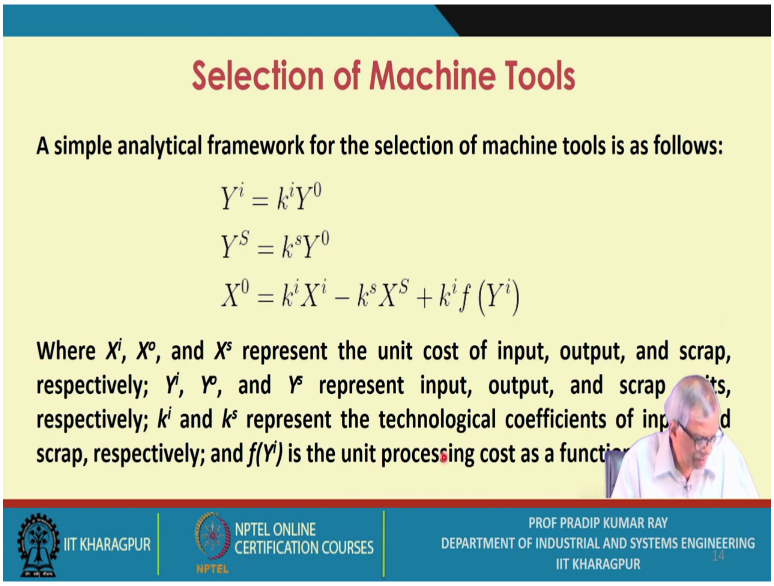

A simple analytical framework for the selection of machine tools as follows:

$$Y^i = k^i Y^0$$
$$Y^S = k^s Y^0$$
$$X^0 = k^i X^i - k^s X^S + k^i f\left(Y^i\right)$$

Where X^i, X^o, and X^s represent the unit cost of input, output, and scrap, respectively; Y^i, Y^o, and Y^s represent input, output, and scrap units, respectively; k^i and k^s represent the technological coefficients of input and scrap, respectively; and $f(Y^i)$ is the unit processing cost as a function of input.

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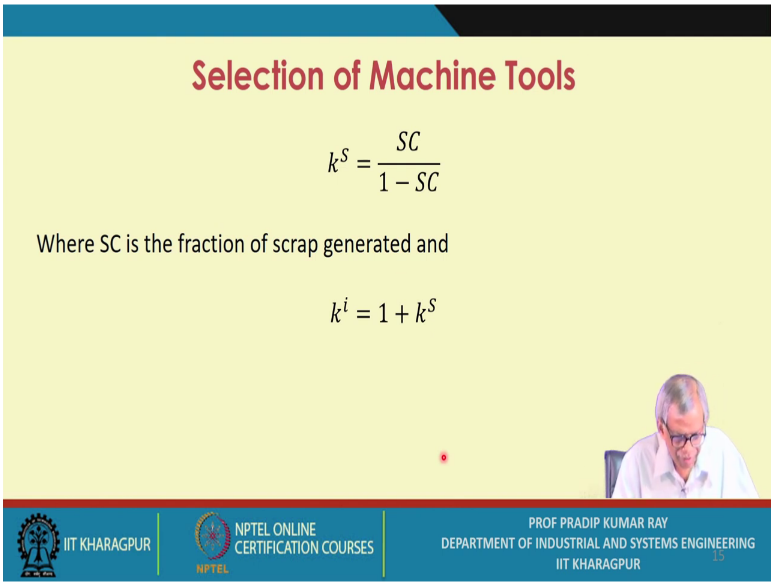

Because and you select that particular machine tool for which the amount of scrap is expected to be very less. So, and it has it must have sufficient capacity as well as the production rate.

$$k^S = \frac{SC}{1 - SC}$$

Where SC is the fraction of scrap generated and

$$k^i = 1 + k^S$$

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A combination of machine tool and cutting tool is required to generate the features of the workpiece. First you have selected the machine tool, now you have to select the cutting tool and the work holding devices. Work-holding devices are used to locate and hold the work-pieces to help generate the features. Inspection equipment is necessary to ensure the dimensional accuracy, tolerances, and surface finish on the features. The major categories include on-line and off-line inspection equipment.

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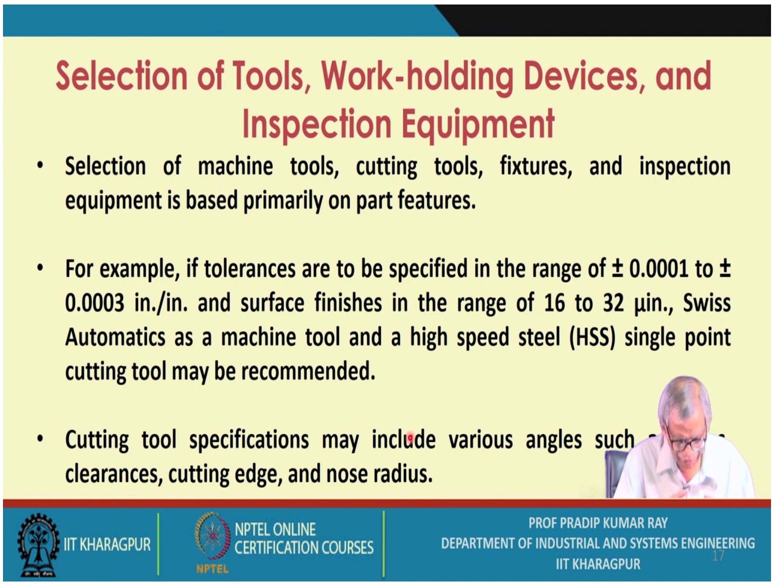

The selection of machine tools, cutting tools, fixtures, and inspection equipment is based primarily on part features.

For example, if tolerances are to be specified in the range of ± 0.0002 to ± 0.0005 in./in. and surface finishes in the range of 16 to 32 µin., Swiss Automatics as a machine tool and a high-speed steel (HSS) single point cutting tool may be recommended. Cutting tool specifications may include various angles such as rakes, clearances, cutting edge, and nose radius.

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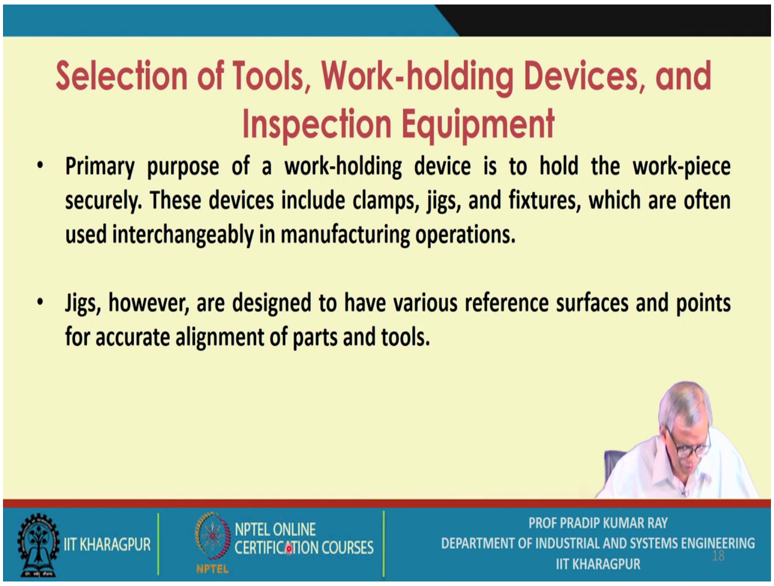

The primary purpose of a work-holding device is to hold the work-piece securely. These devices include clamps, jigs, and fixtures, which are often used interchangeably in manufacturing operations.

Jigs, however, are designed to have various reference surfaces and points for accurate alignment of parts and tools.

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These are the common examples. Manually operated devices like collets, chucks, mandrels, work holding devices, faceplates and various kinds of fixtures. Designed devices such as power chucks and flexible fixtures used in flexible manufacturing systems. The objective is to accommodate a range of part shapes and dimensions with the least need for changes and adjustment requiring operator interventions.

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The shapes, dimensions, accuracy production rate and variety of parts essentially determine the types of work-holding devices required. For example, a four-jaw chuck can accommodate prismatic parts, faceplates are used for clamping irregularly shaped workpiece, and collets are used to hold round bars only and only those within a certain range of diameters. The fixtures are, however, designed for specific shapes and dimensions of parts.

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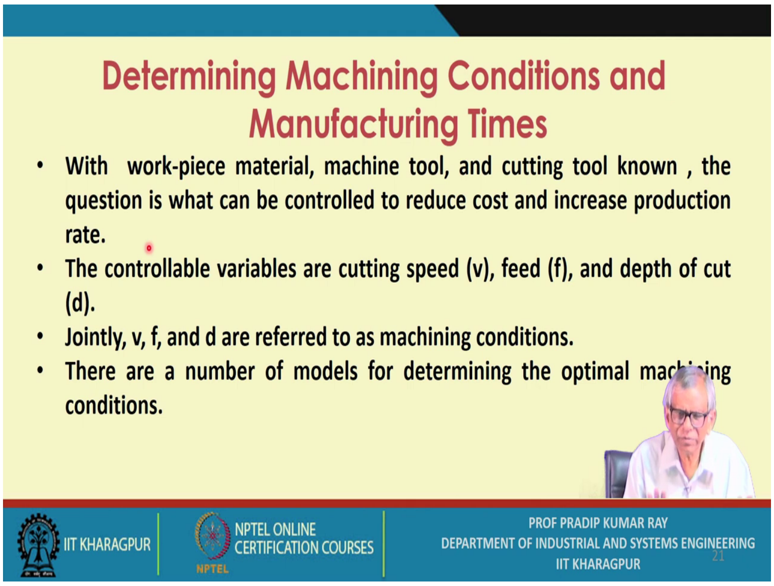

Having specified the work-piece material, machine tool, and cutting tool, the question is what can be controlled to reduce cost and increase production rate. The controllable variables are cutting speed (v), feed (f), and depth of cut (d). Jointly, v, f, and d are referred to as machining conditions. There are a number of models for determining the optimal machining conditions.

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