Automation in Production Systems and Management
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Fundamentals of NC Technology - I
Lecture - 20
Numerical Examples

During the last session of this week, I will be referring to various applications of NC technology. So, this will be our topic of discussion.

NC technology have two types of system-one is direct numerical control and initially you start with the NC system and then we move to the CNC, and there is also one system referred to as the direct numerical control

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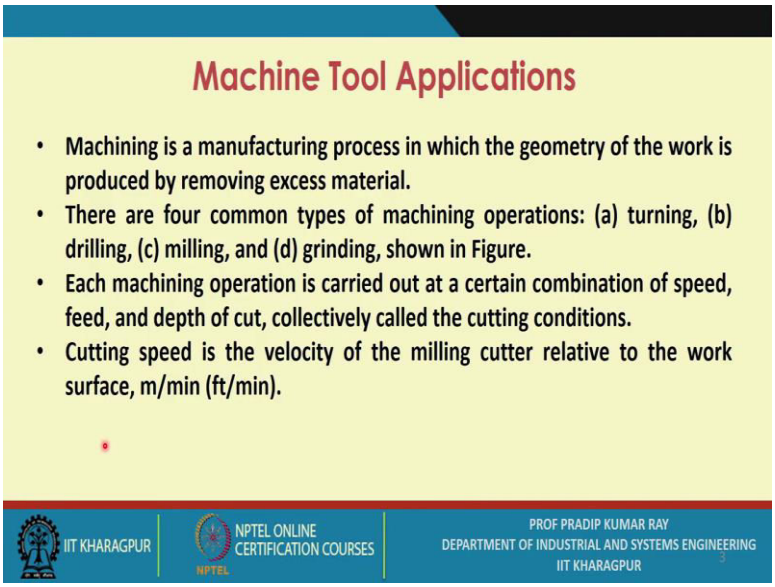

In machine tool applications, machining is a manufacturing process in which the geometry of the work is produced by removing excess material. There are four common types of machining operations. First one is the turning and its varieties, the second one is the drilling and its varieties, third one is milling and its varieties and the last one is the grinding and varieties; grinding is a finishing operation.

So, each machining operation is carried out at a certain combination of the speed, feed and depth of cut. These are basically the process parameters as far as machining is

concerned and they are sometimes referred to as the machining conditions or even cutting conditions.

The cutting speed is the velocity of the milling cutter relative to the work surface, m/min (ft/min).

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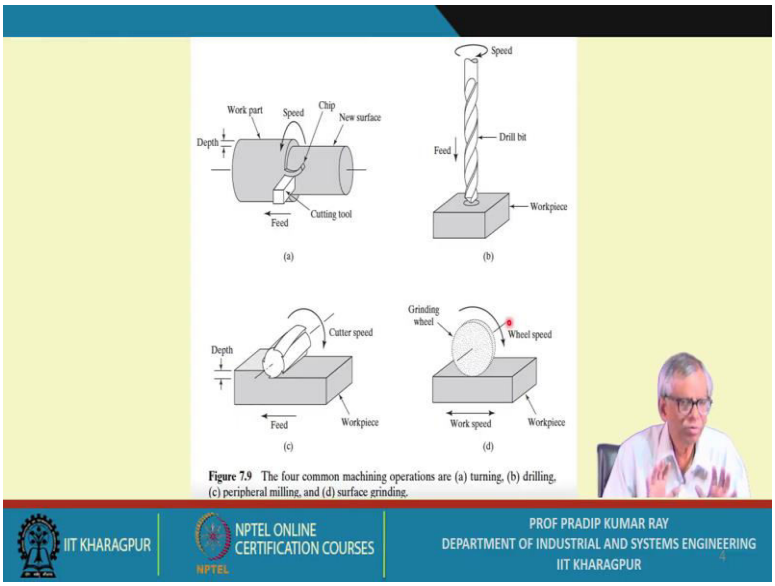

There is a measuring unit. So, this is basically the typical turning operation. This one is a drilling operation and these figures are there in your textbos. So, you just refer to this. This is a typical milling operation and this one is the surface grinding. So, look at these figures and you will get an idea about how a particular cutting tool is getting engaged

So, once these details are known you will come to know that what kind of raw material you use shape and size, the kinds of the cutting tool you need to use and there are reasons that how do you estimate or how do you identify the appropriate number of machining parameters.

So, once you look at these figures you will get an idea about what are those operations are to be carried out and what are the process parameters which are to be under control.

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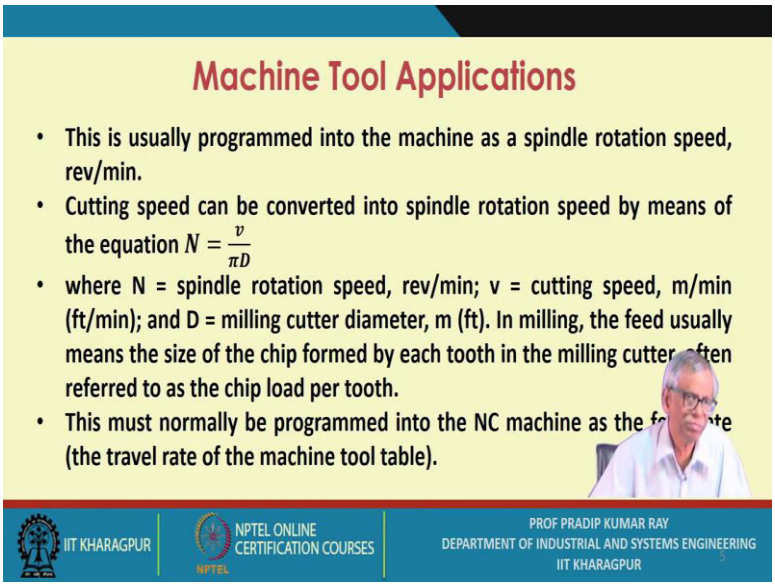

This is usually programmed into the machine as a spindle rotation speed, rev/min.

Cutting speed can be converted into spindle rotation speed by means of the equation

$$N = \frac{v}{\pi D}$$

where N = spindle rotation speed, rev/min; v = cutting speed, m/min (ft/min); and D = milling cutter diameter, m (ft). In milling, the feed usually means the size of the chip formed by each tooth in the milling cutter, often referred to as the chip load per tooth.

This must normally be programmed into the NC machine as the feed rate (the travel rate of the machine tool table).

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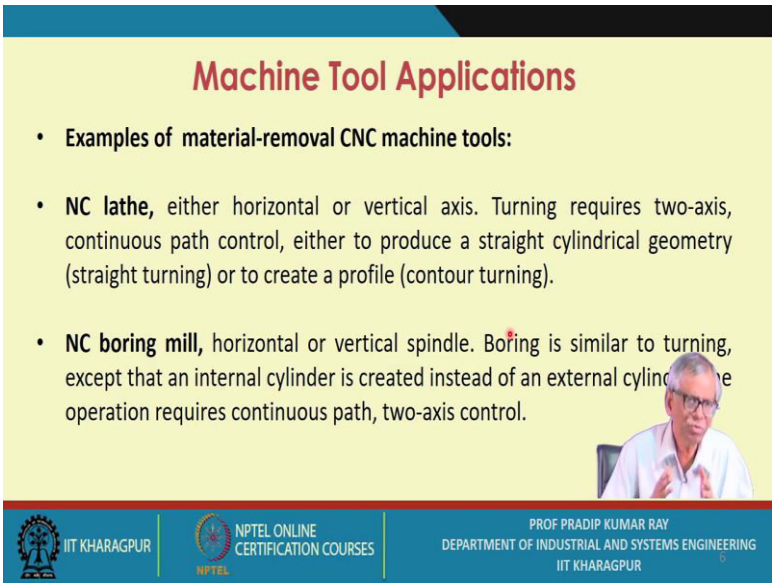

These are three typical process parameters. Now, there are many types of machine tools and NC technology you can apply. So, machine tool becomes NC machine tool and these days you will find that NC is nothing, but CNC (Computer Numerical Control). The following is the list of the common material-removal CNC machine tools along with their typical features:

NC lathe, either horizontal or vertical axis. Turning requires two-axis, continuous path control, either to produce a straight cylindrical geometry (straight turning) or to create a profile (contour turning).

NC boring mill, horizontal or vertical spindle. Boring is similar to turning, except that an internal cylinder is created instead of an external cylinder. The operation requires continuous path, two-axis control.

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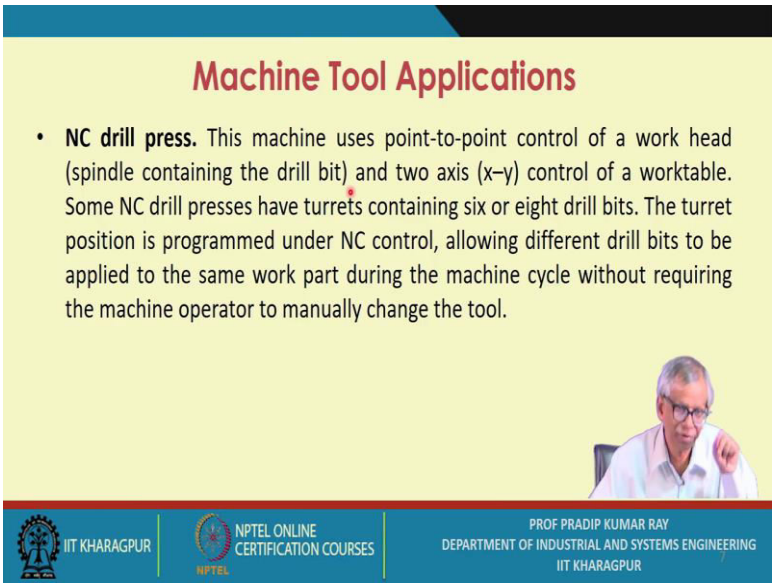

Third one is a NC drill press. This machine uses point-to-point control of a work head (spindle containing the drill bit) and two axis (x–y) control of a worktable. Some NC drill presses have turrets containing six or eight drill bits. The turret position is programmed under NC control, allowing different drill bits to be applied to the same work part during the machine cycle without requiring the machine operator to manually change the tool.

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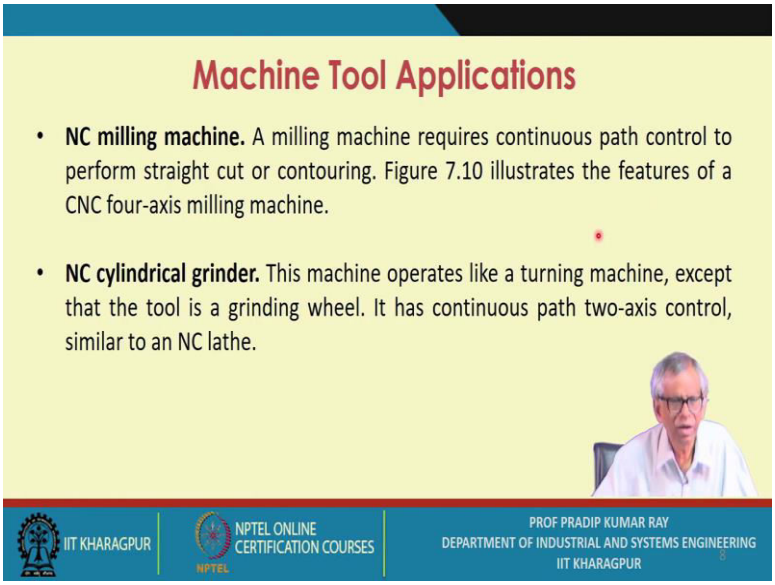

Then the next one is the NC milling machine. A milling machine requires continuous path control to perform straight cut or contouring. Figure 7.10 illustrates the features of a CNC four-axis milling machine.

And, NC cylindrical grinder that is another kind of the grinding machine. This machine operates like a turning machine, except that the tool is a grinding wheel, this is finishing operation.

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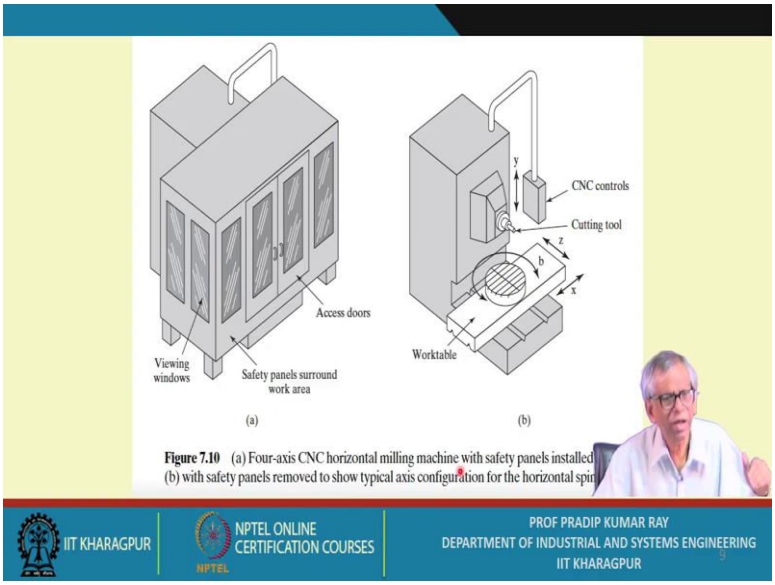

These are the two typical examples. This is the four axis CNC horizontal milling machine maybe the x, y, z and then one rotational axis

So, with safety panel, this is one safety panel and this is the next one, like with safety panels this is without safety panel with and with safety panels removed means, without safety panel.

This is y direction, this is z direction, this is x direction and this is one rotation that is the b cutting tool, so, the cutting tool this is the location of the cutting tool. So, this is a typical CNC horizontal milling machine

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Over many years of machine shop practice, the following part characteristics have been identified as most suited to the application of NC:

Batch production. NC is most appropriate for parts produced in small or medium lot sizes (batch sizes ranging from one unit up to several hundred units). Dedicated automation would not be economical for these quantities because of the high fixed cost. Manual production would require many separate machine setups and would result in higher labour cost, longer lead time, and higher scrap rate.

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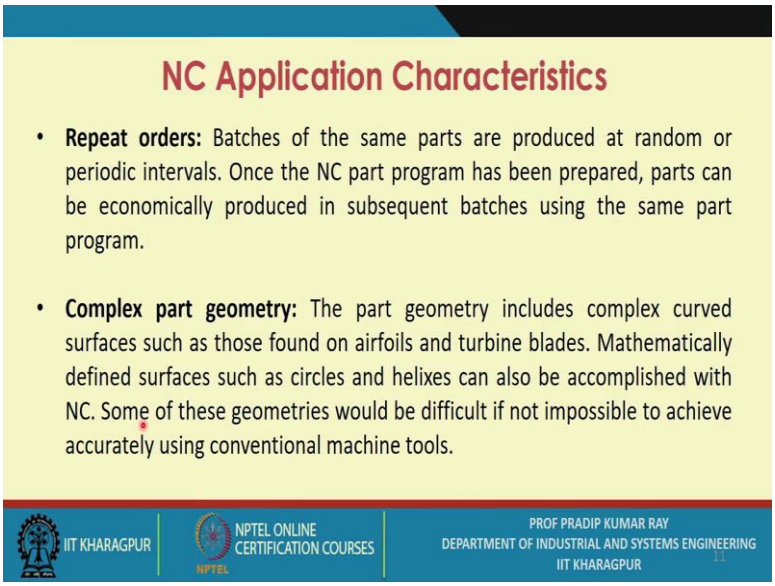

Repeat orders. Batches of the same parts are produced at random or periodic intervals. Once the NC part program has been prepared, parts can be economically produced in subsequent batches using the same part program.

Complex part geometry. The part geometry includes complex curved surfaces such as those found on air foils and turbine blades. Mathematically defined surfaces such as circles and helixes can also be accomplished with NC. Some of these geometries would be difficult if not impossible to achieve accurately using conventional machine tools.

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Much metal needs to be removed from the work part. This condition is often associated with a complex part geometry. The volume and weight of the final machined part is a relatively small fraction of the starting block. Such parts are common in the aircraft industry to fabricate large structural sections with low weights.

Many separate machining operations on the part. This applies to parts consisting of many machined features requiring different cutting tools, such as drilled and/or tapped holes, slots, flats, and so on. If these operations were machined by a series of manual operations, many setups would be needed. The number of setups can be reduced significantly using NC.

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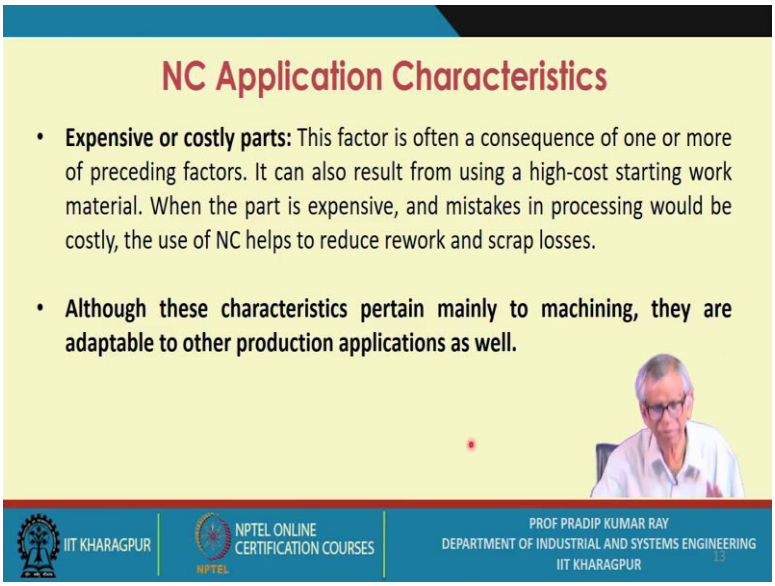

Expensive or the costly parts where raw material is very expensive.

Now, the make sure that the rejection percentage maybe should be almost 0; that means, you need to have 0 defects. Run with a minimum cost, because if there is a failure or if there is a reject it will very expensive.

When the part is expensive and the mistakes in processing would be costly. The use of NC helps to reduce rework and the scrap losses. Normally the scrap cost compared to the rework cost is almost is double, even if you say that the first time when you process it cannot make it 100 percent the defect free.

But, then at least you try to create a system where most of unacceptable output are in the rework category. There will be some reprocessing and then you get defect less output.

This factor is often a consequence of one or more of preceding factors 3, 4, and 5. It can also result from using a high-cost starting work material. When the part is expensive, and mistakes in processing would be costly, the use of NC helps to reduce rework and scrap losses. Although these characteristics pertain mainly to machining, they are adaptable to other production applications as well.

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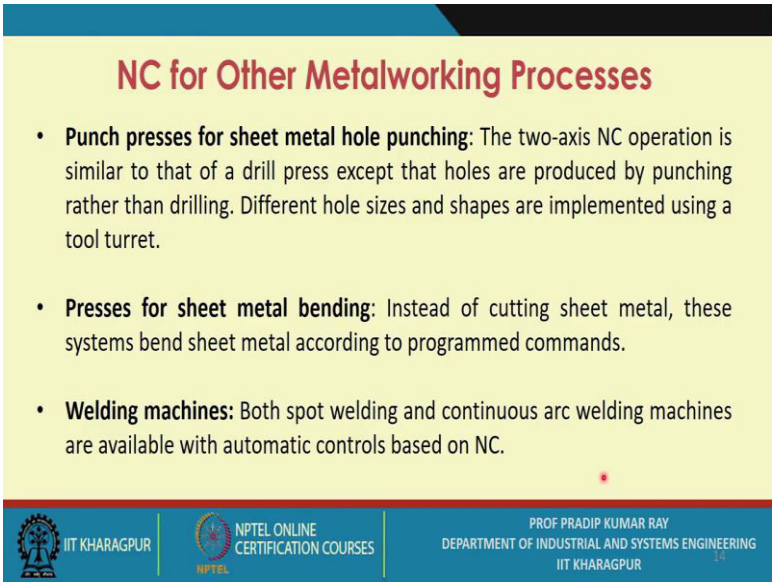

Punch presses for sheet metal hole punching. The two-axis NC operation is similar to that of a drill press except that holes are produced by punching rather than drilling. Different hole sizes and shapes are implemented using a tool turret.

Presses for sheet metal bending. Instead of cutting sheet metal, these systems bend sheet metal according to programmed commands. Welding machines. Both spot welding and continuous arc welding machines are available with automatic controls based on NC.

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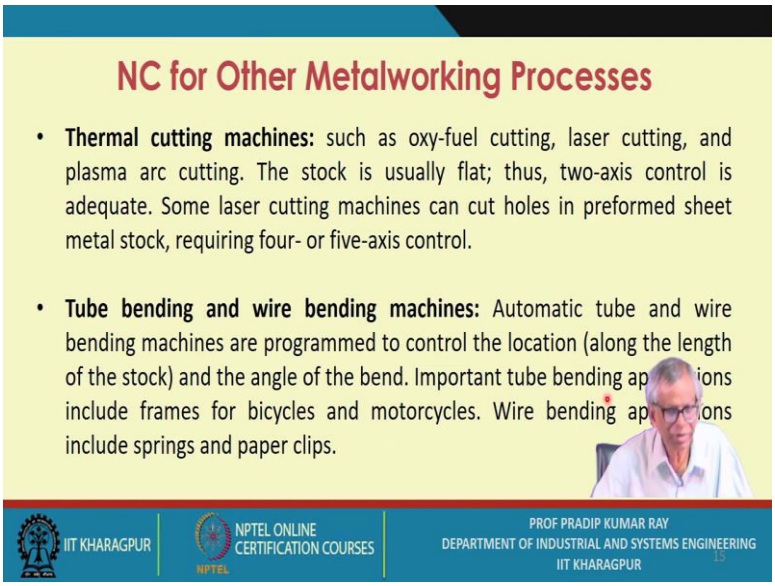

Thermal cutting machines, such as oxy-fuel cutting, laser cutting, and plasma arc cutting. The stock is usually flat; thus, two-axis control is adequate. Some laser cutting machines can cut holes in preformed sheet metal stock, requiring four- or five-axis control.

Tube bending and wire bending machines. Automatic tube and wire bending machines are programmed to control the location (along the length of the stock) and the angle of the bend. Important tube bending applications include frames for bicycles and motorcycles. Wire bending applications include springs and paper clips.

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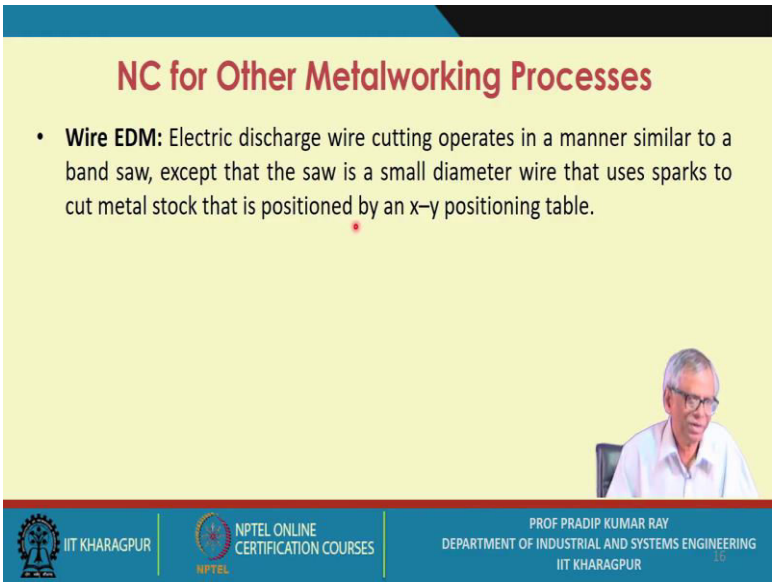

And, EDM electric discharge wire cutting operations. Electric discharge wire cutting operates in a manner similar to a band saw, except that the saw is a small diameter wire that uses sparks to cut metal stock that is positioned by an x–y positioning table.

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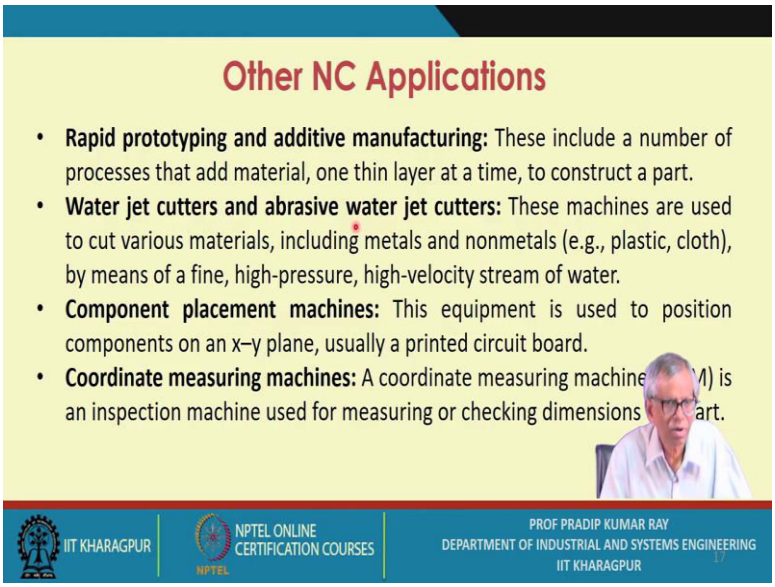

Now, other NC applications are rapid prototyping These include a number of processes that add material, one thin layer at a time, to construct a part.

Water jet cutters and abrasive water jet cutters. These machines are used to cut various materials, including metals and nonmetals (e.g., plastic, cloth), by means of a fine, high-pressure, high-velocity stream of water.

Component placement machines. This equipment is used to position components on an x–y plane, usually a printed circuit board.

Coordinate measuring machines. A coordinate measuring machine (CMM) is an inspection machine used for measuring or checking dimensions of a part.

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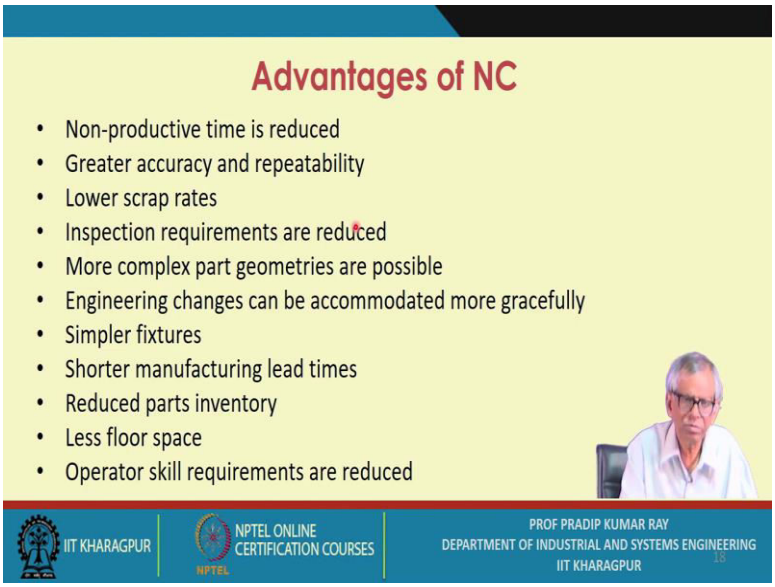

So, what are the advantages of a NC. First one is the non-productive time is reduced, throughput time gets reduced and setup time will be highly reduced in majority of the cases. And the processing time, there is the manufacturing lead time.

Greater accuracy and repeatability, repeatability is basically precision. So, both accuracy as well as the precision will have to increase. The lower scrap rates means it will have a direct impact on quality of the output. So, the quality of the output will be highly improved.

Inspection requirements are reduced and will be reaching to quality assurance system and quality control system. Quality control system, online real time control each and every part you need to inspect either manually or automatically, that means, automated system.

But, when you reach the quality assurance system, part wise no need to inspect I know that next 1000 consecutive parts will be meeting the quality standards or the specifications or the tolerances. I do not need to measure. Beyond 1000, I need to measure. So, that is the level of quality assurance against the particular machine tool.

More complex part geometries are possible which needs 5-axis contouring, 6-axis contouring. Engineering changes can be accommodated more gracefully. Simpler fixtures: the fixtures are very important work holding device, you can design the simpler fixtures.

Shorter manufacturing lead time, parts inventory – it will have a direct impact on working process inventory and if the entire production system is based on NC technology, you expect that the smooth flow of materials within the production system.

And, the smooth flow means, with minimum transfer time, with minimum waiting time. What you can expect that the WIP so, almost if not the continuous processing even if you the discrete part manufacturing system at least the continual are the process system

You can create and under such the conditions what you find that the WIP or work in process inventory becomes minimum. So, that is why reduced parts inventory, less floor space, operator skill requirements are reduced.

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But there are certain disadvantages also and the higher investment cost, but it is maybe the one time and once you calculate the total life cycle cost. So, there are many cases where you will find that if it is an automated system and all other conditions you try to fulfill the total life cycle cost will be as minimum as possible. So is the advantage.

Higher maintenance effort –there is special maintenance group is required, but once they are well trained then it will not be a problem at all, the regular servicing will be made, when the servicing is guaranteed. The maintenance may not be a critical problem. Part programming knowledge is a must, there is a special type of persons to be engaged, referred to as the part programmer.

NC part programming part we will be discussing in the next week. There could be different types of part programming approach and even in these days we will find that this part programming, for the repeat parts can be done by using manual data inputs or MDI systems and can be done by the operator also on a typical say NC machine.

Part programming as an important part and you must have the competency in writing down the part programs. Higher utilization of NC equipment, so, that is to be guaranteed. In many cases what happens in earlier times that NC machine is installed, but then again is utilization is very less, production cost also will be very high. That is not affordable that is why higher utilization of the NC equipment is a must.

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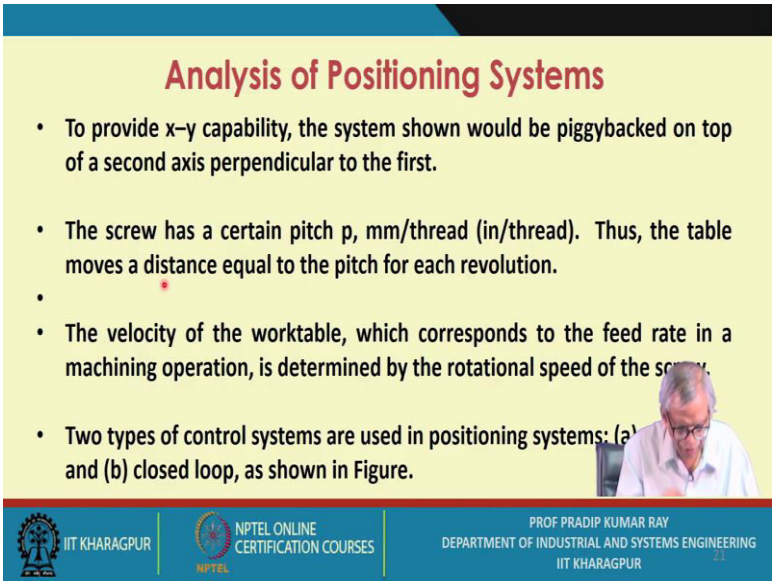

These are the positioning systems already we have discussed. I have again highlighted because all these machines, the NC positioning system you should be aware of and like all these details you please go through them

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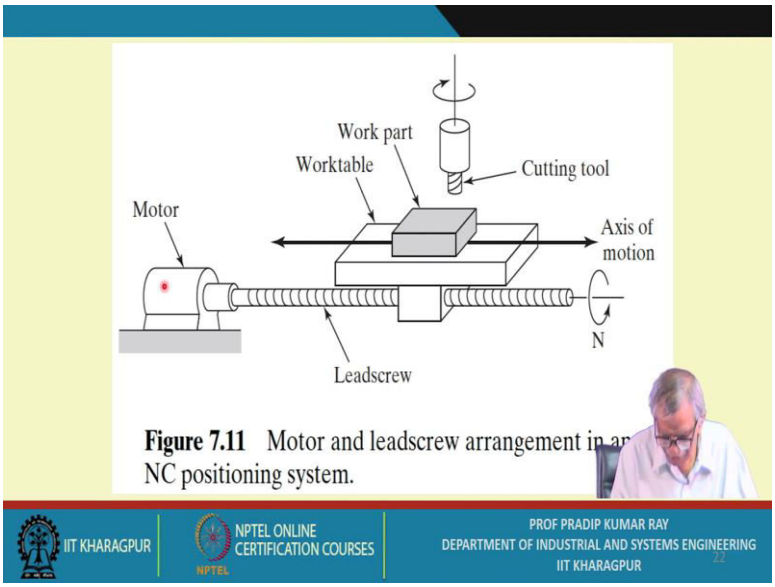

And, this is a typical the NC machines the motor and lead screw arrangement in an NC positioning system.

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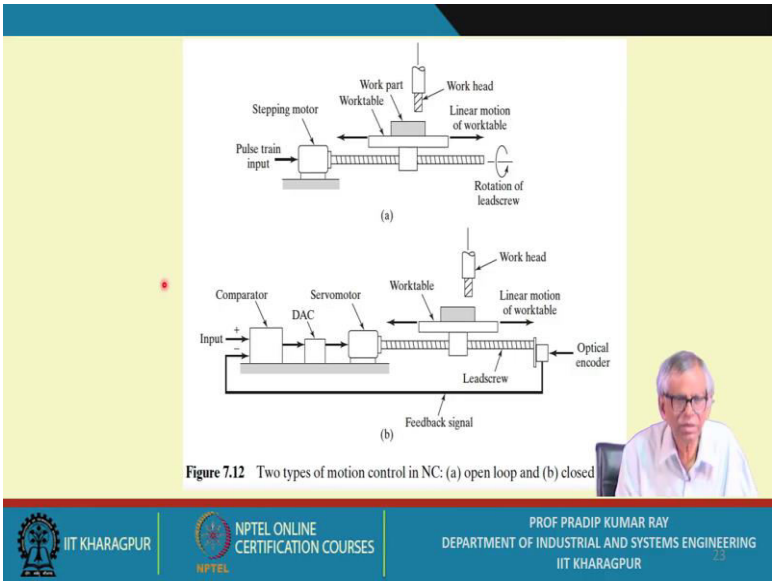

And, this is two types of motion control in NC open loop and closed loop.