Manufacturing Systems Technology

Prof. Shantanu Bhattacharya

Department of Mechanical Engineering and

Department of Industrial and Production Engineering

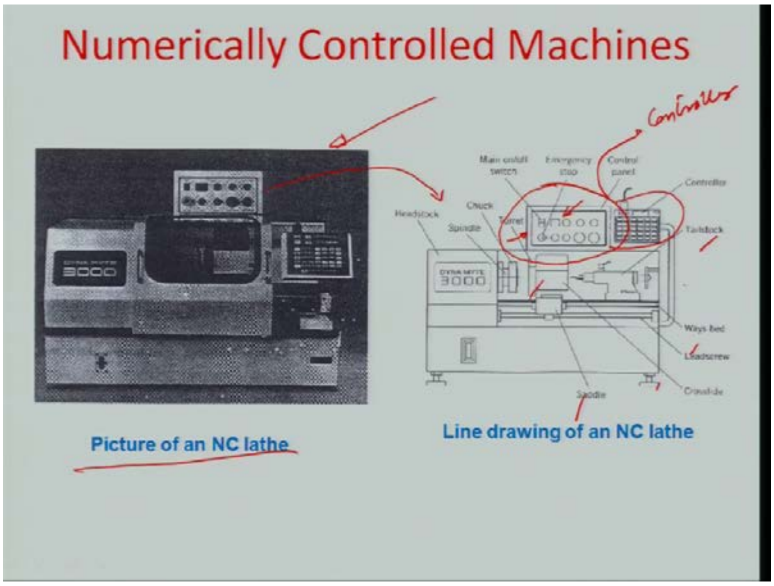
Indian Institute of Technology, Kanpur

Module – 06

Lecture – 32

Hello and welcome to this Manufacturing Systems Technology module 32.

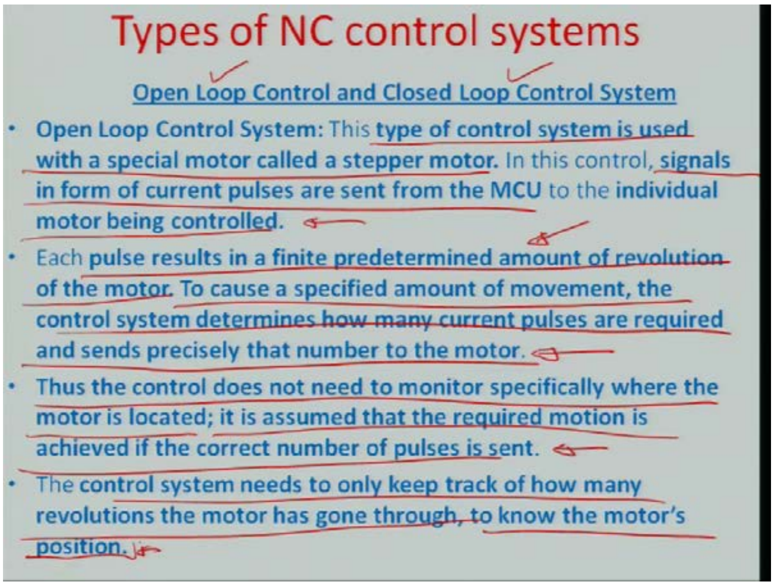
(Refer Slide Time: 00:16)



We were talking about numerically controlled machines and basically, what we discussed in the last class was that there are no different than ordinary machines except the fact that the relative tool to work piece movement is now controlled through a controller process and the human interfaces avoided between the controller and the machine. Although there is; obviously, a human interface between the controller and the external system which wants to develop a certain design in a machining centre.

So, this is a sort of a most recent picture borrowed from a text book of an NC machine, this is called an NC lathe and you can see, if you do a line diagram or a schematic of this particular machine, then it is basically different than a conventional machine only in terms of those whole unit right here, which is actually the controller unit. So; obviously, the controller needs to communicate with the external world. So, you have some kind of a switch board for controlling this controller and you have a control panel on this particular, you know way that you sort of give signals to the controller. And remaining everything else including the leads screw, the cross slide, the saddle, the tails stock, the head stock whatever is just as a conventional machine. So, this gives you an illustration of how NC machines are quite a like technologically to the conventional machines.

(Refer Slide Time: 01:45)



So, if you look at the various the ways in which the automated operations within NC system happens, there are two different kind of motion control which are generally executed within the whole NC domain, one is given by a DC motor, Direct Current motor and other is more like a stepper motor which works are voltage pulses. But, you have a very good control of these stepper motors in terms of number of pulses that you are providing and their actual rotation or actual movement and these are all, you know rotational to linear movement converted in terms of different lead screws etcetera, all in built as a capability of the NC system.

So, typically what you otherwise your earlier achieving in a lathe machine with an operator operating on to the cross slide by means of a lead screw by rotating it with some number of rotations, so that there is a linear movement is now achieved by the stepper motor or DC motor. So, stepper motor is mostly for the fine positioning, DC motor being a high torque motor is mostly for the you know reign where you have to have actually the cutting forces, the trusses, etcetera executed to the particular machine.

So, if you look at the way that these motors are controlled by the controller, there are principally two different control systems which would exit, one is a open loop control system and other is a closed loop control systems. So; obviously, open loop control system I think we are quite aware how this type of control works is used with a special stepper motor and open loop meaning thereby, that there is no feed backs signal; obviously, stepper motor is very accurate.

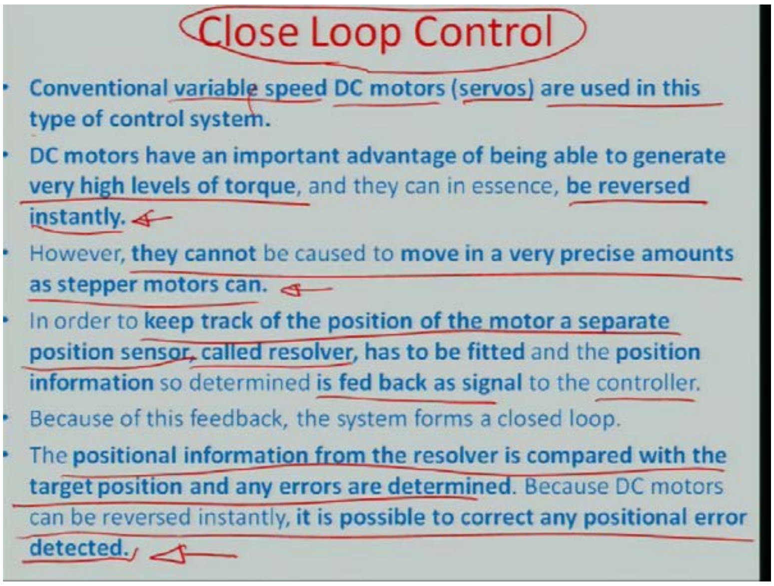
So, you can actually know how much it has proceeded linearly by means of how many pulses has been provided in the stepper, because a stepper actually turns exactly, so many degrees of rotation after one voltage pulse has been given. So, it is a very correctly controlled, very precisely controlled motoring system. So, in this you have signals in form of current pulses and they are sent from the MCU or the Main Control Unit to the individual motor being controlled and there are many such a stepper motors all round the whole NC system, which would allowed to have this relative motion control between tool and work pieces as needed. And each pulse would result in a finite predetermined amount of revolution very, very precisely controlled.

So, you do not have a under shoot or a over shoot problem in this particular case, it is exactly the degree of revolution that you wanted to have is achieved at the end of the whole pulse setting signal and the pulses cut off, then automatically there is a quick stoppage, there is hardly any breaking effort or any time delay which happens between you know analogously between the point on the voltage the current pulses gone and the motion of the motor is still continuing.

So, there are hardly any inertial components of load associated with such a stepper motor, it is a part of the design of the stepper motor system that is how it is designed actually. So, you cause a specified amount of movement and the control system determines how many current pulses are required and sends precisely that number of current pulses to the motor. So, you do not need really an ender positioned kind of a position reader kind of a system in this case, because you are already quite sure of the preciseness at which the rotation would convert in to some kind of a translation and you quite certain that the lead screw would reach a certain position in that particular system.

So, that the control does not need to monitor specifically where the motor is located, it is assumed that the required motion is achieved, if correct number of pulses is sent and that is how the distribution of the signal current signal is carried out by the MCU to such stepper motors. Only you need to, the control system only needs to keep track of how many revolutions the motor has gone through by knowing the counts of the number of current pulses and from that you can actually calculate very accurately, the motors position with respect to time. So, that is how this whole business actually works in case of NC control, open loop control systems.

(Refer Slide Time: 06:03)



On the other hand, for some of the high torque applications as I was telling in machining, we need servos or DC motors and which have analog or variable speeds and they are used in this, you know sort of a closed loop controlled manner. Because, you exactly now need to a certain, where the positioning has happened at the end of the whole DC cycle. And therefore, you need to know exactly the position of the motor in terms of the rotational angle executed after the signal has a started till it actually stops.

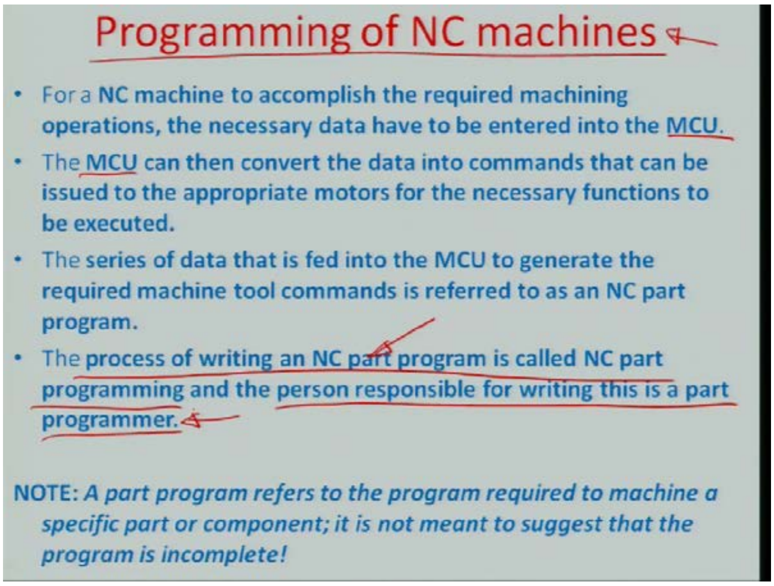
So, you can, the advantages that you can very high level of torques, because that is what an advantages with the DC motors. Obviously, you can reversed the motor that is another very, very big advantage in this particular case that you have a reversal, but they cannot be caused to move in a very precise amounts, just as we were seeing in the open loop case earlier, the precision of stepper motors cannot be executed by DC motor, this is always an understood or you know over shoot kind of a situation, where the motor may just end a few more degrees to what it was required to traverse. Because of it is own inertia, etcetera it takes some time to break and this realistically not a quick start, quick stop kind of a system.

So, in order to keep track of the position of the motor, you need a separate position sensor which is also known as a resolver and this has to be fitted definitely to monitor how the motors performing in terms of it is position and the signal is now fed back. So, that is why it is a closed loop, that this signal in a closed loop manner is fed back and the motor can be sometimes even reversed in order to accurately come back to the position in question.

So, this positional information; obviously, from the resolver would be compared with the target position and the errors are then determined accordingly. Because, DC motors can be reversed instantly it is possible to correct any positional error detected. So, if there is a over shoot in some particular case you can; obviously, send a reverse DC signal by changing the polarity and let it actually now in a very slow manner go to the accurate position from where it had actually over shot. So, this is about what the controller does to the machine.

So, the controller actually is now responsible for sending other shot current pulses or DC current for these different kind of motors to be operational. So, that there is a leads screw motor arrangement, which is now moving relatively the work piece and the tool. The other side of the controller which needs to be really worried about is the side, where you want to command the controller would do something, important and useful and that is how your controller primarily on the whole machine system remains, which leads you to make what you desire and make through the NC machine.

(Refer Slide Time: 09:08)

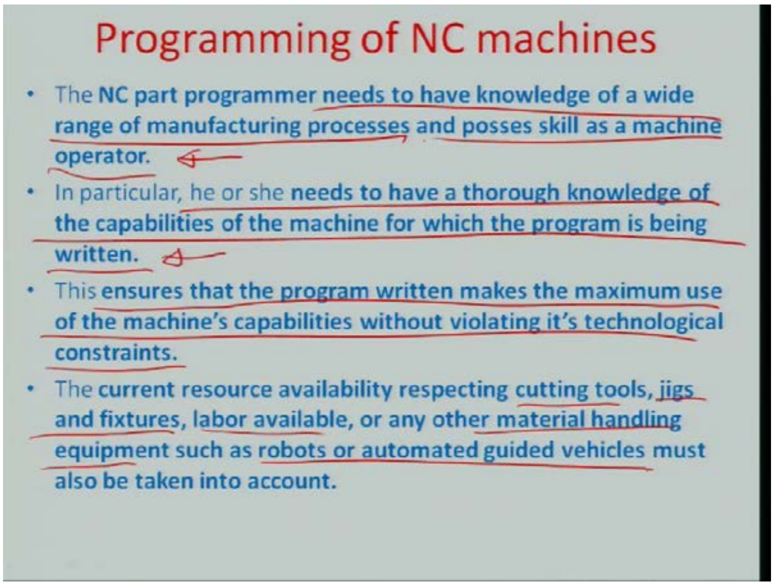


So, therefore, in some manner you have to started interacting with the controller and develop a language for the controller to understand logically and there is where this programming of a NC machines comes very handy and to picture. And therefore, you have to first of all develop a coordinate map based in numerical data and then be able to organize your commands or you are you know communications in a very effective manner. So, that the controller understands you and repeats that understanding every time, you have said something a like you know.

So, therefore a language evolves in that and it is called the NC programming language based on which you can actually start controlling the machine control unit or MCU. So, the process of writing an NC part program is also known as NC part programming and nearly it just means you know the part program just means that your writing it for a engineering part, you do not think it or do not miss read it as part of a program or a partial program or a sub routine nothing like that the part program simply means that you are programming the whole NC system, the numerical control system for developing an engineering part and that is why the term part programming has been mentioned here.

So, NC part programming typically done by a person who is responsible for writing this instructional code which is very conveniently red by the controller and you know that person makes a code and then this code repeats thousands of times and generates as many parts you know with same kind of precision an accuracy as is desired by the concerned person. So, therefore, it is kind of an automated way of manufacturing.

(Refer Slide Time: 10:42)

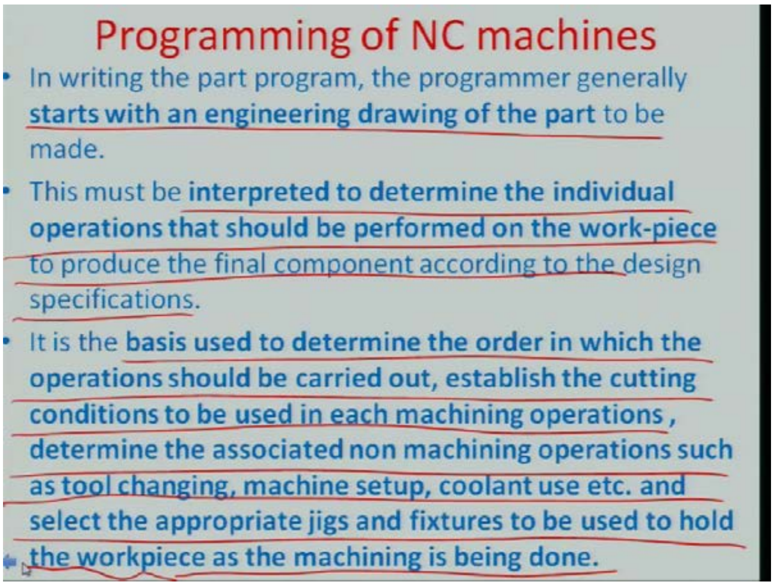


So, what all does a part programmer needs to know in advance before starting such a programming you know activity. So, the NC part programmer should need to have definitely knowledge of a wide range of manufacturing processes and it should also be a able to posses skill as a machine operator. So, that it may be able to see some of the short comings of middle to middle machining processes which would otherwise occur and conventional tools. So, he, she needs to have a thorough knowledge of capabilities of the machine with which the program is to be written.

For example, he needs to know about what is the accuracy with in which what is the surface finish or what is a accuracy within which you need to operate he also needs to have a data about the feeds and speeds at which optimum material removal would happen and all these have been I think in way illustrated earlier in our cap process. So, all this information comes from that operator knowledge which has been embedded in to a computerized process planning system given earlier.

So, this ensures that the program written makes the maximum use of machines capabilities without violating it is technological constraints. And; obviously, there are going to be the cutting tools the jigs and fixtures the available labor any other material handling equipment, such as robots or automated guided vehicles all these as a part of the manufacturing environment which somehow need to be again trigger down to the programmers knowledge base for it to be able to a very effective way manage this whole, so call machining operation the part which the controller has to be communicated and left alone for doing with respect to the particular machine which is giving the deliverables.

(Refer Slide Time: 12:30)

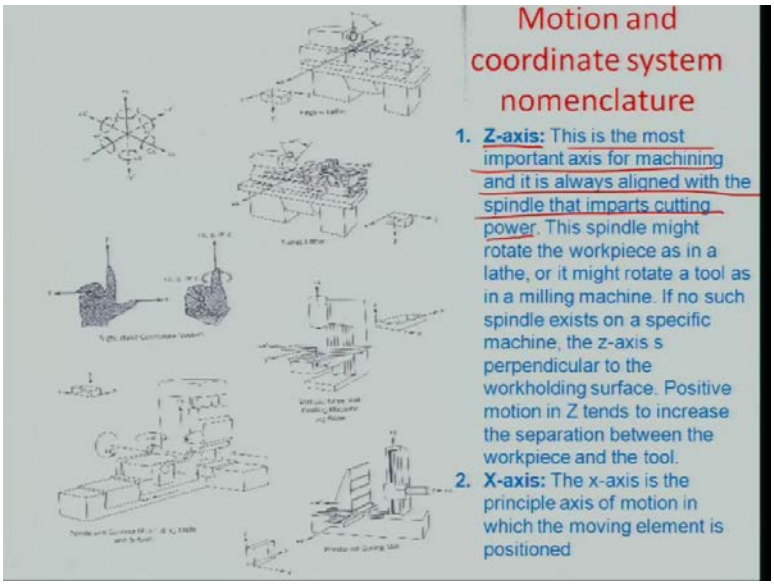


So, in writing a part program, the programmer generally starts with; obviously, an engineering drawing of the part and this drawing is red in some kind of a orthogonal coordinates system, were this must be interpreted to determine the individual operations that should be performed on the work piece to produce a final component according to the design specifications. And this is the basis used to determine the order in which the operation should be carried out establish the cutting conditions to be used in each machining operations, determined the associated non machining operations such as tool changing, machine set up coolant use etcetera and select the appropriate jigs and fixtures to be used to hold the work piece as the machining is being done.

So, in a nutshell these are some of the important steps that a programmers starts with. So, arranges the engineering drawing and determines the individual operations an also sort of establishes conditions of machining etcetera you can borrow it probably from your earlier cap determined strategies etcetera, so that you can start doing the NC program. So, the first think which is of importance for me to discuss here is how you actually try to give a coordinate frame in which you have laid out to the drawing or the design.

How you now try to defined the motion sequence in that coordinates frame as a function of positive distances and negative distances along the different axis of motion. And these are sort of nomenclature these a standard conventions which are used world over to produce NC systems which would generate that how this part would move relatively with respect to the tool or the working tool in such a NC machine.

(Refer Slide Time: 14:33)



So, the first movement which is recorded is typically along the z axis, which is the most important axis for machining and it is always aligned with the spindle that imparts the cutting powers. So, for example, in a lathe this spindle holds of work piece and rotates a work piece, in the same instance if you look at something like a face milling system, the spindle is actually responsible for rotation of the tool. So, it really does not Mather whether it is the tool or the work piece, but the spindle generally is the unit in a any conventional machine which is going to give the cutting power which is going to a certain that machine material removal takes place at a certain rate.

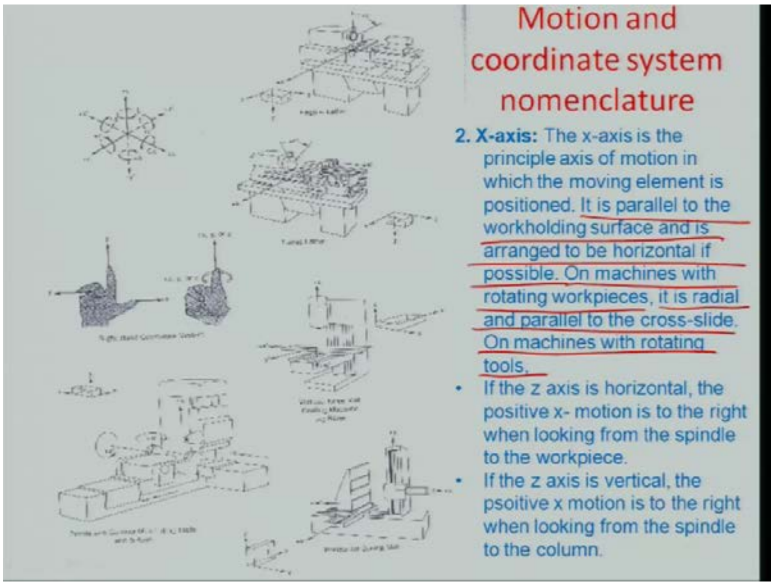
So, one thing is very clear here that the z axis is always the axis of that spindle which gives or delivers the cutting power and you have to just consider that... So, if supposing there is a work piece on the surface of a table, let us say there is a face milling operation where there is a milling tool coming from the top in this work piece. So, if you are moving away from the work piece, it is always signifying a positive z direction and if you are moving in to the work piece it is always signifying a negative z direction. So, this is how you program the coordinates.

So, that now with the stepped approach and a given convention, every time your reading out only the coordinate data which is coming from the drawing or something which is come from the last step of the cap and based on that readout of the numerical data you are actually ascertaining whether there is a certain direction of movement relative with respective to the tool to the work piece.

So, in case of milling machine for example, there is a face milling; obviously, the cell in the spindle is the z axis that is what we said and if you see that if positive z motion tends to increase always the separation between the tool and the work piece; that means, your tool going away from the work piece, it is going in the positive direction and the z direction and if it is going into the works piece, it is going in the negative z direction.

So, given this z axis now if you can define only one other axis x; obviously, in a three dimensional orthogonal coordinate system, if the z an axis non as automatically the y can be known. So, we will go to the next step now which will say how to do the x axis read out.

(Refer Slide Time: 17:02)



So, the x axis is again the principle axis of motion in which moving elements is position, it is parallel to the work holding surface and it is arranged to be horizontal if possible. So, on machines with rotating work pieces for example, lathe etcetera it is radial and parallel to the cross slide on machines with rotating tools for example, milling etcetera the positive axis always now when we are having the such a tool I had always mention that you know this spindle is in the positive z direction, when it is moving away from the work piece the work pieces kept like this.

So, now, the tool is if you look at the way that the spindle is mounted it is always mounted in some kind of a column, which is there in the backhand of the machine which is away from the work piece. So, with that column on board if your rotating the spindle and this is the positive z axis, where the work it is going away from the work piece in this direction to your right is the positive x axis.

So; obviously, if you have the positive z and the positive x would automatically be able to a certain what is the positive y. So, we will do this send more details in the next module, the interest of time we are closing down this module at this point of time. So, in the next module we will start again from looking at some of these principle directions and develop a good nomenclature.

Thank you.